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ASSESSMENT OF ADOLESCENTS' AND THEIR PARENTS' DENTAL ESTHETIC PERCEPTIONS: A LONGITUDINAL STUDY

by

Golnaz Kavand

A thesis submitted in partial fulfillment
of the requirements for the Master of
Science degree in Dental Public Health
in the Graduate College of
The University of Iowa

December 2012

Thesis Supervisor: Professor Steven M. Levy

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Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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This is to certify that the Master's thesis of

Golnaz Kavand

has been approved by the Examining Committee
for the thesis requirement for the Master of Science
degree in Dental Public Health at the December 2012 graduation.

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To My Parents

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TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER 1

INTRODUCTION

According to the World Health Organization (WHO) definition, health is not merely the absence of disease; rather, health is comprised of physical, mental, social and emotional well-being (1). This implies that clinical judgment of health care providers and, in this case, dental professionals should not be the only factor influencing decisions on individuals' treatment plans or for health-related policies. Instead, there should also be emphasis on the importance of individuals' opinions of oral health in assessing their treatment needs. This issue becomes more critical for oral conditions affecting dental esthetics and facial appearance, which have recently attracted considerable public attention, in part due to the influence of widespread advertisement of cosmetic products and services.

Dentofacial esthetics, which plays an important role in overall facial attractiveness, is particularly of interest among adolescents. Adolescence involves the transformation from a dependent child to an independent adult. Major physical and psychological changes occur during this phase of life, including development of self-perception, which plays an important role in development of a healthy sense of self-esteem (2). Furthermore, teenagers place high value on peer group judgment and may pay too much attention to physical attractiveness and facial appearance, including tooth color and alignment. It has been shown that peer and teacher judgments about adolescents' facial attractiveness can affect adolescents' social interactions, peer relations and even educational success (3).

Dental fluorosis is an oral health condition that has various levels of involvement, varying from white streaks on teeth to dark stains and pitting of teeth. This condition is

caused by high consumption of fluoride during the time teeth develop, which for permanent incisors is until approximately four years of age. Fluoride is a trace element that makes tooth structure resistant to cavity development. For this reason, fluoride is used in various forms, such as fluoridated water, mouthrinse, toothpaste, office topical fluoride therapy, and dietary supplements to prevent or reverse the development of tooth decay.

Although there has been a significant reduction in tooth decay in recent years in most developed nations due to these fluoride exposures, dental fluorosis is seen more frequently than before. In the U.S., the prevalence of dental fluorosis in adolescents aged 12-15 has increased from 22.6% in 1986-1987 to 40.7% in 1999-2004 (4). Since the majority of fluorosis cases are very mild or mild (more than 87%) (4), fluorosis is not recognized as a great public health problem in the U.S. However, it has been shown that even mild dental fluorosis can be perceptible to lay people, particularly to adolescents who are more concerned about their appearance, as mentioned above (5).

Malocclusion, or misalignment of teeth, is a highly prevalent esthetic problem which has been reported as the third highest oral health priority in a recent WHO report (6). Dissatisfaction with dental appearance and parental concerns about tooth position are the major causes of seeking orthodontic treatment. Misaligned teeth are often difficult to clean; therefore, they are more susceptible to tooth decay and gingival diseases. Some forms of malocclusion are so severe that normal functions such as chewing and speaking are difficult. Moreover, tooth malpositioning, particularly with maxillary anterior teeth, may result in impaired facial esthetics and impose negative psychological impacts on children and teenagers.

There are several investigations which have assessed children's and adolescents' esthetic perceptions and evaluated their consistency with results of clinical assessment, sociodemographic characteristics and parental esthetic perceptions. However, none of them have focused on changes in perceptions of adolescents and parents during this critical phase of life. Such changes in perceptions may lead the families to seek esthetic dental care such as orthodontic treatment, restorations and bleaching, or conversely may make them less willing to continue esthetic dental care. These changes may also affect adolescents' and their parents' satisfaction with treatment results.

Self-perceptions and their association with oral health conditions should be used to prioritize the oral health problems and treatment needs of individuals or communities, so that adequate treatment can be provided or effective policies and recommendations can be developed to optimize both oral health and the psychosocial well-being of individuals and the community. Therefore, studies are needed to assess how adolescents' concerns about dental esthetics change during this phase and what factors influence their satisfaction.

The primary purpose of this study was to assess how dental esthetic perceptions of adolescents and their parents change from when the adolescents were 13 years old to 15 years old. This study also evaluated how these perceptions were associated with oral health conditions, including dental flouorsis and malocclusion. This study conducted secondary analysis of data collected in an ongoing cohort study, the Iowa Fluoride Study. Adolescents were examined for assessment of fluorosis, occlusal characteristics and caries experience at age 13. Additionally, they filled out questionnaires asking about their dental esthetic perceptions at ages 13 and 15. At the same time, their accompanying

parents also completed similar questionnaires asking about their esthetic perceptions of adolescents' dental appearance.

CHAPTER 2

LITERATURE REVIEW

This study assessed how dental esthetic perceptions of adolescents and their accompanying parents changed from the age of 13 to 15. Then it evaluated how these perceptions were associated with oral health conditions, including dental fluorosis and malocclusion. This chapter provides background information on oral conditions affecting facial esthetics, including fluorosis and malocclusion, and then reviews recent studies of parents' and children's dental esthetic perceptions of fluorosis and malocclusion.

Fluorosis

This section contains information on the etiology, clinical manifestations and prevalence of fluorosis. It also presents available indices that are used to quantify severity of dental fluorosis. At the end, a summary of the Fluorosis section is provided.

Etiology

In the early 20th century, Frederick McKay encountered a prevalent dental condition in long-term residents of Colorado Springs described as "Colorado brown stain". Later in 1916, G.V. Black, in collaboration with McKay (7), described the histological characteristics of this condition, which he called "mottled enamel", since it was not restricted to Colorado only. Two distinct characteristics were noted for mottled enamel: lack of deposition of mineral substances in interprismatic space that resulted in a chalky, opaque appearance of enamel and penetration of external stains into defective enamel following eruption of the tooth, which led to orange or brown staining. It was noted that the condition was common among persons using the same water sources, mostly deep artesian wells (7). Despite the presence of enamel defects, caries experience was lower in areas with endemic mottled enamel; nevertheless, if teeth had carious lesions, it was more difficult to provide adequate restorations in teeth with weakened structure.

In 1931, H.V. Churchill (8) determined concentrations of fluoride (F) up to 14 ppm in several water samples sent by McKay. In the 1930s, H. Trendley Dean started a comprehensive investigation of the relationships between fluoride levels and mottled enamel, which Dean replaced with the term "dental fluorosis". He obtained monthly water samples for one year from different cities and compared results of chemical tests with relevant clinical observations (9). He was the first investigator who identified the approximate minimal threshold of 1 ppm for fluoride level of drinking water and concluded that the F levels below 1 ppm do not cause significant public health problems with fluorosis.

Linking dental fluorosis prevalence data with those for dental caries, Dean and coworkers reported that dental caries is inversely associated with water F levels and dental fluorosis (10). He started a series of investigations known as "The 21 Cities Study", in which findings of dental examinations of 12- to 14-year-old children residing in 21 U.S. cities were compared with the F level of their water supplies (11). The range of 1.0 to 1.2 ppm was identified as the optimum level of fluoride which substantially prevented caries development, but the prevalence and severity of fluorosis were kept at "acceptable" levels (11). Dean's studies have provided much of the fundamental understanding of fluoride's role in the development of dental fluorosis and caries prevention.

Besides the total amount of fluoride intake, its timing is also of interest, since excessive fluoride intake can only lead to dental fluorosis during enamel formation. In 1986, Evans and Stamm (12) conducted an epidemiologic study to determine the period in which maxillary permanent incisors are at the highest risk of development of fluorosis due to exposure to fluoridated water. They found that an eight-month time frame from 20 to 28 months after the birth was the period when children were at greatest risk of development of fluorosis in maxillary central incisors and, within this time frame, four-month period beginning approximately at age of 22 months was the most critical for these

teeth. They also found that excessive exposure to fluoride after this period up to age 36 months was associated with higher risk of development of fluorosis compared to ages younger than 20 months. Finally, they concluded that the risk of dental fluorosis from fluoridated water is minimal during the first 18 months of life; however, they cautioned that these results were based on the exposure to water fluoridation and fluoride supplements might still be associated with some risk of fluorosis prior to age 18 months (12).

In another study by Evans and Stamm (13), the prevalence and severity of dental fluorosis were investigated in Hong Kong following a 0.2 ppm reduction in the fluoride concentration of drinking water. They compared fluorosis status of children with permanent maxillary central incisors developed prior to the reduction in the fluoride level (F level= 0.82 ppm) with a cohort of children who had central incisors developed after the reduction in the fluoride level (F level= 0.63 ppm). The results showed that the prevalence of fluorosis decreased from 64% to 47% and the Community Fluorosis Index (CFI) decreased from 1.01 to 0.75 (13). They concluded that a 0.2 ppm reduction in the fluoride level of drinking water had substantial impact on the prevalence of fluorosis among the children.

As part of the Iowa Fluoride Study, Hong et al. (14) conducted an investigation to assess the association between fluoride intake during the first four years of life and development of fluorosis on upper central incisor teeth. For this study, data from parents of 579 children who completed questionnaires regarding multiple sources of fluoride, including water, selected foods, dietary fluoride supplements and toothpaste every 3-4 months from birth to 48 months, were used. The children were later examined for fluorosis at about the age of 9. Dental fluorosis on both upper central incisors was found on 24% of children.

They found that the first three years of life were most important for incisal edges and incisal thirds, while and the first two years of life were most important for middle and cervical thirds for development of fluorosis (14).

It seems that fluoride influences crystal nucleation and growth of apatite. Electron microscopic studies of enamel specimens with fluorosis have shown that apatite crystals in these specimens are smaller than control specimens; they also have more inter-crystalline spaces and crystal defects (15). Additionally, fluoride inhibits activity of enzymes that are essential for hydrolysis of enamel matrix proteins such as amelogenin. Delay in removal of amelogenin molecules during enamel maturation stage may result in alterations in the structure of enamel (15).

Dental fluorosis manifestations

Dental fluorosis can vary from very mild forms barely detectable by dental professionals to severe cases with fragile enamel that makes normal tooth function impossible. In the very mild forms, the enamel surface has delicate white markings limited to some parts of the surface, which in more involved cases are coalesced to form more discernible white and opaque striations or patches. Moreover, in some cases following tooth eruption, the porosities of the enamel surfaces absorb dietary stains, resulting in orange or brown markings (11). In addition, teeth with dental fluorosis may have more noticeable perikymata and, in severe cases, pits and hypoplastic areas are seen, leading to deviation from normal contour.

Since dental fluorosis is a developmental condition, symmetric enamel defects on both sides of the mouth often occur. In a study by Fejerskov and Thylstrup (16), the fluorosis status of children living in one of three areas with water fluoride levels of 3.5, 6.0 or 21.0 ppm were investigated using a new 10-score classification system. This system, which was called the Thylstrup-Fejerskov Index, is explained in detail in a later section. In this study they found that 58% of paired homologous surfaces had the same

degree of enamel changes and, in 85% of paired surfaces, enamel surfaces were diagnosed with the same or slightly more or less severe enamel changes in one site compared to the opposite site (16). They also found that, in maxillary molars and premolars, lingual surfaces were significantly more likely to be affected with fluorosis than were buccal surfaces; however, in more than half of the cases, both lingual and buccal ones were affected. In maxillary anterior teeth and all mandibular teeth, buccal surfaces were significantly more likely to be affected than lingual surfaces. The same relationship was observed for severity of fluorosis, i.e., the lingual surfaces of maxillary posterior teeth and buccal surfaces of all mandibular teeth were more severely affected. The least affected surfaces were the occlusal surfaces (16).

Prevalence

Since the 1940s, when the impact of fluoride in preventing dental caries was first demonstrated, community water fluoridation programs have been initiated throughout the United States (11), giving rise to a significant reduction in prevalence of dental caries. Besides water fluoridation, by 1960, other fluoride sources, such as dietary fluoride supplements and fluoride-containing toothpastes, became more available in the U.S. This further reduced caries, but also put children at elevated risk for dental fluorosis due to increased total fluoride intake from multiple sources.

Beltran-Aguilar et al. (17) assessed the trends in dental fluorosis in the U.S. between 1986-7 and 1999-2004 using the NIDR and National Health and Nutrition Examination Survey (NHANES) data, respectively. They found that more than 23% of the U.S. population in 1999-2004 was affected by dental fluorosis; however, this was primarily mild, with 16.0% having very mild, 4.8% having mild fluorosis, 2.0% having moderate fluorosis, and less than 1% having severe fluorosis. Based on the same data, fluorosis was more prevalent among adolescents aged 12-15 (40.7%) compared to middle-aged adults aged 40-49 (8.7%). In addition, prevalence of fluorosis in adolescents

in 1999-2004 (40.7%) was higher than the same age group in 1986-1987, which had been 22.6%.

Summary

Since the early 1900s, when the endemic mottled enamel in Colorado was publicized, many studies have been conducted to document the etiology, clinical and histological characteristics and prevalence of dental fluorosis. Continuous exposure to fluoride during tooth development, particularly the first four years of life, leads to changes in crystal development and maturation of enamel. Dental fluorosis occurs in a wide array of manifestations, ranging from delicate white opacities to pits and obvious defects in severe cases; however, the large majority of fluorosis cases in the U.S are very mild or mild.

Clinical measures of fluorosis

Dental fluorosis is manifested as hypomineralization of dental enamel, with various degrees of severity and on different tooth surfaces. Several indices have been developed to quantify severity of dental fluorosis and have been used in epidemiologic studies. The Dean's Fluorosis Index, Tooth Surface Index of Fluorosis, Thylstrup-Fejerskov Index and the The Fluorosis Risk Index (FRI) will be discussed in the following sections.

Dean's Fluorosis Index

Starting a comprehensive investigation to assess the relationships between fluoride exposures, dental caries, and dental fluorosis, Dean (18) designed an index of fluorosis in the 1930s. His first index had seven ordinal categories, but by 1942 he introduced a revised version with a six-point scale, merging the moderately severe and severe categories. Table 2.1 shows the criteria of the revised Dean's Fluorosis Index. Each individual's score is determined based on the second most severely affected tooth.

Dean suggested that if the Community Fluorosis Index (CFI), the average of all individuals' Dean's Index scores, is above 0.6, then dental fluorosis is of significant public health concern. This method is still recommended by the World Health Organization (WHO) in basic surveys (11).

Table 2.1. Dean's Fluorosis Index criteria (18).

0	Normal	"The enamel represents the usual translucent semivitriform type of structure. The surface is smooth, glossy, and usually of a pale creamy white color".
0.5	Questionable	"Slight aberrations in translucency, ranging from a few white flecks to occasional white spots."
1	Very mild	"Small opaque paper white areas scattered irregularly or streaked over the tooth surface; involves less than 25% of tooth surface; frequently included in this classification are teeth showing no more than about 1-2 mm of white opacity at tip of summit of cusps, bicusps or second molars."
2	Mild	"White opaque areas more extensive but do not involve as much as 50% of tooth."
3	Moderate	"All enamel surfaces of the teeth affected; surfaces subject to attrition show marked wear; brown stain is frequently a disfiguring feature".
4	Severe	"Includes teeth formerly classified as "moderately severe" and "severe"; all enamel surfaces affected and hypoplasia so marked that general form of tooth may be affected; major diagnostic sign of this classification is the discrete or confluent pitting; brown stains are widespread; teeth often present a corroded-like appearance".

Since the 1930s, the Dean's Index has been used in many epidemiologic studies, but researchers have found several disadvantages with it. For example, this index assigns a single score to each subject and tooth surfaces are not scored individually. This issue is particularly important for buccal surfaces of anterior teeth which have esthetic impact. In other words, Dean's Index scores are based on the second most affected tooth, which may not have esthetic importance; therefore, the person-level Dean's Index score can be

misleading (19). In addition, Dean's score is an ordinal variable which should not be averaged; nevertheless, its average has been reported as the "Community Fluorosis Index". Other indices have been developed, in part to overcome the shortcomings of Dean's system.

Tooth Surface Index of Fluorosis (TSIF)

Researchers at the National Institute of Dental Research (NIDR) introduced the Tooth Surface Index of Fluorosis (TSIF) in the 1980s (20). They assessed 807 children residing in Illinois communities with various fluoride concentrations of water ranging from optimum to 2, 3, and 4 times the optimal level using the TSIF. They concluded that, as the water fluoride level increases, the prevalence and severity of fluorosis increase. For instance, in an area with optimal fluoride levels, 79% of facial surfaces of maxillary anterior teeth were not affected by fluorosis, compared with 16% in areas with 4 times the optimal level (20).

In the TSIF scoring system, each erupted anterior tooth receives 2 scores (labial and lingual) on a scale of 0 to 7, each erupted posterior tooth receives 3 scores (buccal, lingual, and occlusal), and scores are presented with the frequency distribution. The TSIF scoring criteria are shown in Table 2.2. Teeth are not dried, since in everyday social interactions, saliva keeps them wet (21), and the goal is to assess clinical importance.

Table 2.2. The Tooth Surface Index of Fluorosis criteria (21).

0	"Enamel shows no evidence of fluorosis."
1	"Enamel shows definite evidence of fluorosis, namely areas with parchment-white color that total less than one-third of the visible enamel surface. This category includes fluorosis confined only to incisal edges of anterior teeth and cusp tips of posterior teeth ("snowcapping")."
2	"Parchment-white fluorosis totals at least one-third of the visible surface, but less than two-thirds."
3	"Parchment-white fluorosis totals at least two-thirds of the visible surface."
4	"Enamel shows staining in conjunction with any of the preceding levels of fluorosis. Staining is defined as an area of definite discoloration that may range from light to very dark brown."
5	"Discrete pitting of the enamel exists, unaccompanied by evidence of staining of intact enamel. A pit is defined as a definite physical defect in the enamel surface with a rough floor that is surrounded by a wall of intact enamel. The pitted area is usually stained or differs in color from the surrounding enamel."
6	"Both discrete pitting and staining of the intact enamel exist"
7	"Confluent pitting of the enamel surface exists. Large areas of enamel maybe missing and the anatomy of the tooth may be altered. Dark-brown stain is usually present."

Thylstrup-Fejerskov Index (TFI)

Thylstrup and Fejerskov (16) introduced the Thylstrup-Fejerskov Index (TFI) in 1978, which includes 0-9 scores. Although the scores are assigned based on the clinical characteristics, they are correlated closely to histological features, such as degree of subsurface porosity or surface hypomineralization. Since this index requires drying of the teeth, it is more sensitive than the Dean's Index or TSIF in differentiating among various degrees of mild fluorosis. In addition, in this index, one score can be assigned to each tooth surface (buccal, lingual and occlusal) (16); however, as the effects of dental fluorosis on different surfaces of a tooth generally are the same, only one surface for each tooth is usually considered for assessment of fluorosis (11). The TFI criteria are shown in Table 2.3.

Table 2.3. Thylstrup-Fejerskov Index criteria (16).

0	"Normal translucency of enamel remains after prolonged air-drying"
1	"Narrow white lines located corresponding to the perikyinata"
2	**"Smooth surfaces** More pronounced lines of opacity which follow the perikymata. Occasionally confluence of adjacent lines **Occlusal surfaces** Scattered areas of opacity < 2 mm in diameter and pronounced opacity of cuspal ridges"
3	**"Smooth surfaces** Merging and irregular cloudy areas of opacity. Accentuated drawing of perikymata often visible between opacities **Occlusal surfaces** Confluent areas of marked opacity. Worn areas appear almost normal but usually circumscribed by a rim of opaque enamel"
4	**"Smooth surfaces** The entire surface exhibits marked opacity or appears chalky white. Parts of surface exposed to attrition appear less affected **Occlusal surface** Entire surface exhibits marked opacity. Attrition is often pronounced shortly after eruption"
5	**"Smooth and occlusal surfaces** Entire surface displays marked opacity with focal loss of outermost enamel (pits) <2 mm in diameter"
6	"Smooth surfaces Pits are regularly arranged In horizontal bands < 2 mm in vertical extension Occlusal surfaces Confluent areas < 3 mm in diameter exhibit loss of enamel. Marked attrition"
7	**"Smooth surfaces** Loss of outermost enamel in irregular areas involving < 1/2 of entire surface **Occlusal surfaces** Changes in the morphology caused by merging pits and marked attrition"
8	**"Smooth and occlusal surfaces** Loss of outermost enamel involving >1/2 of surface"
9	**"Smooth and occlusal surfaces** Loss of main part of enamel with change in anatomic appearance of surface. Cervical rim of almost unaffected enamel is often noted"

The Fluorosis Risk Index (FRI)

The Fluorosis Risk Index (FRI) was established more recently for use in analytical epidemiologic studies (22). This index is designed to identify age-specific risk of fluorosis development in a specific tooth-site due to exposure to specific sources of fluoride. Hence, it reduces non-differential misclassification through considering the effect of age on both development of specific tooth-site and exposure to specific fluoride sources (22).

The FRI classifies selected enamel-surface zones into 2 categories based on the time of commencement of enamel formation (22). Classification I zones are enamel-surface zones with secretory phases of enamel formation commencing during the first 12 months of life. The occlusal surfaces of upper and lower permanent first molars and the incisal edges of lower permanent central and lateral incisors and upper permanent central incisors are recorded at Classification I. Therefore, fluorosis development on these surfaces results from exposure to fluoride during or after the first year of life. Classification II includes enamel-surface zones with secretory phases of enamel formation that begin during the third to sixth years of life. The cervical thirds of all incisors, middle thirds of canines, and middle and occlusal thirds and occlusal tables of all premolars and second molars are assigned as Classification II. Hence, excessive exposure to fluoride during the third to sixth years of life or after this period may result in fluorosis development on these surfaces (22). Teeth are not dried for assessment of the FRI. The FRI clinical criteria are shown in Table 2.4.

Table 2.4. Fluorosis Risk Index Criteria (22).

Negative finding: Score=0	A surface zone will receive a score of 0 when there is absolutely no indication of fluorosis being present. There must be a complete absence of any white spots or striations, and tooth surface coloration must appear normal.
Questionable finding: Score=1	Any surface zone that is questionable as to whether there is fluorosis present (i.e., white spots, striations, or fluorotic defects cover 50 percent or less of the surface zone) should be scored as 1.
Positive finding: Score=2	A smooth surface zone will be diagnosed as being positive for enamel fluorosis if greater than 50 percent of the zone displays parchment-white striations typical of enamel fluorosis. Incisal edges and occlusal tables will be scored as positive for enamel fluorosis if greater than 50 percent of that surface is marked by the snow-capping typical of enamel fluorosis.
Score=3	A surface zone will be diagnosed as positive for severe fluorosis if greater than 50 percent of the zone displays pitting, staining, and deformity, indicative of severe fluorosis.
Score=7	Any surface zone that has an opacity that appears to be a nonfluoride opacity should be scored as 7.
Surface Zone Excluded: Score=9	A surface zone is categorized as excluded (i.e., not adequately visible for a diagnosis to be made) when any of the following conditions exist: Incomplete eruption: Rule 1: If a tooth is in proximal contact but the occlusal surface is not parallel with existing occlusion, the occlusal two-thirds of the tooth is scored, but the cervical one-third is recorded as excluded. Rule 2: If a tooth is erupted, but not yet in contact, the incisal/occlusal edge is scored, but all other surfaces are recorded as excluded Orthodontic appliances and bands: Rule1: If there is an orthodontic band present on a tooth only the occlusal table or incisal edge should be scored. Rule 2: If greater than 50 percent of the surface zones are banded, the subject should be excluded from the examination. Surfaces crowned or restored: Rule: Surface zones that are replaced by either a crown or restoration covering greater than 50 percent of the surface zone should be recorded as excluded. Rule: Any subject with gross deposits of plaque or debris on greater than 50 percent of the surface zones should be excluded from examination.

Summary

There are several normative indices developed to evaluate severity of dental fluorosis in epidemiologic studies. Dean's Fluorosis Index is one of the earliest indices which is still recommended by the WHO in basic screenings. Its major version has 6 levels assigning one score to each tooth. Fluorosis level of the second most severely affected tooth is considered as the subject-level score. The Tooth Surface Index of Fluorosis and Thylstrup-Fejerskov Index are on 8- and 10-level scales, respectively. The Tooth Surface Index of Fluorosis assigns a score to each tooth surface, 2 scores to anterior teeth (facial and lingual surfaces) and 3 to posterior ones (facial, lingual and occlusal surfaces), whereas with the Thylstrup-Fejerskov Index only one surface of each tooth is usually scored. Thylstrup-Fejerskov Index criteria for scoring are designed to associate clinical and histological features. It is more sensitive than the Dean's Index, TSIF, or FRI due to the drying requirement of tooth surfaces.

The Fluorosis Risk Index was developed more recently to assess risk of fluorosis development on specific tooth surfaces due to exposure to particular amounts of fluoride at specific ages. It categorizes tooth surfaces into 2 groups based on their timing of enamel secretory phase. Group 1 surface zones start the enamel secretory phase during the first year of life, and group 2 surface zones start the secretory phase during the third to sixth years of life. Four surface zones of each tooth, including the occlusal zone as well as the cervical, middle and incisal thirds of the buccal surface, are scored separately. This system is used in analytical studies to determine risk of fluorosis development during various years of life.

Malocclusion

Prevalence

Based on data from NHANES III in 1988-1994, crowding of anterior teeth was observed in the majority of people, regardless of their race and ethnicity (23). Approximately 15% of the U.S. population had severe tooth irregularities which could only be corrected through arch expansion or tooth extraction, and 20% had an abnormal bite relationship. In addition, the analysis of Index of Orthodontic Treatment Need (IOTN) showed that 57%-59% of the surveyed population needed orthodontic treatment to some extent (23).

Although the prevalence of crowding of anterior teeth and malocclusion class II and III were higher among Mexican-Americans, and severe malocclusion was more frequently seen in African-Americans, only 11% of Mexican-Americans and 8% of African-Americans had received orthodontic treatment compared to 30% of the white population who reported receiving orthodontic care (23).

Clinical measures of malocclusion

Malocclusion or misalignment of teeth is a prevalent oral condition, whose impact is considerably influenced by individuals' perceptions and social and cultural determinants. This issue has hindered development of a standard malocclusion index which can be widely used in epidemiologic studies (11).

Traditional malocclusion classifications, such as deep bite, open bite, crossbite, and Angle's classification, only assess specific aspects of malocclusion, including anterior, posterior, transverse or vertical relationships. Since the 1970s, the significance of psychosocial impacts of malocclusion has been cited by several investigators. Since there was a need to an index which combined clinical features and psychosocial impacts of malocclusion, epidemiologists developed indices that provide comprehensive measures of occlusion status (24). The Dental Aesthetic Index (DAI), developed by Cons

and co-workers in 1986 (25), is an index that puts dental esthetics into a quantitative scale. It is described in the following section.

Dental Aesthetic Index

The Dental Aesthetic Index combines multiple dimensions of malocclusion and merges objective measures of occlusion with a person's desire to receive orthodontic treatment, as well as social acceptability of the condition (25). All these criteria are essential for identification of orthodontic treatment need. In fact, the DAI is a measure of social disability which is caused by deviations from normal societal occlusal features. Besides use by investigators in epidemiologic and analytic studies, it can be used by dental insurance companies and dental health administrators to determine eligibility of patients for subsidized orthodontic treatment (25).

For development of this index, 200 photographs showing a wide range of occlusal conditions were assessed for social acceptability by about 1,600 American high school students and adults (25). Based on the mean score for social acceptability given to each photograph, a regression equation was developed which included 10 occlusal traits and related regression coefficients/weights. This final equation is called the Standard Dental Aesthetic Index. Based on the percentile in which individual's DAI score falls, one can estimate where an individual's score falls along the range of socially acceptable dental appearance. Ten occlusal traits and their related regression coefficients are shown in Table 2.5.

Making DAI more practical, Jenny et al. (26, 27) conducted investigations to establish DAI cut-off scores for identification of malocclusion severity levels. A sample of 1,306 teenagers aged 15-18 years, whose study models were available and were representative of a half million population of adolescents aged 15-18 years with untreated occlusions, were selected. Then they were examined by orthodontists. Comparing orthodontists' judgment and subjects' DAI scores showed that DAI scores equal to or

greater than 36 represented handicapping malocclusions where treatment was considered essential (27).

Table 2.5. DAI occlusal traits and their regression coefficients (26).

DAI Component	Regression Coefficient
Missing visible teeth (incisors, canines and premolars in the maxillary and mandibular arches)	6
Crowding in the incisal segments (0=no segments crowded; 1= 1 segment crowded; 2 = 2 segments crowded	1
Spacing in the incisal segments 0 =no segments spaced; 1 = 1 segment spaced; 2 = 2 segments spaced	1
Diastema in mm	3
Largest anterior irregularity (upper) in mm	1
Largest anterior irregularity (lower) in mm	1
Anterior maxillary overjet (upper) in mm	2
Anterior maxillary overjet (lower) in mm	4
Vertical anterior open bite in mm	4
Assessment of antero-posterior molar relation; largest deviation from normal either left or right (0 =normal; 1 = 1/2 cusp either mesial or distal; 2 =one full cusp or more either mesial or distal)	3
Constant	13

A later study by Jenny and Cons (26) used the DAI scores of the same sample of 1,306 teenagers, which was mentioned above. Besides that, frequency distributions of various severity levels of malocclusion, including normal occlusion, minor malocclusion, definite malocclusion, severe malocclusion, and very severe (handicapping) malocclusion, were obtained from a report by the National Center for Health Statistics

(NCHS) in 1977 (28). The report contained occlusal characteristics of a sample of 7,500 teenagers aged 12-17 years, representing a population of 22.7 million U.S. teenagers.

To provide cut-off points of various severity levels of malocclusion, the percent distributions of malocclusion levels (from the NCHS report) were correlated with the cumulative distributions of the DAI scores (from the sample of 1,306 teenagers) (26). The results showed that DAI scores of 25 or below were correlated with normal occlusion or minor malocclusion, which did not need orthodontic treatment or needed slight corrections; DAI scores of 26 to 30 were correlated with definite malocclusion, where orthodontic treatment was elective; DAI scores of 31 to 35 were correlated with severe malocclusion, where orthodontic treatment was highly desirable; and finally, DAI scores of 36 and more were correlated with handicapping malocclusion, where orthodontic treatment was essential (26).

Esthetic perceptions

Importance of dental esthetic perceptions

Clinical measures traditionally were the only methods used to assess the prevalence and severity of oral conditions affecting oral health and appearance. Such indices for fluorosis, including Dean's Index (29), the Thylstrup- Fejerskov Index for Fluorosis (16), The Tooth Surface Index of Fluorosis (20) and the Fluorosis Risk Index (22), provide reliable and valid methods for assessment of oral diseases in descriptive and analytical epidemiologic studies. In response to more attention to esthetics in society, more efforts were directed toward involvement of societal acceptability in dental esthetic-related indices such as the DAI (25). However, neither clinical measures nor indices that consider societal acceptability assess self-perceptions of dental appearance and the possible impact of oral diseases on individual's psychosocial well-being. Based on the comprehensive definition of health, social and emotional well-being are as important as physical health and thus, should be included in any assessment of health (6).

It has been shown that facial attractiveness has a significant impact on psychological well-being and social interactions, particularly in children and young adults. For instance, attractive students are perceived more positively by their classmates and teachers, they are more successful in making friends than unattractive students, and they are more likely to react favorably to peer pressure (30, 31).

Using objective indices for evaluating trends in prevalence of dental fluorosis has provided evidence of an increase in dental fluorosis prevalence in the U.S. This is an issue that "anti-fluoridationists" use purposely to stop fluoridating drinking water. Whether or not the increase in prevalence of mild fluorosis has led children, adolescents or their families to be concerned about or dissatisfied with tooth appearance is an important issue that should be considered, since impaired dental esthetics is the only possible major complication of mild dental fluorosis (32).

Since the 1990s, there has been more study of esthetic perceptions and psychological indicators of oral health and self-evaluation of appearance. Studies have used various designs and questionnaires and also have tried to assess relationships between self-esthetic perceptions and oral conditions/ dental treatments affecting dental appearance. It is important to note that dental esthetics perceived by the individuals may be different from the way dental professionals such as orthodontists judge the appearance (33).The most relevant studies on esthetic perceptions of dental fluorosis and malocclusion will be discussed in the next sections. It should also be noted that this chapter does not cover studies on the Oral Health-Related Quality of Life (OHRQoL), as the OHRQoL was not the focus of this study.

Review of studies on esthetic perceptions of dental fluorosis

Children's/ adolescents' esthetic perceptions of fluorosis

In 1993, Clark et al. (32) had a study published evaluating how school-aged children and their parents in British Columbia, Canada, perceived possible esthetic problems related to fluorosis. In this cross-section/retrospective study, 1131 school-aged children were recruited from two communities with similar regional and socioeconomic characteristics, one with a fluoridated water supply (1.2 ppm) and the other with non-fluoridated water (lower than 0.1ppm).

Children were examined for dental fluorosis using the Tooth Surface Index of Fluorosis (TSIF) (32). After the examination, children were asked if they liked the color of their front teeth. The recorded answers were "yes", "no, due to fluorosis", "no, due to enamel opacities", "no due to other reasons", "no, they are too yellow" or "I don't know". If children answered "I don't know" or when fluorosis or enamel opacities were barely noticeable, the question was repeated again while they were looking into a hand mirror.

Descriptive analysis showed that prevalence of fluorosis in the fluoridated community (65%) was significantly higher than in the non-fluoridated area (52%) ($P<0.001$) (32). However, percentages of children with TSIF scores of at least 2 were only 7% and 10% in non-fluoridated and fluoridated communities, respectively. With an increase in TSIF score, the percentage of children who were dissatisfied with the color of the front teeth due to fluorosis increased. For instance, only 2% of children with TSIF score of 1 were dissatisfied with the color of their front teeth compared to 21% of children with TSIF score of 4 or more. Using fluoride exposure data, among children with no history of exposure to systemic fluoride, children with lifelong exposure and

children with history of exposure to fluoride supplements, there were no significant differences in showing concerns about dental esthetics.

There is no clear definition of fluorosis cases and subject-based fluorosis scoring in this study (32). In addition, response options such as “no, due to fluorosis” or “no, due to other reasons” might be misleading since children may not understand the meaning of these terms. Furthermore, asking children to look at a hand mirror and repeating the questions can interfere with true expression of children’s concerns; therefore, responses may not be fully reflective of their own perceptions.

In a follow-up study of the previous investigation by Clark (34), published in 1995, 35mm slides of anterior maxillary teeth of sampled children were prepared. The slides showed anterior teeth ranging from normal appearance to TSIF scores of 1to 7 or enamel hypoplasia. A perception questionnaire related to fluorosis was developed based on a Social Acceptability Scale of Occlusal Conditions (SASOC). This scale which originally had been used in development of the Dental Aesthetic Index (DAI) consists of 10 pairs of “polar adjectives” such as ugly/beautiful which are scored on a 6-point scale. The questionnaire results in a score ranging from zero to 300, in which 300 is the highest level of esthetic acceptability. Six slides were repeated during the display of slides to raters in order to analyze internal validity of the questionnaire.

Child/parent pairs and also a sample of dental professionals were asked to complete the questionnaire based on the slides (34). Then, the average of scores assigned by each group of subjects to each category of slides, such as normal enamel or various TSIF scores, was calculated. Results showed that children were able to distinguish between dental fluorosis and non-fluorosis slides. For example, the mean score reported for TSIF of zero (190) was significantly better than the mean score reported for TSIF of 1 (125). They were also capable of distinguishing between non-fluorosis enamel hypoplasia and normal enamel, i.e., enamel hypoplasia received a significantly lower mean score (163). In addition, it was shown that the internal validity of the questionnaire was low,

with a correlation coefficient of 0.18 to 0.46. The investigator admitted that fatigue or confusion of raters after observing several slides might be a reason for poor internal validity.

In another study by Shulman et al. (35) published in 2004, the esthetic perceptions of children about tooth color were compared with those of their parents and dentists in British Columbia, Canada. This study analyzed epidemiologic data from the longitudinal British Columbia Fluoridation Cessation study in which 8,281children in grades two, three, eight and nine were examined for dental fluorosis in nursing stations of schools using the Thylstrup Fejerskov Index (TFI). The maximum TFI of the six maxillary anterior teeth was recorded as the TFI score for each subject. In addition, children, their parents and dentist examiners were asked to state their level of agreement with a reference statement: "The color of these teeth (mine or my child's) is pleasing and looks nice." Response options were provided on a 5-level scale, varying from 1= strongly agree to 5= strongly disagree.

Based on the results of previous studies and clinical experiences of investigators, several hypotheses were suggested as follows (35):

1- Girls were more likely to express dissatisfaction with their tooth color than were boys.
2- Parents of girls were more likely to be dissatisfied with their child's tooth color than were parents of boys.
3- Parents of older children were more likely to be dissatisfied with their child's tooth color than were parents of younger children.
4- Dentists were more likely to show dissatisfaction with girls' tooth color than boys'.
5- Dentists were more likely to show dissatisfaction with older children's tooth color than younger children's.

6- Parents from higher SES families were more likely to show dissatisfaction with their child's tooth color, since they had higher expectations.

Of 8,281 examined subjects, 2,495 subjects were included for analyses since dentist's, parent's, and subject's perceptions and other covariates such as age, sex, SES, and TFI score were all available for them (35). About 27% of subjects had a TFI score more than 0, but only 4.3% of them had a TFI score ≥3. Overall, 31.6% of children disagreed with the reference statement. Having yellow teeth and fluorosis were the reasons for dissatisfaction for 70% and 11% of them, respectively. Results showed that the mean level of disagreement for girls was more than for boys ($P<0.05$), and for younger (6-13 years old) subjects was more than for older (14 years or more) ones ($P<0.05$), indicating that girls and younger subjects were more critical of their tooth color than were their counterparts. There were no statistically significant differences in the level of disagreement between subjects with a TFI score of zero and a TFI score of 1 or 2. Parents' and dentists' perceptions are explained further in the subsequent sections.

In another study conducted by Meneghim et al. (36) in 2004, 12-year-old Brazilian children's perceptions about dental fluorosis and other oral health problems were evaluated. The population was recruited from private and public schools of Ponta Grossa, Paraná, Brazil. Schools were randomly selected from a list of all schools in the area. The data were collected from 3 sources. First, a questionnaire was administered about the child's perceptions of his/her oral health status; it asked children to describe the oral problem, its location, and their expectations regarding treatment of the oral condition. Second, a photo album was shown to children to assess their perceptions of severity of various oral problems, including dental caries, malocclusion, periodontitis, oral cancer, and different levels of dental fluorosis; then children were asked to order the photos from the least severe to the most severe. Finally, children underwent oral examination for evaluation of fluorosis. Before the exam, each child was given a tooth brush and dentifrice to brush their teeth, and then they were examined under natural light

using mirror and gauze. All permanent teeth were evaluated for fluorosis using the Thylstrup-Fejerskov Index.

The results showed that, of 401 children, 18.2% had fluorosis that was all TFI score of 1 or 2 (36). About 48.9% of children reported having some sort of oral problems, and the majority of them were impaired esthetics or dental pain. About 60% of them believed that orthodontic treatment would solve their esthetic problems and 33% cited restorations as their treatment. Interestingly, none of the children with TFI score of 1 reported tooth color abnormalities or tooth staining as a reason for their problem, and only 2 children with a TFI score of 2 perceived stained teeth as an esthetic problem; however, they believed that their esthetic problem would be solved by orthodontic treatment. Therefore, investigators concluded that the children did not perceive mild-to-moderate fluorosis as an esthetic problem. While arranging the photos, the majority of children categorized photos of dental fluorosis with TFI score of 7-9 as the most severe oral problem, followed by advanced periodontitis, oral cancer and dental caries; however, fluorosis cases with TFI scores of 1-3 were cited as the least severe oral problems, which was in agreement with the results of self-perception questionnaire.

In 1997, Wondwossen et al. (37) evaluated how 12- to 15- year-old Ethiopian children and their parents perceived different TFI scores. Subjects were recruited from three villages, with two of them (Village A: F level of 0.3-1.8ppm and village M: F level of 0.8-2.2 ppm) having moderate and one (Village K: F level of 10.0-14.0 ppm) having high fluoride concentration in community water supplies. Photos of maxillary central incisors with randomly ordered TFI scores were shown to children and their parents. Then they were asked to complete a questionnaire about the presented teeth. In addition, two questions regarding tooth color and tooth form were used to assess self-perceived oral health (37). This study showed that the overall TF score mean was 2.97 and TF means were significantly different among the three villages (2.1, 2.7 and 4.1 in villages M, A and K, respectively). The authors concluded that children's perceptions of various

TFI scores generally were similar to parents'. However, at higher scores (more severe cases), parents were more negative about dental appearance of fluorosis cases than were children ($P<0.001$).

In summary, there is substantial consistency among the studies that assess children's perceptions of dental fluorosis, and they showed that children's negative perceptions of dental fluorosis follow a severity gradient of dental fluorosis, i.e., children are not usually critical of very mild to mild fluorosis, whereas as severity of fluorosis increases, higher percentages of children show dissatisfaction with the dental appearance.

Parents' esthetic perceptions of dental fluorosis

In the study of Clark et al. (32) in 1992, with methods explained in a previous section, parents of selected children were also asked to complete questionnaires regarding children's exposures during the children's 6^{th} year of life, which included fluoridated water, infant formula, fluoride supplements, and fluoride toothpaste. In addition, they were asked if they were concerned about their children's tooth color. Similar to the children, with an increase in TSIF score, the percentage of parents who expressed having a "problem with color of their child's front teeth" also increased. For example, 33% of parents with child's TSIF score of 1 were concerned about tooth color compared to 58% of parents with child's TSIF score of 4 or more.

Additionally, in the follow-up study of the previous investigation (34), parents were asked to rate slides of children's anterior teeth. The questionnaire and method of scoring the slides were explained in detail in a previous section. It was found that slides showing fluorosis cases were given lower mean scores compared to normal enamel slides by the parents, for example, 138 for TSIF of 1 compared to 213 for TSIF of 0. Also, the lowest esthetic scores were assigned to TSIF of 6 and 7 by the parents.

Lalumandier and Rozier (38) had a study published in 1998 to evaluate associations between parents' levels of satisfaction with children's tooth color and

fluorosis. In this study, 1,004 children with an age range of 5 to 19 were randomly selected from participants in a dental clinic in North Carolina. Finally, 708 children were examined for dental fluorosis using the Tooth Surface Index of Fluorosis (TSIF). Children were considered as fluorosis cases if any of their tooth surfaces (buccal, lingual, or occlusal (posterior teeth)) had TSIF scores of greater than 0. The highest TSIF score per person was used as the fluorosis severity score. Children with fluorosis scores greater than 3, were grouped into one group due to the small number of children with TSIF scores of 4, 5, 6 or 7. While the children were examined for dental fluorosis, parents were asked about their satisfaction with their child's dental color, selecting from four options: very satisfied, somewhat satisfied, somewhat dissatisfied and very dissatisfied. However, for statistical analysis, responses were collapsed into 2 groups, satisfied and dissatisfied. Stepwise multivariable logistic regression analysis was used to assess the association between fluorosis and satisfaction after controlling for other factors, including sex, age, parental education, income and frequency of dental visits.

Results showed that 78% of children were identified as having fluorosis (TSIF score more than 0) (38). The proportion of dissatisfied parents with child's dental color in very mild fluorosis children (TSIF=1) was significantly higher than the proportion for children without fluorosis (37% vs. 26%). The association between fluorosis and satisfaction at both the bivariable and multivariable levels was statistically significant. Among the predictor variables, fluorosis was the only variable that remained in the final model. The odds of being satisfied with child's dental color for parents whose children did not have fluorosis was 2.5 times that for the fluorosis group.

In the study of Shulman et al. (35) which was explained in detail in a previous section, 19.2% of parents disagreed with the reference statement: "The color of these teeth (mine or my child's) is pleasing and looks nice." Yellow tooth color and fluorosis were the reasons for dissatisfaction in 60% and 19% of them, respectively. In contrast to children, parents of girls and parents of younger children (6-13 years old) showed lower

levels of disagreement with the reference statement ($P<0.05$), indicating that they were less critical of their children's tooth color than were their counterparts. However, similar to children, parents of children with a TFI score of 1 or 2 were not significantly different from parents of children with TFI score of zero in level of satisfaction with their child's tooth color.

Besides the British Columbia studies, similar investigations have been conducted in other places such as Europe. Sigurjóns et al. (39) carried out a study published in 2004 to assess the views of parents of 9-year-old children living in three communities in Ireland (with optimally fluoridated drinking water), Iceland and England (with non-fluoridated drinking water) about the appearance and color of their child's permanent maxillary central incisors. In telephone interviews, parents were asked about three major questions:

1. Are you happy with the appearance of your child's upper front teeth?
2. What is it you do not like, if anything, about the appearance of your child's teeth?
3. In what way are you unhappy with the color?

All parents were asked the first question (39). Then, a response of "no" to the first question was followed by the second question. If the parents raised the issue of tooth color, then they were asked the third question. The associations between parents' responses and TFI score of their child were evaluated. However, the published study lacks clear description of the dental examinations. The study showed that, for a higher TFI score (more severe fluorosis), a greater percentage of parents were unhappy with their children's appearance, but the differences were not statistically significant ($P = 0.20$). Generally, the main reason for being unhappy at lower TFI score was tooth alignment, but for children with TFI score of 3, color was the main reason. For TFI grades 2 and 3, white lines or patches and pits were of concern for 15% of parents, whereas for TFI grade of 1, only 6% of parents were concerned.

The longitudinal Iowa Fluoride Study provided data on parental dental esthetic perceptions of children's dentition when children were at age 9, 11, 13, and 15. When children were nine years old in 2001-2004, 557 children were assessed for fluorosis using the FRI (40). If children had at least 2 permanent incisors with a FRI score of 2 or 3, they were classified in the definitive fluorosis group. If they had only one permanent incisor with a FRI score of 2 or 3 or if their maximum FRI score was 1, they were classified as questionable fluorosis. In addition, parents were asked to complete a dental esthetic questionnaire, asking about their perceptions of their child's mixed dentition. This questionnaire is the same one we used in this study, and it is explained in detail in the Methods section. Kendall's tau-b and Fisher's exact test were used to evaluate the relationships between parents' perceptions and children's fluorosis status.

The results showed that both fluorosis and non-fluorosis opacities were inversely associated with satisfaction with overall dental appearance (tau-b=0.148; P<0.001 and tau-b=0.082; P=0.04, respectively) (40). However, only fluorosis was negatively associated with overall dental color (tau-b=0.114; P=0.003). Among parents of the children with definitive fluorosis, 50% were concerned about tooth color and 44% were concerned about color irregularities (blotchy appearance). These percentages were significantly (P=0.02 and P<0.001, respectively) higher than those of the non-fluorosis group (40% and 9%, respectively). Furthermore, associations between different aspects of dental esthetic concerns and dissatisfaction with overall dental appearance showed that alignment, crowding, and spacing were associated with dissatisfaction. The authors stated that, since fluorosis was only associated with concerns about tooth color and color irregularities and these concerns were not related to dissatisfaction with overall appearance, fluorosis was of less importance to the parents than were alignment, crowding, and spacing. However, the children were in the mixed dentition stage when canines and premolars are not erupted and substantial spacing is normally expected; therefore, generalization of these results to the other ages should be done with caution.

Lawson et al. (41) conducted another study on the participants of the IFS at age 9 to compare the importance of tooth color and tooth alignment in parental perceptions of their child's dental esthetics. One of two trained and calibrated dentists examined the children's dentition for fluorosis and other non-fluorosis tooth color aberrations. The Fluorosis Risk Index (FRI) was used for assessment of fluorosis on permanent incisors and molars. Of the 580 IFS participants with available dental casts at age 9, 200 children were selected, and their dental casts were scored for occlusion status using the Dental Aesthetic Index (DAI). In this study, the DAI scoring was adapted for mixed dentition. For example, unerupted teeth were not considered as an anterior open bite or anterior missing teeth; also if a tooth was missing, it was scored once as a missing tooth and not again as spacing. In addition, parents of children completed esthetic questionnaires regarding their satisfaction with their children's dental appearance and tooth color.

Logistic regression modeling showed that, both in single and multiple variable models, DAI score and fluorosis were significantly associated with parental esthetic dissatisfaction, whereas non-fluorosis opacities were not (41). Therefore, they concluded that fluorosis and increased DAI scores are negatively associated with parental perception of children's dental appearance and it is essential for dental professionals to take into account both malocclusion and color aberrations in their treatment planning. However, the associations of dental esthetic-related concerns with satisfaction level showed that being concerned about alignment, crowding, or spacing was significantly associated with dissatisfaction with overall dental appearance, whereas concerns about tooth color and color irregularities were not, indicating that fluorosis was not as important as malocclusion to the parents. Nevertheless, the participating children were at the mixed dentition stage, and any extrapolation to other age groups should be made with caution. This current thesis study is a continuation of Lawson et al.'s study (41). These sequential studies provide the opportunity to compare parents' perceptions while children are passing through different stages of dentition, and facial and psychological development.

In another study, Cannon et al. (42) analyzed data from the longitudinal IFS to assess the changes in the parental satisfaction with the children's mixed dentition over the time. Overall, 376 parent-child pairs who had the same parent complete the parental dental esthetic questionnaire at both ages 9 and 11 years were included for the final analyses. At both ages 9 and 11 years, parents- one parent of each child- completed the dental esthetic questionnaires. At age 9, trained and calibrated dentist examiners examined the children's mixed dentition for fluorosis using the FRI. No dental exams were done at age 11. Children with at least one maxillary incisor tooth with the FRI= 2 or 3 were grouped in the definitive fluorosis group, and those with the FRI= 1 were considered as questionable fluorosis. According to the mother's education level and annual family income level at recruitment (children's birth), children were classified into three socioeconomic status (SES) groups: low (15%), middle (44%), and high (37%). The Cochran-Armitage Trend test and Fisher's test were used for comparisons among the none, questionable and definitive fluorosis groups. The McNemar and Bowker tests of symmetry were used for comparisons between responses when the children were 9 years old and 11 years old.

Results showed that about 36% of children had definitive fluorosis (mostly mild fluorosis (FRI= 2)) and 28% had questionable fluorosis (42). Cross-sectional analysis of parental perceptions for 11-year-old children showed that fluorosis was inversely associated with the parents' level of satisfaction with overall appearance and overall color of children's teeth; ($P=0.003$ and $P=0.004$, respectively). The percentage of parents who were concerned about tooth color irregularities was significantly higher in the definitive fluorosis group compared to the other groups (38% in definitive fluorosis group, 23% in questionable group, and 16% in no fluorosis group); nevertheless, 62% of parents in the definitive fluorosis group still had no concerns about the children's tooth color irregularities.

Overall, parental perceptions of children's dental esthetics were stable over the two years (from age 9 to age 11) (42). However, for those parents who showed changes over the time, they were significantly more likely to show a decrease in satisfaction with overall color ($P<0.05$), an increase in concern about tooth shape and color ($P=0.003$ for both), or a decrease in concern about spacing ($P=0.004$). Additionally, there were no significant associations between changes in parental satisfaction with overall dental appearance and fluorosis status of the children. Ordinal logistic regression at the bivariate level showed that higher SES and having started orthodontic treatment were positively associated with improved satisfaction with overall dental appearance (outcome variable). However, fluorosis status, non-fluorosis opacities, child's and parent's gender, mother's educational level, and family income were not significantly associated with the outcome variable.

The authors explained the decreased level of parents' satisfaction with overall dental color at age 11 compared to age 9 by the fact that, following eruption of canines and premolars with higher prevalence of fluorosis, parents could notice the anterior tooth color more than before (42). Also, as the child grows, parents could become more critical of their tooth color and shape. Nevertheless, fluorosis status was not associated with these changes over the time. More studies need to be done to provide a clearer picture of trends in parental dental esthetic perceptions with increasing child age.

In summary, studies that evaluated associations of parental perceptions and dental fluorosis showed varying associations. While some studies found no difference in parental perceptions of mild fluorosis versus normal dentition, in other studies parents were significantly more critical of mild fluorosis than of normal enamel.

Dentists'/dental students' esthetic perceptions of dental fluorosis

In the study by Clark (34) which was discussed in previous sections, a sample of dental professionals-including dentists, dental hygienists, and dental assistants- rated slides showing anterior teeth of school-aged children. Dental professionals distinguished between normal teeth and teeth with fluorosis, including TSIF of 1 and enamel hypoplasia. The mean score given to TSIF of 1 was significantly lower than that given to TSIF of 0 (167 and 239, respectively).

McKnight et al. (43) conducted a pilot study in 1996 to evaluate freshman dental students' perceptions of mild fluorosis and compare them with their perceptions of diastema and non-fluoride isolated opacities. Computer-generated images of the dental conditions were used in this study to avoid unwanted effects of other features, such as occlusion, tooth shape and size, and gingival position and color. Four pairs of images- normal/mild fluorosis, mild fluorosis/diastema, isolated opacities/more involved fluorosis, mild fluorosis confined to the incisal third/more extensive fluorosis- were shown to 61 University of Iowa dental students in 1996, and then they were asked about their perceptions of these conditions.

Overall results of all six questions of the questionnaire showed that dental students rated mild fluorosis less pleasing than normal dentition and isolated opacities, but more pleasing than the diastema, and, if they had teeth with mild fluorosis, they would smile less frequently than when they had normal teeth or teeth with isolated opacities (43). However, the freshman dental students might be more sensitive to dental appearance than lay people and their opinions might not be fully representative of experienced dental students' or dental professionals' perceptions.

In 2000, Levy et al. (44) conducted a follow-up study of fourth-year dental students' perceptions, recruiting the same dental students who participated in the previous study. The methods of the previously explained study (43) were used in this study, and 45

of the 61 students of the previous study successfully rated the four pairs of images again after about three and a half years. Overall, there were no significant differences in directions of preferences of fluorosis versus other conditions between first-year and fourth-year dental students, indicating that fluorosis was still less favorable than isolated opacities and normal appearance. However, in paired analyses, fourth-year dental students were less critical of fluorosis, opacities, and diastema than they had been as first-year dental students. The authors suggested that, since experienced dental students were more knowledgeable of oral diseases, they were aware that mild fluorosis and diastemas were not serious conditions; therefore, they probably were more tolerant of these conditions compared to when they were first-year students. The same comparison might be true for educated lay people versus dental professionals, i.e., dental professionals may be more tolerant of fluorosis than are lay people.

In the study by Shulman et al. (35), which was described in detail in a previous section, it was found that only 8.5% of dentists were critical of children's tooth color. Among them, about 32% identified yellow tooth color as the reason for dissatisfaction and 30% considered fluorosis as the reason. In contrast to the children and similar to the parents, dentists rated boys as having more unsatisfactory tooth color than girls ($P<0.05$). However, dentists' dental esthetic perceptions were associated with children's age. There were no significant differences between dentists' satisfaction with tooth color of children who had TFI score of 0 and 1. However, dentists' satisfaction with TFI scores of 2 and 3 was significantly less than for TFI scores of 0 and 1.

In summary, among the studies that assessed dental professionals' perceptions of fluorosis, we see substantial heterogeneity both in degree of dental practice experiences and in the results. However, it seems generally that, while dental professionals can distinguish very mild fluorosis from normal appearance, they are not critical of this condition most of the time.

Comparison of esthetic perceptions of dental fluorosis among various groups

In the study by Clark et al. (32), which was discussed in previous sections, children's concerns on tooth color were compared with those of their parents. It was shown that, as the TSIF increased, the percentages of parents and children who were concerned about tooth color increased. There was agreement in over 60% of pairs on the esthetic rating of children's front teeth, and the level of agreement was not significantly associated with parental educational levels. However, in children with TSIF scores of one or more, parents were more frequently concerned with the color of children's teeth than were the children. Furthermore, in the follow-up study of the previous investigation (34), it was shown that dental professionals assigned significantly better scores for esthetic acceptability to normal enamel, TSIF of 1, and enamel hypoplasia compared to parents and children. Also, parents assigned better scores than did children.

Similarly, Shulman et al. (35) found that subjects, with relatively wide age range of 6 to more than 14 years, were 1.7 and 3.7 times as likely as parents and dentists, respectively, to be critical of tooth color. Interestingly, yellow tooth color was the major reason for dissatisfaction by children and parents (for more than 60% of them), whereas fluorosis was not. In contrast, yellow tooth color and fluorosis were equally cited as the reasons for dissatisfaction by dentists. According to Shulman et al. (35), the fact that lay people are more critical of dental appearance than are dentists suggests that, although dentists are more capable of diagnosis of deviations from normal, they may not consider the conditions as important as lay people perceive them.

Chankanka et al. (45) reviewed English-language articles on fluorosis and perceptions that were published between 1985 and March 2009. They found 35 relevant original studies and divided them into 3 groups: participants were asked about perceptions of photographs, participants were asked about perceptions of study subjects' dentitions and participants were asked about psychosocial impacts of oral problems.

From all studies assessing participants' perceptions about photographs, severe dental fluorosis was significantly associated with reduced satisfaction. However, results for mild fluorosis were contradictory; some studies reported reduced satisfaction with mild fluorosis, while some others did not find any significant association. Comparing different participants' perceptions, first year dental students were reported to be more critical than fourth-year students and another study reported that mothers were less satisfied with fluorosis than were children. Also, comparing perceptions on dental fluorosis with other oral problems, diastema and dental caries were rated as less satisfactory conditions than mild fluorosis, whereas rotated teeth were rated more favorably than fluorosis.

There was substantial heterogeneity among "self- and subject-assessment studies" in the fluorosis scoring systems, definitions of "very mild" and "mild" fluorosis and study respondents. All these inconsistencies made comparisons and drawing conclusions difficult. In studies using the Thylstrup-Fejerskov Index (TFI) or Tooth Surface Index of Fluorosis (TSIF), the majority of studies reported no significant associations between children'/ parents' perceptions and very mild/mild fluorosis (TFI score of 1, 2 or 3, TSIF score of 1), but there were a few reporting significant associations of mild fluorosis with reduced satisfaction. Comparing different categories of respondents' perceptions, one study reported dentists to be less critical of fluorosis than lay people, while another study reported them to be more critical of enamel hypomineralization. Also, there were two studies that found that parents rated dental fluorosis less favorably than did children.

Among all studies that used Oral Health Related Quality of Life (OHRQoL), none of them found any negative impacts on daily activities for mild fluorosis. One study even reported improved OHRQoL in the presence of mild dental fluorosis compared to normal enamel. On the other hand, of the few available studies on this topic, almost all showed significantly worse OHRQoL in children with severe fluorosis compared to children with normal enamel or mild fluorosis.

In summary, available studies on the perceptions of dental fluorosis assessed children's, parents', and/or dental professionals' dental esthetic perceptions, and their relationships with clinical examinations of dental fluorosis and/or none-fluoride opacities. Also, they usually compared perceptions of one group with those of another group, such as children versus parents, or parents versus dental professionals.

Use of different indices for assessment of fluorosis, and questionnaires for assessment of perceptions as well as recruitment of various age groups of children and adolescents has led to heterogeneity in the results among the studies. Nevertheless, the available studies on children's perceptions of dental fluorosis usually recruited school-aged children; all these studies assessed children's perceptions in cross-sectional settings. Overall, children were not critical of very mild to mild fluorosis, whereas higher proportions of children showed dissatisfaction with the dental appearance with more severe fluorosis. Investigation of associations of parental perceptions and dental fluorosis showed varying results. Several studies found no difference in parent satisfaction levels with mild fluorosis versus normal dentition, but in other studies parents were more dissatisfied with mild fluorosis compared to normal enamel.

Comparison of dental esthetic perceptions of different groups showed that lay people were generally less tolerant of mild fluorosis than were dental professionals, most likely because dental professionals are aware that mild fluorosis does not have any substantial impacts on the tooth structure and oral health. There are only few studies on comparing children's perceptions with their parents. Only one study found that children, with wide age range of 6 to 14 years, were more critical of mild fluorosis, but two other studies found parents less tolerant of fluorosis than children. Also one longitudinal study assessed parents' dental esthetic perceptions, and it showed that during the mixed dentition stage parent satisfaction with children's dental appearance decreased over the time; however, the changes were not significantly associated with dental fluorosis.

Review of studies on esthetic perceptions of malocclusion

This section provides a review of several key studies on the associations of malocclusion with esthetic perceptions of children, adolescents, and young adults, but it does not review studies of the relationship between malocclusion and quality of life, since it is not the focus of this thesis. Limitations of using esthetic perception questionnaires are discussed in detail in the Discussion Chapter.

During 1993-1997, Birkeland et al. (46) conducted a prospective cohort study in Bergen, Norway, to compare the relationships of changes in occlusal traits and degree of satisfaction between orthodontically treated and non-treated children and their parents. In 1993 (time 1), Bergen was divided into four demographic areas and 2 schools were randomly selected from each area. Questionnaires were completed by 359 children and parents. The questionnaire asked about two issues: concerns with orthodontic treatment and self-esteem (the Global Negative Self-Evaluation Scale). In addition, children's dental casts were scored for the Dental Health Component (DHC) and Aesthetic Component (AC) grades of the Index of Orthodontic Treatment Need (IOTN) and the Peer Assessment Rating index (PAR).

In 1996-97 (time 2), 293 15-yr-old children from the same group were re-evaluated (46). Seventy-four children who had active orthodontic treatment at the time were excluded. Thus, the final sample size became 224. Questionnaires were completed by the children and parents and the same indices were assessed. Children were divided into orthodontically treated – children with completed removable or fixed orthodontic treatment at time 2) and non-treated groups.

Results showed that those who were treated with fixed orthodontic appliances had the greatest improvement in parents' and children's satisfaction level (46). Children who did not receive any orthodontic treatment still showed a significant improvement in satisfaction after four years, but their parents' satisfaction changes were not statistically significant. The self-esteem level of both treated and non-treated groups improved and no

statistically significant differences in changes in self-esteem were observed between groups. The treated group showed improvement in occlusal indices (from time 1 to time 2), whereas in the non-treated group occlusal indices become worse. Finally, 45% of children who had received orthodontic treatment and 30% of their parents believed that orthodontic treatment had had positive impacts on psychosocial well-being.

Josefsson et al. (47) conducted a qualitative study to assess the influence of poor dental aesthetics on the lives of young adults to develop a theory about the concerns of young adults with poor dental aesthetics and the mechanisms they use to address their aesthetic problems. The study participants were 19 to 20 years old (seven females and six males) and included seven natives of Sweden and six who were immigrants. An inclusion criterion was poor dental aesthetics based on the Index of Orthodontic Treatment Need (IOTN). An open-ended taped conversation was conducted about their family situation, geographic origin, history of earlier orthodontic consultation and treatment, factors influencing the decision to undergo or not to undergo treatment, consequences of the decision, dental appearance, body image, interpersonal relationships and future aspirations.

As soon as the interview was conducted, it was analyzed line-by-line by one of the investigators (47). Using the Grounded Theories (GT) method, collected data were grouped into codes, subcategories and finally core categories to form a theory. The major concern of young adults with poor dental aesthetics was “Being under the pressure of social norms” that were formed under the influence of television, magazines, advertisements, the internet, peers’ comments, and even dental providers’ opinions. Facing these concerns, they reported three different mechanisms for coping with this concern, including “avoiding showing the teeth”, “minimizing the importance of appearance” and “seeking orthodontic treatment.” Those who were trying to minimize the importance of tooth appearance believed that function would be more important than

dental appearance and having only natural and clean teeth would be essential for general health.

While the study (47) provided insights into dental esthetics, this study lacks generalizability due to the limited number of participants. In addition, besides considering poor IOTN score as an inclusion criterion, this study does not provide any information on the occlusal status of the participants; therefore, the associations of the results with normative occlusal characteristics are not clear.

Peres et al. (48) investigated the impacts of malocclusion on adolescent satisfaction level with appearance, after controlling for other physical features, including height and weight. A random sample of 900 Brazilian adolescents was selected from participants of the Pelotas birth cohort study. A team of eight calibrated dental students conducted the dental exams at adolescents' homes. They examined adolescents for malocclusion using the WHO criteria for assessment of malocclusion (49). Based on these criteria, malocclusion status was defined by three groups: normal occlusion; mild malocclusion that included certain occlusion anomalies, such as rotation, crowding, or spacing; and moderate/severe malocclusion that included crossbite, open bite, diastema, crowding/spacing ≥4 mm, or overjet ≥9 mm. Adolescents' weight and height were measured using portable UNICEF scale and stadiometer, respectively. Also, adolescents completed a questionnaire asking about skin color and satisfaction with appearance (with only yes/no response options).

For statistical analysis, Poisson regression models with robust variance were built separately for girls and boys (48). The authors commented that, since the prevalence of "being satisfied with appearance" was close to 50% (38%), using logistic regression and calculation of odds ratio would overestimate the prevalence ratio. As a result, they used Poisson regression analysis to provide more accurate estimation of the prevalence ratio. Variables which were significant at the bivariate level ($P< 0.2$) and family income, regardless of the bivariate P-value, were forced in the final model. Also possible

interactions between BMI and caries, and between malocclusion and weight and height were tested.

In this study (48), prevalence of moderate or severe malocclusion was about 32% and approximately 38% of adolescents were not satisfied with their appearance. The Poisson regression analysis showed that, for boys, BMI was the only predictor variable significantly associated with appearance satisfaction, while P-values for skin color and height were slightly above 0.05. On the other hand, for girls, malocclusion and family income were significantly associated with satisfaction, while BMI and dental caries were borderline. The study concluded that, in male adolescents, body and physical features were more important than malocclusion, whereas in female adolescents, alignment of teeth had a more important impact on perception of appearance.

Hamamci et al. (50) conducted a study to evaluate associations of malocclusion with self-awareness of malocclusion and satisfaction with appearance. In this study, 841 Turkish young adults with no history of orthodontic treatment were randomly selected from a university. They were asked to complete a questionnaire containing two questions: whether they perceived their teeth to be aligned improperly and whether they were satisfied with their dental appearance. Both awareness of malocclusion and satisfaction were measured on a scale of one to four. Then they underwent dental examinations by an orthodontist for assessment of malocclusion with the DAI score. For statistical analysis, Spearman rank-order correlation coefficients were used for assessment of the relationships between the DAI and four-level measure of satisfaction with dental appearance.

The results showed that, as the DAI increased, level of satisfaction with dental appearance decreased; however, interestingly as the DAI increased, level of awareness of malocclusion decreased (50). The authors commented that the negative correlation of the DAI and awareness of malocclusion was indicative of poor dental awareness in Turkey, which was consistent with other similar studies in that country. In addition, they found

that level of satisfaction with dental appearance was lower for older groups than for younger groups. They concluded that, for young adults, 17 to 26 years old, the level of satisfaction with dental appearance decreased with age. However, more studies are needed, since it was a cross-sectional study and it did not conduct a multivariable analysis.

A recent study by Tessarello et al. (51) investigated the relationships of 13-year-old adolescents' dissatisfaction with dental appearance with malocclusion using the DAI for assessment of malocclusion. In this study, 704 Brazilian adolescents aged 12-13 years were selected from 11 secondary schools in a city located in southern Brazil. The adolescents completed a perceptions questionnaire containing three main questions which asked about self-perception of dental appearance, speech, and chewing. The response options were very poor, poor, fair, good, and very good. An orthodontist examined the adolescents for malocclusion using the DAI.

For statistical analysis, Pearson correlation tests were performed to evaluate the relationship between the DAI score and dental perceptions (51). Then logistic regression was conducted to further evaluate the association of the DAI score (as a continuous variable), and other demographic variables with the outcome variables, which were whether the adolescents reported poor or very poor status for their dental appearance, and masticatory and speech functions. In addition, logistic regression was used to assess the associations of different DAI components with outcome variables.

The Pearson correlation tests showed that, as the DAI score increased, the level of dissatisfaction with dental appearance increased (P= 0.001), but the correlations between the DAI and oral functions (mastication and speech) were not significant (51). The results showed that the percentage of adolescents who reported poor dental appearance (19%) was significantly higher than the percentages that reported poor mastication (4%) and speech (2%). In the logistic regression analysis, the DAI was the only variable significantly associated with dissatisfaction with oral appearance, unlike maternal

education level, gender, age, and race. Furthermore, among the 10 components of the DAI, missing teeth and largest irregularity in maxilla and mandible were the only components significantly associated with self-rated dental appearance. This study concluded that malocclusion, particularly missing teeth and anterior irregularities, was associated with the self-perception of poor dental appearance in Brazilian adolescents, but not with other functions (51). This implies that improvement of appearance should be seen as the main priority in orthodontic treatment. Nevertheless, further extrapolation of the results to the main goals of orthodontic treatment should be considered with caution, since a valid oral health-related quality of life instrument was not used in the study.

In summary, studies on the associations between malocclusion and esthetic perceptions used different criteria for measurement of occlusion status, ranging from simple categories of mild, moderate, or severe malocclusion to the pretested indices such as the DAI and IOTN. Heterogeneity in the methods of evaluation of malocclusion could contribute to the inconsistencies we observed among the studies. Nevertheless, most of these studies found significant associations between malocclusion and dental esthetic perceptions of adolescents and young adults. One study among girls found that malocclusion was also associated with satisfaction with overall appearance, after adjusting for BMI and skin color. Another study showed that satisfaction with dental appearance decreases with age in a group of young adults.

Finally, substantial variation was observed in geographic locations where these studies were conducted, ranging from Brazil to Turkey and Scandinavian countries; however, none of them were from the North America. Since societal context and cultural values can contribute to esthetic perceptions and the way malocclusion impacts perceptions, studies are needed to assess such associations among U.S. populations.

Summary of review of literature

Increased exposure to fluoride during tooth development, particularly the first four years of life, has led to an increase in the prevalence of dental fluorosis among children and adolescents. However, the majority of fluorosis cases in the U.S are very mild or mild.

Several normative indices have been developed to evaluate the severity of dental fluorosis in epidemiologic studies, including Dean's Fluorosis Index, the Tooth Surface Index of Fluorosis, the Thylstrup-Fejerskov Index, and the Fluorosis Risk Index. The Fluorosis Risk Index was developed more recently to assess risk of fluorosis development on specific tooth surfaces due to exposure to particular amounts of fluoride at specific ages. In this system, four surface zones, the occlusal zone and cervical, middle and incisal thirds of the buccal surface, are scored separately and it is usually used in analytical longitudinal studies to determine risk of fluorosis development during various years of life.

About 15% of the U.S. population has severe malocclusion, i.e., arch expansion or tooth extraction was essential for correction of malocclusion. In addition, about 60% of them need orthodontic treatment to some extent based on the analysis of Index of Orthodontic Treatment Need (IOTN).

The Dental Aesthetic Index is an index for measurement of malocclusion in epidemiologic and analytical studies. It combines objective measures of occlusion with social acceptability of different aspects of occlusion. It has been shown that DAI scores $\leq$25 were correlated with normal occlusion or minor malocclusion with no need to orthodontic treatment, the DAI scores from 26 to 30 were correlated with definite malocclusion where orthodontic treatment was elective, the DAI scores from 31 to 35 were correlated with severe malocclusion where orthodontic treatment was highly desirable, and finally the DAI scores $\geq$36 were correlated with handicapping malocclusion, where orthodontic treatment was essential.

However, clinical measures do not account for self-perceptions of dental appearance and the possible impact of oral diseases on an individual's psychosocial well-being. Since the 1990s, there has been more study of esthetic perceptions and self-evaluation of appearance. These studies have tried to assess relationships between self-esthetic perceptions and oral conditions/ dental treatments affecting dental appearance. In this chapter, studies on the relationships of esthetic perceptions with dental fluorosis and malocclusion were reviewed. Nevertheless, recent investigations have focused more on effects of the oral conditions on quality of life. As assessment of quality of life was not included in this thesis project, studies of quality of life were not covered in this chapter.

Studies on perceptions of dental fluorosis showed that parents generally rated dental fluorosis less favorably than children, and dentists generally were less critical of fluorosis than lay people, but they were more critical of enamel hypomineralization. In fact, dental professionals could distinguish very mild fluorosis from normal appearance, but they were not considerably critical of this condition.

Most studies on the association of malocclusion and esthetic perceptions found significant associations between malocclusion and dental esthetic perceptions of adolescents and young adults. However, there was considerable heterogeneity in the methods of measurement of malocclusion, geographic distribution of studies, and variables that were used as confounders in the model.

This review of the literature has shown that few studies assessed the relationships of esthetic perceptions of adolescents and their parents with both fluorosis and malocclusion at the same time, and none of them were longitudinal. Since adolescents undergo major physical and cognitive development, changes in their perceptions of dental appearance are likely. Therefore, such longitudinal studies would provide clearer picture of how adolescents perceive their dental appearance. The aim of this study was to assess changes in dental esthetic perceptions of adolescents and their parents from the age of 13 to 15 and to evaluate the associations of the changes in perceptions with the oral health

conditions of dental fluorosis and malocclusion. Furthermore, this study investigated the dental esthetic perceptions of 15-year-old adolescents and their parents using cross-sectional data.

CHAPTER 3

MATERIALS AND METHODS

Overview

This study assessed and compared changes in adolescents' and their parents' dental esthetic perceptions from 13 years old to 15 years old and how fluorosis, occlusal characteristics and other predictor variables were associated with these changes. In addition, it compared 15-year-old adolescents' dental esthetic perceptions cross-sectionally with those of their parents and assessed how fluorosis was associated with these satisfaction levels.

Adolescence is a developmental phase of life when both physical and psychological changes occur that probably affect dental esthetic perceptions. Other factors, including familial characteristics, parental perceptions and oral problems such as fluorosis and malocclusion, can also influence the way teenagers perceive their dental appearance. This study was conducted to enhance understanding of adolescents' perceptions of dental appearance.

The data had been collected previously as part of the longitudinal Iowa Fluoride Study (IFS). This study performed secondary analyses of the IFS data concerning adolescents' and parents' esthetic perceptions at two points in time. Previously published articles, using data from the IFS, analyzed parents' perceptions about the children's mixed dentition (40, 41). One paper also compared 13-year-old adolescents' perceptions with their parents' (52). When adolescents were about 13 years old, they underwent dental examinations and completed dental esthetic perception questionnaires. The accompanying parents also completed similar questionnaires. About 2 years later when adolescents were about 15 years old, both the adolescents and their accompanying parents completed dental esthetic perception questionnaires again. Conducting secondary analyses of the IFS data, the primary purpose of this study was to evaluate and compare changes in adolescents' and parents' perceptions from age 13 to age 15 and determine

how they were associated with several factors, such as oral problems including fluorosis and malocclusion. In addition, a secondary purpose was to compare dental esthetic perceptions of 15-year-old adolescents with those of their parents.

This section describes the Main Iowa Fluoride Study purpose and activities first, and then it explains activities that were specifically conducted for the thesis, as well as the variables, hypotheses and, statistical methods of the thesis.

Main Iowa Fluoride Study description and activities

Sample population

The primary purpose of the IFS was to investigate fluoride exposures and their relationships with the development of dental fluorosis and caries (53, 54). During the period from March 1992 to February 1995, mothers and their newborns were recruited from postpartum wards of 8 hospitals in Iowa, which accounted for approximately 20% (8,000 annually) of the total number of births in the state of Iowa (55). One part-time recruiter worked in each hospital an average of about 4 hours per week, inviting as many parents with newborns as possible to participate in the study (56).

About 50% of invited parents declined to participate, often after reasoning that having a new baby would not allow them to spend time on participating in this study. Furthermore, some of them were not certain about living in Iowa for at least 4 years following recruitment (55). At the beginning of the study, 1,882 mothers with newborns were enrolled in the IFS, and among them, 1,390 (74%) remained in the study 6 months after their enrollment (57).

IRB approval

The Iowa Fluoride Study (IFS) was first approved by the University of Iowa Institutional Review Board (IRB) in 1991. Since then, it has been resubmitted for

approval at least annually. For all clinical procedures, parents provided informed consent, and subjects provided assent.

Data collection

Questionnaires

Parents completed structured mailed questionnaires regarding their child's sources and intake of water, possible intake of dietary fluoride supplement (if any), use of fluoride toothpaste, any intake of different types of beverages, frequency of child's dental visits, and non-nutritive sucking habits. These were sent when the children were at the ages of 1.5, 3, 6, 9, 12, 16, 20, 24, 28, 32, 36, 40, 44, and 48 months, and then at 6-month intervals until the age of 108 months. In addition, three-day intake diaries of all beverages and food were completed by the parents for the study children.

In addition, dental esthetic perception questionnaires were completed by parents when children were approximately age 9, 11, 13 and 15 years. Adolescents completed dental esthetic questionnaires only at ages 13 and 15. The questionnaires were designed based on previous investigations by Clark et al. (32, 34), McKnight et al. (43, 58) and Levy et al. (40). Copies of the questionnaires are provided in the Appendix. Adolescents and their accompanying parents completed self-administered questionnaires separately to ensure that parents were not aware of adolescents' responses and vice versa.

The parent and adolescent dental esthetic perception questionnaires were very similar, except that the parent questionnaire asked about parent's thoughts on his/her child's teeth. The esthetic perceptions questionnaire was composed of three main parts: the first part asked about the adolescent's/ parent's thoughts on the overall appearance of the teeth and response options were very satisfied, somewhat satisfied, somewhat dissatisfied and very dissatisfied. The second part asked about dental esthetic-related factors that could cause concern. These factors were as follows: shape of teeth, color of teeth, alignment of teeth, spacing of teeth, crowding of teeth, color irregularities and

other. If they responded yes to any, then they were asked to choose from a specific list of possible concerns for that factor. The characteristics for shape were jagged/chipped, pointed, irregular and other; and for color, they were brown hues, yellow hues, grey hues and other; for alignment, they were rotated, front teeth flared (buck teeth), abnormal bite and "other"; for spacing, they were abnormally large space, adult tooth missing and "other"; for crowding, they were extra teeth, overlapping and other; for color irregularities, they were white spots, yellow spots, brown spots, white lines, yellow lines, brown lines, speckled/spotted/streaky irregular/blotchy appearance and "other". The lists of characteristics were provided to help respondents understand questions properly and avoid them being confused about dental terminology. The third part asked about the adolescent's/ parent's thoughts on the overall color of the teeth, and response options were very satisfied, somewhat satisfied, somewhat dissatisfied and very dissatisfied.

Parents were also asked to complete a questionnaire regarding their children's experiences with orthodontic treatment, bleaching and front tooth repair due to trauma. Lastly, at the time of recruitment and in 2007, family demographic information, including parents' occupation, educational levels and family income, was collected from all families participating in the IFS.

Dental examinations

Children underwent dental examinations of the primary dentition (between age 4 and age 7), the mixed dentition (at age 9), and the permanent dentition (at ages 13 and 17). There were no dental examinations at age 15. At each examination time, trained and calibrated dental examiners examined children using portable equipment and halogen headlights for assessment of fluorosis status, non-fluorosis opacities, caries status, and occlusal characteristics.

Assessment of fluorosis and non-fluoride opacities

For assessment of dental fluorosis at age 13, teeth were cleaned with a piece of gauze, and all teeth were examined under a halogen headlight. The Fluorosis Risk Index (FRI) score was determined for the occlusal table of all molars and premolars, incisal edges of anterior teeth and 3 buccal zones (incisal, middle and cervical thirds) of all teeth. However, only the FRI scores of anterior maxillary teeth (4 surface zones for each tooth x 6 anterior maxillary teeth = 24 zones) were included in variable definitions for fluorosis and statistical analyses for this thesis. The FRI clinical criteria are shown in Table 3.1.

Also, non-fluoride opacities and/or hypoplasia were identified for each tooth. Russell's criteria were used to distinguish non-fluoride opacities from fluorosis (59). Unlike mild fluorosis, non-fluorosis opacities are well-defined, often round or oval, centered on smooth surfaces, and have generally random distribution in the mouth.

Occlusal characteristics

Occlusal characteristics, including molar relationship, and vertical (open bite, deep bite or within normal limits), transverse (posterior crossbite or within normal limits), and anterior-posterior relationships (anterior crossbite, excessive overjet or within normal limits), were recorded through intraoral examination. In addition, alginate impressions and wax bites were taken from most subjects. Dental casts of participants at age 13 were scored for assessment of occlusion by a calibrated dental student using the Dental Aesthetic Index (DAI) (60). A detailed description of the DAI is presented in the Chapter 2, and is also described in a subsequent section of this chapter.

Data management

The questionnaires and examination record forms were scanned and processed by one of the IFS employees, using Verity® TeleForm® Software; then the stored data sheets were checked for any possible errors and required corrections were made. The data sets were stored in SAS and/or excel files.

Table 3.1. Fluorosis Risk Index Criteria (22).

Negative finding: Score=0	A surface zone will receive a score of 0 when there is absolutely no indication of fluorosis being present. There must be a complete absence of any white spots or striations, and tooth surface coloration must appear normal.
Questionable finding: Score=1	Any surface zone that is questionable as to whether there is fluorosis present (i.e., white spots, striations, or fluorotic defects cover 50 percent or less of the surface zone) should be scored as 1.
Positive finding: Score=2	A smooth surface zone will be diagnosed as being positive for enamel fluorosis if greater than 50 percent of the zone displays parchment-white striations typical of enamel fluorosis. Incisal edges and occlusal tables will be scored as positive for enamel fluorosis if greater than 50 percent of that surface is marked by the snow-capping typical of enamel fluorosis.
Score=3	A surface zone will be diagnosed as positive for severe fluorosis if greater than 50 percent of the zone displays pitting, staining, and deformity, indicative of severe fluorosis.
Score=7	Any surface zone that has an opacity that appears to be a nonfluoride opacity should be scored as 7.
Surface Zone Excluded: Score=9	A surface zone is categorized as excluded (i.e., not adequately visible for a diagnosis to be made) when any of the following conditions exist: Incomplete eruption: Rule 1: If a tooth is in proximal contact but the occlusal surface is not parallel with existing occlusion, the occlusal two-thirds of the tooth is scored, but the cervical one-third is recorded as excluded. Rule 2: If a tooth is erupted, but not yet in contact, the incisal/occlusal edge is scored, but all other surfaces are recorded as excluded. Orthodontic appliances and bands: Rule 1: If there is an orthodontic band present on a tooth only the occlusal table or incisal edge should be scored. Rule 2: If greater than 50 percent of the surface zones are banded, the subject should be excluded from the examination. Surfaces crowned or restored: Rule 1: Surface zones that are replaced by either a crown or restoration covering greater than 50 percent of the surface zone should be recorded as excluded. Rule 2: Any subject with gross deposits of plaque or debris on greater than 50 percent of the surface zones should be excluded from examination.

Thesis-related activities

In order to allow the author to have access to the data for analysis, a modification was made to the IRB application to include her, and then it was submitted and approved by the University of Iowa IRB, 2011.

This thesis analyzed the IFS data which were collected when children were ages 13 and 15. The data for this study came from two time points. First, available data on parents' and adolescents' dental esthetic perceptions and dental examination of adolescents were from when they were 13 years old, and second, available data on parents' and adolescents' dental esthetic perceptions were from when the adolescents were 15 years old. In addition, the data on demographic characteristics, including family annual income level and parental education level in 2007, were added to the main data set. Finally, results of questionnaires concerning history of orthodontic treatment, bleaching, and trauma- collected at age 13 and 15- and results of questionnaires concerning dental visits- collected every six months- were added to the data set. All data sets were provided in the Excel, and then were transferred to SAS for merging and analyzing.

Only adolescents who did not have any history of orthodontic treatment before or at age 15 and had parental perception questionnaires completed by the same parent at both ages 13 and 15 were included for final analysis.

Of 161 subjects who were included in this study, 145 had dental casts available from age 13 for calculating the DAI scores. Since not all of them had been scored before (n=120), the author was trained by Dr. John Warren to assign DAI scores to the remaining models (n=25=145-120). After a training and calibration session, the author scored the rest of the study models using the DAI method (n=25). In addition, those models which had been assessed earlier and had DAI scores above 30 (n=19), were reviewed again by the author to ensure consistency of the two sets of measurements.

There were 8 cases of inconsistency which were reviewed by Dr. Warren and agreement on the final score was reached by the author and Dr. Warren.

For calculation of the DAI scores, the 10 DAI components were measured and multiplied by their regression coefficients. Products were summed and added to a constant value to result in the final DAI score. The DAI components and their regression coefficients are presented in Table 3.2.

Table 3.2. DAI components and their regression coefficients (26).

DAI Component	Regression Coefficient (rounded weights)
Missing visible teeth	6
Crowding	1
Spacing	1
Diastema	3
Largest anterior irregularity (upper)	1
Largest anterior irregularity (lower)	1
Anterior maxillary overjet (upper)	2
Anterior maxillary overjet (lower)	4
Vertical anterior overbite	4

Operational definitions

1. Satisfaction with overall appearance: Adolescents and parents separately were asked to choose one of these four options which best described their thoughts about the overall appearance of their/their children's teeth. The responses were very satisfied, somewhat satisfied, somewhat dissatisfied or very dissatisfied.

2. Satisfaction with overall tooth color: Adolescents and parents separately were asked to choose one of these four options which best described their thoughts about the overall color of their/their children's teeth. The responses were very satisfied, somewhat satisfied, somewhat dissatisfied or very dissatisfied.
3. Concern with tooth shape: Adolescents and parents separately were asked if shape of teeth was a concern for them and, if yes, which characteristics concerned them, including jagged/chipped, pointed or irregular shape.
4. Concern with tooth color: Adolescents and parents separately were asked if color of teeth was a concern for them and, if yes, which characteristics concerned them, including brown hues, yellow hues or gray hues.
5. Concern with tooth alignment: Adolescents and parents separately were asked if alignment of teeth was a concern for them and, if yes, which characteristics concerned them, including rotated, front teeth flared or abnormal bite.
6. Concern with tooth spacing: Adolescents and parents separately were asked if spacing of teeth was a concern for them and, if yes, which characteristics concerned them, including abnormally large space or adult tooth missing.
7. Concern with tooth crowding: Adolescents and parents separately were asked if crowding of teeth was a concern for them and, if yes, which characteristics concerned them, including extra teeth or overlapping.
8. Concern with tooth shape: Adolescents and parents separately were asked if tooth color irregularities were concern for them and, if yes, which characteristics concerned them, including white spot, yellow spot, brown spot, white lines, yellow lines, brown lines or speckled/spotted/streaky irregular/blotchy appearance.
9. Dental fluorosis was identified when there was at least one permanent maxillary anterior tooth showing one or more zones with FRI scores of 2 or more (out of the 4 zones included for each tooth). Also, total fluorosis score was identified as the

total number of surface zones on maxillary anterior teeth showing FRI scores of 2 or more.

10. Non-fluoride opacities were identified when there was one or more permanent maxillary anterior teeth showing non-fluorosis opacity.
11. Molar relationship was defined as class I, II or III.
12. Vertical jaw relationship was defined as within normal limits, open bite or deep bite.
13. Transverse jaw relationship was defined as within normal limits or crossbite.
14. Anterior-posterior jaw relationship was defined as within normal limits, crossbite or more than 4mm overjet.
15. A Dental Aesthetic Index score was assigned based on measurements made on the dental models provided at age 13. DAI scores less than or equal to 25 generally represent no or slight need for orthodontic treatment, DAI scores more than 25 and less than 31 generally represent elective orthodontic treatment need, whereas DAI score of 31 or more generally indicates that orthodontic treatment is highly desirable (25).

Dependent variables

There were two sets of dependent variables. The first set of dependent variables was related to changes in dental esthetic perceptions of adolescents and their parents from age 13 to 15. The second set of variables was related to adolescents' and their parents' perceptions cross-sectionally at age 15. The first set of variables included changes in levels of satisfaction with the overall dental appearance, changes in levels of satisfaction with the overall color of teeth, and changes in concerns with tooth shape, color, alignment, spacing, crowding, and color irregularities. All the variables were defined separately for adolescents and their parents. The types of variables and the ways they were categorized are presented in Tables 3.3 and 3.4.

Table 3.3. Names, types and categories of dependent variables related to changes in adolescents' dental esthetic perceptions.

Dependent variable	Type of variable	Ordinal levels
Change in adolescent's satisfaction* with overall dental appearance	Categorical-ordinal	Seven levels of change: 3-level decrease to 3-level increase (-3 to +3)
Change in adolescent's satisfaction* with overall color of teeth	Categorical-ordinal	Seven levels of change: 3-level decrease to 3-level increase (-3 to +3)
Change in concern** with tooth shape	Categorical-ordinal	Changed from concerned to non-concerned No change (stayed non-concerned or Stayed concerned) Changed from non-concerned to concerned
Change in concern** with tooth color	Categorical-ordinal	Changed from concerned to non-concerned No change (stayed non-concerned or stayed concerned) Changed from non-concerned to concerned
Change in concern** with tooth alignment	Categorical-ordinal	Changed from concerned to non-concerned No change (stayed non-concerned or Stayed concerned) Changed from non-concerned to concerned
Change in concern** with spacing	Categorical-ordinal	Changed from concerned to non-concerned No change (stayed non-concerned or stayed concerned) Changed from non-concerned to concerned
Change in concern** with crowding	Categorical-ordinal	Changed from concerned to non-concerned No change (stayed non-concerned or stayed concerned) Changed from non-concerned to concerned
Change in concern** with tooth color irregularities	Categorical-ordinal	Changed from concerned to non-concerned No change (stayed non-concerned or stayed concerned) Changed from non-concerned to concerned

*Categorized into 4 levels: very satisfied, somewhat satisfied, very dissatisfied and somewhat dissatisfied and changes were determined based on these 4 levels.

** Concerned vs. non-concerned

Table 3.4. Names, types and categories of dependent variables related to changes in parents' dental esthetic perceptions.

Dependent Variable	Type of variable	Ordinal levels
Change in parent's satisfaction* with overall dental appearance	Categorical-ordinal	Seven levels of change: 3-level decrease to 3-level increase (-3 to +3)
Change in parent's satisfaction* with overall color of teeth	Categorical-ordinal	Seven levels of change: 3-level decrease to 3-level increase (-3 to +3)
Change in concern** with tooth shape	Categorical-ordinal	Changed from concerned to non-concerned / No change (stayed non-concerned or stayed concerned)/ Changed from non-concerned to concerned
Change in concern** with tooth color	Categorical-ordinal	Changed from concerned to non-concerned/ No change (stayed non-concerned or stayed concerned)/ Changed from non-concerned to concerned
Change in concern** with tooth alignment	Categorical-ordinal	Changed from concerned to non-concerned/ No change (stayed non-concerned or stayed concerned)/ Changed from non-concerned to concerned
Change in concern** with spacing	Categorical-ordinal	Changed from concerned to non-concerned/ No change (stayed non-concerned or stayed concerned)/ Changed from non-concerned to concerned
Change in concern** with crowding	Categorical-ordinal	Changed from concerned to non-concerned/ No change (stayed non-concerned or stayed concerned)/ Changed from non-concerned to concerned
Change in concern** with tooth color irregularities	Categorical-ordinal	Changed from concerned to non-concerned/ No change (stayed non-concerned or stayed concerned)/ Changed from non-concerned to concerned

*Categorized into 4 levels: very satisfied, somewhat satisfied, very dissatisfied and somewhat dissatisfied and changes were determined based on these 4 levels.

** Concerned vs. non-concerned

The second set of variables that assessed perceptions cross-sectionally at age 15 included level of satisfaction with the overall dental appearance, level of satisfaction with the overall color of teeth and being concerned with tooth shape, color, alignment, spacing, crowding and color irregularities. All the variables were defined separately for adolescents and their parents. The type of variables and the ways they were categorized are shown in Tables 3.5 and 3.6.

Table 3.5. Names, types and categories of dependent variables related to adolescents' dental esthetic perceptions at age 15.

Adolescents-age 15 Dependent Variable	Type of variable	Categories
Adolescent's level of satisfaction with overall dental appearance	Categorical-ordinal	Very satisfied Somewhat satisfied Very dissatisfied Somewhat dissatisfied
Adolescent's level of satisfaction with overall color of teeth	Categorical-ordinal	Very satisfied Somewhat satisfied Very dissatisfied Somewhat dissatisfied
Being concerned with tooth shape	Categorical-dichotomous	Yes/No
Being concerned with tooth color	Categorical-dichotomous	Yes/No
Being concerned with tooth alignment	Categorical-dichotomous	Yes/No
Being concerned with spacing	Categorical-dichotomous	Yes/No
Being concerned with crowding	Categorical-dichotomous	Yes/No
Being concerned with tooth irregularities	Categorical-dichotomous	Yes/No

Table 3.6. Names, types and categories of dependent variables related to parents' dental esthetic perceptions at age 15.

Parents-age 15 Dependent Variable	Type of variable	Categories
Parent's level of satisfaction with overall dental appearance	Categorical-ordinal	Very satisfied Somewhat satisfied Very dissatisfied Somewhat dissatisfied
Parent's level of satisfaction with overall color of teeth	Categorical-ordinal	Very satisfied Somewhat satisfied Very dissatisfied Somewhat dissatisfied
Being concerned with tooth shape	Categorical- dichotomous	Yes/No
Being concerned with tooth color	Categorical- dichotomous	Yes/No
Being concerned with tooth alignment	Categorical- dichotomous	Yes/No
Being concerned with tooth spacing	Categorical- dichotomous	Yes/No
Being concerned with crowding	Categorical- dichotomous	Yes/No
Being concerned with tooth irregularities	Categorical- dichotomous	Yes/No

Independent variables

The independent variables in the study were as follows (Table 3.7):

1. Gender of adolescent: Gender of the participant adolescent was defined as male or female.

2. Gender of accompanying parent at age 13 and 15: Gender of the accompanying parent who completed the parent questionnaires when the participants came for the exam at age 13 and 15.
3. History of orthodontic treatment before or at age 15: Having any experience of orthodontic treatment before or at the age 15.
4. History of tooth repair due to fall, injury, or trauma before or at age 13: Having any experience of repaired front teeth due to fall, injury, or trauma before or at the age 13.
5. History of tooth repair due to fall, injury, or trauma before or at age 15: Having any experience of repaired front teeth due to fall, injury, or trauma before or at the age 15.
6. History of tooth bleaching before or at age 13: Having any experience of tooth bleaching before or at the age 13.
7. History of tooth bleaching before or at age 15: Having any experience of tooth bleaching before or at the age 15.
8. Number of zones with fluorosis on the maxillary anterior teeth: Number of surface zones on maxillary anterior teeth showing FRI scores of 2 or more.
9. Fluorosis on the maxillary anterior teeth: Having at least one permanent maxillary anterior tooth showing one or more zones with FRI scores of 2 or more.
10. Non-fluoride opacity on the maxillary anterior teeth: Having one or more permanent maxillary anterior teeth showing non-fluorosis opacity.
11. Vertical jaw relationship: Vertical jaw relationship, which was defined as within normal limits, open bite or deep bite.
12. Transverse jaw relationship: Transverse jaw relationship, which was defined as within normal limits or crossbite.
13. Anterior-posterior jaw relationship: Anterior-posterior jaw relationship which was defined as within normal limits, crossbite or more than 4mm overjet.

14. Dental Aesthetic Index: A Dental Aesthetic Index score was assigned to each participant based on measurements made on the dental models provided at age 13. Previous studies showed that DAI scores less than or equal to 25 generally represent no or slight need for orthodontic treatment, DAI scores more than 25 and less than 31 generally represent elective orthodontic treatment need, and DAI scores of 31 or more generally indicate that orthodontic treatment is highly desirable. These categories were used in this study (25).
15. Parent's educational level: Educational levels were defined separately for both parents as some high school or high school diploma (or GED), some college or 2-year college degree or technical beauty school, 4-year college degree, and post-graduate or professional degree.
16. Annual family income level: Family annual income level in 2007 was defined as less than $20,000, $20,000-$39,999, $40,000-$59,999, $60,000-$79,999, and $80,000 or more.
17. Dental visit: Questionnaires were sent every six months asking if they had visited a dentist over the previous 6 months. Using all the returned questionnaires, the dental visit proportion was calculated using number of six-month periods with reported dental visits divided by the number of returned questionnaires from age twelve and one half years to age fifteen.

From an esthetic standpoint, dental caries and fillings generally are of modest importance, unless they are placed on anterior maxillary teeth. However, the data showed that only 4 subjects (2%) had caries and/or fillings on maxillary anterior teeth at age 13. Therefore, dental caries was not considered as a predictor variable in this study.

Table 3.7. Names, types and categories of independent variables.

Independent Variable	Type	Categories
Gender of adolescent	Categorical-dichotomous	Male/Female
Gender of accompanying parent	Categorical-dichotomous	Male/Female
History of orthodontic treatment before/at age 15	Categorical-ordinal	Yes/No
History of tooth repair due to fall, injury, or trauma before or at age 15 exam	Categorical-dichotomous	Yes/No
History of tooth repair due to fall, injury, or trauma before or at age 13 exam	Categorical-dichotomous	Yes/No
History of tooth bleaching before or at age 15 exam	Categorical-dichotomous	Yes/No
History of tooth bleaching before or at age 15 exam	Categorical-dichotomous	Yes/No
Number of surface zones with fluorosis on maxillary anterior teeth	Quantitative	
Fluorosis on maxillary anterior teeth	Categorical-dichotomous	Yes/No
Non-fluorosis opacity on maxillary anterior teeth	Categorical-dichotomous	Yes/No
Vertical jaw relationship	Categorical-nominal	Within Normal Limits(WNL)/Open/Deep
Transverse jaw relationship	Categorical-nominal	Within Normal Limits(WNL)/crossbite
Anterior-Posterior jaw relationship	Categorical-nominal	Within Normal Limits(WNL)/crossbite/>4mm overjet
Dental Aesthetic Index category	Categorical-ordinal	≤25/26-30/≥31
Parent's educational level	Categorical-ordinal	1. High school/GED or less, 2. college degree or technical beauty school, 3. post-graduate or professional degree
Annual family income level	Categorical-ordinal	1. Less than $20,000, 2. $20,000-$39,999, 3. $40,000-$59,999, 4. $60,000-$79,999, 5. $80,000 or more
Dental visits	Quantitative	Number of six-month periods with reported dental visits divided by the total number of returned questionnaires which were sent every six months from age twelve and half years to age fifteen years.

Hypotheses

I. General Hypotheses I-1 to I-4 were related to changes in dental esthetic perceptions of adolescents and their parents from the age 13 to 15 exams.

General Hypothesis I-1

Dental esthetic perceptions of adolescents at age 15 were different from their perceptions at age 13.

Specific Hypotheses

A. The primary hypotheses (#1 and #2) were related to overall satisfaction:

1. Adolescents' levels of satisfaction with overall dental appearance at age 15 were significantly lower than their satisfaction levels at age 13.

2. Adolescents' levels of satisfaction with overall dental color at age 15 were significantly lower than their satisfaction levels at age 13.

B. The secondary hypotheses (#3 to #8) were related to specific concerns:

3. Adolescents' concerns about tooth shape at age 15 were significantly higher than their concerns at age 13.

4. Adolescents' concerns about tooth color at age 15 were significantly higher than their concerns at age 13.

5. Adolescents' concerns about tooth alignment at age 15 were significantly lower than their concerns at age 13.

6. Adolescents' concerns about tooth spacing at age 15 were significantly lower than their concerns at age 13.

7. Adolescents' concerns about tooth crowding at age 15 were significantly lower than their concerns at age 13.

8. Adolescents' concerns about tooth color irregularities at age 15 were significantly higher than their concerns at age 13.

General Hypothesis I-2

Dental esthetic perceptions of parents about their adolescents at age 15 were different from their perceptions about them at age 13.

Specific Hypotheses

A. The primary hypotheses (#9 and #10) were related to overall satisfaction:

9. Parents' levels of satisfaction with overall dental appearance of adolescents at age 15 were significantly lower than their satisfaction levels at age 13.

10. Parents' levels of satisfaction with overall dental color of their adolescents at age 15 were significantly lower than their satisfaction levels at age 13.

B. The secondary hypotheses (#11 to #16) were related to specific concerns:

11. Parents' concerns about tooth shape of their adolescents at age 15 were significantly higher than their concerns at age 13.

12. Parents' concerns about tooth color of their adolescents at age 15 were significantly higher than their concerns at age 13.

13. Parents' concerns about tooth alignment of their adolescents at age 15 were significantly lower than their concerns at age 13.

14. Parents' concerns about tooth spacing of their adolescents at age 15 were significantly lower than their concerns at age 13.

15. Parents' concerns about tooth crowding of their adolescents at age 15 were significantly lower than their concerns at age 13.

16. Parents' concerns about tooth color irregularities of their adolescents at age 15 were significantly higher than their concerns at age 13.

General Hypothesis I-3

Changes in dental esthetic perceptions of adolescents from age 13 to 15 were different from those of their parents.

A. The primary hypotheses (#17 and #18) were related to overall satisfaction:

Specific Hypotheses

17. Adolescents' changes in satisfaction with overall dental appearances from age 13 to 15 were more than those of their parents.

18. Adolescents' changes in satisfaction with overall color of the teeth from age 13 to 15 were more than those of their parents.

B. The secondary hypotheses (#19 to #24) were related to specific concerns:

19. Adolescents' changes in concerns with tooth shape from age 13 to 15 were more than those of their parents.

20. Adolescents' changes in concerns with tooth color from age 13 to 15 were more than those of their parents.

21. Adolescents' changes in concerns with tooth alignment from age 13 to 15 were more than those of their parents.

22. Adolescents' changes in concerns with spacing of teeth from age 13 to 15 were more than those of their parents.

23. Adolescents' changes in concerns with crowding of teeth from age 13 to 15 were more than those of their parents.

24. Adolescents' changes in concerns with tooth color irregularities from age 13 to 15 were more than those of their parents.

General Hypothesis I-4

Changes in adolescents' satisfaction levels with overall dental appearance were associated with, fluorosis on the maxillary anterior teeth at age 13, non-fluorosis opacities on the maxillary anterior teeth at age 13, enamel hypoplasia on the maxillary anterior teeth at age 13, the DAI score at age 13, occlusal characteristics at age 13, parental education levels, family annual income level, frequency of dental visits and gender.

Specific Hypotheses

25. Changes in adolescents' satisfaction with overall dental appearances were associated with fluorosis on the maxillary anterior teeth at age 13.

26. Changes in adolescents' satisfaction with overall dental appearance were associated with non-fluorosis opacities on the maxillary anterior teeth at age 13.

27. Changes in adolescents' satisfaction with dental appearances were associated with DAI scores at age 13.

28. Changes in adolescents' satisfaction with dental appearances were associated with occlusal characteristics at age 13.

29. Changes in adolescents' satisfaction with dental appearances were associated with parental education levels.

30. Changes in adolescents' satisfaction with dental appearances were associated with family annual income level.

31. Changes in adolescents' satisfaction with dental appearances were associated with frequency of dental visits.

32. Changes in adolescents' satisfaction with dental appearances were associated with gender.

General Hypothesis I-5

Changes in parents' satisfaction levels with overall dental appearance were associated with, fluorosis and non-fluorosis opacities on the maxillary anterior teeth at age 13, the DAI score at age 13, occlusal characteristics at age 13, parental education levels, family annual income level, frequency of dental visits and gender.

Specific Hypotheses

33. Changes in parents' satisfaction with overall dental appearances of adolescents were associated with fluorosis on the maxillary anterior teeth at age 13.

34. Changes in Parents' satisfaction with overall dental appearance of adolescents were associated with non-fluorosis opacities on the maxillary anterior teeth at age 13.

35. Changes in parents' satisfaction with overall dental appearance of adolescents were associated with DAI scores at age 13.

36. Changes in parents' satisfaction with overall dental appearance of adolescents were associated with occlusal characteristics at age 13.

37. Changes in parents' satisfaction with overall dental appearance of adolescents were associated with parental education levels.

38. Changes in parents' satisfaction with overall dental appearance of adolescents were associated with family annual income level.

39. Changes in parents' satisfaction with overall dental appearance of adolescents were associated with frequency of dental visits.

40. Changes in parents' satisfaction with overall dental appearance of adolescents were associated with adolescents' gender.

II. General Hypotheses II-1 to II-3 were related to dental esthetic perceptions of adolescents and their parents cross-sectionally at age 15.

General Hypothesis II-1

Adolescents' dental esthetic perceptions at age 15 were associated in bivariate analyses with dental fluorosis assessed when adolescents were 13 years old.

Specific Hypotheses

A. The primary hypotheses (#35 and #36) were related to overall satisfaction:

41. Adolescents with dental fluorosis at age 13 were more likely to show lower satisfaction with overall dental appearance at age 15 than adolescents without fluorosis.

42. Adolescents with dental fluorosis at age 13 were more likely to show lower satisfaction with overall color of the teeth at age 15 than adolescents without fluorosis.

B. The secondary hypotheses (#37 and #38) were related to specific concerns:

43. Adolescents with dental fluorosis at age 13 were more likely to be concerned with tooth color at age 15 than adolescents without fluorosis.

44. Adolescents with dental fluorosis at age 13 were more likely to be concerned with tooth color irregularities at age 15 than adolescents without fluorosis.

General Hypothesis II-2

Parents' dental esthetic perceptions at age 15 were associated in bivariate analyses with dental fluorosis assessed when adolescents were 13 years old.

Specific Hypotheses

A. The primary hypotheses (#39 and #40) were related to overall satisfaction:

45. Parents whose adolescents had dental fluorosis at age 13 were more likely to show lower satisfaction with overall dental appearance of their adolescents at age 15 than other parents.

46. Parents whose adolescents had dental fluorosis at age 13 were more likely to show lower satisfaction with overall color of their adolescents' teeth at age 15 than other parents.

B. The secondary hypotheses (#41 to #42) were related to specific concerns:

47. Parents whose adolescents had dental fluorosis at age 13 were more likely to be concerned with tooth color of their adolescents at age 15 than other parents.

48. Parents whose adolescents had dental fluorosis at age 13 were more likely to be concerned with tooth color irregularities of their adolescents at age 15 than other parents.

General Hypothesis II-3

Adolescents' dental esthetic perceptions at age 15 were different from their parents' dental esthetic perceptions.

Specific Hypotheses

A. The primary hypotheses (#43 and #44) were related to overall satisfaction:

49. Adolescents' levels of satisfaction with overall dental appearance at age 15 were lower than their parents' levels of satisfaction.

50. Adolescents' levels of satisfaction with overall color of the teeth at age 15 were lower than their parents' levels of satisfaction.

B. The secondary hypotheses (#45 to #50) were related to specific concerns:

51. The proportion of adolescents who were concerned with tooth shape at age 15 was higher than the proportion of parents who were concerned with their adolescents' tooth shape at that time.

52. The proportion of adolescents who were concerned with tooth color at age 15 was higher than the proportion of parents who were concerned with their adolescents' tooth color at that time.

53. The proportion of adolescents who were concerned with tooth alignment at age 15 was higher than the proportion of parents who were concerned with their adolescents' tooth alignment at that time.

54. The proportion of adolescents who were concerned with spacing of teeth at age 15 was higher than the proportion of parents who were concerned with their adolescents' spacing of teeth at that time.

55. The proportion of adolescents who were concerned with crowding of teeth at age 15 was higher than the proportion of parents who were concerned with their adolescents' crowding of teeth at that time.

56. The proportion of adolescents who were concerned with tooth color irregularities at age 15 was higher than the proportion of parents who were concerned with their adolescents' tooth color irregularities at that time.

General Hypothesis II-4

Adolescents' satisfaction levels with overall dental appearance at age 15 were associated in multivariable analyses with fluorosis and non-fluoride opacities on the maxillary anterior teeth at age 13, the DAI score at age 13, occlusal characteristics at age 13, parental education levels, family annual income level, frequency of dental visits, and gender.

Specific Hypotheses

57. Adolescents' levels of satisfaction with overall dental appearance at age 15 were negatively associated with fluorosis on the maxillary anterior teeth at age 13.

58. Adolescents' levels of satisfaction with overall dental appearance at age 15 were negatively associated with non-fluoride opacities on the maxillary anterior teeth at age 13.

59. Adolescents' levels of satisfaction with overall dental appearance at age 15 were negatively associated with DAI score at age 13.

60. Adolescents' levels of satisfaction with overall dental appearance at age 15 were negatively associated with occlusal characteristics at age 13.

61. Adolescents' levels of satisfaction with overall dental appearance age 15 were associated with parental education levels.

62. Adolescents' levels of satisfaction with overall dental appearance at age 15 were associated with family annual income level.

63. Adolescents' levels of satisfaction with overall dental appearance at age 15 were associated with frequency of dental visits.

64. Adolescents' levels of satisfaction with overall dental appearance at age 15 were associated with gender.

Statistical analysis

Descriptive analyses were conducted to identify characteristics of the subjects and their families, including participants' gender, family annual income level, and educational levels of parents; prevalence of fluorosis, non-fluorosis opacities and hypoplasia on maxillary anterior teeth; histories of orthodontic treatment, broken teeth and bleaching; frequency of various occlusal characteristics; and distribution of DAI scores.

Bivariate and multivariable analyses were conducted based on the hypotheses of the study using P-value = 0.05 as the level of significance for bivariate analyses and P-value = 0.15 as the level of significance and cutoff point for selection of variables for the final regression models. Because of the small sample size, P-value = 0.15 was used for variable selection to ensure that variables with P-values slightly above 0.05 would not be removed from the final parsimonious models.

The plan of analyses was as follows:

For General Hypotheses I-1, I-2 and I-3, kappa coefficients (or weighted kappa coefficients, if the variable had more than 2 levels), Wilcoxon signed rank tests and Bowker's and McNemar's tests of symmetry were used to assess and compare changes in dental esthetic perceptions of adolescents and their parents from age 13 to 15. It is widely accepted that the kappa values of less than 0.41 indicate modest to fair agreement, values of 0.41 to 0.60 indicate moderate agreement, and more than 0.60 indicate substantial agreement (61).

For General Hypotheses I-4, I-5, and II-4, ordinal logistic regression was used to separately evaluate the associations of 1) changes in adolescents' levels of satisfaction with overall dental appearance, 2) changes in parents' levels of satisfaction with overall dental appearance, and 3) 15-year-old adolescents' satisfaction levels with overall dental appearance (outcome variables). The predictors included maxillary anterior fluorosis, and other potential predictors: maxillary anterior non-fluorosis opacities, the DAI score,

occlusal characteristics, parental education levels, family annual income level, frequency of dental visits, history of recent broken teeth, history of recent bleaching, and adolescent's and parent's gender. Construction of the final regression model started with a forced entry of the predictor variables with P-values less than 0.15 at the univariable level. Then, a backward elimination technique was used for selection of the predictors which remained in the final model with P-values less than 0.15. Finally, the possible 2-way interactions between variables which remained in the final model were tested. The generalized logit model was used if the proportional odds assumption, which is required for ordinal logistic regression, was violated.

For General Hypotheses II-1, Cochran-Armitage Trend tests were used to evaluate the associations of adolescents' levels of satisfaction with overall dental appearance and overall color of teeth at age 15 with maxillary anterior fluorosis status assessed at age 13. Also, Fisher's Exact tests were used to evaluate associations of adolescents' concerns about the tooth color and color irregularities with maxillary anterior fluorosis status assessed at age 13.

For General Hypothesis II-2, Cochran-Armitage Trend tests were used to evaluate the associations of parent satisfaction levels with overall dental appearance and overall dental color at age 15 with the adolescents' maxillary anterior fluorosis status assessed at age 13. Also, Fisher's Exact tests were used to evaluate the associations of parent concerns about the tooth color and color irregularities with the adolescents' maxillary anterior fluorosis status.

For General Hypothesis II-3, Wilcoxon signed rank tests were used to compare adolescents' satisfaction with overall dental appearance and overall color of the teeth with parents' satisfaction at age 15, and also to compare adolescents' dental esthetic-related concerns with those of their parents.

All statistical analyses were conducted using SAS 9.2 (62).

Post-hoc power analysis was conducted to assess the power of study, since the sample size was fixed at the time this study was implemented. Assessment of changes in adolescents' level of satisfaction with the overall dental appearance from age 13 to 15 showed that 45.1% of adolescents had some change in satisfaction level. Moreover, the difference between percentages of adolescents with improved satisfaction versus decreased satisfaction was only 3.8%. Considering these percentages, alpha level of 0.05 and sample size of 165, the power of the study for comparing the percentage of adolescents with improved satisfaction with overall dental appearance from age 13 to 15 versus the percentage of adolescents with decreased satisfaction levels was about 14.9%, using SAS 9.2 (62). Conducting the same analysis for parents showed that 28.8% of parents showed some changes in level of satisfaction with overall dental appearance. The difference between the percentage of parents with improved satisfaction and the percentage with decreased satisfaction was 9.2%. Considering these percentages, alpha level of 0.05 and sample size of 146, the power of study for comparing the percentage of parents with improved satisfaction with overall dental appearance from age 13 to 15 versus the percentage of parents with decreased satisfaction levels was about 62.1%.

CHAPTER 4

RESULTS

Sample characteristics

This study assessed changes in dental esthetic perceptions of a group of adolescents who did not have any experiences of orthodontic treatment and their parents from age 13 to age 15. In addition, it compared 15-year-old adolescents' dental esthetic perceptions cross-sectionally with those of their parents.

There were 550 adolescents who completed the esthetic perception questionnaires at the age 13 exam and 406 adolescents who completed the questionnaires at the age 15 visit. There were 188 adolescents in total who did not have any experience of orthodontic treatment by the age 15 visit. Overall, 161 adolescents who completed the esthetic perception questionnaires at both ages and had history of not receiving orthodontic treatment by age 15 visit were included in this study. Moreover, 140 adolescents had parental esthetic perception questionnaires completed by the same parent at both ages and did not have history of orthodontic treatment; therefore, their parental dental esthetic perceptions were included in analyses.

Descriptive analysis showed that 42% of the study subjects and 95% of the parents who completed the esthetic questionnaires were female (Table 4.1). Also, 93% of the subjects were non-Hispanic white. In addition, available data on the socioeconomic status of the subjects showed that 12% of fathers and 14% of mothers had a graduate or professional degree and 56% of fathers and 70% of mothers had some college education or a college degree. Also, only 22% of the subjects had family income in 2007 less than $40,000. Finally, a total of six questionnaires were sent every six months from age twelve and one half years to age fifteen, asking if subjects had visited a dentist over the previous 6 months. Considering all the returned questionnaires, about 47% of the adolescents

reported having dental visits in all the returned questionnaires from age twelve and one half years to age fifteen (dental visit proportion=1).

Table 4.1. Demographic characteristics of the subjects and families.

Variable	Percentage	
Adolescent's gender	(N=161)	
Male	58.4	
Female	41.6	
Parent's gender	(N=140)	
Male	5.0	
Female	95.0	
Adolescent's race/ethnicity	(N=161)	
Non-Hispanic white	93.1	
Other	6.9	
Educational level	Father (N=143)	Mother (N=159)
≤ High school diploma or G.E.D.	32.2	15.1
Some college education or college degree	55.9	70.4
Graduate/professional degree	11.9	14.5
Family income (2007)	(N=156)	
<$40,000	22.4	
$40,000-$79,999	46.8	
≥$80,000	30.8	
Dental visit proportion*	(N=161)	
0-0.39	15.5	
0.40-0.69	18.0	
0.70-0.99	19.9	
1	46.6	

* The dental visit proportion was calculated using number of six-month periods with reported dental visits divided by the number of returned questionnaires from age twelve and one half years to age fifteen (maximum of six periods).

Descriptive analysis of dental characteristics of the subjects showed that 9% of the adolescents reported experience of tooth repair due to trauma prior to the age 13 exam, and 4% did between the age 13 and 15 visits (Table 4-2). Also, 3% of the adolescents had received tooth bleaching prior to age 13, 7% between the age 13 and 15 visits, and 1% both prior to the age 13 and between the age 13 and 15 visits.

Dental exams at age 13 showed that about 33% of the adolescents had definitive fluorosis on one or more maxillary anterior teeth (maximum Fluorosis Risk Index (FRI) score= 2 or 3), including one subject who had severe fluorosis (maximum FRI score= 3) (Table 4.2). About 14% of the adolescents were reported to have non-fluoride opacities on one or more anterior maxillary teeth.

Based on the assessment of occlusal characteristics at age 13, about 3% of the adolescents had open bite, 4% had deep bite, and 4% had excessive overjet. Moreover, 8% and 6% had posterior and anterior crossbites, respectively. Based on Dental Aesthetic Index (DAI) scores, 58% of the subjects did not need orthodontic treatment or had a slight need (DAI$\leq$ 25), 31% needed elective orthodontic treatment (25<DAI<31), and for 11% orthodontic treatment was highly desirable (DAI$\geq$31) (27).

From an esthetic standpoint, dental caries and fillings are of modest importance unless they are placed on anterior maxillary teeth; however, the data showed that only 4 (2%) subjects had caries and/or fillings due to dental caries on maxillary anterior teeth at age 13. Therefore, dental caries was not considered as a predictor variable in this study. In addition, only 2 subjects had enamel hypoplasia on their maxillary anterior teeth; one subject had enamel hypoplasia and a FRI score of 1on a maxillary lateral incisor, and another subject had enamel hypoplasia and non-fluoride opacity on a maxillary lateral and a maxillary central incisors.

Table 4.2. Dental characteristics of the subjects.

Variable	%
History of tooth repair due to trauma	(N=161)
No	87.6
Yes, prior to age 13 exam	8.7
Yes, between age 13 and 15 exams	3.7
History of tooth bleaching	(N=161)
No	88.2
Yes, prior to age 13 exam	3.1
Yes, between age 13 and 15 exams	7.5
Yes, both prior to age 13 exam and between age 13 and 15 exams	1.2
Maximum FRI score on maxillary anterior teeth	(N=161)
0	29.8
1	36.7
2	32.9
3	0.6
Number of zones with definitive fluorosis on six maxillary anterior teeth	(N=161)
0	66.5
1	9.3
2	4.3
3	5.6
4	3.8
5	4.3
6	3.1
7 or more	3.1
Non-fluoride opacities on six maxillary anterior teeth	(N=161)
Yes	13.7
No	86.3
Vertical jaw relationship	(N=161)
Normal	93.8
Open bite	2.5
Deep bite	3.7
Transverse relationship	(N=161)
Normal	92.5
Posterior crossbite	7.5
Anterior-posterior relationship	(N=161)
Normal	90.1
Crossbite	5.6
More than 4mm overjet	4.3

Table 4.2. Continued.

Dental Aesthetic Index group	(N=145)
DAI ≤ 25	57.9
25 < DAI <31	31.0
31 ≤ DAI	11.1

Longitudinal analyses of adolescents' and parents' dental esthetic perceptions

Changes in adolescents' dental esthetic perceptions from age 13 to age 15

To address specific hypothesis 1, Table 4.3 shows changes in level of satisfaction of adolescents with their overall dental appearance from age 13 to age 15 visits. Of 39 adolescents (25%) who were very satisfied at age 13, 14 of them stayed very satisfied at age 15, whereas 23 adolescents showed one level of decrease and two showed two levels of decrease in satisfaction with overall dental appearance. Of 102 adolescents (64%) who were somewhat satisfied at age 13, 69 were still somewhat satisfied at age 15 and the rest showed one level increase or decrease, i.e., 21 became very satisfied and 12 became somewhat satisfied. Only 17 adolescents (10%) were somewhat dissatisfied at age 13 and 10 of them became somewhat satisfied at 15, five stayed somewhat dissatisfied and two became very dissatisfied. Finally, only two were very dissatisfied at age 13 (approximately 1%) and both stayed very dissatisfied.

The weighted kappa coefficient of 0.275 (95% CI: 0.137-0.414) indicated a modest agreement between the adolescents' age 13 and 15 levels of satisfaction with

overall dental appearance. A Bowker's test of symmetry did not find enough evidence to show that distribution of subjects in off-diagonal cells of the following table were not symmetrical (P=0.640).

Table 4.3. Changes in adolescents' level of satisfaction with overall dental appearance (N=160).

Age 15 / Age 13	Very satisfied N (%)	Somewhat satisfied N (%)	Somewhat dissatisfied N (%)	Very dissatisfied N (%)	Total N (%)
Very satisfied	14 (9)	23 (15)	2 (1)	0	39 (25)
Somewhat satisfied	21 (13)	69 (43)	12 (8)	0	102 (64)
Somewhat dissatisfied	0	10 (6)	5 (3)	2 (1)	17 (10)
Very dissatisfied	0	0	0	2 (1)	2 (1)
Total	35 (22)	102 (64)	19 (12)	4 (2)	160

Note: The weighted kappa coefficient was 0.275 (95% CI: 0.137-0.414), indicating modest agreement between the adolescents' age 13 and 15 levels of satisfaction with overall dental appearance. A Bowker's test of symmetry did not find enough evidence to show that distribution of subjects in the off-diagonal cells was not symmetrical (P=0.640).

Overall, about 56% of adolescents did not show any change in level of satisfaction with overall dental appearance from age 13 to age 15, 19% had a one level increase, 23% had a one-level decrease and only 1% had a two-level of decrease (Table 4.4). A Wilcoxon-signed rank test did not show a significant difference in the direction of changes in satisfaction level, i.e., the proportion of adolescents who showed increased satisfaction was not significantly different from the proportion of those who had declined satisfaction with dental appearance (P= 0.253).

Table 4.4. Frequency distribution of adolescents by magnitude of change in level of satisfaction with overall dental appearance from age 13 to 15 (n=160).

Change in level of satisfaction	Frequency	Percent
3 level increase	0	0
2 level increase	0	0
1 level increase	31	19.4
No change	90	56.2
1 level decrease	37	23.1
2 level decrease	2	1.3
3 level decrease	0	0
Total	160	100

Note: Wilcoxon signed-rank test, P= 0.253- No significant difference was found in in the direction of changes in satisfaction with overall dental appearance from age 13 to age 15 (Specific hypothesis 1).

To address specific hypothesis 2, Table 4.5 shows changes in level of satisfaction of adolescents with their dental color from age 13 to age 15. Of 35 adolescents (21%) who were very satisfied at age 13, 11 of them stayed very satisfied at age 15, whereas 21 of them showed one level decrease and three showed two levels of decrease in satisfaction with dental color. Of 95 adolescents (59%) who were somewhat satisfied at age 13, 68 were still somewhat satisfied at age 15, 14 subjects showed one level increase, and 13 had one level decrease. Twenty-eight adolescents (17%) were somewhat dissatisfied at age 13, and 19 of them showed one or two levels of increase in satisfaction at the 15, eight stayed somewhat dissatisfied and one became very dissatisfied. Finally, of three subjects (approximately 3%) who were very dissatisfied at age 13, one became somewhat satisfied and one somewhat dissatisfied at age 15.

The weighted kappa coefficient of 0.234 (95% CI: 0.102-0.361) indicated low agreement in adolescents' satisfaction with dental color between ages 13 and 15. The Bowker's test of symmetry did not find enough evidence for statistically significant

asymmetry in the distribution of subjects with increased versus decreased satisfaction (P=0.792).

Table 4.5. Changes in adolescents' level of satisfaction with overall dental color in 4x4 Table (n=161).

Age 15 / Age 13	Very satisfied N (%)	Somewhat satisfied N (%)	Somewhat dissatisfied N (%)	Very dissatisfied N (%)	Total N (%)
Very satisfied	11 (6)	21 (13)	3(2)	0	35 (21)
Somewhat satisfied	14 (9)	68 (42)	13 (8)	0	95 (59)
Somewhat dissatisfied	2 (1)	17 (10)	8 (5)	1 (1)	28 (17)
Very dissatisfied	0	1 (1)	1 (1)	1 (1)	3 (3)
Total	27 (16)	107 (66)	25 (16)	2 (2)	161

Note: The weighted kappa coefficient of 0.234 (95% CI: 0.102-0.361) indicated modest agreement in adolescents' satisfaction with dental color between ages 13 and 15. A Bowker's test of symmetry did not find enough evidence for statistically significant asymmetry in the distribution of subjects with increased versus decreased satisfaction (P=0.792).

Similar to satisfaction with overall dental appearance, about 55% of adolescents did not show any change in level of satisfaction with overall dental color from the age 13 to the age 15, 22% had a one- or two-level increase and 24% had a one- or two- level decrease in satisfaction (Table 4.6). Based on a Wilcoxon-signed rank test, there was no significant difference in direction of change in adolescents' satisfaction with dental color from age 13 to age 15 (P= 0.758).

Table 4.6. Frequency distribution of adolescents by magnitude of change in level of satisfaction with overall dental color from age 13 to 15 (n=161).

Change in level of satisfaction	Frequency	Percent
3 level increase	0	0
2 level increase	3	1.9
1 level increase	32	19.9
No change	88	54.7
1 level decrease	35	21.7
2 level decrease	3	1.9
3 level increase	0	0
Total	161	100

Note: Wilcoxon-signed rank test, P=0.758- There was no significant difference in direction of change in adolescents' satisfaction with dental color from age 13 to age 15. (Specific hypothesis 2).

To address specific hypotheses 3 to 8, comparisons of adolescents' causes of concerns about dental esthetics at ages 13 and 15 are shown in Table 4.7. The majority of adolescents were not concerned at either age about the tooth shape (69%), alignment (62%), crowding (75%), spacing (76%), and color irregularities (65%). However, 26% of adolescents were concerned about tooth color at both ages 13 and 15, and 16% became concerned about tooth color after having not been concerned.

The assessment of changes in adolescents' concerns about dental esthetics showed that the kappa coefficient was the lowest for concerns about tooth shape (0.082), compared to other causes of concern, indicating very low agreement in adolescents' concerns about tooth shape between ages 13 and 15. However, based on both a McNemar's test of symmetry (P=0.879) and Wilcoxon signed-rank test (P=0.881), there was no significant difference in direction of change among those who showed changes in

concern about tooth shape. In fact, McNemar's test of symmetry (P=0.049) and Wilcoxon signed-rank test (P=0.048) showed significant results only for tooth crowding, i.e., from age 13 to 15 adolescents were significantly more likely to show reduced concerns about tooth crowding than increased concerns.

Table 4.7. Changes in adolescents' concerns about dental esthetics from age 13 to 15.

Concerned at age 15 / Concerned at age 13		Adolescents		Kappa (95% CI)	Wilcoxon P-value	Test of symmetry P-value
		Yes %	No %			
Tooth Shape (N=160)	Yes %	4	14	0.082 (-0.087-0.252)	0.881	0.879
	No %	13	69			
Tooth Color (N=161)	Yes %	26	18	0.301 (0.153-0.450)	0.690	0.686
	No %	16	40			
Tooth Alignment (N=160)	Yes %	20	11	0.531 (0.386-0.675)	0.378	0.369
	No %	8	62			
Tooth Crowding (N=161)	Yes %	9	11	0.442 (0.264-0.620)	**0.048**	**0.049**
	No %	5	75			
Tooth Spacing (N=161)	Yes %	9	9	0.450 (0.265-0.635)	0.426	0.414
	No %	6	76			
Color irregularities (N=161)	Yes %	13	14	0.405 (0.243-0.567)	0.130	0.128
	No %	8	65			

Note: Wilcoxon signed-rank test, P= 0.04- Adolescents were significantly more likely to show reduced concern about tooth crowding than increased concern at age 15 compared to age 13. Differences in directions of changes of other dental esthetic-related concerns from age 13 to age 15 were not statistically significant (specific hypotheses 3 to 8).

Changes in parents' dental esthetic perceptions from age 13 to age 15

To address specific hypothesis 9, Table 4.8 shows changes in level of satisfaction of parents with their adolescent's overall dental appearance from age 13 to age 15. Of 63 parents (45%) who were very satisfied at age 13, 53 stayed very satisfied at age 15, nine showed one level of decrease and one parent's perception changed from very satisfied at age 13 to very dissatisfied at age 15. Of 59 parents (41%) who were somewhat satisfied at age 13, 40 were still somewhat satisfied at age 15 and the rest showed one level increase or decrease, i.e., 16 became very satisfied and three became somewhat dissatisfied. Among the 15 parents (11%) who were somewhat dissatisfied at age 13, seven were still somewhat dissatisfied at age 15, seven became somewhat satisfied, and one became very satisfied at 15. Finally, only three parents (approximately 3%) were very dissatisfied at age 13, and two of them stayed very dissatisfied after two years.

The weighted kappa coefficient of 0.607 (95% CI: 0.491-0.723) indicated moderate to good agreement in parents' satisfaction with adolescents' dental appearance between ages 13 and 15. Based on the Bowker's test of symmetry, there was no statistically significant asymmetry in the distribution of parents with increased versus decreased satisfaction with dental appearance (P=0.363).

Overall, about 73% of parents did not show any change in level of satisfaction with overall dental appearance from age 13 to age 15, 17% had a one-level increase and 1% had a 2- level increase in satisfaction, compared to 9% with a one-level decrease and 1% with a 2-level decrease (Table 4.9). The Wilcoxon-signed rank test showed that the difference in direction of change in parents' level of satisfaction with overall dental appearance from ages 13 to age 15 was not statistically significant (P= 0.072); however, the proportion of parents who showed increased satisfaction was somewhat higher than that for parents with decreased satisfaction (18% vs. 9%).

Table 4.8. Changes in parents' level of satisfaction with overall dental appearance of their adolescent in 4x4 Table (n=140).

Age 15 / Age 13	Very satisfied (% of total number)	Somewhat satisfied (% of total number)	Somewhat dissatisfied (% of total number)	Very Dissatisfied (% of total number)	Total
Very satisfied	53 (38)	9 (6)	0	1 (1)	63 (45)
Somewhat satisfied	16 (11)	40 (28)	3 (2)	0	59 (41)
Somewhat dissatisfied	1 (1)	7 (5)	7 (5)	0	15 (11)
Very dissatisfied	0	0	1 (1)	2 (2)	3 (3)
Total	70 (50)	56 (39)	11 (8)	3 (3)	140*

Note: The weighted kappa coefficient was 0.607 (95% CI: 0.491-0.723), indicating moderate to good agreement in parents' satisfaction with dental appearance between ages 13 and 15. There was no statistically significant asymmetry in distribution of parents in the off-diagonal cells (Bowker's test of symmetry, P=0.363).

*Total number of responses where the same parent completed the esthetic perception questionnaires at both ages 13 and 15.

To address specific hypothesis 10, Table 4.10 shows changes in level of satisfaction of parents with overall dental color from when the adolescents were 13 years old to age 15. Results showed that 51 parents (36%) were very satisfied at age 13 exam, and 41 stayed very satisfied until age 15 visit, but nine showed a one-level decrease in satisfaction - became somewhat satisfied - and one parent's satisfaction level was changed from very satisfied to very dissatisfied. Overall, 71 parents (51%) were somewhat satisfied at the age 13 exam; 46 stayed somewhat satisfied at age 15 visit, 17 became very satisfied at age 15 exam, but eight showed a one or two level decrease in satisfaction. There were 18 parents (13%) who were somewhat dissatisfied at the age 13

exam, but 12 became somewhat satisfied or very satisfied at the age 15 exam. There were no parents who were very dissatisfied with their adolescent's dental color at age 13 or 15.

Table 4.9. Frequency distribution of parents by magnitude of change in level of satisfaction with overall dental appearance of their adolescent from age 13 to 15 (n=140).

Change in level of satisfaction	Frequency	Percent
3 level increase	0	0
2 level increase	1	0.7
1 level increase	24	17.1
No change	104	72.9
1 level decrease	12	8.6
2 level decrease	0	0
3 level decrease	1	0.7
Total	140	100

Note: Wilcoxon signed-rank test, P= 0.072- Parents tended to be more likely to show improved satisfaction with dental appearance from age 13 to age 15 exams (specific hypothesis 9).

The weighted kappa coefficient was 0.472 (95% CI: 0.351, 0.593), indicating moderate agreement in parents' levels of satisfaction with dental color between ages 13 and 15. Based on the Bowker's test of symmetry, there was no statistically significant asymmetry in the distribution of parents with increased versus decreased satisfaction with dental color from age 13 to age 15 (P=0.322).

Overall, about 66% of parents did not show any change in level of satisfaction with their adolescent's dental color from age 13 to age 15, about 21% had a one- or two-level increase and about 13% had a one- or two-level decrease in satisfaction (Table 4.11). The Wilcoxon signed-rank test showed that the proportion of parents with increased satisfaction was not significantly different from the proportion of parents with decreased satisfaction level with adolescents' dental color from age 13 to age 15 (P= 0.162).

Table 4.10. Change in parents' level of satisfaction with overall color of their adolescent's teeth in 4x4 Table (n=140).

Age 15 / Age 13	Very satisfied	Somewhat satisfied	Somewhat dissatisfied	Very Dissatisfied	Total
Very satisfied	41 (29)	9 (6)	0	1 (1)	51 (36)
Somewhat satisfied	17 (12)	46 (33)	7 (5)	1 (1)	71 (51)
Somewhat dissatisfied	2 (2)	10 (7)	6 (4)	0	18 (13)
Very dissatisfied	0	0	0	0	0
Total	60 (43)	65 (46)	13 (9)	2 (2)	140

Note: The weighted kappa coefficient was 0.472 (95% CI: 0.351, 0.593), indicating moderate agreement. Bowker's test of symmetry did not find statistically significant asymmetry in the distribution of parents with increased versus decreased satisfaction with dental color from age 13 to age 15 (P=0.322).

To address specific hypotheses 11 to 16, proportions of parents who were concerned about different aspects of dental esthetics at age 15 were compared with those at age 13 (Table 4.12). Tooth color was the most frequent aspect of dental esthetics that parents were concerned about (29% of parents were concerned about their adolescent's tooth color at both the age 13 and 15 exams).

The kappa coefficients for the different aspects of dental esthetics (0.323 to 0.578) showed generally moderate agreement in parents' concerns at ages 13 and 15. The Wilcoxon signed-rank tests and McNemar's tests of symmetry showed that parents at the age 15 exam were significantly less likely to be concerned about tooth color compared to the age 13 exam. In addition, they were marginally less likely to be concerned about tooth crowding of their adolescents at age 15 compared to age 13.

Table 4-11. Frequency distribution of parents by magnitude of change in level of satisfaction with overall color of their adolescent's teeth from age 13 to 15 (n=140).

Change in level of satisfaction	Frequency	Percent
3 level increase	0	0
2 level increase	2	1.4
1 level increase	27	19.3
No change	93	66.4
1 level decrease	16	11.5
2 level decrease	1	0.7
3 level decrease	1	0.7
Total	140	100

Note: Wilcoxon signed-rank test, P=0.162- There was no significant difference in parents' satisfaction level with adolescents' dental color from age 13 to 15 (specific hypothesis 10).

Table 4.12. Frequency distribution of parents by change in concern about their adolescent's teeth from age 13 to 15.

Concerned at age 15 / Concerned at age 13		Parents		Kappa (95% CI)	Wilcoxon P-value	McNemar's test P-value
		Yes %	No %			
Tooth Shape (N=140)	Yes %	4	7	0.323 (0.072-0.575)	0.454	0.317
	No %	4	85			
Tooth Color (N=139)	Yes %	29	18	0.503 (0.363-0.643)	**0.001***	**0.002**
	No %	6	47			
Tooth Alignment (N=140)	Yes %	16	9	0.549 (0.386-0.712)	0.543	0.532
	No %	7	68			
Tooth Crowding (N=140)	Yes %	8	10	0.482 (0.285-0.679)	0.064*	**0.039**
	No %	4	78			
Tooth Spacing (N=140)	Yes %	7	7	0.471 (0.257-0.685)	0.629	0.467
	No %	5	81			
Color irregularities (N=140)	Yes %	14	10	0.578 (0.414-0.742)	0.115	0.074
	No %	4	72			

*Wilcoxon signed-rank test, P=0.001- Parents at age 15 were less likely to be concerned about tooth color compared to age 13(specific hypothesis 12). P=0.064- Parents at age 15 were slightly less likely to be concerned about tooth crowding of compared to age 13 (specific hypothesis 15).

Comparison of changes in adolescents' versus parents' dental esthetic perceptions from age 13 to age

To address specific hypothesis 17, adolescents' direction of changes in level of satisfaction with overall dental appearance from age 13 to 15 was compared with that of parents (Table 4.13). The results showed that, of 139 adolescent-parent pairs, 58 pairs (41%) did not show any changes in parent's and adolescent's level of satisfaction. In three pairs, both parents and adolescents showed decline in satisfaction, while in five pairs, both parents and adolescents showed increase in satisfaction. Overall, in 66 pairs (47%), both parent and adolescent had the same direction of change in satisfaction (3+58+5=66).

In 29 pairs, adolescents showed decline in satisfaction, while parents had no change or a positive change in satisfaction. Also, in 15 pairs, adolescents showed no change, whereas parents had a positive change in satisfaction level; therefore, in 44 adolescent-parent pairs (32%), adolescents had relatively more negative change in level of satisfaction with overall dental appearance compared to parents (15+29=44).

On the other hand, in 10 pairs, parents showed decline in satisfaction, while adolescents had no change or a positive change in satisfaction. Also, in 19 pairs, parents showed no change, whereas adolescents had a positive change in satisfaction level; therefore, in total 29 adolescent-parent pairs (21%), parents had relatively more negative change in level of satisfaction with overall dental appearance compared to adolescents (10+19=29).

The weighted kappa was 0.008 (95% CI: -0.106, 0.122), indicating very low agreement in changes in level of satisfaction with overall dental appearance between parents and adolescents. The Bowker's test of symmetry showed that there was statistically significant asymmetry in the distribution of parent-adolescent pairs with opposite direction of changes (P=0.021). Additionally, the Wilcoxon signed-rank test

showed that the difference in changes in satisfaction with overall dental appearance between adolescents and parents was close to being statistically significant (P=0.062), i.e., in discordant pairs adolescents tended to be more likely to show relatively negative change in level of satisfaction with overall dental appearance compared to parents.

Table 4.13. Comparison of changes in level of satisfaction with overall dental appearance between adolescents and parents (N=139).

Parent / Adolescent	Decline in satisfaction (%)	No change (%)	Increase in satisfaction (%)	Total
Decline in satisfaction	3 (2)	24 (17)	5 (4)	32 (23)
No change	8 (6)	58 (41)	15 (11)	81 (58)
Increase in satisfaction	2 (1)	19 (14)	5 (4)	26 (19)
Total	13 (9)	101 (72)	25 (19)	139

Note: The weighted kappa was 0.008 (95% CI: -0.106, 0.122), indicating very low agreement. Bowker's test of symmetry, P=0.021- There was statistically significant asymmetry in the distribution of discordant parent-adolescent pairs. Wilcoxon signed-rank test, P=0.062- Adolescents tended to be more likely to show relatively negative change in level of satisfaction with overall dental appearance compared to parents (specific hypothesis 17).

To address specific hypothesis 18, direction of change in level of satisfaction with overall dental color was compared between adolescents and parents (Table 4.14). Of 140 adolescent-parent pairs, in 61 pairs (44%) both adolescents and parents had the same direction of change. Overall, in 47 adolescent-parent pairs (33%), adolescents showed relatively more negative change in satisfaction level with overall dental color, i.e., in 31 pairs, adolescents showed decline in satisfaction, whereas parents had no change or an increase in satisfaction level; additionally, in 16 pairs, adolescents had no change, but parents showed increased satisfaction (31+16=47). On the other hand, in 32 pairs (23%),

parents showed relatively more negative change in satisfaction. In fact, in 14 pairs, parents had decreased satisfaction, compared to adolescents with no change or increased satisfaction; moreover, in 18 pairs, parents showed no change, but adolescents had increased satisfaction (14+18=32).

The weighted kappa was 0.033 (95% CI: -0.086, 0.152), indicating very low agreement between adolescents' and parents' changes in satisfaction with dental color. Based on Bowker's test of symmetry, there was marginally significant asymmetry in the distribution of adolescent-parent discordant pairs (P=0.082). In addition, the Wilcoxon signed-rank test showed that the difference in changes in satisfaction with overall dental color between adolescents and parents was marginally significant (P=0.095), i.e., in discordant pairs, adolescents were marginally more likely to have more negative change in satisfaction with dental color relative to parents.

To address specific hypotheses 19 to 24, Tables 4.15 to 4.20 show comparisons of changes in concerns about various aspects of dental esthetics between adolescents and parents. Higher numbers of adolescents showed changes in all aspects of concerns than did parents; for example, 39 adolescents showed changes in concern about tooth shape compared to 16 parents. In addition, the weighted kappa coefficients for all aspects of dental esthetics were below 0.20, suggesting poor agreement in changes in concerns between adolescents and parents.

Table 4.14. Comparison of changes in level of satisfaction with overall dental appearance between adolescents and parents (N=139).

Parent / Adolescent	Decline in satisfaction	No change	Increase in satisfaction	Total
Decline in satisfaction	4 (3)	26 (19)	5 (3)	35 (25)
No change	11 (8)	49 (35)	16 (11)	76 (54)
Increase in satisfaction	3 (2)	18 (13)	8 (6)	29 (21)
Total	18 (13)	93 (67)	29 (20)	140

The weighted kappa was 0.033 (95% CI: -0.086, 0.152), indicating very low agreement. Bowker's test of symmetry, P=0.082-There was marginally significant asymmetry in the distribution of adolescent-parent discordant pairs. Wilcoxon signed-rank test, P=0.095- Adolescents were marginally more likely to show relatively negative change in level of satisfaction with overall dental appearance compared to parents (specific hypothesis 18).

Table 4.15. Comparison of changes in concern about tooth shape between adolescents and parents (N=139).

Parent / Adolescent	Changed from non-concerned to concerned	No change	Changed from concerned to non-concerned
Changed from non-concerned to concerned	0	16 (12)	2 (1)
No change	5 (4)	90 (65)	5 (4)
Changed from concerned to non-concerned	1 (1)	17 (12)	3 (2)

Note: Weighted kappa coefficient: 0.028 (95% CI: -0.087, 0.144). Bowker's test of symmetry, P=0.005- There was statistically significant asymmetry in the distribution of adolescent-parent discordant pairs. Wilcoxon-signed rank test, P=0.890- No significant difference was found in the direction of change in concerns about tooth shape in adolescents versus parents (Specific hypothesis 19).

Table 4.16. Comparison of changes in concern about tooth color between adolescents and parents (N=139).

Adolescent \ Parent	Changed from non-concerned to concerned	No change	Changed from concerned to non-concerned
Changed from non-concerned to concerned	4 (3)	17 (12)	2 (2)
No change	3 (2)	70 (50)	19 (14)
Changed from concerned to non-concerned	1 (1)	18 (13)	5 (4)

Note: weighted kappa coefficient: 0.058 (95% CI: -0.081, 0.197). Bowker's test of symmetry, P=0.017: there was statistically significant asymmetry in the distribution of adolescent-parent discordant pairs. Wilcoxon-signed rank test, P=0.040- adolescents were more likely to change toward concern about tooth color relative to parents (specific hypothesis 20).

Table 4.17. Comparison of changes in concern about tooth alignment between adolescents and parents (N=139).

Adolescent \ Parent	Changed from non-concerned to concerned	No change	Changed from concerned to non-concerned
Changed from non-concerned to concerned	2 (2)	6 (4)	2 (2)
No change	8 (6)	95 (68)	11 (8)
Changed from concerned to non-concerned	0	15 (11)	0

Note: The weighted kappa coefficient: -0.006 (95% CI: -0.127, 0.115). Bowker's test of symmetry, P=0.407- There was not sufficient evidence for statistically significant asymmetry in the distribution of adolescent-parent discordant pairs. Wilcoxon-signed rank test, P=0.782- No significant difference was found in the direction of changes in concern about tooth alignment between adolescents and parents (Specific hypothesis 21).

Table 4.18. Comparison of changes in concern about tooth crowding between adolescents and parents (N=140).

Parent / Adolescent	Changed from non-concerned to concerned	No change	Changed from concerned to non-concerned
Changed from non-concerned to concerned	0	7 (5)	0
No change	4 (3)	103 (74)	11 (8)
Changed from concerned to non-concerned	1 (1)	11 (8)	3 (2)

Note: The weighted kappa coefficient: 0.067 (95% CI: -0.085, 0.218). Bowker's test of symmetry, P=0.611- There was not sufficient evidence for statistically significant asymmetry in the distribution of adolescent-parent discordant pairs. Wilcoxon-signed rank test, P=0.872- No significant difference was found in the direction of changes in concern about tooth crowding between adolescents and parents (Specific hypothesis 22).

Table 4.19. Comparison of changes in concern about tooth spacing between adolescents and parents (N=140).

Parent / Adolescent	Changed from non-concerned to concerned	No change	Changed from concerned to non-concerned
Changed from non-concerned to concerned	0	6 (4)	2 (2)
No change	7 (5)	104 (74)	7 (5)
Changed from concerned to non-concerned	0	13 (9)	1 (1)

Note: The weighted kappa coefficient: -0.022 (95% CI: -0.123, 0.079). Bowker's test of symmetry, P=0.275- There was not sufficient evidence for statistically significant asymmetry in the distribution of adolescent-parent discordant pairs. Wilcoxon-signed rank test, P=0.654- No significant difference was found in the direction of changes in concern about tooth spacing between adolescents and parents (Specific hypothesis 23).

Table 4.20. Comparison of changes in concern about tooth color irregularities between adolescents and parents in 3x3 Table (N=140).

Parent / Adolescent	Changed from non-concerned to concerned	No change	Changed from concerned to non-concerned
Changed from non-concerned to concerned	1 (1)	11 (8)	0
No change	5 (4)	92 (66)	11 (8)
Changed from concerned to non-concerned	0	17 (12)	3 (2)

Note: The weighted kappa coefficient 0.063 (95% CI: -0.077, 0.203). Bowker's test of symmetry, P=0.316- There was not sufficient evidence for statistically significant asymmetry in the distribution of adolescent-parent discordant pairs. Wilcoxon-signed rank test, P=1.000- No significant difference was found in the direction of changes in concern about tooth color irregularities between adolescents and parents (Specific hypothesis 24).

Associations between adolescents' changes in satisfaction level with overall dental appearance from age 13 to age 15 and predictor variables

To address specific hypotheses 25 to 32, Table 4.21 shows the results of univariable ordinal logistic regression. The models predict adolescents' positive change in level of satisfaction with overall dental appearance (from negative change to no change or from no change to positive change). In ordinal logistic regression, the odds ratios are assumed to be the same for every unit positive change in satisfaction (proportional odds assumption). The assumption was satisfied in all the analyses in this section.

Table 4.21. Univariable ordinal logistic regressions predicting adolescent's one-unit positive change in level of satisfaction with overall dental appearance from age 13 to 15 (Outcome variable)[§].

Variable	N	Reference Group	O.R. (95% CI)	P-value
Adolescent gender	160	Male	0.88 (0.48, 1.63)	0.692
Non-Hispanic white	160	None	2.20 (0.67, 7.19)	0.191
Mother's educational level	158	Ordinal (1-3)	0.88 (0.50, 1.53)	0.644
Father's educational level	142	Ordinal (1-3)	0.94 (0.57, 1.55)	0.803
Family income	155	Ordinal (1-3)	1.27 (0.83, 1.93)	0.274
Dental visit proportion*	160	Ordinal (1-4)	1.01 (0.78, 1.32)	0.924
History of recent broken anterior maxillary tooth**	160	None	1.16 (0.24, 5.65)	0.850
History of dental bleaching**	160	None	0.40 (0.14, 1.17)	**0.096**
Number of fluorosis zones on anterior maxillary teeth	160	Ordinal (0-7)	1.07 (0.92, 1.24)	0.405
Non-fluoride opacity on anterior maxillary teeth	160	None	0.75 (0.31, 1.80)	0.523
Anterior crossbite	160	None	0.84 (0.23, 3.01)	0.800
Posterior crossbite	160	None	0.41 (0.12, 1.33)	**0.136**
≥4mm overjet	160	None	0.53 (0.12, 2.29)	0.398
Open bite	160	None	0.27 (0.04, 1.91)	0.191
DAI score	144	Ordinal (1-3)	0.64 (0.40, 1.02)	**0.062**

§ From negative change to no change, or from no change to positive change.

* The dental visit proportion was calculated using number of six-month periods with reported dental visits divided by the number of returned questionnaires from age twelve and one half years to age fifteen.

** Occurred between age 13 and 15 visits.

Although results in Tables 4-3 to 4-20 on the bivariate analyses of changes in adolescents' and parents' dental esthetic perceptions from age 13 to age 15 used P-value < 0.05 as the signficance level, in the regression analyses, due to small sample size and desire to not miss any important variables, we used P-value < 0.15 for model selection.

Among the tested predictor variables, bleaching experience between the age 13 and age 15 exams (recent bleaching), having posterior crossbite and higher DAI category (≤25, 25-31 and ≤31) resulted in P-values less than 0.15; therefore, they were selected for initial inclusion in the multivariable analysis. Then, the backward elimination technique was used to select the most parsimonious model having all the variables which stayed in the model with P-values below 0.15 (Table 4.22). Posterior crossbite was removed from the multivariable model, since its P-value was above 0.15 at the multivariable level (p=0.200). Recent bleaching and DAI category were included in the final model, as both were associated with adolescents' changes in satisfaction with dental appearance (P=0.051 and P=0.041, respectively). This means that, for the subjects who received tooth bleaching between the age 13 and 15 visits, compared to the others, the odds of showing relatively more positive change (from negative change to no change or from no change to positive change) was 0.32. In addition, for the adolescents in one DAI group, compared to those in the next lower group, the odds of showing relatively more positive change (from negative change to no change or from no change to positive change) was 0.61. There was no significant interaction between history of bleaching and DAI categories.

Table 4.22. Multivariable ordinal logistic regressions predicting adolescent's one-unit positive change in level of satisfaction with overall dental appearance from age 13 to 15[§] (n=144).

Variable	Reference Group	O.R. (95% CI)	P-value
History of recent dental bleaching*	None	0.32 (0.10, 1.00)	**0.051**
DAI score	Ordinal (1-3)	0.61 (0.38, 0.98)	**0.041**

§ From negative change to no change, or from no change to positive change.

* Occurred between age 13 and 15 visits.

Associations between parents' changes in satisfaction level with overall dental appearance from age 13 to age 15 and predictor variables

To address specific hypotheses 33 to 40, ordinal logistic regression was used to predict parents' positive change in level of satisfaction with overall dental appearance from the age 13 to 15 exams. No variables were significantly associated with change in parents' satisfaction with dental appearance ($P > 0.15$, Table 4.23). However, history of a recent broken anterior maxillary tooth violated the proportional odds assumption, thus generalized logit regression was performed for this variable (Table 4.24). For those that experienced a recent broken tooth, the odds of showing reduced satisfaction with overall dental appearance (than no change) was 18.5 times that for those who did not have recent a broken tooth ($p=0.067$).

Cross-sectional analyses of adolescents' and parents' dental esthetic perceptions

Associations between adolescents' dental esthetic perceptions at age 15 and dental fluorosis

To address specific hypotheses 41 to 44, Table 4.25 compares levels of satisfaction with overall dental appearance and dental color, and concerns about tooth color and color irregularities, between adolescents who had definitive dental fluorosis at age 13 and the others. The Cochran-Armitage trend test was used for evaluation of associations between fluorosis and satisfaction levels and the Fisher's exact was used for assessment of the associations between fluorosis and concerns. The results showed that none of the aforementioned variables of adolescents' dental esthetic perceptions were related to their status of dental fluorosis at age 13 ($P >0.05$).

Table 4.23. Univariable ordinal logistic regressions predicting parent's one-unit positive change in level of satisfaction with overall dental appearance from age 13 to 15 (Outcome variable)[§].

Variable	N	Reference Group	O.R. (95% CI)	P-value
Adolescent gender	140	Male	0.67 (0.31, 1.43)	0.302
Parent gender	140	Male	0.81 (0.16, 4.03)	0.799
Accompanying parent educational level	131	Ordinal (1-3)	1.33 (0.64, 2.79)	0.445
Family income	135	Ordinal (1-3)	0.85 (0.51, 1.42)	0.532
Non- Hispanic white	140	None	0.73 (0.14, 3.82)	0.714
Dental visit proportion*	140	Ordinal (1-4)	1.07 (0.77, 1.48)	0.698
History of recent broken anterior maxillary tooth** ¥	140	None	0.68 (0.09, 5.11)	0.708
History of recent dental bleaching**	140	None	0.95 (0.27, 3.40)	0.939
Number of fluorosis zones on anterior maxillary teeth	140	Ordinal (0-7)	0.98 (0.82, 1.18)	0.854
Non-fluoride opacity on anterior maxillary teeth	140	None	1.41 (0.48, 4.15)	0.533
Anterior crossbite	140	None	2.72 (0.51, 14.48)	0.240
Posterior crossbite	140	None	0.43 (0.11, 1.72)	0.230
≥4mm overjet	140	None	3.51 (0.58, 21.16)	0.170
Open bite	140	None	1.91 (0.24, 15.36)	0.542
DAI score	127	Ordinal (1-3)	0.91 (0.51, 1.60)	0.740

§ From negative change to no change, or from no change to positive change.

* The dental visit proportion was calculated using number of six-month periods with reported dental visits divided by the number of returned questionnaires from age twelve and one half years to age fifteen.

** Occurred between age 13 and 15 exams.

¥ Violated proportional odds assumption.

Table 4.24. Univariable generalized logit model predicting parent's change in level of satisfaction with overall dental appearance from age 13 to age 15 (Outcome variable).

Variable¥	Odds of reduced satisfaction to odds of no change	Odds of reduced satisfaction to odds of increased satisfaction	P-value
History of recent broken anterior maxillary tooth**	18.51 (1.54, 200)	2.09 (0.26 , 16.95)	**0.067**

¥ Only for the variable that violated proportional odds assumption; hence, generalized logit models were performed in addition to the ordinal logistic regression.

Table 4.25. Adolescents' dental esthetic perceptions at age 15 by fluorosis status of maxillary anterior teeth at age 13 (N=161).

Item	Adolescent Response	Total %	Adolescent fluorosis status		P-value
			%No (n=107)	%Yes (n=54)	
Overall appearance*	Very satisfied	22	21	22	0.400
	Somewhat satisfied	64	63	67	
	Somewhat dissatisfied	12	12	11	
	Very dissatisfied	2	4	0	
Concerns†	Color	42	43	39	0.735
	Color Irregularities	21	20	22	0.839
Overall color*	Very satisfied	17	18	15	0.684
	Somewhat satisfied	66	64	72	
	Somewhat dissatisfied	16	17	13	
	Very dissatisfied	1	2	0	

* P-value from Cochran-Armitage Trend Test.

† P-value from Fisher's Exact Test.

Associations between parents' dental esthetic perceptions at age 15 and dental fluorosis

To address specific hypotheses 45 to 48, Table 4.26 compares levels of satisfaction with overall dental appearance and dental color, and concerns about tooth color and color irregularities, at age 15 between parents whose adolescents had definitive dental fluorosis at age 13 and parents whose adolescents were fluorosis-free. The Fisher's exact test showed that parents whose adolescents had definitive fluorosis at age 13 were significantly more likely to be concerned about their adolescents' tooth color irregularities than were other parents (33% versus 11%, P=0.001).

Table 4.26. Parents' dental esthetic perceptions at age 15 by fluorosis status of maxillary anterior teeth at age 13 (N=161).

Item	Parent Response	Total %	Adolescent fluorosis status		P-value
			%No (n=107)	%Yes (n=54)	
Overall appearance*	Very satisfied	47	50	43	0.694
	Somewhat satisfied	42	40	44	
	Somewhat dissatisfied	8	6	13	
	Very dissatisfied	3	5	0	
Concerns†	Color	37	35	41	0.490
	Color Irregularities	19	11	33	**0.001**
Overall color*	Very satisfied	40	43	35	0.570
	Somewhat satisfied	48	46	52	
	Somewhat dissatisfied	10	8	13	
	Very dissatisfied	2	3	0	

* P-value from Cochran-Armitage Trend Test.

† P-value from Fisher's Exact Test.

Comparisons of adolescents' versus parents' dental esthetic perceptions at age 15

To address specific hypotheses 49 to 56, Table 4.27 compares adolescents' and parents' dental esthetic perceptions. Approximately 45% and 51% of adolescent-parent pairs had the same level of satisfaction with overall dental appearance and dental color, respectively. Based on the Wilcoxon signed-rank test results concerning discordant pairs, adolescents were significantly more likely to be less satisfied with dental appearance ($P<0.0001$) and dental color ($P<0.0001$) than were their parents. Additionally, in the majority of adolescent-parent pairs adolescents had the same category of concerns about all the aspects of dental esthetics as their parents, except that in discordant pairs, adolescents were more likely to be concerned about tooth shape than were their parents ($P=0.014$). For other aspects of dental esthetics in discordant pairs, the percentage of adolescents who were more concerned was not significantly different from the percentage of parents who were more concerned ($P > 0.05$).

Associations between adolescents' satisfaction levels with overall dental appearance at age 15 and predictor variables

To address specific hypotheses 57 to 64, ordinal logistic regression was used for evaluation of the associations between adolescents' satisfaction with overall dental appearance at age 15 and the proposed predictor variables (Table 4.28). Since the number of subjects in the very dissatisfied group was only four at age 15, this group was merged with the somewhat dissatisfied group. Therefore, a one-unit positive change in level of satisfaction with overall dental appearance, from very/somewhat dissatisfied to somewhat satisfied or from somewhat satisfied to very satisfied, was predicted by the ordinal logistic regression. Due to small sample size, we used P-value < 0.15 for model selection and level of significance in the regression analyses.

Table 4.27. Comparison of esthetic perceptions of adolescent-parent pairs of age 15 (N=161).

Satisfaction with:	Adolescent-parent pairs (%)			P-value*
	Parents less satisfied	Same	Adolescents less satisfied	
Overall appearance	14	45	41	**<0.0001**
Concern:	Parents more concerned	Same	Adolescents more concerned	P-value*
Shape	6	79	15	**0.014**
Color	15	64	21	0.297
Alignment	11	75	14	0.441
Spacing	7	82	11	0.362
Crowding	7	86	7	1.000
Color irregularities	12	74	14	0.543
Satisfaction with:	Parents less satisfied	Same	Adolescents less satisfied	P-value*
Overall dental color	12	51	37	**<0.0001**

* P-value from Wilcoxon signed-rank test. The adolescent vs. parent responses have been collapsed into “Improved”, “Same” and “Declined” for simplicity of presentation. The test employs all data in the off-diagonal cells of the original tables.

Table 4.28. Univariable ordinal logistic regressions predicting adolescent's level of satisfaction with overall dental appearance at age 15 (Outcome variable)[§].

Variable	N	Reference Group	O.R. (95% CI)	P-Value
Adolescent gender	161	Male	0.84 (0.44, 1.59)	0.586
Non-Hispanic white	161	None	2.56 (0.74, 8.93)	**0.138**
Mother's educational level	159	Ordinal (1-3)	0.86 (0.69, 0.48)	0.607
Father's educational level	143	Ordinal (1-3)	1.10 (0.65, 1.84)	0.726
Family income	156	Ordinal (1-3)	1.41 (0.91, 2.20)	**0.125**
Dental visit proportion*	161	Ordinal (1-4)	1.50 (1.12, 2.00)	**0.007**
History of repaired anterior maxillary tooth due to trauma	161	None	0.51 (0.20, 1.35)	0.177
History of dental bleaching¥	161	None	0.74 (0.28, 1.98)	0.554
Number of fluorosis zones on maxillary anterior teeth	161	Ordinal (0-7)	1.04 (1.23, 0.89)	0.586
Non-fluoride opacity on maxillary anterior teeth	161	None	0.36 (0.14, 0.93)	**0.035**
Anterior crossbite	161	None	2.06 (0.52, 8.11)	0.301
Posterior crossbite	161	None	0.32 (0.10, 1.05)	**0.061**
≥4mm overjet	161	None	0.45 (0.10, 2.10)	0.309
Open bite	161	None	0.77 (0.10, 5.85)	0.799
DAI score	145	Ordinal (1-3)	0.46 (0.28, 0.77)	**0.003**

§ Three categories: dissatisfied (somewhat or very dissatisfied), somewhat satisfied, and very satisfied.

¥ Violated proportional odds assumption.

* The dental visit proportion was calculated using number of six-month periods with reported dental visits divided by the number of returned questionnaires from age twelve and one half years to age fifteen.

The six variables showing P-values below 0.15 at the univariable level, non-Hispanic white, family income level, dental visit proportion, non-fluoride opacity, posterior crossbite, and the DAI category, were included in the initial multivariable analysis.

Ordinal logistic regression assumes that the odds ratio of a one-unit increase in satisfaction level from very/somewhat dissatisfied to somewhat satisfied is equal to that from somewhat satisfied to very satisfied (proportional odds assumption). This assumption was satisfied for all the predictor variables, except history of dental bleaching (P-values of the score test for proportional odds assumption was 0.033). Thus, the proportional odds model was not appropriate, and a generalized logit model was built for this variable as an alternative (Table 4.29). In the generalized logit model, two odds ratios were calculated, one for the odds of being very satisfied to the odds of being somewhat satisfied, and another one for the odds of being somewhat satisfied to the odds of being very/somewhat dissatisfied. For example, the odds of being very satisfied to the odds of being somewhat satisfied for those who had dental beaching compared to the subjects with no history of dental bleaching was 0.15.

Table 4.29. Univariable generalized logit model predicting adolescent's level of satisfaction with overall dental appearance at age 15 (Outcome variable)[§].

Variable[¥]	Odds of being very satisfied to odds of being somewhat satisfied	Odds of being somewhat satisfied to odds of being dissatisfied	P-value
History of dental bleaching	0.15 (0.02, 1.16)	4.35 (0.55, 34.48)	**0.085**

§ Three categories: dissatisfied (somewhat or very dissatisfied), somewhat satisfied, and very satisfied.

¥ Only for the variable that violated proportional odds assumption; hence, generalized logit models were performed in addition to the ordinal logistic regression.

Based on the P-value less than 0.15 in the univariable generalized logit model, history of dental bleaching also was included in the multivariable analyses. Then, the

backward elimination procedure was performed to select the variables which remained in the multivariable generalized logit model with P-values less than 0.15 (Table 4.30). Being non-Hispanic white, dental visit proportion, non-fluoride opacity, DAI score and history of dental bleaching were selected by this technique ($P < 0.15$).

Table 4-30. Multivariable generalized logit model predicting adolescents' levels of satisfaction with overall dental appearance at age 15 (Outcome variable)§ resulted from backward elimination ($P<0.15$) ($N=145$).

Variable¥	Odds of being very satisfied to odds of being somewhat satisfied	Odds of being somewhat satisfied to odds of being dissatisfied	P-value
Non-Hispanic white	2.92 (0.32, 26.44)	4.65 (0.85, 25.64)	**0.085**
Dental visit proportion*	1.31 (0.85, 2.03)	1.83 (1.15, 2.91)	**0.009**
Non-fluoride opacity	0.16 (0.02, 1.27)	0.52 (0.14, 1.91)	**0.111**
History of dental bleaching	0.12 (0.01, 0.96)	2.62 (0.29, 23.25)	**0.099**
DAI score	0.71 (0.35, 1.44)	0.33 (0.15, 0.71)	**0.006**

§ Three categories: dissatisfied (somewhat or very dissatisfied), somewhat satisfied, and very satisfied.

¥ Variables with P-values above 0.15 at univariable level from Tables 4.27 and 4.28 were included for the model selection using backward elimination technique.

* The dental visit proportion was calculated using number of six-month periods with reported dental visits divided by the number of returned questionnaires from age twelve and one half years to age fifteen.

Since history of dental bleaching was the only variable in the final model that violated the proportional odds assumption and it had a P-value well above the traditional

significance level of 0.05 at the multivariable level (P=0.099), it was removed from the final model (Table 4.31). Thus, being non-Hispanic white, dental visit proportion, non-fluoride opacity, and DAI score were included in the most parsimonious final model at P-value < 0.15 using the ordinal logistic regression (Table 4.31). No significant two-way interactions were found between the remaining variables in the final model. In addition, there were no significant interactions between gender and any of the four variables.

Table 4.31. Multivariable ordinal logistic regressions predicting adolescent's level of satisfaction with overall dental appearance at age 15 (Outcome variable)§ (N=145).

Variable	Reference Group	O.R. (95% CI)	P-Value
Non-Hispanic white	None	4.88 (1.16, 20.54)	**0.031**
Dental visit proportion*	Ordinal(1-4)	1.55 (1.12, 2.13)	**0.007**
Non-fluoride opacity on maxillary anterior teeth	None	0.32 (0.12, 0.88)	**0.027**
DAI score	Ordinal(1-3)	0.46 (0.27, 0.77)	**0.003**

§ Three categories: dissatisfied (somewhat or very dissatisfied), somewhat satisfied, and very satisfied.

* The dental visit proportion was calculated using number of six-month periods with reported dental visits divided by the number of returned questionnaires from age twelve and one half years to age fifteen.

Summary

Tables 4.32 provides a summary of the analysis results of the main hypotheses related to changes in adolescents' and parents' dental esthetic perceptions from age 13 to age 15.

Table 4.32. A summary of analyses for the main hypotheses related to longitudinal changes in adolescents' and parents' perceptions of dental esthetics from age 13 to age 15.

Hypothesis No.	Analysis result
1	The proportion of adolescents who showed increased satisfaction with dental appearance from age 13 to age 15 was not significantly different from the proportion who showed declined satisfaction with dental appearance.
6	Adolescents were significantly more likely to show reduced concern about tooth crowding than increased concern from age 13 to age 15.
9	The proportion of parents who showed increased satisfaction with dental appearance tended to be higher than the proportion with decreased satisfaction.
1	Parents were significantly more likely to show reduced concern than increased concern about tooth color from age 13 to age 15.
15	Parents tended to be more likely to show reduced concern than increased concern about tooth crowding from age 13 to age 15.
17	Adolescents tended to be more likely to show negative change in level of satisfaction with overall dental appearance compared to parents.
20	Adolescents were more likely to change toward concern about tooth color from age 13 to age 15 relative to parents
25	For adolescents with definitive fluorosis, the odds of showing positive change in dental appearance satisfaction from age 13 to age 15 was not significantly different from that for those with no definitive fluorosis.
26	For adolescents with non-fluoride opacities, the odds of showing positive change in dental appearance satisfaction from age 13 to age 15 was not significantly different from those without non-fluoride opacities.
27	For adolescents in one DAI group (more severe malocclusion), the odds of showing positive change in dental appearance satisfaction from age 13 to age 15 was significantly less than that for those in the next lower DAI group (less severe malocclusion).

Table 4.33. A summary of analyses for the main hypotheses related to comparison of adolescents' and parents' perceptions of dental esthetics at age 15.

Hypothesis No.	Analysis result
41-44	There was no significant association between dental fluorosis and adolescents' dental esthetic perceptions at age 15.
48	Parents whose adolescents had definitive fluorosis at age 13 were significantly more likely to be concerned about their adolescents' tooth color irregularities than were parents of children without fluorosis.
49	Adolescents were significantly more likely to be less satisfied with dental appearance at age 15 than were their parents.
50	Adolescents were significant more likely to be less satisfied with dental color at age 15 than were their parents.
58	There was a significant negative association between adolescents' dental appearance satisfaction at age 15 and having non-fluoride opacities.
59	There was a significant negative association between adolescents' dental appearance satisfaction at age 15 and DAI group.
63	There was a significant positive association between adolescents' dental appearance satisfaction at age 15 and frequency of dental visits.

CHAPTER 5

DISCUSSION

Overview

The primary objectives of this study were to assess and compare the changes in dental esthetic perceptions of adolescents and their parents from when the adolescents were age 13 to age 15, and to assess associations of dental characteristics with these changes, controlling for demographic variables. Furthermore, cross-sectional analyses were conducted to assess adolescents' and parents' perceptions on dental esthetics at age 15 and their associations with dental fluorosis and other predictor variables.

This study found that there were some changes in both parents' and adolescents' dental esthetic perceptions from age 13 to age 15; however, changes in adolescents' perceptions were more frequent than parents'. A decrease in adolescent satisfaction with dental appearance was associated with history of dental bleaching and severity of malocclusion as assessed by DAI (Dental Aesthetic Index) score. In addition, cross-sectional analyses showed that there were some differences between adolescents' and parents' dental esthetic perceptions at age 15, and adolescents' satisfaction with dental appearance was significantly associated with several dental-related predictor variables.

Study sample

Of the 550 adolescents who participated in the study at age 13, 406 returned for the age 15 interview, indicating a fairly high retention rate (74%). However, 218 of the 406 reported receiving orthodontic treatment at or before age 15 (prevalence of orthodontic treatment in 15-year-old adolescents = 54%). Based on the third National Health and Nutrition Examination Survey (NHANES III), the prevalence of orthodontic treatment in the U.S. non-Hispanic White young adults was 30% in 1994 (23). Higher orthodontic treatment prevalence in this study may be attributed to the increased attention

to the dental esthetics, as well as the higher socioeconomic status of the Iowa Fluoride Study participants when compared to the U.S. general population.

It has been shown that both fixed and removable orthodontic treatment had positive impacts on dental appearance satisfaction of adolescents, with greatest improvement seen after the fixed treatment (46, 63). Since information on the type and end date of orthodontic treatment was not available in our study, and there was no dental examination at age 15, adjusting for the type and orthodontic treatment outcomes was not possible; therefore, subjects with any history of orthodontic treatment were excluded to prevent its confounding effects on the dental esthetic perceptions.

Assessment of fluorosis on the study subjects' maxillary anterior teeth showed that approximately 34% of the adolescents had fluorosis (maximum FRI score = 2 or 3), only one of them had severe fluorosis with pitting and staining on at least one maxillary anterior tooth (maximum FRI score = 3). This is comparable to the 41% prevalence of dental fluorosis reported in the U.S. adolescents (12 to 15 years old), based on the NHANES data from 1999-2004 (64).

Main results

Longitudinal analyses of adolescents' and parents' dental esthetic perceptions

In this study, several statistical approaches were used to assess different aspects of changes in dental esthetic perceptions from age 13 to age 15. Since both the Wilcoxon-signed rank tests and tests of symmetry disregard the number of agreement cases, weighted kappa coefficients were also calculated for the ordinal variables of satisfaction level with overall dental appearance and dental color. Weighted kappa coefficients give differential weights to disagreement cases based on the distance from the agreement cases (65), and are sensitive to marginal distributions (66). In addition, Cohen's kappa coefficients were calculated for the binary variables of concerns about different aspects of

dental esthetics. Wilcoxon-signed rank tests and McNemar's tests of symmetry (for binary variables) and Bowker's tests of symmetry (for more than two-category variables) were used for matched pairs and both assess if the distributions of disagreement cases are symmetrical around agreement cases. However, only the Wilcoxon-signed rank test is sensitive to the direction of asymmetry.

P-values below 0.05 were considered statistically significant in the bivariate analyses of changes in adolescents' and parents' esthetic perceptions from age 13 to 15 (Tables 4.3 to 4.20) as well as their perceptions at age 15 (Tables 4.25 to 4.27). However, in regression analyses of adolescents' and parents' changes in satisfaction with dental appearance (Tables 4.21 to 4.24) as well as adolescents' satisfaction with dental appearance at age 15 (Tables 4.28 to 4.31), P-values below 0.15 were used as significance level due to small sample size and desire to not miss important variables in the final model.

Overall, approximately 44% of the adolescents had some changes in satisfaction level with appearance of teeth, compared to 27% of the parents. Comparisons of kappa coefficients between adolescents' and parents' changes showed that generally parents tended to have more stable perceptions over the study period than did adolescents. From age 13 to 15, new psychological and physical changes occur to adolescents that may influence the way they perceive appearance of their teeth. Also, people are generally more aware of their own characteristics than someone else, even parents. Thus, higher prevalence of changes in adolescents' perceptions seems plausible, despite the fact that they had permanent dentitions at both ages, and no major changes in number and appearance of teeth were expected between ages 13 and 15.

On the other hand, among adolescents with changes in dental appearance satisfaction, there was no dominant direction of change, whereas parents with changes in satisfaction tended to become less critical of the appearance of adolescents' teeth over time. This agrees with the results of cross-sectional analyses in this study, which showed

15-year-old adolescents were significantly more critical of (less satisfied with) dental appearance and color than were their parents. There is scarcity of evidence in the literature about how adolescents' self-perceived dental esthetics change during adolescence. In a study by Shulman et al. (35), younger children (13 years or younger) were significantly more critical of their tooth color than were older subjects (14 years or older). However, the validity of this result is not clear, due to the cross-sectional nature of the study. Also, in a recent prospective study by Fue et al. (63), the mean self-scored Aesthetic Component (AC) of the Index of Orthodontic Treatment Need (IOTN) was assessed at both ages 13 and 16. This study did not find a significant difference in the mean scores between the two time points, concluding that adolescents with no orthodontic treatment did not have a dominant direction of change. However, adolescents who were on the waiting list for receiving orthodontic treatment, but did not receive it during the study, had decreased satisfaction with dental appearance.

Based on the present study findings, having concerns about dental color was most frequently reported by the adolescents at both ages 13 (44%) and 15 (42%), compared to the other aspects. Thus, it was not surprising that 12% of our study adolescents had at least one experience of dental bleaching before age 15. Other studies have also reported increasing use of the OTC dental bleaching products among children and young adolescents in recent years due to their concerns about dental discoloration (67).

On the other hand, proportional odds models showed that controlling for malocclusion status, receiving dental bleaching had a negative association with increase in dental appearance satisfaction of adolescents, i.e., those with experience of dental bleaching between ages 13 and 15 were less likely to show an increase satisfaction with appearance than were adolescents without bleaching experience. The biggest advantage of dental bleaching in adolescents has been reported after termination of orthodontic treatment. For instance, in an investigation by Krug and Green (68), adolescents who underwent dental bleaching showed a significant increase in satisfaction with orthodontic

treatment outcomes one-month following the termination of orthodontic treatment. For more conclusive results, prospective studies with adequate sample size and assessment of dental shade before and after utilization of bleaching are required.

Regarding the continuation of concern about tooth color during adolescence, as well as increased availability and advertisement of dental bleaching products, adolescents' overuse of bleaching is likely. The American Academy of Pediatric Dentistry has recommended that dental professionals and parents should be judicious in the use of dental bleaching for children and adolescents (69).

Interestingly, in a study of parental changes in dental esthetic perceptions higher proportion of parents were found to be critical of children's dental color at age 11 compared to age 9 (42). The study concluded that, as permanent canines and premolars which frequently displayed fluorosis erupted, parents became more critical of children's tooth color. As maxillary canines and premolars were most likely fully erupted at both ages 13 and 15, and no major changes in dental occlusion were expected, it seems reasonable to find that parents had generally stable perceptions. For example, more than 70% of the parents had the same level of satisfaction with dental appearance at both ages. However, among the relatively small group of the parents with some changes in dental esthetic perceptions, the parents tended to show an increase in dental appearance satisfaction and a decrease in concern with dental color. One possible explanation could be that, during adolescence, dramatic physical changes occur in other parts of face and body, unlike in the dentition, which may make parents less sensitive to the appearance and color of teeth.

Dental crowding was the only aspect of dental esthetics for which both parents and adolescents showed a significant reduction in concern at age 15 compared to age 13. We expect that the more than half of the IFS adolescents who were excluded from our analyses due to starting orthodontic treatment between ages 13 and 15 had somewhat increased concerns with malocclusion. Thus, it seems reasonable that the subjects who

remained in the study and their parents were likely to show decreased concern about dental crowding.

Based on the proportional odds model, there was a negative association between the DAI categories and positive change in adolescent's dental appearance satisfaction. For instance, adolescents with high need for orthodontic treatment based on DAI scores greater than 31 were less likely to show increased satisfaction with appearance of their teeth than were adolescents with lower DAI category, suggesting slight or modest need for orthodontic treatment. This agrees with results of the cross-sectional analysis, which found that adolescents with higher DAI category (more severe malocclusion) had lower satisfaction level at age 15. The association of malocclusion with lower appearance satisfaction has been shown in other cross-sectional studies as well (50, 51, 70). In addition, in a longitudinal study by Birkeland et al. (46), it was found that orthodontic treatment had a positive impact on increased satisfaction with dental appearance from age 11 to age 15; however, they did not find a significant association between increased self-esteem and experience of orthodontic treatment over the four-year study period. This underscores the fact that any extrapolation from adolescents' esthetic perceptions to their overall psychosocial health should be done with caution.

Despite the continuing concern about dental color at age 15, there was no significant difference in changes in dental esthetic satisfaction between adolescents who had definitive fluorosis and others. More comparisons of perceptions between the two groups will be discussed in the next section.

Cross-sectional analyses of adolescents' and parents' dental esthetic perceptions

Evaluation of the adolescents' dental esthetic perceptions at age 15 showed that the majority of them were satisfied with the appearance (86%) and color (83%) of their teeth. Similar percentages of 13-year-old adolescents were satisfied with dental

appearance and color (52). Nevertheless, based on the comparison of adolescent-parent pairs, 15-year-old adolescents were still less satisfied with dental appearance and color and more critical of tooth shape than were their parents. A comparable result was found in assessment of adolescent-parent pairs of the Iowa Fluoride Study at age 13 (52). Conversely, in another study by Hamadan (71) on patients who attended a university clinic in Jordan to start orthodontic treatment, parents were more critical of patients' occlusion (mean age=15 years) than were the patients, and the parents were more likely to overestimate the treatment needs. This could be explained by the fact that the parents who accompanied their children to the orthodontic clinic were more likely to be worried about their children's appearance than the IFS parents who were from the general population.

Despite the fact that the adolescents were more critical of their dental appearance than were the parents, none of the aspects of their dental esthetic perceptions were significantly associated with the presence of dental fluorosis on at least one maxillary anterior tooth. Since in all the study subjects with fluorosis, except one with FRI=3 (dark staining and/or pitting), the maximum FRI scores were two, we concluded that mild to moderate fluorosis was not significantly associated with more negative perceptions of dental appearance in this group of 15-year-old adolescents. This finding corroborates results from previous studies (35, 36, 52, 71) that identified no substantial impact for mild/moderate fluorosis on children's/teenagers' contentment with dental appearance. Similarly, a review of the association of dental fluorosis and Oral Health Related-Quality of Life (OHRQoL) concluded that the literature generally did not show negative impact of mild cases of fluorosis on OHRQoL (45). Furthermore, no dramatic change in the association of fluorosis and adolescents' perceptions would be expected at mid- to late-adolescence, since based on the longitudinal analyses, fluorosis was not significantly related to changes in dental appearance satisfaction during this time (as discussed in the longitudinal data analysis).

In contrast, parents whose children had definitive fluorosis were more concerned with dental color irregularities than were other parents. When the IFS subjects were younger (9, 11, and 13 years), dental fluorosis was also significantly associated with other aspects of parental dental esthetic perceptions, such as lower satisfaction with dental appearance and dental color (40-42, 52). This inconsistency may be partially explained by the fact that parents showed significant improvement in satisfaction with dental appearance and dental color from age 13 to 15, hence they were no longer dissatisfied with dental fluorosis. However, lack of evidence for the significant association between fluorosis and parental satisfaction level at age 15 could also result from smaller sample size and consequently lower study power in our study, as the percentages of parents who were very satisfied with overall dental appearance and overall dental color in the fluorosis group (43% and 35%, respectively) were lower than those of the non-fluorosis group (50% and 43%, respectively); however, the differences were not statistically significant. The percentages of parents who were very satisfied with the overall dental appearance and the overall dental color in the fluorosis group (43% and 35%, respectively) were lower than those in the non-fluorosis group (50% and 43%, respectively); however, the differences were not statistically significant.

The last part of the analyses focused on the predictors of adolescents' satisfaction with their overall dental appearance at age 15, using ordinal logistic regression. This type of logistic regression requires proportional odds assumption which was met for all the predictor variables, except for dental bleaching. Therefore, the generalized logit model, which does not require the proportional odds assumption, was used for assessing the association between dental bleaching and the outcome variable at both univariable and multivariable levels.

Interestingly, we found that the adolescents with previous dental bleaching tended to be more likely to be somewhat satisfied (neither dissatisfied nor very satisfied) with their dental appearance compared to those without past dental bleaching, but results were

not statistically significant (P = 0.099) (Table 4.30); in fact, of 19 adolescents with bleaching experience, only one was very satisfied with dental appearance. This agrees with the finding from longitudinal analyses that adolescents with recent bleaching were more likely to show a decrease in dental appearance satisfaction. These results could lead to the inference that dental bleaching does not result in desirable dental appearance for adolescents who are dissatisfied with their dental appearance. However, it is noteworthy that the adolescents who sought dental bleaching had been primarily more critical of their dental appearance. Studies that assessed children and teenagers' rating of computer-simulated dental images reported different conclusions; very white teeth resulted from esthetic procedures were rated as the most preferable condition compared to natural tooth shade or very mild fluorosis (72, 73). Nonetheless, not all dental bleaching procedures result in very white teeth. More studies are required to assess adolescents' perceptions of dental color before and after dental bleaching with regard to degree of change in dental color.

A partial proportional odds model was developed for additional assessment of the predictors that did not violate the assumption, because this approach was a more powerful statistical tool in capturing the associations of most of the variables with adolescents' satisfaction level at age 15.

The finding that, unlike dental fluorosis, having non-fluoride opacity on maxillary anterior teeth was significantly associated with lower dental appearance satisfaction at age 15 was intriguing. Several studies that assessed children's ratings of different photographs consistently reported less favorable rankings for non-fluoride opacities compared to mild fluorosis (72-74). This could occur due to the differential characteristics of demarcated opacities versus dental fluorosis that make non-fluoride opacities more noticeable than fluorosis: demarcated opacities are most often seen on the center of smooth surfaces, whereas mild fluorosis often affects the cusp tips and incisal

edges; and demarcated opacities have well-defined margins, but fluorosis blends into normal enamel (59).

Furthermore, adolescents with higher DAI category, suggesting greater need for orthodontic treatment, were more likely to show dissatisfaction with overall dental appearance at age 15. This agrees with the results from longitudinal data analysis, as discussed in the previous section.

Finally, among the socio-demographic and other dental-related variables which were included in the proportional odds models, race/ethnicity (being non-Hispanic White vs. other races/ethnicities) and frequency of dental visits were significantly associated with dental appearance satisfaction of 15-year-old adolescents. Non-Hispanic white adolescents were more likely to have higher satisfaction with their overall dental appearance than were adolescents from other racial/ethnic groups.

It may be argued that race/ethnicity influences the perceptions of dental appearance indirectly through different ways. Notable racial/ethnic differences have been observed according to the prevalence and type of occlusal characteristics (75-79). For instance, in a recent study by Johe et al.(78), African-Americans were more likely to show anterior tooth-size discrepancy than were other racial/ethnic groups. Nevertheless, the association between race/ethnicity and adolescents' dental appearance satisfaction remained statistically significant in our study after controlling for socioeconomic status (parental education and annual family income), frequency of dental visits, and the DAI category. It could highlight the impacts of other aspects of racial differences, such as culture, on the self-perceived dental esthetics. However, given the small number of subjects from racial/ethnic minorities (7% of the sample size), we had to merge all minorities into one group. Future studies should be conducted for better understanding of cultural determinants of dental-esthetic perceptions.

Study strengths

One of the greatest strengths of this study is that it was the first study of its kind that assessed adolescents' and parents' dental esthetic perceptions and their associations with both dental fluorosis and malocclusion on a longitudinal basis. This is of particular interest during adolescence, when adolescents undergo substantial physical and psychological changes. Also, we will be able to compare the results of this study with adolescents' perceptions at age 17 in the future, since the data are being collected as part of the ongoing Iowa Fluoride Study.

This study assessed a wide range of information related to the dental esthetics of adolescents, including dental fluorosis, malocclusion, and past experience of dental bleaching and trauma. There are few studies in the literature that have evaluated the effects of these conditions simultaneously, whereas the perceptions of dental esthetics are influenced by a number of factors, including the combination of alignment, color, and shape of teeth. It is almost impossible for adolescents and parents to isolate one condition/aspect from the others, and to combine them together. Thus it is crucial for both clinicians and researchers to take all components into account while addressing dental esthetic concerns.

Study limitations

The study was part of the longitudinal Iowa Fluoride Study, for which the study subjects were selected in the early- to mid-1990s. Thus, it is likely that those who continued participating in the study have greater appreciation of oral health than those who did not. Furthermore, the majority of adolescents were non-Hispanic white and from high-income and well-educated families. Therefore, they are not representative of the entire U.S. adolescent population, and any broader extrapolation should be done cautiously after considering characteristics of the study sample.

Despite the fairly high retention rate over the two-year study period (approximately 74%), we had to exclude more than half of the adolescents from the analyses, because they had received orthodontic treatment at or before age 15. There was no information available on duration and end date of orthodontic treatment. If we had information on the duration of orthodontic treatment, we could categorize subjects into three groups: those with no history of orthodontic treatment, those who had completed orthodontic treatment and those who had active orthodontic treatment at age 15, and assess their perceptions separately. Interceptive orthodontics may not be as effective as corrective orthodontics in improvement of facial esthetics; however, we could not differentiate between them, as information on the type of orthodontic treatment was unavailable. Without such information, we could not meaningfully evaluate the effect of orthodontic treatment on the adolescents' perceptions.

In addition, exclusion of adolescents with history of orthodontic treatment reduced the generalizability of the findings, as well as the power of the study. For example, as mentioned in the Methods chapter, the post hoc power analysis for comparison of adolescents' dental appearance satisfaction between ages 13 and 15, using McNemar's tests of symmetry, showed that power was only 15%, because of the small sample size and relatively small difference in the percentages of adolescents who showed improved versus decreased satisfaction. Furthermore, there were only four subjects with anterior tooth decay/fillings and two with enamel hypoplasia. Thus, we were unable to include these conditions in the assessment of dental esthetic perceptions. Finally, due to the small number of subjects with two- or three-level change in satisfaction with dental appearance, we combined them with those who had only a one-level change. This might result into losing some information and reducing the power of study in the final analyses.

There was no dental exam at age 15. The majority of adolescents had all permanent teeth fully erupted by age 13, thus we did not expect considerable change in occlusion from age 13 to 15 for the study subjects. Nevertheless, we were unable to

assess possible changes in dental appearance between the two ages due to eruption of the late-erupting teeth, anterior caries development or any esthetic restorations. This can negatively impact the validity of the study findings. Moreover, there was no information available on the oral health status of the parents in this study. We expect that parents' own oral health and dental appearance may affect the way they perceive their children's dental conditions.

Having parents completing the dental esthetic questionnaire four times, when children were 9, 11, 13 and 15 years old, might lead the parents to be more conscious of their children's dental appearance. It also might make them respond to the questions based on their recalls of previous interviews, hence the answers might not fully reflect their current perceptions. These aspects can partially explain parents' stable perceptions over the two-year study period.

Quality of life, which has recently attracted attention in the dental literature, was not assessed in this study at ages 13 or 15 years. There are several measures that specifically assess how oral health conditions impact quality of life and psychosocial well-being. Use of these tools is of great interest now, as they emphasize the importance of oral health as an integral part of the overall health (80). It is expected that some oral conditions associated with elevated concerns/awareness may not necessarily impact daily life. Thus, utilization of the Oral Health-Related Quality of Life (OHRQoL) measures is recommended in future investigations. It is noteworthy that collection and analyses of data on the OHRQoL of 17-year-old adolescents are being conducted now for the IFS subjects.

Future Directions

In later stage of the Iowa Fluoride Study, adolescents and parents complete the esthetic perceptions and OHRQoL questionnaires at age 17; thus, we will be able to assess changes in their perceptions over a longer period of time, from age 13 to 17, and

compare their perceptions with their quality of life score. Furthermore, we will be able to assess the effect of orthodontic treatment on the perceptions, as the majority of subjects have their orthodontic treatment completed by age 17.

Future studies are needed and it is recommended that investigators recruit adequate numbers of subjects from more diverse populations, and assess longitudinal changes in dental esthetic perceptions, as well as facial esthetic perceptions and quality of life, over a longer period of time. These studies should consider several factors, such as types of orthodontic treatment, dental bleaching, fluorosis, non-fluoride opacities, and dental esthetic restorations. Such studies will enable us to better understand adolescents' perceptions and prioritize their dental esthetic and oral health problems in order to optimize their oral health, as well as psychosocial well-being.

Clinical relevance of the study

Adolescents' and parents' perceptions of dentofacial esthetics are complex and dynamic, as they are influenced by a wide range of factors, and vary from time to time. One dental esthetic issue that is of little concern at some time may raise more concern later, and vice versa. This is particularly of importance for adolescents, as they experience physical and psychological changes, and they pay considerable attention to physical appearance under peer pressure.

Patient's preference as an essential component of treatment-planning has been widely acknowledged in the literature (81-85). Self-perceived dental esthetics, which was assessed as a proxy for psychological consequences of dental esthetics in this study, could be used as a complementary tool to the objective measures for assessment of the oral health in epidemiologic studies. Dental clinicians should consistently involve adolescents' and their parents' perceptions in planning the course of treatment, as well as evaluating treatment progress and outcomes. The continuous patient-centered approach

has greatest value for multiple visit dental procedures that primarily aim at improving adolescents' dental esthetics, such as orthodontic treatment and dental bleaching, because these procedures are not successful unless they fulfill patient expectations.

Furthermore, from the public policy perspective, this study supports the findings of previous investigations that mild fluorosis, which is the most prevalent form of dental fluorosis in the U.S., was not associated with considerable dental esthetic concerns among the adolescents. In other words, other aspects of dental esthetics, such as malocclusion and desire to have very white teeth, could overwhelm concerns associated with mild fluorosis at this age. In addition, given the finding that fluorosis was not associated with negative changes in adolescents' perspectives over time, we do not expect dramatic increase in concern with fluorosis later in mid/late adolescence.

CHAPTER 6

CONCLUSIONS

This study involved secondary analyses of the data collected in the Iowa Fluoride Study. The adolescents and their parents completed the dental esthetic perception questionnaire at both ages 13 and 15. The questionnaire assessed their levels of satisfaction with overall dental appearance and dental color of adolescents, and their concerns about six aspects of dental esthetics. Also, the adolescents were examined to assess the presence of dental fluorosis, non-fluoride opacities, and malocclusion at age 13, but not at age 15. This study assessed and compared changes in adolescents' and parents' dental esthetic perceptions from age 13 to age 15, and investigated the associations of these changes with dental and demographic characteristics.

The results revealed that more than half of the study adolescents showed changes in dental appearance and dental color satisfaction from age 13 to age 15. However, there was no dominant direction of the change among the adolescents, i.e., the likelihood of showing increased satisfaction was not significantly different than that of decreased satisfaction. Parents generally had stable perceptions of adolescents' dental esthetics. Nevertheless, among the parents with some changes, the probability of showing an increase in dental appearance satisfaction tended to be higher than the probability of having a decrease in satisfaction. Furthermore, the proportion of parents who were concerned about dental color at age 15 was significantly lower than that at age 13.

The study corroborated the results of previous investigations in that mild fluorosis was not of considerable concern to adolescents. Additionally, based on the longitudinal data analyses, we do not expect dramatic change in the association of fluorosis with adolescents' perceptions later in mid- to late-adolescence

The ordinal logistic regression analyses illustrated that adolescents with dental bleaching experience and in higher DAI category were significantly more likely to have a decrease in dental appearance satisfaction from age 13 to age 15. Similarly, based on the

cross-sectional data analyses, the dental bleaching experience and the DAI category were negatively associated with the adolescents' dental appearance satisfaction at age 15, whereas having frequent dental visits and being non-Hispanic white were associated with higher satisfaction level at age 15.

Given the frequent changes in adolescents' dental esthetic perceptions and their associations with dental bleaching experience and the DAI category, it is recommended for dentists to consistently involve adolescents' opinions and expectations throughout planning, as well as monitoring the course of treatment. This issue is of particular importance in dental esthetic procedures, such as orthodontic treatment and dental bleaching, since dissatisfaction with dental appearance is often the main motivation for adolescents to seek such procedures.

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APPENDIX

QUESTIONNAIRES

Iowa Fluoride Study

Esthetic Perceptions-Child

1. **Which of the following best describes your thoughts about the overall appearance of your teeth?**
    - Very satisfied
    - Somewhat satisfied
    - Somewhat dissatisfied
    - Very dissatisfied

2. **Factors That May Be of Concern to You --- MARK "YES" OR "NO"**

    a. Is <u>Shape</u> of Teeth a Concern? Yes No

    If yes, which shape characteristics concern you?

    1. Jagged/chipped
    2. Pointed
    3. Irregular Shape
    4. Other

    Explain "Other"

    b. Is <u>Color</u> of Teeth a Concern?

    If yes, which color characteristics concern you?

    1. Brown hues
    2. Yellow hues
    3. Gray hues
    4. Other

    Explain “Other”

    c. Is <u>Alignment</u> of Teeth a Concern?

    If yes, which alignment characteristics concern you?

    1. Rotated
    2. Front teeth flared (buck teeth)
    3. Abnormal bite

4. Other

Explain “Other”

d. Is <u>Spacing</u> of Teeth a Concern?

If yes, which spacing characteristics concern you?

1. Abnormally large space
2. Adult tooth missing
3. Other

Explain “Other”

e. Is <u>Crowding</u> of Teeth a Concern?

If yes, which crowding characteristics concern you?

1. Extra teeth
2. Overlapping
3. Other

Explain “Other”

f. Are <u>Color Irregularities</u> of Teeth a Concern?

If yes, which color irregularities characteristics concern you?

1. White spots
2. Yellow spots
3. Brown spots
4. White lines
5. Yellow lines
6. Brown lines
7. Speckled/spotted/streaky

   Irregular/blotchy appearance
8. Other

   Explain “Other”

g. Are any other things a concern to you?

If yes, please explain:

Explain “Other”

3. **Which of the following best describes your thoughts about the overall color of your teeth?**

    - Very satisfied
    - Somewhat satisfied
    - Somewhat dissatisfied
    - Very dissatisfied

Iowa Fluoride Study

Esthetic Perceptions-Parent

2. **Which of the following best describes your thoughts about the overall appearance of your child's teeth?**
    - o Very satisfied
    - o Somewhat satisfied
    - o Somewhat dissatisfied
    - o Very dissatisfied

4. **Factors That May Be of Concern to You --- MARK "YES" OR "NO"**

a. Is <u>Shape</u> of Teeth a Concern? Yes No

If yes, which shape characteristics concern you?

1. Jagged/chipped
2. Pointed
3. Irregular Shape
4. Other

Explain "Other"

b. Is <u>Color</u> of Teeth a Concern?

If yes, which color characteristics concern you?

5. Brown hues
6. Yellow hues
7. Gray hues
8. Other

Explain "Other"

c. Is <u>Alignment</u> of Teeth a Concern?

If yes, which alignment characteristics concern you?

5. Rotated
6. Front teeth flared (buck teeth)
7. Abnormal bite

8. Other

Explain “Other”

d. Is <u>Spacing</u> of Teeth a Concern?

If yes, which spacing characteristics concern you?

4. Abnormally large space
5. Adult tooth missing
6. Other

Explain “Other”

e. Is <u>Crowding</u> of Teeth a Concern?

If yes, which crowding characteristics concern you?

4. Extra teeth
5. Overlapping
6. Other

Explain “Other”

f. Are <u>Color Irregularities</u> of Teeth a Concern?

If yes, which color irregularities characteristics concern you?

9. White spots
10. Yellow spots
11. Brown spots
12. White lines
13. Yellow lines
14. Brown lines
15. Speckled/spotted/streaky

    Irregular/blotchy appearance
16. Other

    Explain “Other”

g. Are any other things a concern to you?

If yes, please explain:

Explain “Other”

5. **Which of the following best describes your thoughts about the overall color of your child’s teeth?**

    - Very satisfied
    - Somewhat satisfied
    - Somewhat dissatisfied
    - Very dissatisfied