Original Article

Relative Esthetic Importance of Orthodontic and Color Abnormalities

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ABSTRACT

Objective: To assess the relative importance of an orthodontic esthetic index, dental fluorosis and nonfluoride opacities, with respect to parents' satisfaction with their children's dental esthetics.

Materials and Methods: Dental examinations of Iowa Fluoride Study participants assessed fluorosis and nonfluoride opacities in the mixed dentition. Dental casts of 200 randomly selected subjects were scored using the Dental Aesthetic Index (DAI) criteria. Parent satisfaction was assessed via multiple items on a questionnaire. Associations were evaluated using logistic regression.

Results: Nineteen percent of parents were somewhat or very dissatisfied with their children's dental esthetics. Overall DAI score was positively associated with dissatisfaction ($P < .001$), as was fluorosis ($P = .003$).

Conclusions: In addition to changes related to DAI scores, parent esthetic satisfaction decreased with the presence of fluorosis. Dental professionals should address both the issues of tooth positioning and color aberration with respect to dental esthetics.

KEY WORDS: Esthetic; Fluorosis; Children

INTRODUCTION

Assessment of dental esthetics is a complex procedure because a large number of factors can contribute to esthetic perceptions. These factors include hard tissue characteristics such as tooth color, shape and alignment, and soft tissue considerations, such as facial expressions and gingival appearance. However, despite the many factors contributing to dental esthetic perceptions, no indices exist that consider more than one of these categories.

The Dental Aesthetic Index (DAI) is an orthodontic index that measures components of dental esthetics[1] and has been widely used since its development in 1976. The DAI purportedly places an individual's dental appearance along a continuum that ranges from excellent to very poor; the higher the score, the less acceptable the dental appearance. The percentile at which a person's DAI score falls is used to estimate the deviation from social norms and is relative to other members of the population. The DAI score provides a reliable means for screening individuals eligible for public or third-party funded orthodontic care based on socially acceptable dental appearance.[2] However, it includes only esthetic components related to tooth positioning, and not other esthetic components related to tooth color, fluorosis, or isolated opacities. Ideally, an esthetic index should include both components, especially with consumer demands for cosmetic and whitening products that are currently driving the dental market.

Foster Page et al[3] used the DAI to assess dentitions of 12- to 13-year-old children, some of whom were in the mixed dentition and some of whom were in the permanent dentition. The DAI was altered slightly to adjust for ''missing'' permanent teeth that had not yet erupted, since they are the most heavily weighted component in the DAI score. The children also completed the Child Perceptions Questionnaire (CPQ) concerning well-being. This study found that subjects in higher malocclusion categories had significantly poorer overall CPQ scores. Clearly declining gradients were also found for the social well-being and emotion-

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al well-being domains of the CPQ as DAI treatment-need category increased.

Dental fluorosis can also influence esthetic perceptions, and its prevalence has increased over the past 50 years. Depending on the site and study design, mild fluorosis affects about 15% to 50% of the North American population, with an estimated 50,000 US schoolchildren having moderate-to-severe fluorosis.[4–6] Relatively few studies of esthetic perceptions concerning fluorosis have been published worldwide, with only three groups having conducted fluorosis studies regarding dental esthetics in North America.

Clark et al[7] conducted early studies using the Tooth Surface Index of Fluorosis (TSIF) to determine the prevalence of fluorosis in fluoridated and nonfluoridated communities in British Columbia. Both parents and children perceived an esthetic problem as TSIF scores increased.

McKnight et al[8] asked adult patients of a university-based family practice clinic to complete a questionnaire assessing esthetic perceptions of paired photographs, with each pair containing an example of fluorotic teeth. Fluorotic teeth were generally viewed less favorably than the other esthetic conditions, and sometimes even mild fluorosis was an esthetic concern. Later, McKnight et al[9] compared esthetic perceptions of mild fluorosis and other conditions using paired computer-generated images made from a base set of normal-appearing teeth among incoming dental students. Mild fluorosis was found to be less favorable than the normal/control teeth, as well as less favorable than isolated opacities.

Lalumandier and Rozier[10] assessed parents' perceptions of fluorosis by surveying 708 parents of pediatric patients about their satisfaction with the color of their children's teeth and other factors affecting their level of satisfaction. Forty-three percent of parents were dissatisfied with the appearance of their children's teeth. Among those with no fluorosis, 73.9% were satisfied with their child's appearance compared with only 24.2% in the presence of moderate to severe fluorosis. In general, the greater the TSIF score, even at mild levels, the more dissatisfied the parents were. Levy et al[11] also investigated parents' esthetic perceptions of fluorosis and demarcated opacities in the mixed dentition, and found that parents' overall esthetic satisfaction decreased with higher fluorosis scores ($P < .001$) and the presence of opacities ($P = .04$).

To the majority of society, attractiveness is crucial for success and happiness, and multiple studies have shown the oral region to be a major determining factor in physical attractiveness.[10] Thus, a better understanding of how different factors contribute to oral esthetics is needed. Specifically, it is not clear whether concern with tooth positioning outweighs concern due to the presence of fluorosis or opacities, or vice versa.

The purpose of this study was to assess the relative importance of an orthodontic esthetic index (specifically the DAI), and color aberrations (specifically fluorosis and nonfluoride opacities), as related to parents' views of their children's dental esthetics.

MATERIALS AND METHODS

This study involved participants in the Iowa Fluoride Study, an ongoing longitudinal study of a cohort recruited at birth in 1992–1995 from postpartum units of eight Iowa hospitals. The Iowa Fluoride Study gathers data concerning fluoride exposures and intake,[12,13] and relates them to dental caries and fluorosis outcomes.[14,15] Parents provided informed consent and children gave assent according to procedures approved by the University of Iowa Institutional Review Board (IRB).

At about age 9, each participant had a dental examination and parents of the participants completed a questionnaire to assess satisfaction with their children's teeth. In the questionnaires, parents were asked about their level of satisfaction with the overall appearance of their children's teeth, as well as specific concerns they had regarding their children's dental esthetics. The esthetics questionnaire, building on work by Clark et al,[7,16,17] McKnight et al,[8,9] and Levy et al[11] contained three main questions and seven sub-questions documenting specific esthetic concerns (Table 1).

As part of the dental exam, the child's mixed dentition was evaluated by one of two trained and calibrated dentists for the presence of fluorosis and nonfluoride opacities on the permanent incisors. Fluorosis was assessed using the Fluorosis Risk Index (FRI), assessing erupted zones of all permanent incisors and first molars.[18] Subjects were also assessed for the presence of any isolated (nonfluoride) opacities. Nonfluoride opacities were differentiated from fluorosis using Russell's criteria.[19] In brief, Russell's criteria state that fluorosis is generally not well-defined, often blends in with normal enamel, and is usually distributed symmetrically in the mouth, whereas nonfluoride opacities have a defined shape, are clearly differentiated from adjacent normal enamel, are often in the middle of the tooth surface, and are more randomly distributed in the mouth. Assessments were also made on the first molars, but are not included in the present report.

Dental casts of the mixed dentition were made for 580 children participating in the Iowa Fluoride Study in order to study dental arch growth and development and relationships with sucking behaviors.[20–22] Two

Table 1. Items on the Parents' Esthetics Questionnaire

1. Which of the following best describes your thoughts overall about the appearance of your child's teeth?	a. Very satisfied b. Somewhat satisfied c. Somewhat dissatisfied d. Very dissatisfied	
2. If not "very satisfied," which of the following are you concerned about? (respondents circled "yes" or "no" for each subcategory)		
a. Shape	1. yes	2. no
b. Color	1. yes	2. no
c. Alignment	1. yes	2. no
d. Spacing between teeth	1. yes	2. no
e. Crowding of teeth	1. yes	2. no
f. Speckled/spotted/streaky/irregular/blotchy appearance	1. yes	2. no
g. Other (respondents were asked to specify)	1. yes	2. no
3. Which of the following best describes your thoughts overall about the color of your child's teeth?	a. Very satisfied b. Somewhat satisfied c. Somewhat dissatisfied d. Very dissatisfied	

Table 2. Components and Regression Coefficients of the Standard Dental Aesthetic Index (DAI) Regression Equation

DAI Components	Regression Coefficients (Rounded Weights)
Number of visibly missing teeth[a]	6
Crowding (0, 1, or 2)[b]	1
Spacing (0, 1, or 2)[b]	1
Diastema, mm[c]	3
Largest anterior maxillary irregularity, mm[d]	1
Largest anterior mandibular irregularity, mm[d]	1
Anterior maxillary overjet, mm[e]	2
Anterior mandibular overjet, mm[e]	4
Vertical anterior open bite, mm[e]	4
Largest anteroposterior molar relation[e]	3
0 = class I occlusion	
1 = 1/2 cusp mesial/distal	
2 = whole cusp mesial/distal	
Constant	13

[a] Not counted if cusp tips were present.
[b] Assessed on incisor segments.
[c] Largest measurement.
[d] Site of greatest rotations or displacement from normal arch alignment.
[e] Measured with teeth in centric occlusion.

hundred casts were selected using stratified random sampling from children with relatively complete eruption of first molars and incisors, and then scored using the DAI methods.[1] The DAI offers a method for measuring dental characteristics that deviate from the norm and are thought to affect a person's self-confidence and psychosocial health.[1] There are 10 DAI components (see Table 2) which are measured and multiplied by their regression coefficients; the products are then summed and a constant is added to the total to provide the overall DAI score.

The DAI was developed for use in the permanent dentition, but in this study, the DAI had to be adapted for the mixed dentition with regard to missing teeth and spacing. Specifically, when a child had a tooth missing, it was counted only once as a missing tooth and not scored again as a spacing issue. If teeth in the opposing arch were still unerupted, the case was not scored as having an anterior open bite.

To explain how the DAI, fluorosis and opacities are related to the parents' assessments of their children's dental esthetics, mean responses were calculated by category of DAI score (low, middle, high) and presence/absence of fluorosis or opacities. Logistic regression[23] modeled relationships for parental dissatisfaction (somewhat or very dissatisfied vs somewhat or very satisfied).

RESULTS

There were 109 girls (54%) and 91 boys (46%). Mothers were 98% non-Hispanic white, two mothers were white Hispanic (1%), one was Asian and one was African-American (0.5% each). At baseline assessment (recruitment), 23% of mothers had a high school education only or less, with 48% of mothers reporting a 4-year college degree or beyond. Only 9% of families indicated a baseline family income under $20,000, with 44% at $20,000–$39,999, 29% at $40,000–$59,999 and 17% at $60,000 or above. Forty-one percent of the children were the first born in their family.

DAI scores ranged from 22 to 60 (Figure 1). Thirty-eight percent of children had dental fluorosis (mostly mild), and 27% had opacities on the permanent incisors. Overall, 31% of parents were "very satisfied" with the appearance of the child's teeth, 49% were "somewhat satisfied," 16% were "somewhat dissatisfied," and 3% were "very dissatisfied."

Mean esthetic satisfaction scores by DAI category and presence of fluorosis or opacities (Table 3) showed that parents were generally less satisfied with the appearance of their children's teeth as the DAI score increased. The exceptions to this general state-

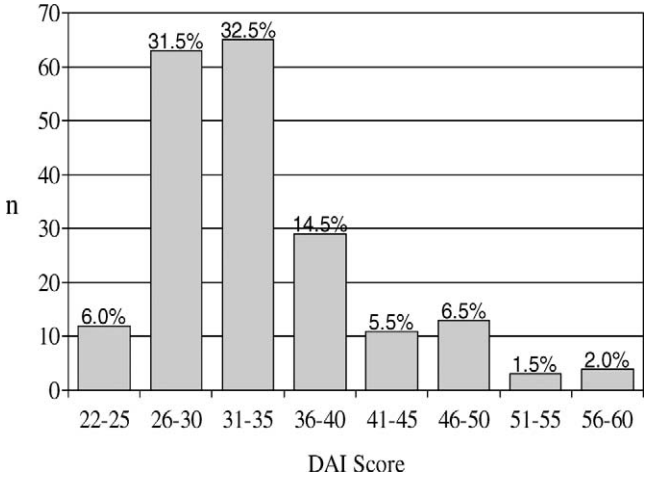

Figure 1. Distribution of Dental Aesthetic Index (DAI) Scores (N=200).

ment are that there was no decreased satisfaction from low- to mid-DAI scores in the absence of opacities and fluorosis, and satisfaction was slightly less for mid-DAI vs high-DAI among those with both fluorosis and opacities. Parental dissatisfaction also generally increased with the presence of either fluorosis or opacities (or both) when the DAI was mid-level or high. Increased dissatisfaction among subjects with low DAI scores was seen only when both fluorosis and opacities were present. As evidenced by the ranges presented in Table 3, there was substantial variation from the mean satisfaction levels.

Table 4 shows logistic regression modeling results for overall esthetic dissatisfaction (somewhat or very dissatisfied vs somewhat or very satisfied). Single variable models (1–3) showed positive associations between dissatisfaction and DAI ($P < .001$) and fluorosis ($P = .003$). Multiple logistic regression models (4–7) showed the DAI to be significantly associated with dissatisfaction even when fluorosis, opacities or both were included in the model (all $P < .001$). Fluorosis was also significantly associated with dissatisfaction (all $P \leq .007$), but the presence of opacities was not (all $P \geq .10$). All models with the DAI had good predictive ability ($c > .73$) relative to chance effects ($c = .50$), and the addition of fluorosis and opacities im-

Table 3. Mean Esthetic Satisfaction Scores[a] by Dental Aesthetic Index (DAI) Category and Presence of Fluorosis and Opacities

	Dental Examination Findings							
	Neither		Opacity Only		Fluorosis Only		Both	
DAI Category	n	Mean (Max[b])	n	Mean (Max[b])	n	Mean (Max[b])	n	Mean (Max[b])
(1) Low (22-29)	36	1.67 (4)	12	1.50 (2)	12	1.33 (2)	4	2.00 (3)
(2) Mid (30-35)	30	1.67 (3)	12	1.92 (3)	26	1.96 (4)	8	2.63 (4)
(3) High (36-60)	22	2.09 (3)	11	2.27 (4)	20	2.35 (4)	7	2.29 (3)

[a] Scores: 1 = very satisfied, 2 = somewhat satisfied, 3 = somewhat dissatisfied, 4 = very dissatisfied.
[b] Minimum response for each cell was 1 = very satisfied. Only maximum scores are listed in addition to means.

Table 4. Logistic Regression[a] Models for Overall Esthetic Dissatisfaction[b]

	Odds Ratio (95% CI)						
	P-Value						
	Single Variable Models			Two-Variable Models			Complete Model
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
DAI Score[c]	1.11 (1.06, 1.16) <.001			1.11 (1.05, 1.16) <.001	1.11 (1.06, 1.16) <.001		1.11 (1.05, 1.16) <.001
Fluorosis[c]		3.07 (1.48, 6.35) .003		2.94 (1.36, 6.37) .007		3.21 (1.53, 6.71) .002	3.12 (1.42, 6.85) .005
Opacities[c]			1.78 (0.84, 3.77) .14		1.75 (0.78, 3.90) .18	1.95 (0.90, 4.24) .10	1.96 (0.86, 4.47) .11
AIC[d]	178.7	189.1	196.3	172.9	178.8	188.4	172.4

[a] Single variable models (1–3) show strength of association for each predictor variable, one at a time; 2-variable and 3-variable models show strength of association after adjusting for the other variables listed in the column.
[b] Very/somewhat dissatisfied vs very/somewhat satisfied.
[c] Dental Aesthetic Index (DAI) odds ratio represents the odds of being very/somewhat dissatisfied vs very/somewhat satisfied for each increase of one unit in the DAI score, presence of fluorosis (vs no fluorosis), and presence of opacities (vs no opacities).
[d] Akaike information criterion (AIC) is a measure of the lack of fit for each model. Models with lower AIC have better fit.

proved the models (higher c) while preserving parsimony (lower Akaike information criterion, AIC).

DISCUSSION

Because public perception is one of the factors that drive the demand for dental treatment, the perspectives of parents were of special interest in this study. This study found that parents were generally, but not uniformly, less satisfied with their children's dental esthetics at higher DAI scores. Parents of children with dental fluorosis on their permanent incisors were also less satisfied with the appearance of their children's teeth. This finding is consistent with those reported by Clark,[16] Woodward et al,[24] Lalumandier and Rozier,[10] and Shulman et al[25] and suggests that fluorosis, and possibly other color aberrations, contribute to dental esthetic concerns.

Parental dissatisfaction also generally increased when fluorosis or opacities were present and the DAI score was mid-level or high. This general pattern of dissatisfaction makes sense; as the DAI score increases (tooth positioning factors get worse), and color abnormalities are present, there is an additive effect. However, we hypothesize that the severity of the malpositioned teeth could be what primarily catches parents' attention. Perhaps high DAI scores initially overwhelm other esthetic components such as tooth color abnormalities. At medium DAI scores, parents may be more likely to notice color aberrations if tooth positioning factors are less severe, as evidenced by the finding of highest mean dissatisfaction scores at mid-level DAI and presence of both fluorosis and opacities.

It appears that, at least initially (prior to orthodontic treatment), dental fluorosis does not impact dental esthetics as much as the DAI score does. However, after orthodontic treatment and debanding of appliances, it may become a more significant concern for both parents and children. This is a hypothesis that still needs to be verified. Regardless, the present findings indicate that incisor fluorosis and/or isolated opacities generally elevated the likelihood of parental dissatisfaction. Therefore, it is suggested that color aberrations should be included in future esthetic indices, since fluorosis, isolated opacities, and other color abnormalities do not go unnoticed by parents.

In today's society, there are dual components to having an esthetically pleasing dentition. The desire for straight teeth and the desire for white teeth appear to go hand in hand. In order to improve patient satisfaction levels, a dentist needs to take both components into account when formulating a treatment plan and sequence. Color aberrations should be pointed out to the patient and parents before orthodontic treatment is initiated in order to minimize misunderstanding at the end of treatment when the teeth are well aligned and the discoloration is more obvious. Missing teeth, anterior maxillary irregularity, anterior maxillary overjet, and fluorosis appear to be the issues that were associated with the highest level of dissatisfaction in this study. The first of these issues usually can be corrected with orthodontic treatment, while the last can be improved upon by a restorative dentist.

It is recommended in treatment sequencing, that orthodontic treatment take top priority over tooth discoloration correction for two reasons: (1) orthodontic treatment, first and foremost, improves form and function and (2) it is more efficient to improve upon discoloration problems after orthodontic treatment is complete. However, as dentists, we can begin addressing discoloration issues throughout orthodontic treatment by providing preventive education to our patients to avoid the development of white spot lesions or opacities while the orthodontic appliances are in place. During the orthodontic treatment process, treatment planning for preexisting discolorations or opacities should be discussed, but not initiated until appliances are removed.

Depending on the opacity type and severity, several treatment options exist to improve upon the condition and, subsequently, improve satisfaction. Among the more conservative options are at-home tray bleaching, in-office professional bleaching, and enamel microabrasion. For much deeper, subsurface lesions, elective root canal treatment with intracanal bleaching and veneers are options. It is imperative that the clinician determine both the severity of the orthodontic issues, as well as patient expectations for improvement, before embarking on a treatment plan that may leave both the patient and clinician feeling less than satisfied.

Limiting this study to 8½- to 9-year-old children may have allowed the substantial tooth position factors of the mixed dentition to overshadow the importance of color aberrations. For this reason, it is imperative that a similar study be conducted in children with a full permanent dentition. Many parents do not consider primary teeth to be as important as permanent teeth because they are eventually exfoliated, so they may not be as concerned with their children's dental esthetics until the permanent dentition has fully erupted and everything can be visualized at once.

Another limitation of the present study was that only 2 of the 77 participants with fluorosis had moderate or severe fluorosis, so that the study primarily represents the impact of mild fluorosis on dental esthetics, and the impact of fluorosis on parents' satisfaction would most likely be more obvious if moderate or severe fluorosis were more prevalent.

Both DAI scores and fluorosis seem to be generally

associated with parental satisfaction concerning their children's dental esthetics, but further study is needed to clarify if the severity of individual traits affects the level of parents' concern. In addition, a larger study should be conducted, encompassing a more ethnically diverse population with more severe cases of dental fluorosis and more complete permanent dentition.

CONCLUSIONS

- In addition to changes related to DAI scores, parent esthetic satisfaction decreased with the presence of fluorosis.
- Dental professionals should address both the issues of tooth positioning and color aberration with respect to dental esthetics prior to initiating orthodontic treatment.

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