SCIENTIFIC ARTICLE

Factors Associated With Parents' Esthetic Perceptions of Children's Mixed Dentition Fluorosis and Demarcated Opacities

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Abstract

Purpose: With the increasing prevalence of dental fluorosis, improved understanding about esthetic perceptions of dental fluorosis is warranted. The purpose of this report was to present results concerning parents' overall satisfaction with the appearance of their children's teeth and factors related to dissatisfaction, comparing subjects with and without fluorosis and demarcated opacities.

Methods: Data were obtained from 577 parents in the Iowa Fluoride Study who answered a questionnaire concerning their satisfaction with the appearance of their children's teeth at age 9 years, as well as several components of dissatisfaction. Concurrent assessment of the mixed dentition was made by 1 of 2 trained dentist examiners.

Results: Overall, 31% of parents were very satisfied, 51% somewhat satisfied, 16% somewhat dissatisfied, and 3% very dissatisfied with appearance. Parents of children without fluorosis were more likely to be very satisfied (46%) than were parents of children with questionable fluorosis (31%) or definitive fluorosis (22%). Among the 401 not "very satisfied," 50% of those with fluorosis vs 40% with no fluorosis were concerned about color, 60% of both groups were concerned about alignment, 44% and 51%, respectively, were concerned about crowding, and 44% and 9%, respectively, were concerned about blotchiness.

Conclusions: Fluorosis was associated with increased parental dissatisfaction with overall appearance, color, and blotchiness of their children's teeth. (Pediatr Dent 2005; 27:486-492)

KEYWORDS: DENTAL FLUOROSIS, DEMARCATED OPACITIES, ESTHETIC PERCEPTIONS, MIXED DENTITION

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While average caries rates have declined in North America and other developed nations, the presence of dental fluorosis has increased.[1] Dental fluorosis prevalence has been estimated to range from about 35% to 60% in fluoridated communities and 20% to 45% in nonfluoridated communities.[2] Trends of decreasing caries rates and increasing dental fluorosis rates can be attributed to the expansion of water fluoridation, use of fluoride dentifrice, topical fluorides, and dietary fluoride supplements.[3]

Dental fluorosis generally is of esthetic concern only, but relatively few studies have assessed esthetic perceptions of dental fluorosis. These studies have used different types of research subjects (dentists, dental students, lay persons, etc) and different approaches. A few considered other types of enamel defects (isolated opacities), but most have not.[4-17] A few studies have been conducted in the United States,[4-7] Europe,[8-10] Canada,[11-15] and Australia.[16,17] Studies involving lay individuals' perceptions of fluorosis are of special interest, as public perceptions of esthetics drive demand for treatment and could, in a larger sense, drive the need to reduce fluorosis prevalence. The studies relevant to this investigation are those involving lay individuals' perceptions of their own teeth or their children's teeth and are discussed next.

Ellwood and O'Mullane[8] investigated the esthetic importance of different types of developmental enamel defects in Ireland using 2 different methods. The first used subjects from 3 different populations with varying levels of fluoride in their drinking water (<0.1 ppm, <0.7 ppm, and <0.9 ppm). Subjects were asked about their teeth, and results were compared to assessments made by a single

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examiner after looking at clinical photographs of the subjects' teeth. The second method compared dental and laypersons' opinions regarding the appearance of the dentition of individuals with different enamel defects.

With the first method, results indicated that that there was no difference with the satisfaction of appearance among the 3 different groups. Both the size of the demarcated enamel opacity and the degree of hypomineralization (fluorosis) related to the satisfaction with appearance. The second method indicated that certain types of enamel defects were ranked less favorably (hypomineralization and medium-large demarcated enamel opacities) and that dentists responded more strongly to the enamel hypomineralization than did laypersons.

Clark[12] developed and distributed a questionnaire about esthetic perceptions of fluorosis to 1,113 school-age children and their parents in British Colombia, Canada. Children, parents, and dental professionals completed a questionnaire about esthetic perceptions while viewing 35 mm slides with different classifications of the Tooth Surface Index of Fluorosis (TSIF) on the anterior maxillary teeth. They reported either "no problem" or "yes, there is a problem with the color of my child's teeth." Results showed that, as the TSIF score increased, both parents and children perceived a greater esthetic problem. Results also showed that there were some differences among the groups that rated the questionnaire; professionals generally rated esthetics more favorably than parents and parents rated esthetics better than children.

Woodward et al[13] studied 779 third-grade students in Ontario, Canada. These students were examined by 1 of 3 trained examiners for malocclusion, fluorosis, periodontal health, calculus, and dental caries. After the examination, parents were asked via telephone, "Teeth can be important to our appearance, to chewing well, and to our ability to speak clearly. Are you satisfied with the appearance of your child's teeth?" Results showed that parents' satisfaction decreased with increasing TSIF score and increasing malocclusion scores.

Lalumandier and Rozier[4] assessed parents' perceptions of dental fluorosis in Asheville, NC. Parents of 708 pediatric dentistry patients were surveyed about their satisfaction with the color of their children's teeth and factors associated with their level of satisfaction. Overall, 78% had some fluorosis on the TSIF and 43% were dissatisfied with their children's tooth color. Lalumandier and Rozier found that the greater the TSIF score, even at mild levels (eg, from 1 to 2), the more dissatisfied the parents were with their children's teeth.

Shulman et al[15] studied the esthetic perceptions of 8,281 schoolchildren in British Columbia, Canada. Dentist examiners, study children, and parents were asked to assess satisfaction with the color of the children's teeth. They were each asked to report agreement or disagreement on a 5-point scale with "the color of these teeth (my or my child's) is pleasing and looks nice." Girls were more critical of their own tooth color than were boys, and parents and dentists each were more critical of boys' tooth color than they were of girls'. Younger children were more critical than were teenagers, but the parents of younger children were less critical than were those of teenagers. It was also indicated that dentists did not associate a specific rating with the subjects' age group. Subjects with Thylstrup Fejerskov fluorosis index (TFI) scores of 1 or 2 were not evaluated more critically than were those with a TFI score of 0. Those with a TFI greater than 3, however, were scored more critically. Enamel opacities were considered in this study, but they were not significantly associated with the ratings of children, parents, or dentists.

The purpose of this study was to assess the effects of dental fluorosis and isolated opacities on esthetic concerns of parents about their children's teeth. In addition to overall perceptions, the study also looked at specific components that could be important in explaining opinions regarding esthetics.

Methods

This study involved participants in the Iowa Fluoride Study,[18] an ongoing longitudinal study of a cohort recruited at birth in 1992-1995 from postpartum units of 8 Iowa hospitals. The Iowa Fluoride Study has gathered data concerning fluoride exposures and intake[3,19] and related them to primary tooth dental caries[20] and fluorosis outcomes.[21] The recruitment process included assessing: (1) parents' ages and educational levels; (2) family income; and (3) whether the child was first born. To estimate combined fluoride intake, data have been gathered periodically via parent questionnaires concerning fluoride exposures and ingestion from: (1) water; (2) other beverages; (3) selected foods; (4) fluoride dentifrice[22]; (5) mouthrinse; and (6) dietary fluoride supplements.[23]

At age 7.7 to 11.9 years old, children had a single dental examination, and the accompanying parent completed a questionnaire to assess satisfaction with the appearance of their child's teeth. Fluorosis was scored by 1 of 2 trained, calibrated dentists using the fluorosis risk index (FRI),[24] assessing all erupted zones of all permanent incisors and first molars. The FRI divides teeth into 4 zones: (1) incisal/occlusal table; (2) incisal one third; (3) middle one third; and (4) cervical one third. Scores were evaluated as such:

1. 0–no indication of fluorosis;
2. 1–questionable fluorosis;
3. 2–50% or more of the zone displayed fluorosis;
4. 3–displayed pitting, staining, or deformity;
5. 7–nonfluoride opacity;
6. 9–the surface zone was excluded due to poor visibility/lack of full eruption.

Separate tooth-level opacity scores were used to mark teeth that had opacities, in addition to the fluorosis scoring.

Training and calibration involved an initial multiday clinical session and a formal midcycle recalibration session. Interexaminer reliability was assessed on an ongoing basis throughout the study.

The FRI index was used, and all visible zones of permanent incisors were scored. For analyses, individuals were classified into 3 different categories. Children with:

1. 2 or more teeth with at least 1 zone with a FRI score of 2 and 3 were considered to have "definitive fluorosis";
2. a FRI score of 1 or with only 1 tooth with a score of 2 or 3 were both considered to have "questionable fluorosis";
3. no scores of 1, 2, or 3 were in the "none" category.

Opacities were differentiated from fluorosis based on the criteria described by Russell.[25] Specifically, isolated opacities were considered as well-defined, demarcated opaque areas of enamel that were clearly differentiated from adjacent normal enamel, and were typically of more consistent color and opaqueness than areas of fluorosis. Fluorosis and opacities were analyzed separately with regard to esthetic perceptions.

The esthetics questionnaire, building on work by Clark et al[11,12,14] and developed from the authors' previous work,[5-7] contained 3 questions:

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 were asked to circle "yes" or "no" for each subcategory)
   a. shape;
   b. color;
   c. alignment;
   d. spacing between teeth;
   e. crowding of teeth;
   f. speckled/spotted/streaky/irregular/blotchy appearance;
   g. other (respondents were asked to specify).
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.

The demographic variables for this study included: (1) age in months at the exam; (2) gender; (3) baseline maternal education and age; (4) race; (5) family income; and (6) whether the child was first born.

Descriptive statistics were presented and Kendall's tau-b was used to assess the relationships between fluorosis status and overall parent satisfaction with appearance of the child's teeth and overall color, shape, alignment, spacing between teeth, crowding of teeth, speckled/spotty/streaky/irregular/blotchy appearance, and other esthetic concerns. Fisher's exact test was used to assess significant relationships in 2×2 tables. Factor analysis was used to generalize components of esthetic concern.

Analyses were conducted with SAS version 8,[27] and *P*-values less than .05 were considered statistically significant.

Results

Demographics were assessed as part of the recruitment process for the Iowa Fluoride Study (Table 1), showing a fairly high level of socioeconomic status. Forty-six percent of mothers were 4-year college graduates, and only 12% of families listed baseline (1992-1995) family income below $20,000. Of the 577 children examined, 37% had definitive fluorosis on 1 or more permanent incisors. At the person level, 31% were classified as having definitive fluorosis (2 or more incisors), 54% had questionable fluo-

Table 1. Demographic of the Sample (N=577)

Variable	Category	%
Child's gender	Male	49
	Female	51
Maternal age (ys)	16-24	17
	25-29	32
	30-34	32
	35-45	19
Maternal education	Did not finish high school	2
	High school diploma or GED	18
	Some college	19
	2-year college degree	16
	4-year college degree	28
	Graduate/professional school	18
Maternal race	White	98
	Minority*	2
First born	No	57
	Yes	43
Family income	<$10,000	4
	$10,000-$19,999	8
	$20,000-$29,999	16
	$30,000-$39,999	21
	$40,000-$49,999	18
	$50,000-$59,999	13
	≥$60,000	20
Incisor fluorosis†	None	15
	Questionable	54
	Definitive	31
Incisor opacity	None	78
	1 or more	22

*Four African American, 2 Asian, 6 Hispanic.
†Definitive=2 or more teeth involved (white striations on more than half of a zone or pitting/staining). Questionable=less than half of each surface zone had white striations, or that a single tooth had white striations on more than half of a surface zone. None=no pitting, staining, or white striations were found on any of the permanent incisors.

Table 2. Percentage Distribution of Parental Satisfaction in Overall Appearance by Presence of Fluorosis and Opacity Categories (N=577)

Question No. 1: satisfaction with overall appearance	Fluorosis			Opacities		Total
	None (15%)	Questionable (54%)	Definitive (31%)	None (78%)	1 or more (22%)	
Very satisfied	46	31	22	33	22	31
Somewhat satisfied	40	53	54	50	57	51
Somewhat/very dissatisfied	14	16	24	17	21	18
Kendall's tau-b	tau-b=0.148; $P<.001$			tau-b=0.082; $P=.04$		

Table 3. Percentages of Parents With Specific Concerns* by Fluorosis Category

Question No. 2: concerned about:	Fluorosis category				
	None	Questionable	Definitive	Kendall's tau-b	*P* value
Shape	4	10	11	0.055	.26
Color	40	32	50	0.117	.02
Alignment	60	55	60	0.023	.64
Spacing	55	35	39	-0.051	.30
Crowding	51	41	44	-0.015	.76
Blotchy	9	21	44	0.269	<.001
Other	6	8	8	0.009	.85

*Excludes parents who were "very satisfied" overall and did not respond to these items; N=401.

Table 4. Percentages of Parents With Specific Concerns* by Presence of Opacities

Question No. 2: concerned about:	No opacities (75%)	1 or more opacities (25%)	Kendall's tau-b	*P* value
Shape	9	12	0.049	.33
Color	38	42	0.034	.51
Alignment	58	55	-0.028	.58
Spacing	37	43	0.052	.30
Crowding	44	43	-0.006	.91
Blotchy	24	39	0.148	.004
Other	7	11	0.064	.20

*Excludes parents who were "very satisfied" overall and did not respond to these items. N=401.

rosis, and 15% had none. Interexaminer reliability was determined using repeat assessments on 39 subjects. Subject-level definitive fluorosis had 82% agreement (K=0.64).

Table 2 shows parental satisfaction with overall appearance of their children's teeth, according to the different levels of fluorosis and presence or absence of opacities. Parents' overall esthetic satisfaction decreased with higher fluorosis scores ($P<.001$). Overall satisfaction was also lower for subjects with opacities ($P=.04$). When comparing subjects having neither definitive fluorosis nor opacities with subjects having either definitive fluorosis or opacities, results were similar. Lower levels of satisfaction were found for the combined group of subjects having either definitive fluorosis or opacities (Kendall's tau-b=0.217; $P<.001$; data not shown).

Table 3 shows, among those 401 not very satisfied with the overall appearance of the children's teeth, the percentages of parents reporting concerns about 7 different aspects of esthetics by fluorosis category. There were strong associations between degree of fluorosis and concern with the categories of "color" and "blotchy" for parents not marking "very satisfied" on overall appearance. Among the parents of children with definitive fluorosis, 50% had concerns about color vs 32% for questionable and 40% for no fluorosis ($P=.02$). Similarly, 44% of the parents of children with definitive fluorosis were concerned with the blotchy appearance of their child's teeth vs 21% of those with questionable fluorosis and 9% of those with no fluorosis ($P<.001$).

Table 4 shows the percentages of parents reporting concerns about the 7 different aspects of esthetics by presence or absence of opacities. There were strong associations between opacities and concern with the category of "blotchy." Among the parents of children with opacities, 39% had concerns about blotchiness vs 24% for no opacities ($P<.001$).

Table 5 summarizes parents' satisfaction with overall color, stratified by different categories of fluorosis and presence of opacities. There was a significant relationship between the degree of fluorosis and parents' satisfaction with the overall color of their child's teeth ($P=.003$). A

greater proportion of parents were "very satisfied" with their child's overall tooth color for children having no (44%) or questionable (41%) fluorosis, compared to parents whose children had definitive fluorosis (31%). There was no significant relationship between occurrence of opacities and parents' satisfaction with the overall color of their child's teeth (P=.19). Slightly fewer parents indicated, however, that they were "very satisfied" with color when opacities were present (35%) vs not present (39%).

Table 6 summarizes parental concern with aspects contributing to overall dissatisfaction with tooth esthetics. There were significant relationships between overall dissatisfaction with appearance and the categories of alignment, spacing, and crowding. Seventy-six percent of those somewhat/very dissatisfied were concerned with alignment, 59% were concerned with crowding, 49% were concerned about spacing, and 46% were concerned about color. Principal components factor analysis (varimax rotation) showed that the 7 aspects of concern separated into 2 distinct factors:

1. The first factor comprised concerns about color (factor loading [FL]=0.713) and concerns about blotchiness (FL=0.770).
2. The second factor comprised concerns about spacing (FL=0.601), alignment (FL=0.535), and crowding (FL=0.527).

Concerns about shape and "other" concerns did not load heavily on either factor.

Discussion

This study found that parents of children with dental fluorosis were less likely to be "very satisfied" with the appearance of their children's teeth than were parents of children without fluorosis. This finding is consistent with those reported by Clark,[12] Woodward et al,[13] Lalumandier and Rozier,[4] and Shulman et al,[15] and suggests that fluorosis does contribute to esthetic concerns. Unlike the study reported by Shulman et al,[15] however, the present study also found that parents of children with isolated enamel opacities were less likely to be "very satisfied" than were parents of children with no isolated opacities. While it is not a surprising finding that isolated opacities could contribute to esthetic concerns,[8] it is unclear why the present study's findings differed from those of Shulman et al.[15] As reported by Ellwood and O'Mullane[8], the size of enamel opacities is related to satisfaction, so it is conceivable that the size of isolated opacities of some children in the present study were more prominent or larger in size than those in the previous study, so that the relationship between enamel opacities and esthetic concerns were more pronounced.

Unlike most previous studies, the present study solicited responses from parents to specific aspects of dental esthetics, including color, spacing, and alignment. The study found that fluorosis was associated with parents' concerns about tooth color, and teeth having a "blotchy" appearance, but not with other factors. Similarly, the presence of opacities was associated with parents' concerns with the teeth having a "blotchy" appearance, but not other factors. The associations between fluorosis and concerns about color are generally consistent with findings of previous studies,[4,12,15] which is not surprising given that fluorosis (as well as opacities) alter tooth color.

Perhaps a more important finding of the present study is that, in assessing parents' concerns with a variety of factors related to dental esthetics—including several not expected to be related to fluorosis—this study begins to provide some context into how the esthetic impact of fluorosis compares with the impact of other esthetic concerns. As demonstrated in Table 6, concerns with alignment,

Table 5. Percentage Distribution of Parental Satisfaction in Overall Color, by Fluorosis and Opacity Categories (N=576)

Question No. 3: satisfaction with overall color	Fluorosis			Opacities		Total
	None	Questionable	Definitive	None	1 or more	
Very satisfied	44	41	31	39	35	38
Somewhat satisfied	44	47	47	47	45	47
Somewhat/very dissatisfied	11	12	21	14	20	15
Kendall's tau-b	tau-b=0.114; P=.003			tau-b=0.052; P=.19		

Table 6. Associations Between Dissatisfaction With Overall Appearance and 7 Aspects of Possible Esthetic Concern*

Question No. 2: concerned about	Question No. 1: satisfaction with overall appearance (%)		P value (2-sided) from Fisher's exact test
	Somewhat satisfied	Somewhat/ very dissatisfied	
Shape	8	12	.25
Color	37	46	.13
Alignment	51	76	<.001
Spacing	35	49	.02
Crowding	38	59	<.001
Blotchy	26	31	.45
Other	6	12	.07

*Excludes parents who were "very satisfied" overall and who did not respond to these items;" N=401.

spacing, and crowding appeared to contribute more to parents' dissatisfaction than did concerns with tooth color or blotchy appearance. Thus, while fluorosis and opacities were associated with esthetic concerns, they could be less important to parents than other factors, specifically tooth alignment and crowding. It is important to note, however, that the age of the children could have impacted the results. Children in the study were assessed in the mixed dentition stage, which typically presents with newly erupted, well-spaced maxillary incisors, and is sometimes referred to as the "ugly duckling" stage.[26] Thus, these findings could reflect the stage of development as much as the true relative contribution of fluorosis or opacities to parents' satisfaction compared to spacing and alignment issues.

One must also be cautious in suggesting that alignment and spacing issues are more important in esthetic perceptions than fluorosis or opacities, because orofacial esthetics is very complex and affected by a wide variety of factors. For example, in addition to the color, alignment, and spacing of teeth, factors such as occlusion (eg, open bite or excessive overjet), gingival color and contour, and lip position affect the appearance of the teeth and mouth. More broadly, factors such as facial symmetry, vertical facial proportions, profile, and facial shape contribute to overall facial esthetics.[26]

Clearly, it is impossible for parents or others to assess esthetic issues involving their children without these other factors influencing their perceptions. Moreover, concerns with certain other factors could overwhelm any concerns with fluorosis or enamel opacities. Thus, esthetic concerns with fluorosis must be put into the context of overall orofacial esthetics, so that such concerns are not overstated and public policy is not unnecessarily impacted. Simply stated, in the context of other esthetic issues, the esthetic concerns associated with fluorosis probably do not warrant dramatic changes in recommendations for the use of fluorides. Much more research, however, particularly research that considers the esthetics of fluorosis in a broader context, is needed to truly assess the impact of fluorosis on orofacial esthetics.

In addition to including only children in the mixed dentition stage, the study had other limitations that could have affected results. This includes a sample of children and parents from a limited geographic area who were mostly Caucasian and of relatively high socioeconomic status (46% of mothers had 4-year college degrees). In addition, the esthetic questions were typically posed to parents while their child was in another room. Hence, parents' assessments were based on recollection rather than having the child or a photograph of the child in view, so that their esthetic perceptions could have been different than if they were able to visualize their children's teeth.

Lastly, the index used to score fluorosis (FRI) was designed to identify definitive fluorosis cases and noncases, so that relationships between severity of fluorosis and esthetic concerns were not able to be addressed.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Parents' esthetic concerns were related to the presence of dental fluorosis and to isolated enamel opacities.
2. Fluorosis was specifically associated with concerns about color and blotchy appearance, and opacities were associated with concerns about blotchy appearance.
3. Overall esthetic perceptions were significantly related to concerns about tooth alignment, spacing, and crowding.
4. Overall esthetic perceptions were not significantly related to concerns about tooth color or blotchiness.

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Abstract of the Scientific Literature

Suppression of Caries-related Microorganisms From Dentin With Chlorhexidine or Antibiotic Treatment

The purpose of this article was to investigate the short-term effect of a 1% clorhexidine- and 1% thymol-containing varnish (Cervitec, CE) and an antibiotic demeclocycline/triamcinolone-containing ointment (Ledermix, LE) on the microflora of carious dentine during a stepwise excavation procedure, compared with a control group. Thirty permanent molars and premolars were investigated. The central carious tissue was removed, leaving leathery dentin, and a sample was taken from that dentin. Next, the cavity floors of 20 teeth were covered either with CE or LE, leaving the remaining 10 as controls. The teeth were covered with a compomer. Samples were reassessed at 6 weeks, and a dentin sample was taken to determine the total viable counts and levels of mutans streptococci and lactobacilli. They found that: (1) LE produced a significant reduction of the total viable counts; (2) mutans streptococci were rarely recovered; and (3) lactobacilli were reduced in the CE and LE groups. The application of clorhexidine or a local antibiotic can reduce the number of microorganisms in the remaining carious dentin.

Comments: This study was conducted on a group of adults with permanent teeth. It would be interesting to see this method's behavior in the carious dentin of primary teeth. **JLC**

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