Association of Melanin Pigmentation in the Gingiva of Children With Parents Who Smoke

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ABSTRACT. *Objective.* The association between gingival pigmentation and active smoking has been established. This investigation is the first to address the relationship between gingival pigmentation in children and passive smoking.

Methods. A case-control study was performed involving 59 nonsmoking children who were selected from patient records of a dental clinic in a rural town in Japan. The number of subjects was based on a power calculation. Two calibrated examiners independently observed labial gingiva via oral photographs.

Results. An interview determined that 61% of children had at least 1 smoking parent. Gingival pigmentation was observed in 71% to 78% of children. Interexaminer agreement was satisfactory ($\kappa = 0.73$). Percentage of smoking parents was higher in children with gingival pigmentation (70–71%) than in those who lacked pigmentation (35%). Odds ratios of parental smoking adjusted by age and gender were 5.6 (95% confidence interval: 1.5–20.0) and 5.4 (1.4–21.2) for the 2 examiners.

Conclusion. These findings suggest that excessive pigmentation in the gingiva of children is associated with passive smoking. The visible pigmentation effect in gingiva of children could be useful in terms of parental education. *Pediatrics* 2005;116:e186–e190. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-2628; *parental smoking, melanin pigmentation, gingiva, child.*

ABBREVIATIONS. ETS, environmental tobacco smoke; OR, odds ratio; CI, confidence interval.

Brownish or black pigmentation in human gingiva has been reported in several countries. The prevalence rate of gingival pigmentation is diverse according to race and country[1–9]; hence, heredity may be a background factor. Intake of antimalarial drugs including chloroquine[10] and quinidine[11] is also associated with oral pigmentation.

Pigmentation in human gingiva derives from melanin granules, which are synthesized in melanosomes of melanocytes.[12] Melanocytes were identified as dendritic cells at the basal layer of gingival epithelium. Melanosomes, which are transferred via dendritic processes to keratinocytes by phagocytic activity, are degraded as they ascend to the surface. Melanin is synthesized from tyrosine and dihydroxyphenylalanine via dopaquinone as a result of the oxidation activity of tyrosinase.[13]

Melanin pigmentation in gingiva is correlated with active smoking: smokers displayed a greater propensity toward pigmentation than did nonsmokers.[3–7,9] A dose-response relationship with prevalence was detected.[4–7] Prevalence of pigmentation decreased in relation to the number of years after smoking cessation.[14] These findings indicate a causal association between tobacco smoke and melanin pigmentation in gingiva. Gingival pigmentation often occurred in the labial area of anterior teeth.[3,6,7,9] Excessive pigmentation in palatal mucosa as a result of tobacco smoke is a rare phenomenon, except in instances of reverse smoking.[15]

The prevalence of gingival pigmentation in smokers increased and approached maximum levels on slight exposure to smoking in minimal categories of duration of smoking and number of cigarettes smoked.[5,7] This characteristic is indicative of the sensitivity of gingival melanocytes to tobacco smoke. The prevalence of gingival pigmentation of workers was compared according to smoking status in 2 workplace locations.[7] The prevalence of pigmentation for current, former, and never smokers was 81%, 27%, and 15%, respectively, among 163 factory workers, whereas those rates among 154 office workers were 85%, 70%, and 37%, respectively. The apparent distinction in the prevalence rates of nonsmoking workers may be attributable to differences in environmental tobacco smoke (ETS) between workplace locations.

To date, few investigations have addressed the association between oral disease and exposure to ETS. On the basis of analyses of data derived from the Third National Health and Nutrition Examination Survey in the United States, the odds ratio (OR) of ETS exposure exceeding 1 hour to periodontal disease was 1.57 (95% confidence interval [CI]: 1.15–2.16)[16]; moreover, that of children who were aged 4 to 11 years and displayed serum cotinine levels of 0.2 to 10 ng/mL to untreated pediatric caries was 2.1 (95% CI: 1.5–2.9).[17] These findings suggest effects of passive smoking on oral condition. Parental smoking status was examined to estimate correlation between
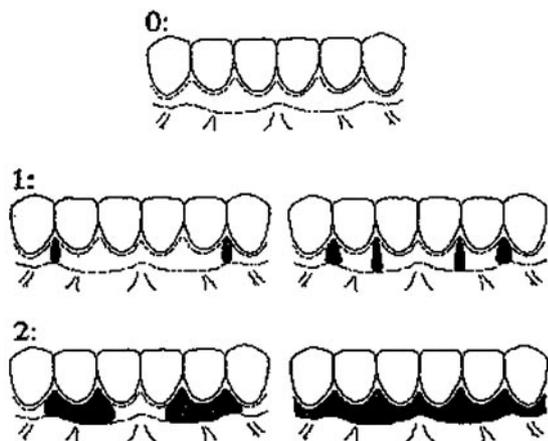
Fig 1. Classification according to extent of brownish or black pigmentation in labial gingiva of anterior teeth: 0, no pigmentation; 1, solitary unit(s) of pigmentation in papillary gingiva without extension between neighboring solitary units; and 2, formation of continuous ribbon extending from neighboring solitary units.

respiratory health and passive smoking in children.[18] The objective of the present study was to assess the relationship between melanin pigmentation in the gingiva of children and passive smoking.

METHODS

Determination of Sample Size

Preliminary documentation related to determination of sample size in the present case-control study is scarce. Furthermore, no published data pertaining to gingival pigmentation of children and parental smoking appear in the literature. Therefore, sample size was determined in accordance with the following reports: effect of active smoking on gingival pigmentation in adults[7] and the relationship between gingival pigmentation of children and their parents (Nakao Shimizu, DDS, written communication, 2002). Power analyses (Sample Power; SPSS Japan Inc, Tokyo, Japan) that were based on these reports indicated an appropriate sample size of 38 to 64 via consideration of overestimation with respect to the chance of exposure to tobacco smoke.

Subjects and Smoking Status

Oral photographs of 59 children (22 boys and 37 girls) aged 6 to 16 years (11.3 ± 2.5) were selected randomly from patient records of a private dental clinic in Yamagata, which is located in the northern region of Japan. Informed consent was obtained; subsequently, smoking status of children and parents was established via interview. Images of the frontal mouth, which were acquired in a standardized manner, were evaluated for gingival pigmentation. Oral images were obtained with a digital camera (EOS D30; Canon Inc, Tokyo, Japan) equipped with wide-angle conversion lens (C-AF1 2X TELEPLUS MC7; Kenko Co, Tokyo, Japan). Parental smoking status was recorded separately on the basis of oral photographs.

Evaluation of Melanin Pigmentation

Gingival pigmentation was assessed in the oral photographs, which were reproduced in a computer display. These reproductions exhibited size similar to that of the actual mouth. Brownish or black pigmentation in gingiva was classified according to extent of pigmentation unit in the labial aspect of anterior teeth (Fig 1). To date, no objective method for evaluation of gingival pigmentation has been developed. Gingival pigmentation was classified according to modification of melanin index categories[3]: 0, no pigmentation; 1, solitary unit(s) of pigmentation in papillary gingiva without formation of continuous ribbon between solitary units; and 2, at least 1 unit of formation of continuous ribbon extending from 2 neighboring solitary units. The current technique, which is subjective, was applied in children for the first time. Consequently, the reliability of this method was evaluated on the basis of interexaminer agreement: 2 examiners independently reviewed identical photographs. Examiners were trained and calibrated using typical photographs. Photographs in which visible pigmentation in the gingiva of children is apparent or lacking are presented in Fig 2. Gingival pigmentation of hemoglobin, melanoid, and carotene was obviously distinguishable from melanin pigmentation.[19] Several factors such as amalgam restoration adjacent to gingiva, melanoma, and long-term usage of antimalarial drugs[10,11] and minocycline[20] are potential confounders in terms of exposure to tobacco smoke; however, none of these parameters was applicable in this study. Status of parental smoking was withheld from the examiners. The current investigation was approved by the Ethics Committee of the Fukuoka Dental College.

Statistical Analysis

Interexaminer agreement was evaluated for the existence and the extent of pigmentation with the κ statistic. Additional analyses were performed using data sets that consisted of scores of gingival pigmentation assessed by the 2 examiners on the basis of parental smoking status, gender, and age. ORs of parental smoking with respect to gingival pigmentation were calculated via logistic regression analyses. Statistical analyses were conducted with software (SPSS; SPSS Japan Inc). The significance level was set at 5%.

RESULTS

No child reported active smoking. At least 1 parent of 36 (61%) children smoked. These parents smoked for 19.8 (±4.2) years on average (±SD), consuming 19.3 (±9.0) cigarettes per day. Two thirds of these parents smoked >20 cigarettes per day. Distribution of gender and age was similar between children in both parental smoking groups (Table 1). κ statistics for existence and extent of pigmentation were 0.73 and 0.68, respectively.

Gingival pigmentation was detected in 42 (71%) and 46 (78%) children by examiners A and B, respectively (Table 2). Prevalence of pigmentation was similar in boys and girls; 73% and 72% according to examiner A and 77% and 81% according to examiner B, respectively (data not shown). Solitary pigmentation was observed in 29% to 32% of the children. Continuous pigmentation, a form more distinct than solitary pigmentation, was noted in 42% to 46% of the children. Percentage of smoking parents was higher in children who displayed gingival pigmentation (70–71%) than in those who lacked pigmenta-

Fig 2. Typical photographs with (A) and without (B) visible pigmentation in the gingiva of children.

TABLE 1. Distribution of Gender and Age by Parental Smoking Status

Smoking Status of Parents	Gender, n (%)		Total	Age, Mean ± SD
	Male	Female		
Nonsmoking	9 (39)	14 (61)	23	11.4 ± 2.5
Smoking	13 (36)	23 (64)	36	11.3 ± 2.5
Total	22 (37)	37 (63)	59	11.3 ± 2.5

tion (35%). Percentage of smoking parents in children with solitary pigmentation (82%) was higher in comparison with those characterized by continuous pigmentation (64%).

Prevalence of gingival pigmentation in children with at least 1 smoking parent was 83% to 89%; in contrast, this condition was less prevalent (52–60%) in children whose parents did not smoke. Prevalence of gingival pigmentation in children was correlated significantly with smoking status of their parents (Table 3). Crude ORs of parental smoking were 4.6 (95% CI: 1.4–15.2, examiner A) and 5.1 (95% CI: 1.4–20.0, examiner B). Adjusted ORs relative to gender and age were 5.6 (95% CI: 1.5–20.0, examiner A) and 5.4 (95% CI: 1.4–21.2, examiner B).

DISCUSSION

Examiners detected gingival pigmentation in 71% to 78% of children. Percentages of parental smoking on the basis of gingival pigmentation score and ORs were similar between examiners. Interexaminer agreement for existence and extent of gingival pigmentation was satisfactory as indicated by the κ statistic. Thus, subjective evaluation of gingival pigmentation in children was sufficiently reliable so as to permit assessment of the association between gingival pigmentation in children and passive smoking.

Gingival pigmentation in Japanese children was described exclusively in an educational literature that introduced results of a survey regarding the prevalence among ~5000 children (age: 1–17 years) in metropolitan areas during 1982–1986.[21] Prevalence of gingival pigmentation increased and reached maximum levels in ~60% of children aged 1 to 6 years; moreover, prevalence continued at this level for nearly 7 years, followed by a gradual decrease to ~40% in children 17 years of age. No information related to smoking status was available; however, the value corresponding to prevalence of gingival pigmentation, which was smaller than that of the present investigation with respect to similar age group, may be attributable to differences associated with method of evaluation, eg, macroscopic versus photographic assessment. In adults, prevalence of melanin pigmentation was 15% to 37% for never smokers among Japanese workers.[7] Thus, prevalence in melanin pigmentation may differ between children and adults. Melanin pigmentation of oral mucosa was detected in 13.5% of Israeli children who were 6 to 10 years of age.[22] Melanin pigmentation varies in prevalence among different races and ethnic groups; for example, prevalence is higher in Asian populations (34.6%) in comparison with Ashkenazi (0.8%) and Sephardic (11.1%) Jews. In the present study, gingival pigmentation in the form of continuous ribbon was detected in 35% and 39% of children derived from the nonsmoking parent group. However, no comparable data exist regarding degree of pigmentation.

The significant association between parental smoking and gingival pigmentation in children suggests the presence of an ETS effect, which originated from parental smoking. No data corresponding to the exact amount of time that smoking parents and their children spent together were available. However, most parents smoked moderately or heavily; thus, their children may have been exposed to passive smoking for certain hours. In the 1999 report of the National Survey for Smoking and Health, 63.2% of Japanese were aware of the effect of ETS on asthma of children. Thus, a few parents in the smoking group may not smoke in the presence of their children. A second factor that skews the determination of the effect of ETS of parental origin is the impact of ETS from additional sources. ETS other than that of parental origin is likely to influence gingival pigmentation in the children. Passive smoking, other than that of parental origin, potentially may be similar or slightly higher in the smoking parental group than in the nonsmoking parental group. In both cases, the effect of ETS of parental origin on gingival pigmentation of children would be underestimated. National law restricting smoking in public areas went into effect in Japan on May 1, 2003.

Active smoking of participants was verified by interview. Parents or children who smoke might fail to report this activity. The smoking rate of male adults at ages corresponding to participating parents was ~60% in Japan. Because ~15% of women smoke, the smoking rate of parents (61%) was reasonable. In Japan, a national survey conducted in 1996 revealed that 0.7% of boys and 0.4% of girls at the age of ~13 years smoked. Therefore, we believe that the influence of smoking parents and children who failed to report is minimal. Future investigations that use determination of cotinine in urine[23] for validation of passive smoking in children could confirm direct association between passive smoking and gingival pigmentation. The present study suggested this relationship indirectly.

To date, a few reports appear in the literature regarding the potential sources that could stimulate melanin production in gingiva. An already high prevalence of gingival pigmentation was enhanced excessively by active smoking.[4] The stimulatory effect could be explained by high-affinity activity of polycyclic amines such as nicotine[24] and benzpyrene[25] in tobacco smoke on melanin; noxious substances in the epithelial cells were eliminated.

Two pathways by which stimulatory substances in ETS enter melanocytes in gingiva of children exist. One route involves penetration through oral mucosa; the second route is characterized by delivery via the bloodstream. Stimulatory agents of pigmentation in ETS can be introduced to saliva and might reach melanocytes through gingival epithelium. Gingival pigmentation was often observed in labial areas,[3,6,7,9] where ETS may not overlap directly. Furthermore,

TABLE 2. Distribution of Smoking Parents by Score of Melanin Pigmentation in the Gingiva of Their Children According to Observations of Two Examiners

Examiner	Score of Pigmentation*	Smoking Status of Parents, n (%)		Total
		Nonsmoking	Smoking	
A	0	11 (65)	6 (35)	17
	1	3 (18)	14 (82)	17
	2	9 (36)	16 (64)	25
	1 and 2	12 (29)	30 (71)	42
B	0	9 (65)	4 (35)	13
	1	6 (18)	13 (82)	19
	2	8 (36)	19 (64)	27
	1 and 2	14 (30)	32 (70)	46
	Total	23 (39)	36 (61)	59

* Scores of pigmentation: 0, no pigmentation; 1, solitary unit(s) of pigmentation in papillary gingiva without extension between neighboring solitary units; 2, formation of continuous ribbon extending from neighboring solitary units.

TABLE 3. OR and 95% CI of Gingival Pigmentation to Parental Smoking Status

Examiner	Smoking Status of Parents	OR (95% CI)	
		Crude	Adjusted*
A	Nonsmoking	1.0	1.0
	Smoking	4.6† (1.4–15.2)	5.6‡ (1.5–20.0)
B	Nonsmoking	1.0	1.0
	Smoking	5.1§ (1.4–20.0)	5.4‖ (1.4–21.2)

* Based on multiple logistic-regression analysis controlling for gender and age.
† $P = .013$.
‡ $P = .010$.
§ $P = .016$.
‖ $P = .015$.

the majority of ETS is aspirated through the nose. Thus, indirect stimulation by nicotine and benzpyrene in ETS of gingival pigmentation via the bloodstream may afford a more plausible explanation.

The effect of parental smoking on gingival pigmentation in children was apparent; however, because the percentage of smoking parents of children who displayed solitary pigmentation was higher than that of children who presented with the more distinct form of continuous pigmentation, the effect in terms of extent of pigmentation was not clear. Additional studies using quantitative analyses with respect to effect of ETS and gingival pigmentation could establish greater detail regarding the association between melanin pigmentation in human gingiva and passive smoking.

Gingival pigmentation might be suggestive of parental smoking; however, gingival pigmentation was frequently observed in children, although prevalence of the symptom was higher in children with smoking parents in comparison with nonsmoking counterparts. Melanocytes normally occur in the gingiva of all humans.[19] Therefore, clinicians should not use gingival pigmentation as an indicator of parental smoking. The present investigation suggested an association between excessive pigmentation in the gingiva of children and passive smoking.

The impact of graphic warning labels of cigarette packages on adult smoking behavior was demonstrated in Canada[26]: two images depicting a diseased mouth and a lung tumor were identified as most effective at discouraging smoking; furthermore, the image of the mouth was selected by more smokers, female individuals, and young adults than its counterparts.[27] Gingival pigmentation in the mouth of a child is visible to parents and practitioners; as a result, melanin pigmentation in gingiva should be introduced to lists that pertain to children's health in relation to ETS,[28] which can be used by pediatric practitioners to educate parents with respect to the dangers of ETS.

CONCLUSIONS

The oral diseases periodontitis and pediatric caries are related to passive smoking. The stimulatory effect of tobacco smoke on melanin pigmentation in gingiva was strong. This study is the first to describe the relationship between excessive pigmentation in the gingiva of children and parental smoking. This result is suggestive of the third effect of ETS exposure on oral symptoms: melanin pigmentation in gingiva of children. Future research may be necessary to confirm this finding such that the visible condition can be used in the education of parents.

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