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ORIGINAL ARTICLE

Fluorosis: Environmental Risk Factor for Periodontal Disease?

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ABSTRACT

Background: Periodontitis is multifactorial in nature. The effects of fluorosis as an environmental factor are not evaluated and researched to designate it as a risk factor similar to smoking. The primary objectives of this study were to investigate whether there is any association between fluorosis and periodontal disease and to assess salivary oxidative stress in fluorosed and nonfluorosed patients with periodontitis contributing to periodontal disease.

Aim: This is a case–control study with an aim to investigate whether fluorosis acts as a risk factor for periodontal disease and to assess salivary oxidative stress in fluorosed and nonfluorosed patients with periodontitis contributing to periodontal disease.

Materials and methods: About 295 systemically healthy patients were divided into test group (n = 154 fluorosed subjects) and control group (n = 141 nonfluorosed subjects) and assessed for their periodontal status. Clinical parameters recorded were plaque index, gingival bleeding index (GBI), and Jackson's fluorosis index to assess the degree of fluorosis, and community periodontal index was to assess the periodontal status. Biochemical analysis of saliva was done for assessment of malondialdehyde (MDA) levels, superoxide dismutase (SOD) levels, and total antioxidant (TAOC) levels.

Results: The plaque and GBI scores were found similar in fluorosed and nonfluorosed groups. Gingivitis was significantly higher in nonfluorosed than in fluorosed group; in contrast, periodontitis was significantly higher in fluorosed group than in nonfluorosed group. Gingivitis appeared to decline as the fluoride status worsened, while periodontitis showed an increasing gradient from lower fluoride score to higher fluoride score. As the degree of fluorosis increased, periodontitis also increased. The salivary antioxidant levels were found similar in both the groups.

Keywords: Community periodontal index, Dental fluorosis, Oral epidemiology, Periodontal disease, Saliva oxidative stress.

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INTRODUCTION

Periodontal diseases are chronic infectious disorders caused primarily by bacteria. The various risk factors associated with periodontal diseases are local factors, host response factors, genetic factors, systemic factors, and environmental factors.[1]

Oxidative stress is a major contributor to the pathogenesis of inflammatory diseases, such as periodontitis. Panjamurthy et al[2] stated that the disturbance in the endogenous antioxidant defense system due to overproduction of lipid peroxidation products at inflammatory sites can be related to a higher level of oxidative stress in patients with periodontitis.

Fluoride inhibits the activities of SOD levels, causing a heavy accumulation of free radicals and hydrogen peroxide resulting in damage to various cells.[3] Wang et al[4] reported a decrease in antioxidants in patients with skeletal fluorosis.

The effect of fluorosis on periodontal health and disease is scarcely discussed in the literature, and a few reports on this issue are not consistent. Epidemiological studies concerning the prevalence of periodontal disease in relation to dental fluorosis have given contradictory results. In general, a higher level of gingival inflammation has been observed in fluorosis than in nonfluorosis areas.[5,6]

Effect of fluoride on caries has been well established but the effect of fluorosis on the periodontium yet remains in shadow. The fluoride concentration of drinking water is considerably high of places in Davangere district, Karnataka, India, where the present study was conducted. The fluoride level ranges from 1.5 to 3.0 ppm in the drinking water; there is virtually no dental care and the socioeconomic status is low in remote village areas. The unique population provides us the opportunity of studying the effect of life-long exposure of fluoride in drinking water on the periodontal status of those subjects with dental fluorosis and provides evidence for long-term exposure to high-fluoride drinking water.

The primary objectives of this study were to investigate whether there is any association between fluorosis and periodontal disease and to assess salivary oxidative stress in fluorosed and nonfluorosed patients with periodontitis contributing to periodontal disease.

MATERIALS AND METHODS

This is a case–control study with an aim to investigate comparative analysis of occurrence of periodontitis in fluorosed and nonfluorosed patients. Out of 1,250 patients who visited the outpatient department of our college (from December 1, 2013 to December 1, 2014, n = 1250), 295 systemically healthy patients who are suffering reported to the clinic with bleeding gums and/or painful gums and stained teeth were studied. Fluorosed subjects with periodontitis were treated as cases, and nonfluorosed patients with periodontitis were considered as control for the study (Table 1). Fluorosed subject's selection was based on following criteria:[7,8] Each patient had (1) lived in the endemic water fluoride area for more than 10 years, (2) consumed water with fluoride levels above 1.2 ppm (Davangere water fluoride levels 0.2 to 2.41 mg/L),[9] and (3) mottled tooth enamel, indicating dental fluorosis. Subjects with other intrinsic dental stains, tetracycline stains, or any other dental developmental anomalies, enamel hypoplasia, amelogenesis imperfecta, dentinogenesis imperfecta, etc.; pregnant or lactating patients, smokers, and alcoholics were excluded from the study. Written consent was taken from all subjects, and ethical clearance was obtained from the institutional review board and according to Rajiv Gandhi University of Health Sciences, Karnataka, protocols. The following clinical parameters were recorded: Jackson's fluorosis index,[10] dichotomous index for plaque and gingival bleeding,[11] and community periodontal index.[12] The code of CPITN was interpreted for the purpose of periodontal status evaluation: Code 0 as healthy periodontal status, code 1 as gingivitis, and codes 3 and 4 as periodontitis. The treatment need was not considered. All examinations were carried out by one examiner with the aid of both a plain mouth mirror and a World Health Organization 621 periodontal probe.[12]

The passive drool method was used to collect whole mouth saliva from the oral cavity. Participants were asked to sit comfortably in an upright position and tilt their heads down slightly to pool saliva in the mouth. The first expectoration was discarded to eliminate food debris and unwanted substance contaminating the sample that may cause analytical inaccuracy. The subsequent unstimulated saliva was then collected by asking the patient to let saliva accumulate in the mouth for 2 minutes and then suction it out with a disposable syringe. It was then transfused into a sterile cuvette (2 mL) and centrifuged at 1,000 rpm for 10 minutes. The samples were then taken for immediate analysis without storage to prevent contamination. Biochemical analysis was done for assessment of MDA levels, SOD levels, and TAOC levels.

Table 1: Demographic data

	Fluorosed (cases)	*Nonfluorosed (control)*	*Total (n)*
No. of subjects	154	141	295

Statistical Analysis

Data analysis was performed using chi-square test. The statistician was also blinded. The software used for the study was Statistical Package for the Social Sciences version 17 (SPSS Inc. Released 2008. SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc.). A p-value < 0.05 was considered statistically significant.

RESULTS

The age and gender were matched. The results of the study are discussed as follows. The plaque ($p = 0.521$) and GBI scores ($p = 0.527$) were found similar in fluorosed and nonfluorosed groups (Tables 2 and 3) and gingivitis was significantly higher in nonfluorosed (34%) than in fluorosed group (27%); in contrast, periodontitis was significantly higher in fluorosed group (74%) than in nonfluorosed group (64%; $p = 0.018$; Table 4). Gingivitis appeared to decline as the fluoride status worsened, while periodontitis showed an increasing gradient from lower fluoride score to higher fluoride score. As the degree of fluorosis increased periodontitis also increased (Tables 5 and 6). The salivary antioxidant levels were found similar in both the groups (Table 7).

Table 2: The GBI scores in fluorosed and nonfluorosed groups

	Fluorosed, n (%)	*Nonfluorosed, n (%)*	*p-value*
GBI scores <50%, n = 154	74 (48%)	80 (46%)	0.527 NS
GBI score >50%, n = 141	64 (52%)	77 (55%)	

NS: Nonsignificant (p-value > 0.05); p-value ≤ 0.05: statistically significant

Table 3: Plaque scores in fluorosed and nonfluorosed groups

Groups	*Fluorosed n (%)*	*Nonfluorosed n (%)*	*p-value*
Plaque scores <50%, n = 117	57 (48.7%)	60 (51.3%)	0.521 NS
Plaque score >50%, n = 178	98 (55.5%)	80 (44.94%)	

NS: Nonsignificant (p-value > 0.05); p-value ≤ 0.05: statistically significant

Table 4: Periodontal status in fluorosed and nonfluorosed groups

CPI score	*Code 1 (gingivitis), n (%)*	*Code 2, n (%)*	*Code 3 (Periodontitis), n (%)*	*Code 4 (Periodontitis), n (%)*	*p-value*
Fluorosed (n = 154)	29 (18.8)	12 (7.8)	56 (36.4%)	57 (37.0%)	0.018 S
Nonfluorosed (n = 141)	48 (34.0%)	1 (0.7%)	41 (29.1%)	51 (36.2%)	

S: Significant (p-value > 0.05); p-value ≤ 0.05: statistically significant

Table 5: Severity of dental fluorosis (Jackson's index score) and periodontal status (incisor)

Periodontal status	*A, n (%)*	*B, n (%)*	*C, n (%)*	*D, n (%)*	*E, n (%)*	*F, n (%)*
Periodontitis	5 (16.3)	5 (14.3)	8 (27.5)	6 (27.3)	9 (42.9)	11 (47.8)
Gingivitis	25 (83.7)	30 (85.7)	21 (72.4)	16 (72.7)	12 (57.1)	12 (52.1)
Total no. of patients	30	35	29	22	21	23

Table 6: Severity of dental fluorosis (Jackson's index score) and periodontal status (molar)

Periodontal status	*A, n (%)*	*B, n (%)*	*C, n (%)*	*D, n (%)*	*E, n (%)*	*F, n (%)*
Periodontitis	11 (36.7)	23 (59)	17 (62.9)	14 (58.3)	18 (85.7)	17 (89.5)
Gingivitis	19 (63.4)	16 (42)	10 (37)	10 (41.7)	3 (14.3)	2 (10.5%)

Table 7: Antioxidant levels in fluorosed and nonfluorosed groups

Mean SD	*SOD*	*MDA*	*TAOC*
Fluorosed	11.30 ± 4.69	14.3 ± 6.25	4.32 ± 3.38
Nonfluorosed	13.28 ± 4.78	15.13 ± 5.90	4.11 ± 2.93
p-value	0.678 NS	0.947 NS	0.168 NS

SD: Standard deviation; NS: Nonsignificant (p-value > 0.05); p-value ≤ 0.05: statistically significant

DISCUSSION

Periodontal diseases are chronic infectious disorders caused primarily by bacteria. The various risk factors associated with periodontal diseases are oral hygiene level, local factors, bacterial specificity, viruses, host response factors, smoking, gender, genetic factors, osteopenia, osteoporosis, socioeconomic status, psychological factor, race/ethnicity, and geographic region.[1]

Fluoride is one of the important micronutrients in humans, which is required for strong teeth and bones. In humans, about 95% of the total body fluoride is found in bones and teeth. The World Health Organization (1984) has prescribed the range of fluoride from 0.6 to 1.5 mg/L in drinking water as suitable for human consumption. The Bureau of Indian Standards (1992) has set a required desirable range of fluoride in drinking water to be between 0.6 and 1.2 mg/L. This required fluoride is supplied to the human body usually through drinking water. Consumption of water with fluoride below or above the prescribed range is detrimental to human health. The beneficial and the detrimental effects of fluoride naturally present in water were well established by the early 1940s.[2] The water fluoride level ranges from 0.2 to 2.41 mg/L[9], in Davangere district which is known to influence the periodontal status.[5,7]

In dental fluorosis, various hard tissue effects seen are hypomineralization of enamel[13,14] and dentin, hypercementosis,[13,14] recession of alveolar crest,[15] root resorption,[16] and hypermineralization of cementum.[17] The soft tissue changes include inhibition of type I collagen synthesis, degree of cross-linking,[18] fibroblast growth inhibition,[19] lethal effects on fibroblasts,[20-22] and morphologic changes.[19]

The occurrence of periodontitis in high water fluoride areas has shown a global variation[7,10,23,24] due to involvement of multiple risk factors in its causation. The fluorosis may play as an environmental risk factor in causing periodontitis through its effects on hard and soft tissues of the periodontium. Fluoride effects on dental hard tissue causing structural malformations or mottling of enamel (dental fluorosis) have been studied extensively; however, effect of fluoride on dental soft tissues (periodontium) is underestimated. Fluoride levels are also known to influence pattern of distribution of serum protein[25] and contribute to genetic alterations inducing upregulation and downregulation of genes.[16] Its influence on matrix metalloproteinase 20 is known to contribute to dental fluorosis in rats.[15] Considering all the evidences, it can be said that fluorosis has the potential not only to influence the periodontium cytologically but molecularly as well, thereby modifying enzymatic actions as well as protein formation.

Even after continuing with the age-old structural changes that take place in mottled enamel, it can be said with scientific plausibility that this factor of surface roughness can or must influence some of the variables in this multifactorial disease of periodontitis. Surface roughness, after analyzing with atomic microscopy, was revealed to be exceedingly high in fluorosis subjects, with roughness increasing with degree of fluorosis.[26] This surface roughness is conducive for the bacteria to survive as well as make it difficult for scaling and root

planing in fluorosed teeth. This could also jeopardize the effectiveness of the regular oral hygiene procedures.

In the current study, the plaque (p = 0.521) and GBI scores (p = 0.527) were found similar in fluorosed and nonfluorosed groups and gingivitis status was significantly higher in nonfluorosed (34%) than in fluorosed (27%) groups; in contrast, periodontitis was significantly higher in fluorosed group (74%) than in nonfluorosed group (64%; p = 0.018). As the degree of fluorosis increased, periodontitis also increased.

The effect of fluorosis on periodontal health and disease is scarcely discussed in the literature, and a few reports on this issue are not consistent. Epidemiological studies concerning the prevalence of periodontal disease in relation to dental fluorosis have given contradictory results. In general, a higher level of gingival inflammation has been observed in fluorosis than in nonfluorosis areas.[27-29] Authors have reported no association between periodontal parameters and fluorosis,[30,31] increased periodontal scores,[5,7] and reduced periodontal scores.[24,32,33] Recently, a review[34,35] has discussed about various detrimental effects of fluoride on periodontal structures.

Going by molecular aspect as well, the excess of fluoride in water can not only influence the microbial flora but the influence of this (possibly) altered microbial flora on the already altered/modified oral tissues remains to be studied. Fluorosis does affect the composition of saliva as well as modifying the electrolytes[36] and the antioxidant properties in many ways. Gavriliuk et al[37] in their study pointed to dose-dependent fluoride intoxication and metabolic imbalance. This changed antioxidant capacity of saliva can influence the integrity of periodontal tissue as well but it remains scarcely studied.

A close association between chronic fluoride toxicity and increased oxidative stress has been previously reported in humans.[38] In erythrocytes of children afflicted with skeletal fluorosis, increases in MDA levels and decrease in SOD activity were reported.[39] Fluoride inhibits the activities of SOD, causing a heavy accumulation of free radicals and hydrogen peroxide resulting in damage to various cells.[3] Wang et al[4] reported a decrease in antioxidants in patients with skeletal fluorosis.

The possible role of fluoride-induced oxidative stress has to be investigated in fluorosed and nonfluorosed periodontitis patients. The comparison of the levels of SOD, TAOC, and MDA in saliva of periodontitis patients with and without dental fluorosis was done for the first time. Fluoride as an oxidizing agent and pronounced oxidative stress in fluorosed patients have been reported in the current study by measuring oxidative markers, such as MDA, SOD, TAOC, and lipid peroxidation. However, the present study could not report any statistically significant differences between the fluorosed and nonfluorosed groups (Table 7). The oxidative stress in fluorosed patients remains distinct as an enhancer of pathogenic mechanism in periodontitis. Thirdly, the genetic role of fluorosis in causation of periodontitis through its effect on collagen and bone is a recent area of research.

CONCLUSION

Considering the role of fluorosis on hard and soft periodontal tissues, oxidative stress influencing pathogenesis, gene polymorphism, and all the risk factors of periodontitis, fluorosis should be recommended strongly as an environmental risk factor for periodontitis in endemic fluorosed areas. Unfortunately, till now, the role of fluorides is extensively studied in relation to dental caries with absolutely no attention to its effect on periodontal tissues globally, although fluorosis is present as an endemic in more than 25 countries. The need of the hour is to study these fluorosed subjects from periodontal perspective using standardized criteria to ascertain, determine, and dissect the role of fluoride in periodontal disease and implement modified treatment measures in fluorosed periodontitis patients as the treatment outcomes vary between fluorosed and nonfluorosed subjects.

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