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Prevalence of Dental Fluorosis and the Role of Calcium Supplementation in its Prevention

[1]Apurva K Srivastava, [2]Aditi Singh, [2]Parul Tripathi and [1]Asha Mathur

More than hundred million people from almost 25 countries, including India, were affected by fluorosis. Thus the objective of the study was to study the prevalence of dental fluorosis in high fluoride areas around Lucknow and to evaluate the role of calcium in dental fluorosis. Water survey from different areas was done to identify high fluoride area in Unnao district of Uttar Pradesh, India. House to house survey of more than 5000 population was done. Biochemical tests were performed in 50 dental fluorotic and 50 non fluorotic randomized subjects. Clinical and biochemical status was recorded after 6 months of calcium supplementation. SPSS was used for statistical analysis. It was showed that 28.64% population had dental fluorosis (total fluorosis: 43%), highest in 13-15 years age group. After 6 months of calcium supplementation, 44% of cases showed reversal of dental fluorosis, whereas, in 40% of them disease did not progress further. Increase in serum calcium and significant decrease in urinary fluoride was observed post supplementation. This first large scale prospective community study, concluded that long term administration of calcium can reverse dental fluorosis especially in children with early grades of fluorosis.

Key words: Prospective study, endemic fluorosis, calcium supplementation, dental fluorosis, hypoplasia

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For further information about this article or if you need reprints, please contact:

Aditi Singh,
Amity Institute of Biotechnology,
Amity University Uttar Pradesh,
Lucknow Campus, Gomti Nagar
Extension, Lucknow, India

Tel:+91 9839009661

ANSInet
Asian Network for Scientific Information

[1]Department of Pathology and Microbiology, Saraswati Dental College, Lucknow, India
[2]Amity Institute of Biotechnology, Amity University Uttar Pradesh, Lucknow Campus, Lucknow, India

INTRODUCTION

Dental Fluorosis is defined as enamel hypoplasia caused by the ingestion of excess fluoride during the time of enamel formation. It is a general term for chronic fluoride poisoning[1]. The main source of fluorine is through drinking water and thus the safe limit of fluoride in drinking water has been put at 1.0 ppm[2]. Fluorosis affects almost all major systems of the body including gastrointestinal system, nervous system and reproductive system but skeletal system and teeth were most affected by this menace. Clinical dental fluorosis is often considered as an irreversible disease[3]. India lies in a geographical fluoride belt, which extends from Turkey upto China and Japan through Iraq, Iran and Afghanistan. Of the 85 million tons of fluoride deposits found on the earth's crust, nearly 12 million tons were in India[4,5]. Fluorosis is an endemic condition prevalent in 17 states of India[6]. Out of 6 lacks villages in India at least 50% have fluoride content in drinking water exceeding 1.0 ppm[7]. Though mortality by chronic fluoride exposure of more than 1.0 ppm is quite low but morbidity is high, ranging from 9.3-27.7% for skeletal fluorosis and 35.0-69.0% for dental fluorosis[8,9]. Endemic fluorosis continues to be a challenging national health problem, particularly in the states of Andhra Pradesh, Punjab, Haryana, Uttar Pradesh, Rajasthan, Gujarat, Maharashtra and Tamil Nadu[7]. It is a paradox that while fluorosis is such a challenging national problem, the use of fluoride in drinking water, toothpastes, gels etc. is still being advocated[10-15].

Calcium is an element essential for normal tooth development and maintenance. Calcium (Ca^{2+}) is a critical component of tooth enamel, dentin and the surrounding extracellular matrix. Tooth enamel is 40% calcium. Calcium also may regulate tooth formation, although the mechanisms for such action were poorly understood[16]. Thus the objective of the study was to study the prevalence of dental fluorosis in high fluoride areas around Lucknow and to evaluate the role of calcium in dental fluorosis.

MATERIALS AND METHODS

Selection of area: Drinking water samples were collected from different sources like wells, hand pumps, government water supply in twenty one different villages and cities of Lucknow, Unnao and Barabanki districts of Uttar Pradesh. Fluoride level estimation was done by fluoride ion analyzer (Expandable Ion analyzer EA 940 Orion). The study area and control were selected on the basis of fluoride content in drinking water.

Subjects: A cross-sectional survey of more than 5000 population was done in high fluoride area and a similar population was taken from low fluoride area. Door to door study was conducted. A written consent of the subjects was taken regarding their participation in the study. The residents were clinically examined by the dental specialist in broad day light, cotton rolls were used to isolate and dry the teeth and diagnostic dental instruments (mouth mirror and probe) were used to examine the teeth. The fluorosis was classified using the WHO criteria and Dean's index[17-18].

- **Normal:** Translucent, smooth enamel with a glossy appearance
- **Questionable:** Seen in endemic areas, borderline between normal and very mild.
- **Very mild:** Small opaque paper-white areas scattered irregularly over the labial and buccal surface of teeth
- **Moderate:** Entire tooth surface involved, minute pitting often present on labial and buccal surfaces, brown surface, brown stains, frequently disfiguring
- **Moderately severe:** Entire tooth surface involved marked pitting with intense brown stains
- **Severe:** Widespread deep brown or black areas, corrosion type of mottled enamel

Fifty dental fluorotic subjects from the study area were taken by random selection and supplemented by one gram elemental calcium per day. Biochemical tests viz serum calcium, serum phosphate, serum alkaline phosphatase and urine fluoride were performed pre-and post-supplementation. Fifty non fluorotic subjects from control area were taken and the above biochemical tests were performed on them also.

Questionnaire: Two structured close-ended pre-tested questionnaire were prepared to record the data having details about factors which have been identified as potential risk factors for fluorosis[19,20]. The first one had information about socio-economic status, occupation, education, source of drinking water, while the second one had details of dental fluorosis, any relevant medical/dental history, diet especially diet rich in calcium, fish intake, the use of fluoride containing tooth paste.

Statistical analysis: SPSS version 10 was used for statistical analysis. The percentage prevalence of dental fluorosis was calculated by taking the number of cases of dental fluorosis as the numerator and total population as the denominator and multiplying it by 100.

RESULTS

Fluoride in water: Water was collected from different sources (Wells, Hand pumps, Tube well, Government Water Supply) in the villages of Lucknow, Barabanki and Unnao districts. It was observed that for majority of the village population wells and hand pumps is a major source of drinking water. Fluoride level estimation was done by fluoride ion analyzer. Water fluoride level in the villages around Lucknow and Barabanki was around 1ppm, thus the villages of Barabanki were selected as control. Majority of the villages in Unnao district had mean

Table 1: Charactereristics of study sample

Variables	Value
Total population	5024
Male:Female Ratio	52:48
Well water for drinking	32%
Hand pump water for drinking	64%
Government water supply	5%
Average water fluoride level	2.32 ppm
Population affected with fluorosis	43%
Population affected with dental fluorosis	28.64%

Control group: Total population: 5121: Fluorosis: 1.99%

Table 2: Age and grade wise distribution of dental fluorosis

Age group	Total population	Questionable	%	Mild	%	Mod	%	Mod-severe	%	Severe	%	Total	%
0-5	683	27	3.95	15	2.20	0	0	1	0.15	0	0	43	6.30
6-12	914	191	20.90	121	13.23	55	8.05	7	0.77	8	0.88	382	41.79
13-15	390	124	31.79	38	9.74	63	6.89	11	2.82	5	1.28	241	61.79
16-30	1348	173	12.83	123	9.12	76	5.64	32	2.37	30	2.23	435	32.27
31-40	684	61	8.92	41	5.99	65	9.50	9	1.32	13	1.90	188	27.49
41+	1005	26	2.58	36	3.58	71	7.06	12	1.19	5	0.50	150	14.93
Total	5024	602	11.98	374	7.44	330	6.57	72	1.43	61	1.21	1439	28.64

Table 3: Effect of calcium supplementation on dental fluorosis of different grades

Grades	Total cases	Improvement	Same	Progressed
Questionable	19	10	8	1
Very mild	13	7	5	1
Moderate	10	3	4	3
Moderate-severe	6	2	1	3
Severe	2	0	2	0
Total	50	22	20	8

water fluoride level more than 1 ppm. In some, it ranged from 2-4 ppm, while Maheshkhera village of Unnao had a maximum fluoride content of 10.5 ppm in ground water. On the basis of fluoride level, 7 villages (Sersa, Marksnagar, Maheshkhera, Makur, Dharakhera, Marocha and Jarurakhera) were selected for the study. All residents in these villages were examined. A total of 5024 population in 7 villages was studied. Age and Sex wise distribution of the total population was made. Out of the total population, male:female ratio is approximately 52:48 (Table 1). A total of 5121 population was surveyed in the villages of Barabanki district taken as control.

Incidence of fluorosis: In the selected villages of Unnao and Barabanki districts, every individual was examined for fluorosis and grading done according to Dean's index. In the high fluoride villages of Unnao district, out of a population of 5024, 43% had fluorosis (dental and skeletal). Dental fluorosis was present in 1439 out of 5024 people, giving a prevalence rate of 28.64% (Table 2). Different grades of dental fluorosis were observed-questionable- 602 (11.98%), very mild- 374 (7.44%), moderate -330 (6.37%), moderately severe- 72(1.43%), Severe- 61(1.21%).

It was found that prevalence was lowest in children of 1-5 age group (6.30%) and maximum in 13-15 age groups (61.79%). After the age of 15 years the prevalence of dental fluorosis gradually declined. In the control villages of Barabanki district out of 5121 population, 102 people had dental fluorosis (1.99%).

Effect of calcium supplementation: To study the role of calcium supplementation in fluorosis, 50 dental fluorotic subjects from the study area were taken by random selection. Their clinical grading according to Dean's index was noted and biochemical tests like serum calcium, serum phosphorous, serum alkaline phosphatase and urine fluoride performed. Calcium supplementation (1 g elemental calcium per day) was given for 6 months after which their dental fluorotic grading and biochemical tests were reperformed. Similarly 50 non fluorotic subjects were taken from low fluoride area and the biochemical tests were done on them as well. It was observed that out of these 50 dental fluorotic subjects 20 showed no progression of the disease while it was significant to note that 22 patients showed actual reversal of clinical dental fluorosis after 6 months of calcium supplementation. In only 8 patients the disease progressed (Table 3).

The pre-and post-supplementation values of biochemical parameters of the 50 dental fluorotic supplemented with calcium and 50 controls were given in Table 4. Serum calcium was low while urinary fluoride level was very high before supplementation. Post-treatment serum calcium improved and the level of urinary fluoride fell significantly. However, in some patients serum alkaline phosphatase level was increased after supplementation.

The biochemical reports of the 50 control individuals taken from low fluoride area showed that their serum calcium was higher and serum phosphate, serum alkaline phosphatase and urinary fluoride was significantly lower than those from high fluoride area (Table 4).

DISCUSSION

The incidence of fluorosis (both dental and skeletal) in the present study was 43%, of these 28.64% had dental fluorosis. In a previous study of villages around Varanasi in Uttar Pradesh found a prevalence of 24.91%[21]. In Alappuzha district of Kerala an overall prevalence of 35.6% has been reported[9]. In 3 districts of Hyderabad where fluoride content in well water ranged from below 1-5 ppm, chalkiness of teeth in 16% and mottled and pitted teeth in 21.7% of the population

Table 4: Biochemical parameters pre-and post-calcium supplementation

	Study area (F>1 ppm)		
	Pre-supplementation	Post-supplementation	Control (F<1ppm)
Serum calcium			
Normal value 9-11 mg dL^{-1})	8.8 ± 0.7	9.6 ± 0.6	9.2 ± 1.0
Serum phosphate			
(Normal value 3-4.5 mg dL^{-1})	4.2 ± 0.8	4.1 ± 0.6	3.7 ± 0.8
Serum Alk Phosphate			
(Normal value < 270 U L^{-1})	394.2 ± 239.3	486.8 ± 284.8	234 ± 114.2
Urine fluoride			
(Normal value < 1 ppm)	6.2 ± 2.9	3.9 ± 2.4	0.7 ± 0.2

Values are represented as Mean±SD

was observed[22]. Prevalence of dental fluorosis was lowest in children of 0-5 years and it gradually increased with age upto 15 years after which it gradually declined. It was highest between 13-15 years of age. This result is in confirmation with data of many previous studies[21-23]. Some studies, however observed that dental fluorosis was more in persons above 15 years of age than amongst those below 15 years[24]. There has been a slight predilection of dental fluorosis in males than females. In one more related study a higher predilection amongst girls than boys were found whereas some observed that both the sexes were equally affected[9,25,26]. However, other reports indicate dental fluorosis is higher amongst males than females and this may be due to higher physical activity by males and hence higher consumption of water (hence fluoride)[22,27]. Also female population above 18 years of age comprise mainly of women, who have immigrated from other villages after marriage, which may not have been endemic for fluorosis.

In this study a positive association of prevalence rates of dental fluorosis with the level of fluoride in drinking water was observed as has been observed by several workers and indicates that the most important factor which determines fluoride toxicity is the concentration of fluoride in drinking water[22,23,25]. Some researchers had identified and demonstrated in experimental animals the major risk factors, which include use of fluoridated drinking water, fluoride supplements, fluoridated toothpastes, gels etc[28]. It was interesting to note that even in villages endemic for fluorosis, people continue to use fluoridated toothpastes, gels, mouthwashes. Fluoride is being indiscriminately used for caries prevention. It was important that the use of external fluoride sources should be limited to areas where the level of fluoride in drinking water is low (<1ppm).

This study showed that fluorosis both dental and skeletal, affects the population. While majority of the population in the study villages was completely or partially edentulous, fluoride is one of the main causes of loss of teeth. Edentulous people suffer nutritionally, being unable to chew, difficulty in speaking and also their face appearance (esthetics) is compromised. While in younger population it causes psychological trauma due to tooth discoloration and destruction. Skeletal fluorosis caused diffuse pain, deformity and even crippling. A number of methods were earlier suggested in fluorosis prevention. Defluoridation methods have been advocated by Teotia and Teotia[7], Teotia *et al*.[29], which use chemicals to remove fluoride from water. However, it was seen that these plants involve high recurring cost on chemicals and maintenance of plants and also the water treated by these plants contain trace elements like magnesium and aluminum, which on long term human consumption may prove harmful. Drilling of deep bore wells and hand pumps was also suggested[3]. Results showed that families using water from deep bore wells and hand pumps were less prone to fluorosis. However, cost effectiveness is a major hurdle in implementing this method for the whole population. It was interesting to note that a village under this study, Maheshkhera, having very high fluoride content had a lesser fluorosis incidence as compared to others[30].

It was said that fluorosis is an irreversible disease with no known treatment[31]. It has been claimed that with a standardized early diagnosis, elimination of fluoride intake and supplementation of a diet rich in essential nutrients and antioxidants, fluorosis can be reversed[31]. Another study claimed that fluorosis can be reversed, at least in children, by a therapeutic regimen that is combination of calcium, vitamin D3 and ascorbic acid supplementation in fluorosis-affected children[32].

CONCLUSION

The present work was one of the longest reported study, which showed that exclusive calcium supplementation over a period of more than six months, causes prevention and reversal of dental fluorosis. In this study 40% of the patients showed no progression of the disease, while 44% of them who were in very early stages of fluorosis showed actual reversal in clinical dental fluorosis. This suggests that calcium had a definitive role in prevention of fluorosis and may also caused reversal of fluorosis in very early stages. Calcium may protect tooth against damage from high fluoride intake and reduces dental fluorosis. With increase in prevalence of dental fluorosis, calcium proved as a cheap and effective method for prevention and treatment of dental fluorosis.

SIGNIFICANCE STATEMENTS

This study discovers the role of calcium supplementation in dental fluorotic subjects that can be beneficial for the

population exposed to high fluoride levels in drinking water. This study will help the researcher to uncover the critical areas of dental fluorosis and its reversal that many researchers were not able to explore. Thus a new theory on calcium supplementation and fluorosis may be arrived at.

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