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Prospective Role of Calcium Supplementation in Prevention of Fluorosis: A Study in Some North Indian Villages

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Abstract

More than a hundred million people from almost twenty-five countries, including India, are affected by fluorosis. An assessment of fluoride in water, a prospective study of dental fluorosis and the role of calcium in preventing or ameliorating dental fluorosis through a long-term community study in endemic high fluoride area in Northern India was done. Water survey from different areas was done to identify high fluoride area in Unnao district of Uttar Pradesh, India. House to house survey of a population of almost 5000 people was done. Biochemical tests were performed in 50 dental fluorotic and 50 non-fluorotic randomized subjects. Clinical and biochemical status was recorded after six months of calcium supplementation. Our results have shown that 28.64% population had dental fluorosis (total fluorosis: 43%), the highest in 13-15 years age group. After six months of calcium supplementation, 44% of cases showed reversal of dental fluorosis, whereas in 40% of them disease did not progress further. An increase in serum calcium and a significant decrease in urinary fluoride was observed post supplementation. In this first large-scale prospective community study of its kind, it is demonstrated that long-term administration of calcium can reverse dental fluorosis especially in children with early grades of fluorosis. Calcium may protect tooth against damage from high fluoride intake and reduces dental fluorosis. With the increase in the prevalence of dental fluorosis, calcium can prove a cheap and effective method for the prevention and treatment of dental fluorosis.

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1. 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 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 the gastrointestinal system, nervous system and reproductive system but the skeletal system and teeth are 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 up to 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 are in India[4,5]. Fluorosis is an endemic condition prevalent in 17 states of India[6]. Out of 6 six 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% to 27.7% for skeletal fluorosis and 35.0% to 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 are 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.

2. Materials and Methods

2.1 Selection of Area

Drinking water samples were collected from different sources like wells, hand pumps, government water supply in 21 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.

2.2 Subjects

A cross-sectional survey of more than 5000 population was done in high fluoride areas and a similar population was taken from low fluoride areas. Door to door study was conducted. Written consent of the subjects was taken regarding their participation in the study. The residents were clinically examined by the dental specialist in broad daylight, 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].

- Normal – Translucent, smooth enamel with a glossy appearance.
- Questionable - Seen in endemic areas, the 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[18]. (Shelcal/Gemcal/Cipcal 500mg tablets BD) Biochemical tests viz serum calcium, serum phosphate, serum alkaline Phosphatase, and urine fluoride were performed pre and post-supplementation. Fifty non-fluorotic subjects from the control area were taken and the above biochemical tests were performed on them also.

2.3 Questionnaire

Two structured close-ended pre-tested questionnaires were prepared to record the data having details about

factors thathave 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 toothpaste.

2.4 Data Analysis

We used SPSS PC version 10 for our 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.

3. Results

3.1 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 the 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. The majority of the villages in Unnao district had mean 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 groundwater. On the basis of fluoride level, seven 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 seven 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.

3.2 Incidence of Fluorosis

In the selected villages of Unnao and Barabanki districts, every individual was examined for fluorosis & 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%).

Table 1. Characteristics of the study sample

Variable	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	QUE.	%	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

3.3 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 were performed. Calcium supplementation (one gram elemental calcium per day) was given for six 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 are 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

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

Table 4. Biochemical parameters pre and post calcium supplementation

	Study Area (F>1ppm)		Control (F<1ppm)
	Pre supplementation	**Post supplementation**	
Serum Calcium (Normal value 9-11 mg/dl)	8.8 ± 0.7	9.6 ± 0.6	9.2 ± 1.0
Serum Phosphate (Normal value 3-4.5 mg/dl)	4.2 ± 0.8	4.1 ± 0.6	3.7 ± 0.8
Serum Alk Phosphate (Normal value <270 U/L)	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

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 were significantly lower than those from high fluoride area (Table 4).

4. Discussion and Conclusion

The incidence of fluorosis (both dental and skeletal) in the present study was 43%, of these 28.64% had dental fluorosis. Ray *et al.* in their study in villages around Varanasi in Uttar Pradesh found a prevalence of 24.91%[21]. Gopalakrishnan and his coworkers in the Alappuzha district of Kerala reported an overall prevalence of 35.6%[22]. Daver in his study in 3 districts of Hyderabad where fluoride content in well water ranged from below 1ppm to 5ppm, observed chalkiness of teeth in 16% and mottled and pitted teeth in 21.7% of the population[23]. Prevalence of dental fluorosis was lowest in children of 0-5 years and it gradually increased with age up to 15 years after which it gradually declined. It was highest between 13-15 years of age. This result is in confirmation with data of Ray *et al.,*[21], Singh *et al.,*[24] and Daver[23] . Bagga and Mehta[25] however observed that dental fluorosis was more in persons above 15 years of age than amongst those below 15 years. We found a slight predilection of dental fluorosis in males than females. Gopalakrishnan *et al.,*[22] found a higher predilection amongst girls than boys. Siddiqui[26,27] observed that both the sexes were equally affected. However other reports[23,28] 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). Also female population above 18 years of age comprises mainly of women who have immigrated from other villages after marriage, which may not have been endemic for fluorosis.

In our 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[23,24,26]. Everett *et al.* identified and demonstrated in experimental animals the major risk factors, which include use of fluoridated drinking water, fluoride supplements, fluoridated toothpastes, gels etc.[29]. 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 is important that the use of external fluoride sources should be limited to areas where the level of fluoride in drinking water is low (<1ppm).

We observed that fluorosis both dental and skeletal affects the population. While the 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 the younger population it causes psychological trauma due

to tooth discoloration and destruction. Skeletal fluorosis causes diffuse pain, deformity and even crippling. A number of methods have been earlier suggested in fluorosis prevention. Defluoridation methods have been advocated by Teotia and his coworkers[7,30], which use chemicals to remove fluoride from water. However, it is 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 has been suggested[31]. We have also observed that families using water from deep bore wells and hand pumps are 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 our study, Maheshkhera, having very high fluoride content had a lesser fluorosis incidence as compared to others[32] .

It has been said that fluorosis is an irreversible disease with no known treatment. Sushila *et al*., 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[33]. Gupta *et al*., claimed that fluorosis can be reversed, at least in children, by a therapeutic regimen that is a combination of calcium, vitamin D3 and ascorbic acid supplementation in fluorosis-affected children[18].

The presently reported study is one of the longest, which shows that exclusive calcium supplementation over a period of more than six months, causes prevention and reversal of dental fluorosis. In the study, we observed that 40% of the patients showed no progression of the disease, while 44% of them who were in very early stages of fluorosis showed an actual reversal in clinical dental fluorosis. This suggests that calcium has a definitive role in the prevention of fluorosis and may also cause a reversal of fluorosis in very early stages.

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