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## A Reversal of Bony Deformities Due to Fluorosis among Children and Young Adults in Central India

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### ABSTRACT

*The prolonged intake of water containing excess fluoride may results in the medical condition known as fluorosis. Fluorosis affects multiple organs and systems of the body and results in various clinical manifestations starting from damaged and discoloured teeth to crippling condition. A cross sectional intervention study was carried out during the period of 1997 to 2003 in Mandla district of Madhya Pradesh. The main objective of the study was to assess an impact of successful intervention through supply of safe drinking water, therapeutical supplementation of calcium, vitamin c and D<sub>3</sub> and dietary modification. One village namely Tilapani was purposely selected for the study on the basis of base line data collected in year 1995. Total 72 children and young adults from 32 households, who was having sing and symptoms of fluorosis was covered for the study. To see the difference between pre & post intervention Chi-square tests was applied. There is significant ( $p < 0.05$ ) reduction in genuvalgum 58% to 18.6% was observed after intervention. Knock knee and bowing of lower limbs, which were seen in 1996, disappeared in 2003. Complete reversals of bowing among mild cases were seen. Very few reports are available regarding reversibility of bone deformities. Therefore these findings will be very important and useful for any further intervention study regarding fluorosis mitigation.*

**Key word:** fluorosis, fluoride, Nutrition, Intervention, Genuvalgum.

## INTRODUCTION

The prolonged intake of water containing excess fluoride may result in the Medical condition known as fluorosis. Fluorosis affects in various clinical manifestations starting from damaged and discolored teeth's to crippling condition<sup>1</sup>. Madhya Pradesh is one of the largest states located in central India with a population of over 72 million<sup>2</sup> and most of districts have excess fluoride in ground water<sup>3</sup>. In 1995 an epidemiological study was carried out in one of the most affected village namely Tilaipani of Mandla district. The prevalence of Genuvalgum was 58% and Dental mottling was 84% among <20 years of age group. The skeletal deformity was much more severe among school going children. Apart from Genuvalgum, severe anterior bowing and Flattening of Tibia and Fibula were also evident. A few X-rays showed Juxta articular bone resorption of metacarpals and phalanges. The water fluoride level was ranging from 9.2 ppm to 10.8 ppm. About 40.8% urine sample had > 2ppm urine fluoride levels<sup>3</sup>. The intake of dietary calcium and Vitamin C was much lower than recommended levels. The majority of the affected population belonged to tribals. They are traditionally, economically and nutritionally more vulnerable than other social group. It might be one to the cause of severity of the disease in same village.

Considering these results a subsequent intervention study was under taken in one village namely Tilaipani of Mandla district by Regional Medical Research Centre for Tribals Jabalpur with support from Government of Madhya Pradesh, Rajiv Gandhi National Drinking Water Mission New Delhi, between 1997 to 2003. The main focus of the

study was to ensure adequate amount of Calcium, Vitamin C, Vitamin D<sub>3</sub> and Iron, provided to fluorosis affected children along with safe drinking water and dietary modification through easily available local food staff, rich in these micronutrients. After the intervention we carried out resurvey in same village and same children & young adults. This paper presents the finding of five years successful intervention and follow-up regarding the reversal of bony deformities.

There are very few studies available regarding reversibility of bony deformities. Therefore these findings will be very useful for any further intervention study regarding fluorosis mitigation.

## METHODOLOGY

### Study Design:

A cross sectional intervention study was carried out during 1996 to 2003 in Mandla district of Madhya Pradesh. One of the most affected village namely Tilaipani was purposely selected for the study, on the basis of base line data collected in the April 1995. Total 72 Children and young adults <20 years from 32 Households, who was having sing and symptoms of fluorosis were selected for the study. Medical Officer, Biochemist, Nutritionist, Medical Social Worker were involved during the entire study using standard equipments and procedure.

### Data Collection:

During the pre & post intervention periods a complete clinical examination was done by Medical officer. All drinking water sources were tested and their respective fluoride concentrations were determined. Spot urine sample of those showing

skeletal abnormalities were analyzed for fluoride estimation using an ION Selective electrode (ISE) meter. X-ray was done in government district Hospital Mandla of the affected children and young adults. Diet survey was conducted using the 24-hours recall methods<sup>4</sup>. Data was collected from women who cook and serve foods to household's members.

### Data Analysis

Data was entered into a specially developed programme using MS Access software. Double data entries were done as a procedure to check for data entry errors. Using SPSS windows version 11.0 univariate analyses was undertaken to determine the prevalence of fluorosis in different age group. A cross tabulation was performed to determine any association of pre & post intervention. Chi-square test was used to assess the statistical significance between pre and post intervention. The average daily intake of food were computed and compared with pre-intervention data<sup>5</sup>. The average daily intakes on nutrients were calculated using food composition tables and compared with the recommended daily allowances for Indians<sup>6</sup>.

### Intervention Measures:

On the basis of baseline data which was collected in the April 1995 the findings of the study were communicated to the Rajiv Gandhi Drinking Water Mission, Govt. of India, Ministry of Rural Development and Govt. of Madhya Pradesh for fluorosis mitigation of the affected village. Recommendations given to Govt. of Madhya Pradesh are: close all contaminated hand-pumps

immediately. Provide safe drinking water to community in affected villages. Provide therapeutically tablet Calcium 500 mg, Vitamin C 500mg, Vitamin D<sub>3</sub> 800 IU, Iron 100mg daily for 3 to 6 month and initiate ICDS activities for nutritional supplementation and health education in the village as this village was not covered at that time under ICDS scheme being an urban village.

The Government of Madhya Pradesh accepted our recommendations in year 1996 and started intervention programme with the help of Rajiv Gandhi Drinking Water Mission, under the supervision of Regional Medical Research Centre for Tribals in village Tilaipani.

Public Health Engineering Department (PHED) closed all contaminated water sources and started pipe water supply (fluoride level<1ppm). Through government district hospital tablet Calcium, Vitamin C, Vitamin D<sub>3</sub> and Iron were supplied for 3-6 month to all affected individuals. Department of women and child development started ICDS activities (Open Aganwadi Centre in the same village) and also started supplementary food programme along with nutritional and health education.

During the intervention period of about 5 years we frequently visited this village and organized several group meetings with the women to create awareness and also verify the nutrition intervention undertaken by the villagers. On each visit instruction was reinforced by RMRCT staffs and explained to the community regarding the importance of safe drinking water and nutrition supplementation for mitigation of fluoride toxicity.

**RESULTS**

The overall prevalence of Genuvalgum (knock - knee) was 58% at base line which significantly ( $\chi^2$ -24.74, OR 6.351, p< 0.001) reduced to 18.6% after intervention. The prevalence of dental mottling among children and young adults under the age of <20 years was 84% in base line which significantly ( $\chi^2$ -4.02, OR 2.221, p<0.05) reduced to 70.8% after intervention. Males were more affected than Females (Table -1). At the end of the study, no new case was reported in same village.

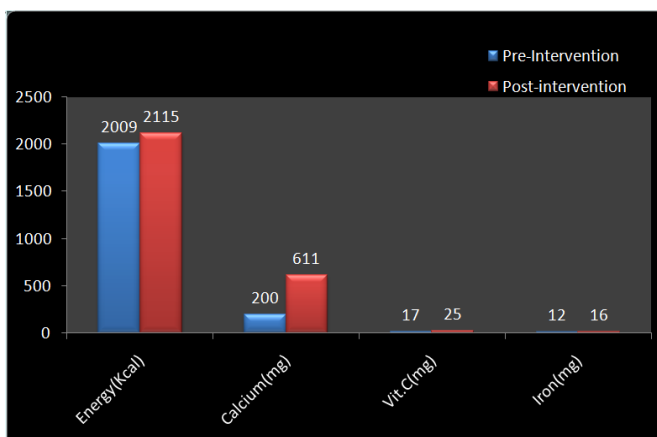
**Table 1- Prevalence of Genuvalgum and Dental Mottling before and after intervention, among children and young adults <20 Years of Tilaipani village, Mandla district of Madhya Pradesh**

Variable	Pre-Intervention		Post-Intervention	
	Genu valgum	Dental fluorosis	Genu valgum	Dental fluorosis
Male (45)	29 (64.0)	40 (88.9)	9 (20.0)	34 (75.5)
Female (27)	13 (48.0)	21 (77.8)	4 (14.8)	17 (62.9)
Total (72)	42 (58.0)*	61 (84.0)**	13 (18.6)*	51 (70.8)**

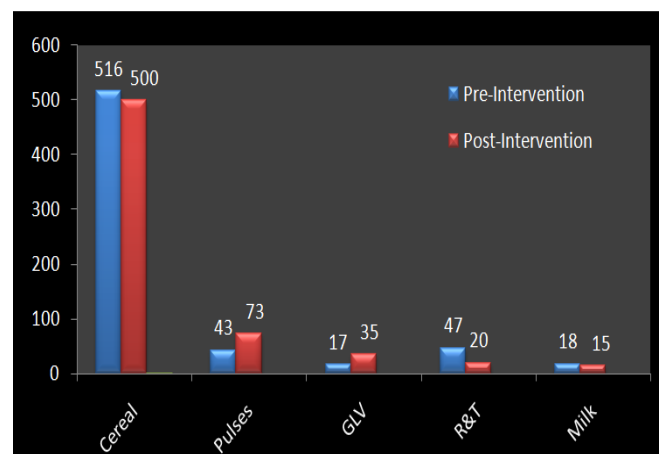
\* $\chi^2$  =24.74, OR-6.351, p< 0.001

\*\* $\chi^2$  =4.02, OR-2.221, p< 0.05

**Figure 1- Average Nutrient intake of fluorosis affected households at Pre-intervention and Post-intervention n=22**



**Figure 2- Average foodstuff intake of fluorosis affected households at Pre-intervention and Post-intervention n=22**



GLV-- Green Leafy Vegetable R& T—Root & Tubers

Photo of severe form of skeletal fluorosis (Genuvalgum and Genuvarum) among Children of Mandla district (Year1995)



The reversal of skeletal Deformity after Intervention

1995 Pre Intervention

2003 Post Intervention



After the Recommendation of RMRCT Government of Madhya Pradesh

Launched safe drinking water supply and ICDS Activity1



Dismantled hand pump

Launched safe drinking water supply and ICDS Activity2

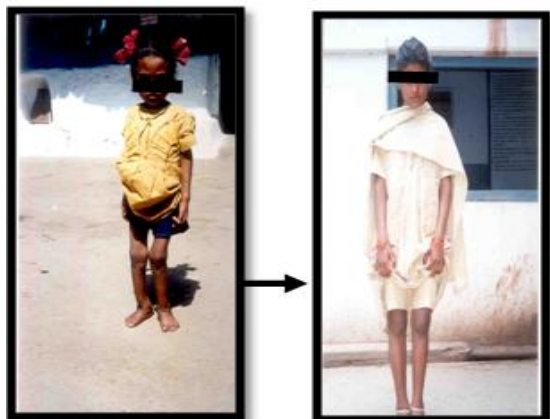


Safe drinking water supply

**Impact of intervention on clinical parameters of knock-knee**

1995 Pre Intervention

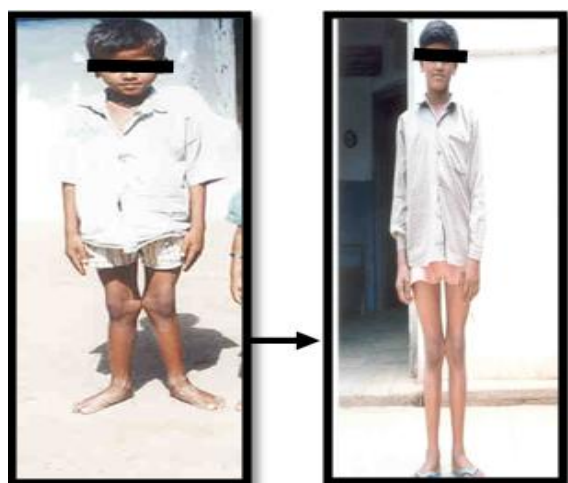
2003 post Intervention



**Impact of intervention on clinical and radiological parameters of Bow leg**

1995 Pre Intervention

2003 Post intervention



The bowing of lower limbs, which were seen in 1996, disappeared in 2003. There was a complete reversal of bowing among mild cases and partial reversal in severe cases. Radiological features like coarse trabecular pattern. Multiple growth arrest line, thickening of cortex which was present in most of the cases at base line was not seen in the present series of X-rays of the same individuals. Mild form of bowing of tibia & fibula which were seen in many cases were totally corrected after intervention. Even the severe case of bending, Bony exostosis, which is considered to be one of the severe forms of

skeletal fluorosis, was seen in few cases at baseline. In the present series of X-rays of the same children no bony exostosis was seen. Drinking water fluoride level ranged from 9.2 to 10.8 ppm at base line. After dismantled of all contaminated hand-pumps safe drinking water (Fluoride Free <1ppm) was provided by PHED. About 41% spot urine samples had acceptable (<2ppm) levels of fluoride in 1996. This proportion increased to 91% in 2003.

The Average dietary intake of Protein, Calories, Calcium and Iron was less than the recommended level. Due to cereal based diet the consumption of cereals and pulses were higher than recommended level, while protective food staff such as green leafy vegetable, sugar and jaggery, milk and milk products oil & fat was below the Recommended Dietary Allowance (Figure -1). However the intake of micronutrient like Iron, Calcium, Vitamin C, increased after intervention especially after dietary modification. This is mainly due to increased intake of green leafy vegetables, locally available green leaf called Chakoda Bhaji (Cassia Tora) (Figure -2). The intake of milk was grossly inadequate during pre & post intervention period.

## DISCUSSION & CONCLUSION

Dental mottling is a developmental disturbance of dental enamel, caused by excessive exposures to high concentrations of fluoride during tooth development leading to enamel with lower mineral content and increased porosity<sup>7</sup>. It is visible by the discoloration of the teeth from white to yellow, brown to black away from the gum margin to the edge of the tooth. Hence dental mottling is considered to be irreversible. However we observed

that even dental mottling could be reversible to some extent especially in terms of its severity. Genuvalgum (knock-knee) and Genuvarum (Bow leg) due to fluorosis is caused by continuous weight bearing on a weak bone (Tibia and Fibula)<sup>8</sup>.

Most of the literature states that that skeletal fluorosis is a non reversible phenomenon<sup>9</sup>. There are very few studies indicated that skeletal fluorosis can be reversible<sup>10, 11, 12, 13</sup>. Gupta et al<sup>11</sup> reported fluorosis is reversible in children after supplementation of Calcium, Vitamin C and Vitamin D<sub>3</sub>. However his study was not supported with radiological evidence of reversibility. Other reports<sup>10, 12, 13</sup> of reversibility is mainly based on the laboratory data like Serum calcium level, Serum fluoride level etc in few cases. But in our study reversibility is being reported based on clinical, biochemical and radiological parameters. There was complete reversal in mild and moderate cases of skeletal fluorosis and partial reversal of severe deformities. We treated with 500mg ascorbic acid in two equally divided doses, 500mg calcium, Iron 100mg and Vitamin D<sub>3</sub> 800 IU per day for 3 to 6 months depending upon the clinical severity of the cases. PHED provided safe drinking water with fluoride <1ppm; department of women and child development provided health and nutritional education along with RMRCT. This also shows the inter-sectoral collaboration between PHED, State Health Services, Women and Child development along with a Research Institute i.e. our institute which is essential for any fluorosis mitigation programme.

Mandla is a tribal district and diet pattern of people was different as compared to other rural areas. Diet

survey shows that milk intake was much lower than recommended level. Milk is like a hard cash for them. They were selling all milk to nearby market and purchasing the other staple food items like wheat, rice etc required for the family members. They do not give milk to their children. Since milk is one of the main sources of calcium, reduced intake of it caused severe calcium deficiency which might have aggravated the severity of diseases in these particular children. During the survey we found that one of the green leafy vegetable namely Fetid Cassia, (botanical name Cassia Tora) and locally called Chakoda Bhaji are rich with Calcium (520mg/100gram fresh leaves, 3200mg /100gram dry leaves), Vitamin C (82mg/100gm fresh leaves), Iron (12.4mg/100gm fresh leaves) [source-nutritive value of Indian food's National Institute of Nutrition Hyderabad India] was available in same village and people were consuming occasionally. All these three micronutrients are essential for bone mineralization. We just advocated the community to increase the consumption of these leaves. At base line villagers were using these leaves once in a week or fortnightly. We could increase its use 3-4 times in week after the intervention. We did not introduce the leaves to them. They were traditionally using it for generations. We only diversified their diet pattern to include it in their routine diet. This had a great impact on the long run as Genuvalgum significantly reduced from 58% to 18.6% among same children. Though it is very difficult to conclude whether therapeutic supplementation alone has worked or withdrawal of fluoridated water had better impact, we conclude that that it is the comprehensive management of all

three component, i.e. (a) withdrawal of fluoride contaminated water (b) therapeutic supplementation of micronutrients like calcium, vitamin C and Vitamin D<sub>3</sub> and Iron and (c) dietary diversification of micronutrient diet which resulted in reversal. Initial therapeutic supplementation of calcium and vitamin C has definitely enhanced the elimination of accumulated fluoride from the body through urine and stool<sup>14,15</sup> as Calcium supplementation interferes with fluoride absorption in humans, presumably due to the strong affinity between Ca<sup>++</sup> and fluoride and the low solubility of CaF<sub>2</sub>. Subsequent inclusion of micronutrient rich food stuff like cassia tora might have helped in remodeling the bones to the extent of normal or near normal.

These findings were disseminated in various National and International forum. UNICEF Madhya Pradesh implemented the same intervention model in Dhar and Jhabua district of Madhya-Pradesh through NGO in the year 2006-07, with technical guidance from Regional Medical Research Centre for Tribals Jabalpur. After one year intervention they also reported about 30% reduction of fluorosis cases (personal communication).

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**Conflict of interests:**

The authors declare that there is no conflict of interests regarding publication of this paper.

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