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Relation between water and salivary fluoride levels among children residing in communities having different naturally occuring water fluoride levels in Andhra Pradesh, India

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Abstract
A precise definition of the amount at which fluoride affects both dental caries and dental fluorosis will help to promote more judicious use of fluoride in caries prevention. The aim of this study was to assess the relation between water fluoride level and salivary fluoride level in 12-year old school children residing in various communities having different naturally occuring water fluoride levels in Andhra Pradesh, India. A cross sectional study was carried out among 116 school children from three different communities having 1, 4, and 11 ppm of water fluoride level at Prakasam District, Andhra Pradesh, India. Preliminary data was collected by using a questionnaire, Type–II clinical examination to assess dental caries and dental fluorosis, and paraffin stimulated whole saliva was collected for laboratory analysis of salivary fluoride level. The mean salivary fluoride levels are 7.4 ± 2.25, 3.73 ± 1.17, and 2.83 ± 1.08 μmol for 11, 4, and 1 ppm water fluoride community which are statistically significant ($p < 0.000$)***. There was significant difference among the severity of dental fluorosis with increase of water fluoride level and no significant difference in prevalence of dental caries. It is concluded that as the salivary fluoride level is directly proportional to water fluoride level, but it has no effect on the prevalence of dental caries.

Keywords: Dental caries; salivary fluoride level; water fluoride level.

Introduction

Over the past few decades, a substantial decline in dental caries has occurred and the widespread use of fluoride has been postulated as the major reason for decline in dental caries (Selwitz *et al.*, 1998). Fluoride in drinking water prevent dental caries but excessive ingestion during the period of tooth mineralization causes dental fluorosis (Narbutaité *et al.*, 2007). It was known that individuals living in fluoridated area have a lower incidence of dental caries than those living in a non-fluoridated area (Twetman *et al.*, 1990). Beginning in the 1980s, growing concern has been voiced regarding the effect on dental fluorosis of increased consumption of fluoride from a number of sources in both fluoridated and non-fluoridated communities. Although dental fluorosis remains more prevalent in fluoridated than non-fluoridated communities, but it has increased proportionally more in non-fluoridated than fluoridated communities over the past five or six decades (Selwitz *et al.*, 1998).

The relationship between the fluoride concentration in drinking water and the development of dental fluorosis was first described by Dean. Previous studies among 12-year old children in Japan (Tsutsui *et al.*, 2000), China (Ruan *et al.*, 2005), and USA (Heller *et al.*, 1997) have confirmed a higher prevalence and severity of dental fluorosis and lower prevalence of dental caries in children residing in areas with high fluoride content in drinking water than for children in low fluoride areas. However, contrary findings with higher prevalence's of both dental caries and dental fluorosis had been reported for high fluoride areas in Sudan (Ibrahim *et al.*, 1997), and Ethiopia (Wondwossen *et al.*, 2004).

Over the past few decades understanding regarding the mechanism of fluoride action has been improved. Now it is agreed that fluoride available in the oral cavity in the topical form plays a significant role in caries reduction. Hence the focus of the fluoride usage is on topical fluorides. But water fluoridation is also considered as one of the major public health initiative, which

reduces the health related disparities among various communities. Hence water fluoridation is also an effective tool in reducing dental caries as a part of mass strategy.

Fluoride concentration in whole saliva has been related to the efficacy of caries prevention and there is a dearth of literature comparing the salivary and water fluoride levels and the effect of salivary fluoride level on dental fluorosis and dental caries. So, better understanding regarding mechanism of action of fluoride as salivary fluoride level is need for an hour.

Hence the aim of the present study was to compare the water fluoride levels, salivary fluoride levels and dental caries in 12-year old school children residing in communities having different naturally occurring water fluoride levels in Andhra Pradesh.

Materials and Methods

A cross sectional study was conducted in the three villages of Prakasam District, Andhra Pradesh, India with different naturally occurring water fluoride levels namely Neredupally, Yedavally, and Kammavaripally with 1, 4, and 11 ppm, respectively. The study population comprised of 12-year old school children 36 each from the three respective schools.

List of villages, where main source of drinking water was from deep bore wells was obtained. Totally 12 such villages were selected from the list, water samples were collected and fluoride analysis was done with ion electrode method. Out of 12 villages, three villages were selected depending on water fluoride level. The water fluoride levels were Neredupally (1 ppm optimum), Yedavally (4 ppm moderately high), and Kammavaripally (11 ppm high).

Before the clinical examination, all the participants were asked to fill the questionnaire which included the questions about the demographic data, source of water and the duration of usage, and about the type of dentifrice used. Children aged 12-years and enrolled in the respective schools, and those who were consuming water from the same source since 10-years were included in the study and a parent who doesn't want their child to participate was excluded from the study.

Ethical clearance was taken from the institutional review board of Sri Sai College of Dental Surgery, Vikarabad, Ranga Reddy District, Andhra Pradesh, India. The purpose of the study was explained to the subjects and the concerned authorities, permission was taken prior to the study. Informed consent was obtained from all the participants. The study was done from August 1st to 31st 2011.

Data collection

The saliva samples were collected from the children of three respective schools between 9 am and 12 pm. The saliva collected was paraffin stimulated. The children were instructed to expectorate the saliva into sterile plastic vials for 3 minutes and then sealed, and sent to the laboratory for fluoride analysis. During the clinical examination, dental caries was measured using decay missing filled (DMF) index (1938) and dental fluorosis was measured using modified Dean's fluorosis index (1942).

Examination procedure

A single calibrated examiner performed clinical examination with the help of trained recorder at the respective schools with the children seated in a chair under natural light using mouth mirror and CPI probe. Dental caries was measured using DMF index (1938) and dental fluorosis was assessed with modified Dean's criteria (1942). Inter and intra examiner reliability was found to be satisfactory.

The saliva samples were incubated for 3 hours at 37°C in the presence of phosphatase enzyme in order to hydrolyse any monofluorophosphate ions (FPO_3^{2-}) to F^-. 0.1 ml of 5 U/ml of enzyme was mixed with 0.1 ml of 0.1 mol/L of sodium acetate buffer (pH 4.8) and added to 1 ml of saliva sample. Fluoride ion activity was then measured with ion-specific electrode (Nagpal and Damle, 2007).

Statistical analysis was done using SPSS software version 16.0. Continuous variables were assessed as mean ± SD and categorical variables reported as percentages. Student's *t*-test was used for the analysis of continuous variables. Pearson's correlation coefficient was used to determine the association between water fluoride and mean salivary fluoride levels.

Results

The study population comprised of 116 school children aged 12-years among which 61 (51.5%) were boys and 55 (48.5%) were girls. Out of

116 children, 59 (50.86%) were using tooth paste and 57 (49.14%) were not using any kind of tooth paste. Among the 59 children using tooth paste 39 (66%) were using fluoridated and 20 (34%) were using the non-fluoridated tooth paste. 15% of the study population were using tooth paste from less than 6 months, while 39% and 46% were using since 1–2 years and more than 2 years respectively. The mean salivary fluoride levels for boys was 6.425 ($n = 61$), and for girls was 5.212 ($n = 55$) which was found to be statistically insignificant. There was no significant difference associated ($p = 0.266$) between salivary fluoride and the use of fluoridated, non-fluoridated, and herbal tooth pastes.

Table 1 shows the comparison of water fluoride level and mean salivary fluoride levels at 1, 4, and 11ppm of fluoride respectively, and was found to be statistically significant ($p = 0.000$)***.

Table 1: The comparison of water fluoride level and mean salivary fluoride levels.

Water fluoride (ppm)	Mean salivary fluoride (μM)	*p*-value
1	2.83 ± 1.08	0.000***
4	3.73 ± 1.17	
11	7.4 ± 2.25	

Table 2 shows the prevalence of dental caries and dental fluorosis at various water fluoride levels. There was a significant difference among the severity of dental fluorosis with increase of water fluoride level and no significant difference was seen in the prevalence of dental caries.

Table 2: The prevalence of dental caries and dental fluorosis at various water fluoride levels.

Water fluoride (ppm)	Dental caries	Dental fluorosis
1	0.73 (1.03)	2.02 (1.05)
4	0.71 (0.85)	3.07 (1.4)
11	0.76 (0.81)	3.07 (1.2)

Discussion

The intent of the present study was to estimate the relative effect of water fluoride on salivary fluoride, dental caries, and dental fluorosis among communities having varying levels of fluoride in drinking water. The source of water and water fluoride levels changes frequently in the study areas, as water fluoride is naturally occurring phenomenon, the exact dose relationship between water fluoride levels and dental caries and dental fluorosis are difficult to establish unless documented evidence regarding fluctuations in water fluoride level over 10–15 years was available.

However, the relationship between water fluoride and salivary fluoride levels can be assessed in these kinds of settings. Ethical and safety issues are the key obstacles in conducting study with same objective. In this study, a naturally occurring phenomenon i.e., varying water fluoride levels was used as an opportunistic epidemiological study. The use of water from unknown water sources is always an obstacle when people in less remote areas are surveyed.

The results of this study showed a positive correlation between the salivary fluoride and the water fluoride levels, as the salivary fluoride concentration is two-thirds of the plasma concentration (Hellwig and Lennon, 2004; Oliveby *et al.*, 1989). This finding was similar with the study done by Bruun and Thylstrup (1984) and Ingram and Morgan (1987), but none of these studies used water fluoride level more than 4ppm and most of these studies were conducted in artificially fluoridated communities where water fluoride level is optimum or below optimum.

There was a significant difference in the severity of dental fluorosis, with a high prevalence in area with a high concentration of fluoride in drinking water. This findings were in accordance with studies from Denmark (Bårdsen *et al.*, 1999), Norway (Bårdsen *et al.*, 1999), and South Africa (Grobleri *et al.*, 2001).

Salivary fluoride doesn't have any positive correlation with the gender and the type of dentifrice used.

Availability of fluoride in saliva and dental plaque contributes for caries prevention by increasing remineralisation and decreasing demineralization (Hellwig and Lennon, 2004). Salivary fluoride concentration of 0.03 ppm or higher is sufficient for anticaries effect (Pizzo *et al.*, 2007; Featherstone, 1999). Continuous availability of such concentration in oral cavity will have maximum anticaries effect, whereas use of topical fluorides has short term rise in salivary and plaque fluoride levels i.e., up to 2 hours.

Since there is linear relation between water fluoride and salivary fluoride level which is more or less constant throughout the day might have long lasting anticaries effect. Hence better understanding of exact relation between water fluorides and salivary fluorides was needed i.e.,

what concentration of fluoride in water gives salivary fluoride level that should have reasonable anticaries effect with minimal chance of dental fluorosis. The salivary fluoride level is directly proportional to water fluoride level, but it has no effect on the prevalence of dental caries.

Ethical Approval

The study was approved by the Ethics Committee of Sri Sai College of Dental Surgery, Vikarabad, Ranga Reddy District, Andhra Pradesh, India.

Conflict of Interests

None declared.

Authors' Contributions

All authors contributed equally to this study.

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