RESEARCH ARTICLE

Prevalence of Arrested Caries in Three Areas of South India with Different Groundwater Fluoride Levels: An Epidemiological Study

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Abstract

Background: Dental caries, though a progressive disease, if intervened early may become arrested, provided there is a change in the oral environment. One such factor which may lead to caries arrest is prolonged exposure to naturally available groundwater fluoride.

Aim: The aim of the study is to know the prevalence of arrested caries in three geographical areas with different levels of fluoride in groundwater and to attribute if there is any correlation between the natural high fluoride levels in groundwater and the prevalence of arrested caries.

Design: A cross-sectional study is conducted on schoolchildren residing in three geographical areas of south India with high, moderate, and low groundwater fluoride levels. A total of 5,982 children, from all the three regions between the age-groups 5–9 years, are examined and 1,514 children with caries are included in the study. The teeth and surfaces with active and arrested caries are identified and recorded in a structured pro forma. All the data obtained was tabulated and subjected to statistical analysis.

Results: The prevalence of arrested carious lesions is found to be significantly higher in areas with high groundwater fluoride level when compared to the other two areas.

Conclusion: It can be concluded that the progression of caries in children residing in areas with high groundwater fluoride level is slow and gets arrested early in the presence of a high amount of fluoride.

Keywords: Arrested caries, Groundwater fluoride level, Prevalence, Schoolchildren, South India.

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Introduction

Dental caries is one of the most prevalent diseases affecting around 60 to 90% of school-going children.[1] Fluoride is used in many topical and systemic formulations for control of caries.[2,3] In the presence of fluoride an active caries lesion may become arrested and was actually considered as healing process.[4–7] Groundwater fluoride level in India varies from as low as 0.1 ppm to as high as 20 ppm.[8,9] These geographical areas with variable groundwater fluoride levels provide natural environment to compare the long term and continuous effects of high concentrations of naturally available fluoride on teeth. Even though the effect of fluoride on dental caries is proven and multifaceted; *there is less data available which correlate the topical effect of long-term exposure of fluoride in groundwater with the progression of caries. Hence an epidemiological study is undertaken on children residing in three areas of south India with varied fluoride levels to know the prevalence of the arrested caries lesions in these areas. The present study will provide more insight in to the mechanism of caries arrest and further research in this aspect may pave way for discovery of early and less invasive treatment modalities for caries.

Materials and Methods

The study sample comprises of schoolchildren with mixed dentition residing in the selected areas. The data was collected in three phases at three different areas of south India over a period of 2 months.

Areas selection: The present cross-sectional study was conducted in three regions of Telangana and Andhra Pradesh states of South India. These states varied levels [0.4–12 ppm] of groundwater fluoride.[9-13]

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The following areas were selected for study after obtaining the groundwater fluoride levels in each region from the respective area water boards.

- Area with low fluoride level: East Godavari district [< 0.6 ppm]
- Area with moderate fluoride level: Hyderabad [0.6–1.5 ppm]
- Area with high fluoride level: Nalgonda: [1.5–12 ppm]

The study is approved by the Institutional Ethics Committee of Government Dental College & Hospital, Hyderabad. Before

conducting the survey permission was obtained from the concerned educational officials in each area, heads of the respective schools and parents of the schoolchildren.

Sample selection: Children who were studying in government schools located in these regions were selected for this study. A well-structured pro forma was prepared which included the demographic data, oral hygiene aids used, level of groundwater fluoride in the region where the child was residing, teeth present in the oral cavity, number of teeth with active caries, and arrested caries.

Inclusion Criteria

- Children studying in government schools
- Children with mixed dentition of age range between 5 and 9 years
- Children who are permanent residents of the selected areas
- Children with at least one carious lesion either active or arrested.

Exclusion Criteria

- Children who are free of caries
- Children who underwent any kind of dental treatment
- Children residing in villages facilitated with defluoridation plants, and
- Children who migrated from other places in recent years.

Method of Examination

Dental screening and assessment of active and arrested caries was performed by a single calibrated examiner. In order to avoid the possibility of bias the examiner was well trained. Type 3, Mirror, tactile dental examination by American Dental Association (ADA) was employed in the study, where the children were examined under natural light and artificial battery operated light source was used whenever required.[14] Plain mouth mirrors and blunt probes were used for examination and CPITN probes were used to check the consistency of carious surface of an arrested lesion. Disposable cotton swabs were used to remove any food debris and plaque. A total of 5,982 children were examined in all the three regions. Only 1,514 children had met all the inclusion criteria, hence were considered to be as study sample. The details of decayed and arrested teeth were entered in the above mentioned pro forma.

Recording Active or Arrested Caries

DFT/dft criteria was used for the lesion to be considered as active instead of DMFT/ DMFS as the study group considered in the sample is from 5 to 9 years, and it is not always possible to find out whether the tooth has extracted due to caries or it is naturally exfoliated.[15] A lesion can be classified as arrested caries when it is darkly pigmented, leathery and hard, even eburnated, usually not painful, slow in progression, with painless sclerotic, and pigmented dentin based on Miller's clinical criteria [1959] as quoted in other study.[16]

All the recorded data obtained was segregated and tabulated. Statistical analysis was done using Chi-square test, SPSS version 21.0. The prevalence of arrested caries among three areas was found in percentages.

Results

Out of 1,514 children included in the study, 505 were from low fluoride area, 506 were from moderate fluoride area and 503 were from high fluoride area. The total number of decayed teeth (both active and arrested) in low, moderate, and high fluoridated areas was 2141, 1818, and 1340, respectively. In low fluoridated area, out of 2141 decayed teeth, 110 [5.14%] teeth had arrested caries in them. In moderate fluoride area out of 1818 decayed teeth only 55 [3.03%] lesions were arrested whereas, in high fluoride area 434 [32.39%] lesions were arrested out of 1340 decayed teeth (Table 1). The prevalence of arrested caries was significantly high [$p < 0.001$] in high fluoride area when compared to other two areas. When compared between boys and girls, percentage of arrested caries was slightly higher in girls in low and high fluoride areas (Table 2). But the difference was not statistically significant [$p = 0.807$]. There was no significant difference [$p > 0.05$] in all the three regions in prevalence of arrested caries whether the toothpaste was used as oral hygiene aid or not (Table 3). When both the arches were compared, prevalence of arrested caries was higher in mandibular arch in all the three regions with different fluoride levels than in maxillary arch (Table 4).

Discussion

The discovery of fluoride and its beneficial effects on teeth had led to start of a new era in the field of dentistry. The mechanism of action of fluoride on caries had been the most sought-after research arena for modern day dental field. Many countries across the world are experiencing preventive effect of low fluoride concentration of water on dental caries.

But in some parts of India, fluoride in groundwater is far above the optimum level. The amount of fluoride exposure is more dependent on the water fluoride level whereas the amount of fluoride intake through food is less.[17]

Newbrun stated that caries is a pathological process of localized destruction of tooth tissue by microorganisms.[18] According to Brauer et al. arrested caries is characterized by a complete cessation of caries process.[19]

The arrested carious lesions are more resistant to carious process, and enzyme attack.[4,5,20] These lesions don't need any treatment as arrest of caries lesion protects the pulpal tissue from further attack and provides time for repair.[6,21] Malone W F et al. suggested the two most obvious clinical differences from the active caries lesion which are the increased surface hardness and pigmentation of the arrested lesion.[6] An early caries lesion is considered as white spot lesion which in the future it can be transformed in to a "brown spot lesion," "a remineralized lesion," "an arrested lesion," and occasionally even disappears completely as a "caries reversal."[22]

But the actual transformation of carious lesion from soft through leathery into a hard surface with a brownish or black discoloration is a long process taking several years usually.[23] Levine RS stated that remineralization is the natural repair process

Table 1: Prevalence of arrested caries in three areas with different fluoride levels

Fluoride level of the area	*Total no. of decayed teeth*	*No. of teeth with arrested caries*	*% of teeth with arrested caries*
Low	2141	110	5.14%
Moderate	1818	55	3.03%
High	1340	434	32.39%*

$X^2 = 799.590$; df = 2; * $p < 0.001$; Highly significant

Table 2: Prevalence of arrested caries teeth in boys and girls

Fluoride level of the area	*Boys*			*Girls*		
	No. of carious teeth	*No. of teeth with arrested caries*	*% of teeth with arrested caries*	*No. of carious teeth*	*No. of teeth with arrested caries*	*% of teeth with arrested caries*
Low	946	44	4.65%	1195	66	5.52%
Moderate	823	30	3.65%	995	25	2.51%
High	639	201	31.46%*	701	233	33.24% *
	2408	275	11.42%	2891	324	11.02%

X^2= 0.059; df = 1: p = 0.807; * Not significant

Table 3: Prevalence of arrested caries in children using toothpaste and children not using toothpaste

Fluoride level of the area	*Children not using toothpaste*			*Children using toothpaste*			x^2	*p value*
	No. of teeth with caries	*No. of teeth with arrested caries*	*% of teeth with arrested caries*	*No. of teeth with caries*	*No. of teeth with arrested caries*	*% of teeth with arrested caries*		
Low	139	9	6.47%	2002	101	5.04%	0.545	0.460NS
Moderate	342	9	2.63%	1476	46	3.12%	0.223	0.637NS
High	385	123	31.95%	955	311	32.57%	0.048	0.827NS

NS- Not significant

Table 4: Prevalence of arrested caries in maxillary and mandibular teeth

Fluoride level of the area	*Maxillary teeth*			*Mandibular teeth*		
	No. of carious teeth	*No. of teeth with arrested caries*	*% of teeth with arrested caries*	*No. of carious teeth*	*No. of teeth with arrested caries*	*% of teeth with arrested caries*
Low	1035	25	2.42%	1106	85	7.69%
Moderate	791	15	1.90%	1027	40	3.89%
High	639	170	26.60%	701	264	37.66%
X^2	362.158			457.08		
p value	< 0.001**			< 0.001**		

**Highly significant

for noncavitated lesions.[4] Featherstone JDB showed that this remineralization, relies on salivary calcium and phosphate ions assisted by fluoride to rebuild a new surface on existing crystal remnants in subsurface lesions remaining after demineralization, further, these remineralized crystals are acid resistant, being much less insoluble than the original mineral. Fluoride speeds up this remineralization process as itself gets absorbed during remineralization and forms an integral part of the new veneer on the crystal surface.[24] Shafer WG et al. stated that sclerosis of dentinal tubules and secondary dentin formation commonly occur in cases of arrested caries.[25] Schupbach P et al. suggested that the tubular sclerosis is the basic condition for a successful arrest of lesion progression.[26] To become arrested, fluoride chiefly from saliva is to be deposited in the surface zone during or after surface remineralization.[4] So if the superficial infected layer of dentin is removed and underlying practically bacteria free layer can be arrested and once the sclerosis of dentin and reparative dentin formation proceeds, it prevents further injury and provides protection to pulp.[18] Differentiating between the active and arrested caries is important as it helps in diagnosing pulpal status and treatment option.[6,27]

Three areas, Nalgonda district, Hyderabad city, East Godavari district, in different geographic locations, with different groundwater fluoride levels were selected for present study.

Past research showed that majority of places in Nalgonda district of Telangana state have high groundwater fluoride levels which are well above the value approved by WHO.[12,13,28-31] This area has less rainfall and arid climate, favoring weathering of rocks and evaporation of groundwater resources which in turn increases the groundwater fluoride level.[12,29] Owing to the above reason schools in certain parts of the Nalgonda district are ideal for the present study, representing area with high groundwater fluoride levels.

According to the report of Telangana state water supply control board, the areas in and around the city of Hyderabad have moderate groundwater fluoride levels.[11,29] Hence the schools in this area are selected for sample representing area with moderate groundwater fluoride levels.

The groundwater fluoride levels of East Godavari district are found to be very low or below the ranging between 0.4 and 0.6 ppm. The climatic conditions, rainfall, and soil type especially in the villages on river banks result in this low fluoride values.[10,15,33]

Children studying in government schools were selected because they have least access to dental treatment owing to their socioeconomic status. Children who had undergone any dental treatment were excluded from the present study as it might have exposed them to certain amount of therapeutic fluoride. During the study period, these children were also educated about the common dental diseases, their prevention, and their treatment.

Fig. 1: Arrested caries on the buccal surface of the mandibular primary molar

Fig. 2: Arrested caries on the occlusal surface of the mandibular primary molar

Children meeting the inclusion criteria were examined and arrested lesions were noted when present. A lesion was clinically considered arrest when it was seen on enamel/dentin which appeared shiny, smooth, of hard consistency and with different degrees of brownish discoloration (Figs. 1 and 2).

The prevalence of arrested caries is significantly high in children living in high fluoride areas when compared with children living in other two areas. This is probably the result of continuous exposure of teeth to high concentration of fluoride by the means of water. Many studies showed that continuous exposure to fluoride will lead to conversion of an active lesion into inactive or arrested caries lesion.[27,34-36]

Prevalence of arrested caries in children living in moderately fluoridated areas is not intermediate to what is found in high fluoridated and is sometimes found to be even lower in when compared to low fluoridated areas. The reason could not be explained, and further survey including a larger sample may answer this question.

When the prevalence of teeth with arrested caries was compared between boys and girls, no significant difference [$p = 0.807$] was observed. The slightly higher prevalence of arrested caries found in girls in high and low fluoridated areas is probably due to the early eruption of teeth resulting in their exposure to environmental fluorides for a longer duration. Though many studies have confirmed that the use of fluoridated toothpaste increases caries cessation and favors arrest,[2,37] the present study did not show any significant difference between children using and children not using fluoridated toothpaste as an oral hygiene aid.

Mandibular teeth showed significantly [$p < 0.001$] higher incidence of arrested caries when compared to maxillary teeth in all the three regions. In low fluoride area, 2.42% of maxillary teeth and 7.69% of mandibular teeth have arrested caries whereas in moderate fluoride area, 1.90% and 3.89% and in high fluoride area 26.60% and 37.66%, respectively. The reason may be that mandibular teeth are continuously bathed in saliva rich in fluoride ions, which is not the case with maxillary teeth. This was seen more obviously in molar teeth, when both deciduous and permanent dentitions were assessed. These results are in accordance to Larsen MJ & Fejerskov O who suggested that remineralization tends to take place more in areas where the medium [saliva] is easily available and mineral ions are likely to be exchanged relatively often.[38]

A change in oral cavity such as loss of adjacent teeth causing self-cleansing action or removal of any plaque retentive factors may favor the change of caries from an active to inactive lesion.[23,39] Such a condition can be seen in mixed dentition where the tooth exfoliation may favor the caries lesion on adjacent tooth to get arrest.

Apart from the chronic exposure to drinking water with high fluoride levels, milk and its products, green leafy vegetables, tubers, and other food grains cultivated in the geographical location with fluorosis might have contributed to the higher fluoride environment in the oral cavity. There is very little literature available about prevalence of arrested caries due to natural fluoride resources. But to confirm the findings longitudinal studies with larger samples need to be undertaken.

Conclusion

When all the results are assessed, the prevalence of arrested caries is found to be significantly higher in the area with high fluoride levels in groundwater. The only probable explanation that can be given for this phenomenon may be the availability of excessive fluorides in the oral environment through natural sources. Although many other factors like change in diet, improvement in oral hygiene, removal of plaque retentive factors, play a role in change of active lesion to an arrested lesion, fluoride do play a major role in the conversion. With this study it can be concluded that the fluoride available through natural resources can arrest the progression of caries. But the limitation of the study is that, it is a cross sectional study and children were not followed up to know the status of carious pattern for prolonged period. However, further research with other population groups in other geographical regions with different groundwater fluoride levels, as well as longitudinal studies are required to assess the generalization of the action of natural fluoride in groundwater and on progression of dental caries and utility of this knowledge in interventional studies.

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