Lead Exposure and its Relation to Dental Caries in Children

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Environmental pollution is a significant health hazard and is mainly caused by commercialization. The etiology of dental caries is multifactorial and one such factor is exposure to trace element such as lead. ***Aim:*** *Hence, the present study was carried out to find out the correlation between the levels of lead in the enamel, saliva and dental caries in children.* ***Method****: 90 children aged 5 years consisting of both genders from different kindergartens along Coastal Karnataka were included in the study. The selected children were divided into 3 groups as; control group, early childhood caries (ECC) group and severe-ECC (S-ECC) group respectively. Enamel and salivary lead level was assessed by using graphite atomic absorption spectrophotometry.* ***Results:*** *Mean enamel lead levels in the control, ECC and S-ECC group were 47.7, 85.45 and 90.43 ppm respectively and mean salivary lead levels were 0.23, 1.7 and 1.77 ppm respectively which was statistically very highly significant ($p < 0.001$) with no gender predilection. There was a positive correlation seen between the enamel and the salivary lead levels ($p > 0.05$).* ***Conclusion:*** *The enamel and the saliva of all the children had measurable amounts of lead and its levels increased with increase in severity of dental caries proving the cariogenic potential of lead. A positive correlation was seen between the enamel and the salivary lead levels.*

Keywords: *Enamel lead, salivary lead, dental caries, deciduous teeth, primary teeth.*

INTRODUCTION

South Canara is an industrialized region with industries such as petrochemicals, chemicals, fertilizers, tile industries. The environment in this region is getting polluted due to the release of smoke and waste from these industries that contains lead. This is a coastal region where people have an increased tendency to consume regularly sea food, which is known to contain higher amounts of lead than other food items.[1] The houses have peeling lead based paint because of increase in rainfall which children may ingest. Other sources of increased lead consumption are water supply through pipes coated with lead and use of toys painted with lead.[2] All these factors can increase the daily total human body exposure to lead.

Lead is a widely used metal, but it is simultaneously a versatile, subtle, and persistent poison. It has no biological value and is not a required nutrient. Human activities and extensive use of lead in various fields have resulted in its redistribution in the environment leading to contamination of air, water, and food and thereby increasing lead concentration in teeth.[3] Significant exposure to lead is an environmental threat to optimal health and to physical development in young children that affects all socioeconomic groups. The most susceptible populations are children particularly toddlers, infants in the neonatal period and the fetus.[4]

Teeth accumulate lead over a long period of time and provide an integrated record of lead exposure since intrauterine life. The dental hard tissues are relatively stable; metals deposited in teeth during mineralization are, to a large extent, retained. Deciduous teeth may thus be used as indicators of long-term lead exposure during early life.[5]

The diagnostic use of saliva has attracted the attention of numerous investigators because of, simple, frequent, noninvasive collection by stress-free techniques. Salivary samples may be collected many times a day requires no special equipment. The ability to measure and monitor a wide range of molecular components in saliva and to compare them to serum components has made it feasible to study chemicals.[6, 7]

The margin of safety with lead is very narrow. According to Centers for disease control, blood lead level less than 10 ppm is considered normal. Some investigators regard even this level to be more than 600 times higher than the natural levels of lead in humans. There are no normal levels of lead in enamel or saliva. Levels of lead in enamel have been recorded up to 5,920 ppm using enamel biopsy whereas, in saliva it can be up to 10 ppm.[4, 8]

Lead mimics calcium and may affect salivary glands, clearly enhancing susceptibility to dental caries.[9] It may, in turn, be associated with modifications in the physicochemical behavior of the enamel and making it more susceptible to demineralization.[10]

In the face of a severe paucity of data pertaining to lead levels in enamel, saliva and dental caries in Indian population; it is vital that data be collected, correlated and compared with that of different populations. There was lack of such data seen in children in Coastal Karnataka. Hence, the present study was carried out with an aim to find out the correlation between the levels of lead in the enamel, saliva and dental caries in children along the coastal area of Karnataka.

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Table 1. Enamel lead levels in different groups.

	Group			H	p-value
	Group I	Group II	Group III		
n	30	30	30		
Enamel lead levels (ppm) Mean ± Standard deviation	47.70 ± 13.14	85.45 ± 12.34	90.43 ± 8.33	60.46	< 0.001vhs

H – Kruskal Wallis test. n – Sample number, p > .05 Not significant (ns) , p < .001 Very highly significant (vhs)

Table 2. Salivary lead levels in different groups.

Group	N	Salivary lead levels (ppm) Mean ± Standard deviation	H	p-value
Group I	30	0.23 ± 0.16	59.35	< 0.001 vhs
Group II	30	1.70 ± 0.30		
Group III	30	1.77 ± 0.60		

MATERIALS AND METHOD

The study included 5 year old children selected from 10 kindergartens in the South Canara region. Children who were uncooperative and whose right and left deciduous lower central incisors are decayed, missing or filled were not included. Informed consent was taken from parents or guardians of all children included in the study.

The caries status of the children was recorded using dmfs (decayed, missing, filled surfaces) index according to criteria of WHO (World Health Organization).[11] using a mouth mirror and CPI (Community Periodontal Index) probe after drying the surfaces of teeth using cotton. Visual and tactile examinations were carried out under natural lighting conditions.

Based on the caries severity, 90 children (45 males and 45 females) were selected and divided into 3 groups of 30 each, based on the caries experience with equal number of males and females in each group.

1. Group I - Control group (caries free)
2. Group II – ECC (Early Childhood Caries) group
3. Group III - S-ECC (Severe Early Childhood Caries) group. Children were divided into ECC and S-ECC group based on the criteria given by AAPD (American Academy of Pediatric Dentistry).[12]

Enamel biopsy was performed on one of the deciduous lower central incisors for the children in all the 3 groups to estimate the enamel lead level. The tooth on which biopsy was performed was cleaned, dried and isolated using cotton wool rolls. Adhesive tape with a central perforation of 1.6 mm diameter (±0.03) was firmly stuck onto the vestibular surface of one of the lower central deciduous incisors (71 or 81) of each participant in the study, hereby demarcating the area of the biopsy. Enamel microbiopsy technique was performed and the sample was collected.[13]

First the phosphorous levels in the enamel microbiopsy sample was determined using Fiske and Subbarow calorimetric method.[14] Considering that the dental enamel contains 17% of phosphorous by weight, the exact amount of enamel obtained in the microbiopsy sample from each subject was determined. This was done so that the quantity of lead could be calculated in ppm (parts per million) of enamel removed.

About 1 ml of unstimulated whole saliva was collected from each subject in a plastic tube. All subjects were instructed to refrain from eating and drinking for 1 hour prior to saliva collection. Unstimulated whole saliva samples were collected sitting in the "coachman" position; on the edge of the chair, the patient passively drooled saliva into a funnel inserted into a graduated cylinder for 5 min.[15] The lead determination in the enamel and saliva was performed using a graphite furnace atomic absorption spectrophotometry.[13]

The data obtained was subjected to statistical analysis using the Statistical Package for Social Sciences-17 software for windows. For group and intra group comparison Kruskal Wallis test was used while Mann-Whitney U test and correlation used Spearman's correlation co-efficient test (p - value <0.05 was considered significant).

RESULTS

The mean enamel lead levels in group I was 47.7 ppm, whereas in group II and group III, it was 85.45 and 90.43 ppm respectively. There was an increase in the mean enamel lead levels from group I to II and group I to III which was statistically very highly significant (p< 0.001). There was minimal increase in mean enamel lead level from group II to III which was not statistically significant (p - 0.114) (Table 1).

The mean salivary lead levels in group I was 0.23 ppm, whereas in group II and group III, it was 1.7 and 1.77 ppm respectively. There was an increase in the mean salivary lead levels from group I to II and group I to III which was statistically very highly significant (p< 0.001). There was minimal increase in mean salivary lead level from group II to III which was not statistically significant (p - 0.923) (Table 2).

The mean enamel lead levels between male and female children was 75.53 and 73.52 ppm respectively which was statistically not significant (p - 0.812). The mean salivary lead level between male and female children was 1.30 and 1.17 ppm respectively which was statistically not significant (p - 0.413) (Table 3).

When enamel and salivary lead levels were correlated among different groups, all the 3 groups showed a positive correlation which means when the enamel lead level was increased, the salivary lead level in the corresponding group also increased. The difference was found to be statistically not significant among all the 3 groups (p - >0.05) (Table 4).

DISCUSSION

All the children from Coastal Karnataka showed varied amounts of lead in enamel and saliva clearly indicating the lead pollution

Table 3. Lead levels in enamel, saliva among males and females in different groups

Lead level (ppm)	Gender	n	Mean ± Standard deviation (ppm)	Z	p-value
Enamel	Male	45	75.53 ± 21.73	0.238	0.812 ns
	Female	45	73.52 ± 23.02		
Saliva	Male	45	1.30 ± 0.87	0.819	0.413 ns
	Female	45	1.17 ± 0.76		

Z- Mann Whitney U test

Table 4. Correlation of lead levels in enamel, saliva among different groups.

Group		Salivary lead level (ppm)
I Enamel lead level (ppm)	r	0.120
	p	0.949 ns
II Enamel lead level (ppm)	r	0.327
	p	0.078 ns
III Enamel lead level (ppm)	r	0.231
	p	0.219 ns

r - Spearman's correlation co-efficient test

from the environment among all growing children. Pediatric lead poisoning is associated with increased risk of adverse effects in a variety of target organs, with central nervous system, hematopoietic and renal system receiving greatest attention.[16] In teeth, there is no turnover of apatite and much of lead deposited in teeth during mineralization is retained. Therefore, primary teeth may be used as indicators of long term exposure to lead during early life.[5] The use of primary teeth to assess lead levels helps us to provide adequate preventive measures at the earliest for those with high lead levels in the tooth enamel, if the lead appears to be cariogenic.

Deciduous mandibular central incisors are the first teeth to exfoliate and most resistant to decay and hence was used in the present study for enamel biopsy.

The presence of lead in enamel was detected both in the control group and the study group. The enamel of children in the control group had lesser lead content when compared with the study group. The mean enamel lead levels in our study increased from the control group to ECC group and from ECC group to S-ECC group. So, the lead levels increased with the increase in the caries rate.[8,13,17] This explains the fact that lead is cariogenic. The increased association of enamel lead levels with increased caries rate could be due to enamel defect formation or modifications in the physicochemical behavior of the enamel, making it more susceptible to demineralization.[18] The reason that the male children had slightly more enamel lead level[5, 19] could be because of early eruption and less pre-eruptive accumulation of lead in teeth in females when compared to males.

Salivary lead arises from the diffusible fraction of plasma lead and doesn't relate to the bound fraction. Salivary lead represents the portion of circulating lead that is readily available for distribution to the hard and soft tissues. Amount of lead in the saliva reflects the recent exposure of the individual to lead.[8]

The presence of lead in saliva was detected both in the control group and the study group. The saliva of children in the control group had lesser lead content when compared with the study group. The mean salivary lead levels in our study increased from the control group to ECC group and from ECC group to S-ECC group. So, the lead levels increased with the increase in the caries rate. The increased association of salivary lead levels with increased caries rate could be due to modifications in the enamel during normal demineralization and remineralization cycle, making it more susceptible to demineralization.[18]

The difference between the mean enamel and the salivary lead levels in ECC group and S-ECC group in this study was not significant though the caries severity was more in S-ECC group. This suggests that lead is actually cariogenic but the severity of caries in S-ECC group could have been influenced more by other factors responsible for dental caries than ECC group.

The reason that the male children had slightly more salivary lead level could be because of increased outdoor activities seen in males when compared to females. Lead concentrations of saliva showed a large variation among subjects. This could be because the whole saliva is often contaminated with lead from the oral environment or due to factors other than level of exposure to lead.[8, 18]

There was a positive correlation seen in the lead levels between the enamel and the saliva of all the children. Enamel lead gives a cumulative effect whereas, salivary lead indicates immediate exposure. Positive correlation could be due to the continuous exposure of the children to different sources of lead.

More research and studies on larger samples are needed before confirming the actual role of lead in enamel, saliva and dental caries. The presence of lead was also detected in the enamel, saliva of children in the control group but it was much lesser than the children of study group. So, adequate measures should also be taken for these children to prevent their further exposure to lead.

CONCLUSION

The enamel and the saliva of all the children had measurable amounts of lead and its levels increased with increase in severity of dental caries proving the cariogenic potential of lead. Gender had no relation in accumulation of lead in enamel or saliva. A positive correlation was seen between the enamel and the salivary lead levels.

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