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Analysis of 35 Inorganic Elements in Teeth in Relation to Caries Formation

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Abstract As caries is a most common affliction of teeth, which are predominantly composed of inorganic elements, it was considered worthwhile to determine their elemental composition and to find if it bears any relation to caries formation. For this purpose, 35 inorganic elements were determined in 15 non-carious and an equal number of carious whole teeth after their dissolution in nitric acid. The results showed that out of 35 elements, strontium was the only element found to be present in significantly lower amount in carious teeth, thus strongly suggesting that its deficiency may help form caries. The decrease in Ca, Mg, Ti, P, Li, Be, V, Ni, Zn, Nb, Ag, Cd, Sb, Ba, La , W, Pb, and Bi and slight increase in K, Cr, Cu, and As was not statistically significant. However, statistically significantly greater amount of boron, manganese, molybdenum, and fluorine in the carious teeth indicates towards their possible role in predisposing or causing dental caries.

Keywords Teeth · Caries · Inorganic elements · Strontium · Fluorine

Introduction

The physical and chemical properties of a substance are manifestation of its structure—elemental composition, chemical ligands, and crystal architecture. This is also true for teeth. Is there anything inherent in the tooth which makes it more susceptible or resistant to destruction during caries formation? In order to find out an answer to this question, we have attempted to determine, as many as possible, inorganic elements constituting the tooth. We here report the results of chemical analysis of a total of 35 elements present in human teeth. Such attempts have been made in the past [1–4]. All these suffer from the criticism that teeth were cut to obtain enamel and later ground, which causes positive contamination of trace elements.

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Materials and Methods

This study was conducted in the Department of Biochemistry, S. G. T. Dental College, Budhera, Gurgaon, India. In order to analyze 35 different elements in teeth and to evaluate if there is any difference in the composition of carious and sound teeth, 15 carious and 15 non-carious teeth extracted in Oral Surgery Department were taken as study material. The selection criteria were as follows:

Inclusion criteria:

1. Sound molars and premolars that had been extracted for orthodontic reasons were taken as control.
2. Carious molars and premolars that had been extracted due to carious destruction were taken as experimental.

Exclusion criterion:

1. Extracted teeth with developmental anomalies and fluorosis were not included in the study.

We have selected only molars and premolars because they are more susceptible for caries than incisors and canines. The extracted teeth were washed thoroughly under tap water to remove saliva, blood, and tissue debris and then blotted dry with the help of filter paper. After that, all teeth were weighed and volume was measured by water displacement method. All teeth were separately placed in 5 ml of concentrated nitric acid for 2 days for complete dissolution. After that, the volume of the solution was made up to 100 ml by adding double distilled water.

Thirty-four elements (Si, Al, Fe, Ca, Mg, K, Mn, Ti, P, Li, Be, B, V, Cr, Co, Ni, Cu, Zn, As, Sr, Y, Nb, Mo, Ag, Cd, Sn, Sb, Ba, La, Ce, W, Pb, Bi, and Zr) were analyzed by inductively coupled plasma–atomic emission spectrophotometry (Make-Geoplasma; model BJY-70) technique, while fluorine was analyzed by ion sensitive electrode method. The results of chemical analysis of the two groups were statistically analyzed by unpaired Student's t test.

Results and Discussion

Out of a total of 35 elements (which is about one third of naturally occurring elements) estimated in 15 sound and 15 permanent carious teeth, eight elements (Si, Al, Fe, Co, Y, Ce, Zr, and Sn) could not be detected by this technique. The result of the remaining 27 elements are summarized in Table 1. It can be seen that most of the elements were present in decreased concentration in carious teeth except four elements (boron, molybdenum, fluorine, and manganese). The concentration of these four elements was found to increase significantly in carious teeth as compared to non-carious teeth ($P<0.05$), while the concentration of potassium, chromium, copper, and arsenic was insignificantly increased (unaltered). The decreased concentration of most of the elements in carious teeth is explained on the basis that caries formation involves the loss of all minerals present in tooth. However, the decrease was not statistically significant even in calcium and phosphorous, which may be because these are abundantly present in tooth.

Perhaps of greater interest are the elements (boron, manganese, molybdenum, and fluorine) which were found to be significantly increased in carious teeth than non-carious teeth despite loss of minerals during cariogenesis. Boron is an essential element for plants, but so far not considered essential for humans [5]. It is surprising that boron was found in teeth in the range as high as 25–85 ppm. Manganese is considered an essential element; it

Table 1 Elemental Composition of Teeth

S. No.	Element	Non-carious	Carious
1	Ca	367.4±120.6	343.9±84.5
2	Mg	0.81±0.27	0.79±0.21
3	K	0.12±0.16	0.13±0.17
4	Mn	0.0007±0.0025	0.004±0.0041*
5	Ti	0.048±0.01	0.040±0.01
6	P	154.7±50.2	144.5±37.9
7	Li	4.39±4.02	3.93±3.66
8	Be	12.45±5.92	10.90±3.37
9	B	39.05±8.19	49.85±18.15*
10	V	7.53±5.35	6.26±4.68
11	Cr	15.41±9.36	15.92±13.04
12	Ni	8.71±4.93	7.19±5.56
13	Cu	5.22±3.03	6.59±8.43
14	Zn	194.61±109.07	190.18±77.97
15	As	10.6±5.39	10.82±4.55
16	Sr	389.2±136.51	238.57±87.36*
17	Nb	29.06±5.97	28.94±11.33
18	Mo	1.92±1.75	3.54±1.13*
19	Ag	0.75±0.32	0.60±0.27
20	Cd	2.48±2.44	1.63±2.15
21	Sb	7.84±2.87	6.64±2.22
22	Ba	148.58±40.32	137.95±44.47
23	La	12.22±9.92	10.32±3.84
24	W	28.77±13.81	26.88±14.81
25	Pb	87.69±18.64	85.63±21.90
26	Bi	57.74±18.17	51.16±21.76
27	F	2.61±1.93	5.05±3.86*

All values are μg/g whole teeth except Ca and P which are in mg/g. Si, Al, Fe, Co, Y, Ce, Zr, and Sn were not detected by this technique

Values are mean±SD

*$P<0.05$

has a role in the synthesis of glycoprotein and proteoglycans. Its blood level is 4–20 μg/100 ml [6], but in teeth, it was detected in only parts per billion level. Molybdenum was present in non-carious teeth in about 5 ppm and was significantly raised in carious teeth. This element is also recognized as an essential element, as it is a constituent of enzyme, xanthine oxidase, and high intake of Mo has been attributed to hyperuricemia and gout [6].

The most important element found to be raised in carious teeth is fluorine. In our study, the average concentration in carious teeth was just double that of non-carious teeth. On the contrary, the concentration of F, K, Al, and Fe were found by Shashikiran et al. [4] to be significantly higher ($P<0.05$) in the sound enamel of permanent teeth. Interestingly, we could not detect the last two elements even by using a much more sensitive technique. Their method of crushing teeth enamel mechanically using stone grinder is not advisable, for subsequent trace element analysis as stone is a potential source of these elements. In our view, the finding of significant increase in B, Mn, Mo, and F in carious teeth despite overall loss of minerals during cariogenesis indicates the possibility of these elements somehow being involved in making teeth susceptible to caries formation. In this connection, the multifarious role of fluorine in teeth depending on its intake is well known [7].

The most important finding of this study is the significantly decreased content of strontium in carious teeth. It is well known that the strontium content of the food and hence the human intake varies considerably [8]. It is quite possible that decreased strontium intake makes the teeth vulnerable to caries [9]. A possible relationship between strontium and caries is supported by (1) epidemiological studies that the lowest incidence of caries occurred in areas with strontium levels of 5.4 to 8.3 mg/L in drinking water, with increased incidence at higher and lower levels [10], (2) animal studies by Rygh [11] showing that strontium stimulates calcium deposition in bones and teeth of rats and guinea pigs, (3) experimental studies that giving strontium to rats in their diet increases the buildup of dentin in their teeth [12], (4) analytical studies reporting lower strontium level in the enamel of carious teeth compared to sound teeth [13], and (5) our own in vitro studies, simulating conditions of dental caries, showed significant decrease in calcium release from both carious as well as non-carious teeth after pretreatment with strontium salt [14]. Further, strontium is in the same group of periodic table as calcium, so has similar properties to it, but is more reactive [15]. It is interesting to note that strontium salts are now being successfully used in the treatment of fractures and osteoporosis [16].

Perhaps, future studies on dental caries might examine the utility of using suitable strontium salt as a mouth rinse/gel/varnish/tooth paste/topical applicant.

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References

1. Curzon ME, Losee FL (1978) Dental caries and trace element composition of whole human enamel: Western United States. J Am Dent Assoc 96:819–822
2. Verbic V, Stuper J (1980) Dental caries and the concentration of aluminium and strontium in enamel. Caries Res 14:141–147
3. Verbic V, Stuper J, Byrne AR (1987) Trace element content of primary and permanent tooth enamel. Caries Res 21:37–39
4. Shashikiran ND, Subba Reddy VV, Hiremath MC (2007) Estimation of trace elements in sound and carious enamel of primary and permanent teeth by atomic absorption spectrophotometry: an in vitro study. Ind J Dent Res 18:157–162
5. Schroeder HA (1976) The trace elements and nutrition. Faber and Faber, London
6. Sharma DC (1999) A textbook of biochemistry. Paras Medical Publishers, Hyderabad
7. Neville BW, Damm DD, Allen CM, Bouquot IE (2002) Oral and maxillofacial pathology, 2nd edn. Saunders, Philadelphia
8. Schroeder HA, Tipton JH, Nason AP (1972) Trace metals in man: strontium and barium. J Chronic Dis 25:491–517
9. Curzon MEJ, Adkins BL, Bibby BG, Losee FL (1970) Combined effect of trace elements and fluorine on caries. J Dent Res 49:526–528
10. Anonymous (1983) Strontium and dental caries. Nutr Rev 41:342–344
11. Rygh O (1949) Recherches sur les oligo elements—I. des 1'importance du strontium, du barium et du zinc. Bull Soc Chim Biol 31:1052
12. Weinmann JP (1942) Effects of strontium on the incisor of the rat—I. Injections of small doses of strontium chloride as a means of measuring the rate of incremental dentine apposition. J Dent Res 21:497
13. Curzon MEJ, Losee FL (1977) Strontium content of enamel and dental caries. Caries Res 11:321–326
14. Riyat M, Sharma DC (2009) An experimental study on the effect of strontium pre-treatment on calcium release from carious and non-carious teeth. (in press)
15. Block JH, Roche EB, Soine TO, Wilson CO (1986) Inorganic medicinal and pharmaceutical chemistry. Lea and Febiger, Philadelphia
16. Anonymous (2005) Strontium: the first bone builder. Adv Orthomol Res 3:1–11