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P. V. C. PINO, AND S. O'NEILL

Reprinted for private circulation from
JOURNAL OF DENTAL RESEARCH
Vol. 45, No. 2, March-April 1966
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Strontium-90 Content of Deciduous Teeth of Children

HAROLD L. ROSENTHAL, JOHN T. BIRD, JOHN E. GILSTER, P. V. C. PINTO, and SHEILA O'NEILL

Departments of Physiological Chemistry, Dental Medicine, and Pedodontics,
Washington University School of Dentistry, St. Louis, Missouri

SYNOPSIS IN INTERLINGUA

Contenido de Strontium-90 in Dentes Decidue de Juveniles.—Le contenu de strontium-90 del corona de dantes decidue de juveniles nate inter 1950 e 1958 es adequademente descripte per le equation $C_T = K C_a$ ubi $C_T$ es le $Sr^{90}$ del corona dental e $C_a$ le $Sr^{90}$ del lacte. Pro incisores e cuspides intacte e prime e secunde molares cariosi, le pendentia $K$ es 0.59, 0.76, 0.69, e 0.77, respectivamente. Le equation predic niveles de inter 12 e 16 pC $Sr^{90}$/gm Ca in incisores e secundae molares pro juveniles nate durante le anno 1963 quando le concentration medie de $Sr^{90}$ in le lacte atingeva un nivel maximal de 21 pC $Sr^{90}$/gm Ca in St. Louis, Missouri, U.S.A.

The strontium-90 content of noncarious deciduous incisors increased from 0.18 to 3.65 pC per gram of calcium for children born in St. Louis between 1949 and 1958, a period of increasing $Sr^{90}$ fallout. The $Sr^{90}$ content of deciduous incisors of American children also compares favorably with bone values determined during the first year after birth. Our studies suggest that the $Sr^{90}$ content of deciduous teeth represents a measure of the total body burden of the nuclide during the time the teeth are formed. In contrast to skeletal bones which are subject to change due to remodeling, exchange, and turnover, the erupted crown of the tooth is a relatively stable calcified tissue with minimal exchange, remodeling, or turnover. Although secondary dentin is deposited, the amount formed is small in comparison with the total mass of the crown, and the amount of $Sr^{90}$ incorporated in the crown by this process is presumed to be minimal. Kulp and Schulert, however, have voiced a series of objections to the use of deciduous teeth as a measure of $Sr^{90}$ body burden based on the great effort required to obtain enough tooth material for analysis, the complex relationship between calcium deposition in teeth and in bone, and the fact that it is, at best, an indirect method.

To determine the usefulness of deciduous teeth as a measure of $Sr^{90}$ body burden, a series of studies was undertaken to define the variation in the $Sr^{90}$ content of the various types of deciduous teeth (incisors, cuspids, and first and second molars). It was also of interest to determine the effect of breast feeding versus bottle feeding and the effect of caries on the accumulation of $Sr^{90}$ in teeth. Although many factors remain to be studied and qualified, it was deemed advisable to report the information that is currently available.

Materials and Methods

Deciduous teeth of children born within a radius of 150 miles of St. Louis were collected for the birth years 1947 to 1958. The teeth were classified as to type, the length of time the child was fed by breast or bottle, and whether the teeth were carious or sound. Deciduous teeth with restorations were considered to have been carious. Residual root material was removed from the crown at the cementoenamel junction, and restorations and carious material were removed. Root samples of molars from breast- and bottle-fed children were analyzed separately, but the data were averaged because no significant differences could be found.

Teeth were classified in the "breast-fed" group if the children were breast-fed for 6 weeks or more. The average time of breast feeding was 24 weeks for incisors (40 samples), 27 weeks for first molars (56 samples),
and 28 weeks for second molars (63 samples). If the children were breast-fed for less than 6 weeks, the teeth were considered to be from bottle-fed children.

For children born between 1947 and 1952, when S^28 fallout was low, sufficient material was pooled to make samples containing 2.5 Gm. of calcium. Thereafter, as the S^28 content increased, the amount of sample material was progressively decreased to yield a minimum of 0.5 Gm. of calcium in 1957 and thereafter. Samples obtained during the first and last 6 months of each year were analyzed separately, but the data were averaged to yield values for yearly intervals. The samples were ashed at 600° C. and analyzed for S^28 and calcium by methods previously described. The S^28 content of commercial milk for the St. Louis area was obtained as previously described. The distribution of s28 and sam in crowns of first and second molars was calculated from known calcium percentages in dry dentin (26.5 per cent) and dry enamel (13.8 per cent) as reported by Sobot, Roehmocher, and Kraner.

Results

The accumulation of S^28 in deciduous sound incisors, canines, first and second molars, and carious second molars from bottle-fed children is shown (Fig. 1). From 1947, when the S^28 content of all types of teeth averaged about 0.15 pC. of S^28 per gram of calcium, the concentration of S^28 continued to increase steadily, reaching a value of 4.7 pC. S^28/Gm. of calcium for carious second molars of children born during 1980.

For teeth of children born during 1956, demonstrate the variation of S^28 content for the various kinds of teeth of children who were breast-fed or bottle-fed (Table 1). The largest difference (30 per cent) was between curious first molars of children born in 1956. The weighted average for all of the teeth of children born in 1956 was 2.1 pC. S^28/Gm. of calcium. This figure is in good agreement with skeletal bone values of 1.9 pC. S^28/Gm. of calcium, determined in North American children who were born to 4 years old in 1953 (1) and 1.7 pC. S^28/Gm. of calcium for children who were between 1 and 2 years old in 1957 children born during 1956 (3). Although the differences for the various classifications were statistically significant, the determined values were within the range of the weighted average and the analytical error of the S^28 determinations.

A further comparison (Table 2) showed that curious first and second molars from breast-fed children contained 28 per cent and 19 per cent less S^28 than comparable teeth from bottle-fed children, and these differences were consistent for the years thus far studied (Fig. 2). Furthermore, sound first and second molars from bottle-fed children consistently contained 34 per cent and 20 per cent less S^28 than comparable carious teeth (Table 2). The correlation for S^28 in the crowns of sound and carious teeth is shown (Fig. 4). The crowns of sound teeth contained proportionately more dentin calcium and less enamel calcium than carious first molars, while the opposite relationship was found for second molars (Table 3).

The roots of first and second carious molars from bottle-fed children, born in 1949, contained proportionately more S^28 than carious crown samples, but the root/crown ratio gradually decreased with time and approached a value of 1 in 1958 (Fig. 4).

The correlation between the accumula-
TABLE 3
CALCULATED DISTRIBUTION OF ENAMEL AND DENTIN FOR DECIDUOUS MOLARS

<table>
<thead>
<tr>
<th>Tooth Type</th>
<th>No. Molars</th>
<th>Enamel %</th>
<th>Dentin %</th>
<th>C/D Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st molar</td>
<td>Sound</td>
<td>78</td>
<td>44.36</td>
<td>65.64</td>
</tr>
<tr>
<td></td>
<td>Carious</td>
<td>108</td>
<td>24.69</td>
<td>75.31</td>
</tr>
<tr>
<td>2nd molar</td>
<td>Sound</td>
<td>58</td>
<td>60.75</td>
<td>39.25</td>
</tr>
<tr>
<td></td>
<td>Carious</td>
<td>179</td>
<td>52.77</td>
<td>47.23</td>
</tr>
</tbody>
</table>

*The calcium percentages are based on wet weight of the whole crown, as described in "Methods and Materials."

Fig. 5 shows that there are differences in the amount of calcium content in milk between Sound and Carious teeth. The difference is significant for both Sound and Carious teeth. The data is consistent with the previous findings reported by Bryant and others.

Discussion

The results of the present study demonstrate the increasing accumulation of Sr2+ in the deciduous incisors, cuspid, and molar teeth of children born during 1947-1950, when the Sr2+ fallout was increasing. The accumulation is essentially comparable to that described for deciduous incisors during the same period.

Different kinds of deciduous teeth vary in their concentration, depending on the time of development in a physiological environment. The difference in the deposition of Sr2+ in deciduous incisors and deciduous second molars may be due to the difference in the period of development. In the first 6 months, there was a significant increase in the concentration of Sr2+ in deciduous incisors compared to deciduous second molars.

The finding that the roots of deciduous molars contained higher concentrations of Sr2+ than comparable crowns between 1949 and 1955 probably reflects the time element of formation of various calcified tissues and the diet. The crown of the deciduous tooth is developed over a relatively short period of less than 1 year and, once calcified, is no longer subject to changes in remodeling, exchange, or turnover. Although various teeth may deposit secondary or sclerotic dentin (or both) that may augment or inhibit ionic exchange between more distal dentin and the circulatory system, such as reported by Rowland,11 we assume this factor to be significant with respect to the amount of mineral matter originally present in the crown.
deposited in the tooth crown. The crown, therefore, primarily represents the accumula-
tion of S\textsuperscript{mg} available during the time of its formation. In contrast to the stability of the crown, the roots undergo continual and varying degrees of resorption, remodeling, exchange, and turnover. During a period of increasing S\textsuperscript{mg} fallout, the roots reflect the availability of greater amounts of the "dentine" during root metabolism. Conversely, when root formation occurs during a time when the availability of S\textsuperscript{mg} is lower than that occurring when the crown is formed, roots contain less S\textsuperscript{mg} than tooth crowns. The fact that roots and crowns appear to contain equal concentrations of S\textsuperscript{mg} between 1956 and 1958 may be fortuitous, but suggests that the availability of S\textsuperscript{mg} was essentially similar during the time of crown and root formation.

It is interesting to speculate on the lower S\textsuperscript{mg} content for the crowns of sounds teeth as compared with carious teeth. The simplest explanation would be that the carious tooth crown represents a larger proportion of dentin (which would contain more S\textsuperscript{mg}) due to later development in a higher S\textsuperscript{mg} environment than does a sound tooth crown. This explanation appears not to be acceptable because the sound crowns of both first and second molars contain less S\textsuperscript{mg} than carious crowns, and the distribution of dentin in carious first molars is diametrically opposite to the distribution in second molar crowns. Furthermore, it is known that dental calcium contains only about 10 per cent more S\textsuperscript{mg} than excreted calcium. It is more probable that intrinsic differences in either crystal structure or chemical composition of carious enamel and dentin may be associated with increased S\textsuperscript{mg} accumula-
tion. Unfortunately, sufficient sound first and second molar roots are not yet available for testing this hypothesis by analytical measurements of separated dentin and enamel.

The good correlation between the S\textsuperscript{mg} content of tooth crown and the S\textsuperscript{mg} content of milk and the minor degree of variance found between various kinds of teeth between 1949 to 1958 make it possible to use the tooth content of S\textsuperscript{mg} as a measure of the dietary S\textsuperscript{mg} intake during the time of tooth formation. It is also apparent that the objec-
tions voiced by Kelz and Schreder \cite{8} are not valid: (1) The collection of large num-
bers of deciduous tooth crowns can be obtained with relative ease and does not in-
volve any more effort than the collection of bone samples at either biopsy or necropsy. The mechanism for calcium deposition in teeth is less complex than that in bone, because the factors of turnover, exchange, and remodeling are essentially absent in the crown of teeth once they are formed. Deciduous tooth crowns are formed over a relatively short period and appear to accu-
rate ref.: the S\textsuperscript{mg} content of the diet during the time of tooth formation.

(3) The criticism that the S\textsuperscript{mg} content of tooth crown is an indirect measure of body burden can not be refuted; however, this indirect measure appears to be of value when direct analyses of the diet are not readily available. A more valid criticism is the fact that the S\textsuperscript{mg} content of deciduous teeth reflects the S\textsuperscript{mg} accumulation some 5 to 10 years previous for incisors and second molars, re-
respectively. For correlation of the S\textsuperscript{mg} content of crown tooth and the diet, however, makes it possible to estimate the dietary S\textsuperscript{mg} content prior to 1955--before milk and diet levels were known. The S\textsuperscript{mg} content of teeth, therefore, furnishes a permanent record of the S\textsuperscript{mg} body burden at the time the teeth are formed.

Summary

The S\textsuperscript{mg} content of deciduous tooth crowns increased from 0.15 to 4.7 P.S.\textsuperscript{mg} (un. of Ca between 1947 and 1958, respec-
tively, for children born in the St. Louis area and who were breast-fed from birth. The variation of S\textsuperscript{mg} content in deciduous incisors, canines, and first and second molars, between carious and sound teeth or be-
tween teeth from children who were breast-
fed or bottle-fed during the time of tooth formation, was less than 30 per cent. This small variation suggests that pooled samples of tooth crown, without regard to these classifications, may adequately serve as a measure of the S\textsuperscript{mg} body burden during the time of tooth formation.

For the teeth of children who were bottle-
fed, a relationship between the S\textsuperscript{mg} content of tooth crown (C) and the diet (C) is adequately described by the equation C = X\textsuperscript{2} + S, where the slope (S) must be deter-
mined experimentally. The value of X was 0.59 for sound incisors, 0.69 for carious first molars, 0.76 for sound canines, and 0.77 for carious second molars. This relationship makes it possible to estimate the dietary S\textsuperscript{mg} content from tooth values for years prior to the initiation of dietary S\textsuperscript{mg} estima-
tions.

We thank Sylvia Raymond, Sylvia Goodman, and Vegetie Logan for the collection of deciduous teeth from the laboratory assistant, and the Greater St. Louis Citizens’ Committee for Nuclear Information for operations of the Baby Teeth Survey.

References