STRONTIUM-90 CONTENT OF FIRST BICUSPIDS

By

Prof. HAROLD L. ROSENTHAL, JOHN T. BIRD

and

JOHN E. GILSTER

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THE tooth crown, once formed, is a stable calcified structure removed from direct equilibrium with body fluids and therefore undergoes minimal remodelling, exchange or turnover of mineral elements. During development and calcification, the mineral elements of the crown are in equilibrium with body fluids and, indirectly, with the diet. The concentration of strontium-90 in the tooth crown is, therefore, a measure of the equilibrium between the tooth and dietary strontium-90, and the tooth crown represents a permanent record of the equilibrium existing at the time of tooth formation.

We have recently reported[1,2] that the accumulation of fall-out strontium-90 in deciduous teeth of children is adequately described by a linear equation of the form $C_T = K\,C_D$, where C_T and C_D are the strontium-90 concentrations expressed as pc. strontium-90/g calcium in the tooth crown (C_T) and the diet (C_D). The slope, K, was derived from considerations of the percentage of the tooth crown formed *in utero* and *post partum*, known discrimination factors between the foetus and its mother, and discrimination factors between the baby and its diet. The slope, K, varies with the type of tooth and time of formation and has been found to be 0·59, 0·76, 0·69 and 0·77 for healthy incisors, healthy cuspids, carious first molars and carious second molars, respectively. The strontium-90 content of the deciduous teeth represents a function of the dietary strontium-90 content some 5–8 years before natural exfoliation.

For permanent teeth that are formed after birth and are predominantly formed after breast feeding is discontinued, the factors of placental discrimination and the influence of the maternal nutrition are effectively absent. Thus, the slope (K) of the equation is simplified and is primarily equivalent to the discrimination factor between permanent tooth crown strontium-90 and the dietary strontium-90. The slope (K) must be experimentally determined. Sound first bicuspids, often extracted for orthodontic purposes, are readily available for estimation of strontium-90 content[3]. Furthermore, the rate of growth of the first bicuspid crown is well characterized[4], and data concerning the age of the patient, geographical area of

birth and later development and other pertinent information may be readily obtained.

This report describes the strontium-90 content of the crowns of first bicuspids and the relationship to dietary strontium-90 from fall-out.

Healthy first bicuspids, extracted between July 1, 1964, and May 1965, from children born within a 150-mile radius of St. Louis, Missouri, and ranging in age from 9 years to 17 years were analysed for strontium-90 by methods previously described[1,2,5]. The crowns and roots were separated at the crown-enamel junction and the crowns were pooled to make a sample containing four crowns and weighing 2–4 g. Of forty-six samples analysed, twenty-four samples (52 per cent) contained four crowns from one child, eighteen samples (40 per cent) were pooled from two or three children, and four samples (8 per cent) were pools of teeth from four children. When crowns were pooled, care was taken to check that they came from children born within 6 months of each other. Because strontium-90 analysis of milk in the St. Louis area was not carried out before 1959, milk strontium-90 values were estimated as previously described[1]. For American children of this age group, previous estimates have shown that the daily dietary strontium-90 intake is equal to the milk strontium-90/g calcium multiplied by 1·20 (ref. 6).

The first bicuspid forms between the ages of 1·5 years and 6 years[4], and an average value of 4 years after birth was taken as the mid-point for time of development.

As shown in Fig. 1, the strontium-90 concentration in the crowns of permanent first bicuspids increases with time for children born between 1948 and 1955, corresponding to a tooth development time between 1952 and

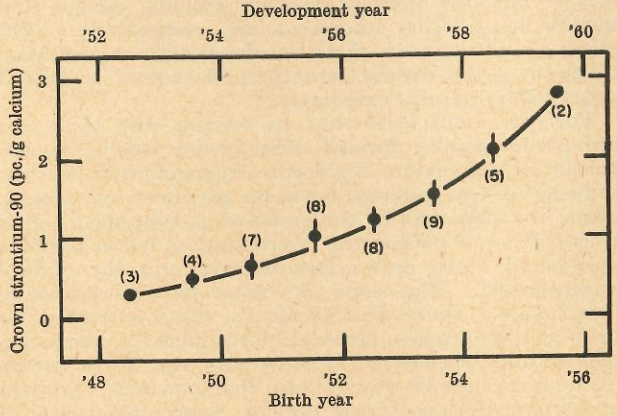

Fig. 1. Strontium-90 content of first bicuspid crown versus year of birth and year of average development. Vertical lines are standard error of the mean for the number of samples in parenthesis

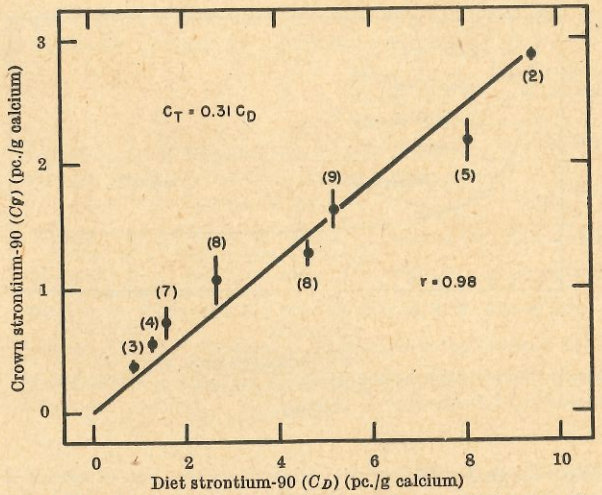

Fig. 2. Strontium-90 content of first bicuspid crown (C_T) versus diet strontium-90 (C_D). Vertical lines are standard error of the mean for the number of samples in parenthesis

1959, a period associated with increasing fall-out. When the strontium-90 content of the tooth crown is plotted against the strontium-90 content of the diet (Fig. 2), the data are adequately described by a linear equation, $C_T = K\, C_D$ (calculated by the method of average points), with a high correlation coefficient of 0·98. The slope of the line (K), equivalent to the discrimination factor between tooth crown and diet, is calculated from the data to be 0·31.

Discrimination against strontium relative to that of calcium is assumed to be absent in new-born infants[7] and a factor of 0·25 has been accepted for calcified tissues of adult subjects between 20 years and old age[8]. These and other known discrimination factors have been plotted (Fig. 3) to indicate the rapid decrease of the discrimination factor from the time of birth until about 4 years of age, thereafter decreasing slowly to adult values. We estimate, therefore, that the discrimination factor approaches the adult value at about 10–12 years of age.

The data described in the present report for first bicuspids and our previous reports for deciduous teeth[1,2,5] indicate the usefulness of the teeth as a permanent record of strontium-90 deposition at the time of tooth formation. Furthermore, the stability of the formed crown with respect to minimal turnover time, exchange and remodelling and the known time for tooth development[4] makes it possible to estimate the changing discrimination factors in the growing child—estimates that are difficult to determine by other means.

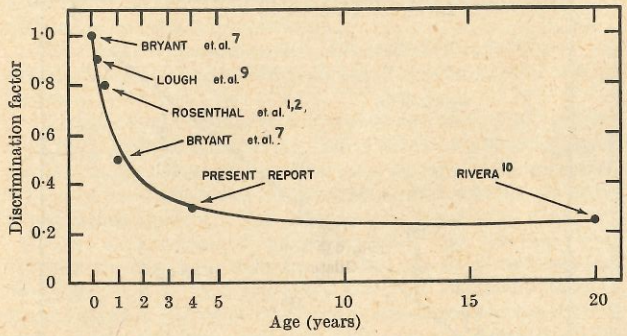

Fig. 3. Discrimination factor $\left(\frac{\text{pc. } ^{90}\text{Sr/g Ca in bone}}{\text{pc. } ^{90}\text{Sr/g Ca in diet}}\right)$ versus age of children

We recognize the influence of the time lag of about 4 years for development of the bicuspid crown and the fact that the crown consists of enamel and dentine that calcify at different times. These and other factors need to be clarified, but they would not seem to influence seriously the results and are presumed to be much smaller than the analytical error of strontium-90 analysis. Although Starkey, Bryant and Henderson[3] have criticized the usefulness of deciduous teeth and have preferred to analyse permanent first bicuspid and third molars, we believe that the tooth crown reflects the equilibrium between calcified tissues and diet strontium-90 concentrations at the time of tooth formation.

Deciduous teeth are useful because they are readily available in large numbers by natural exfoliation, reflecting the strontium-90 incorporation during a short calcification period of less than 1 year. The various factors influencing the strontium-90 content of deciduous teeth such as discrimination by the placental barrier during *in utero* development, or discrimination between the baby and its diet, have already been evaluated[1]. Permanent teeth, although not so readily available as deciduous teeth, are larger, require fewer teeth for adequate sampling and represent the strontium-90 equilibrium with the diet in the absence of minimal maternal influence. The longer development time of permanent teeth represents an average incorporation of strontium-90 during the period of calcification, thus obviating the influence of sharp and rapid changes in dietary strontium-90 levels.

It appears, therefore, that all kinds of teeth may be useful as an index of dietary strontium-90 when due consideration is given to the many factors involved in tooth and bone formation and metabolism.

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HAROLD L. ROSENTHAL
JOHN T. BIRD
JOHN E. GILSTER

Department of Physiological Chemistry,
Washington University, School of Dentistry,
St. Louis, Missouri.

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