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THE FLUORIDE CONCENTRATION IN THE ENAMEL OF PERMANENT CENTRAL INCISORS

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INTRODUCTION

THE caries inhibitory effect of fluoride is well documented (Brudevold *et al*, 1967; Horowitz and Heifetz, 1970). As the initial site of the caries lesion occurs on the surface of the tooth at the plaque/tooth interface, the fluoride concentration in the surface layers of enamel is important in combating the carious process (Isaac *et al*, 1958; Naylor, 1969).

The fluoride in the enamel is derived from the circulating plasma fluoride during the pre-eruptive phase. After eruption changes in the fluoride concentration in the enamel are related to the fluoride content of the drinking water and the saliva, and the ingested food (Fig. 1).

X-ray diffraction and electron microscopic studies led Gerould (1945) to postulate that the fluorine in enamel is present as fluorapatite. McCann (1953) showed that only fluorapatite can, in fact, form from the low concentration of fluoride in the tissue fluids and in drinking water. The fluoride ion exchange which takes place both pre- and post-eruptively is a simple hetero-ionic one between the fluoride ions in the solution phase and the dissimilar hydroxl ions in the solid phase (Joyston-Bechal, Duckworth and Braden, 1967).

The reaction is as follows:

$$Ca_{10}\ (PO4)_6\ (OH)_2 + 2\overline{F} \rightarrow Ca_{10}\ (PO4)_6\ F_2 + 2(\overline{OH})$$

McCann (1969) referred to an additional mechanism for fluoride fixation in enamel. He observed that there was a higher fluoride retention when it was treated with an aluminium salt solution prior to the application of a topical fluoride solution. He suggested that fluorine can bind to polyvoient metal ions to form strong complexes.

The object of this investigation was to determine the fluoride concentration in the surface layers of the enamel of central incisors of persons resident on the Witwatersrand. The drinking water in this area is supplied by the Rand Water Board and has an average fluoride concentration of 0.2 ppm.*

*Rand Water Board—1969 monthly average of water constituents.

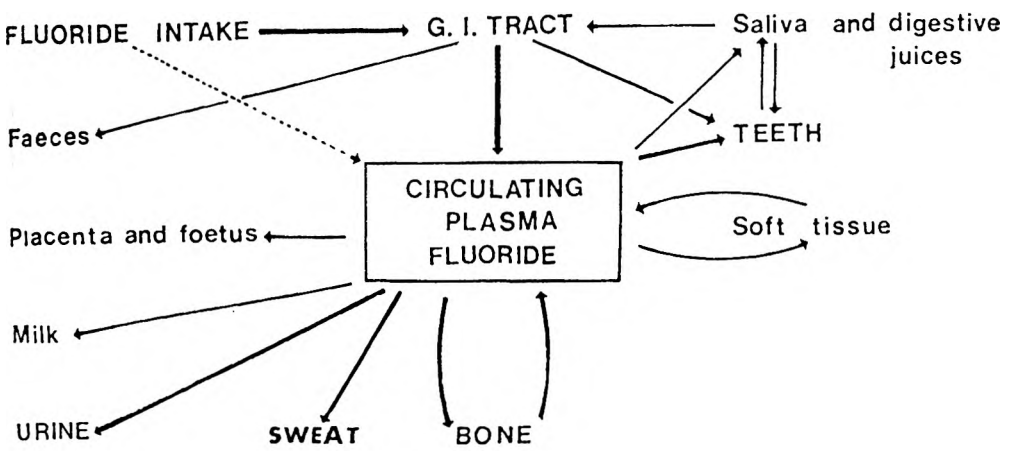

FIG. 1. The source of the fluoride content of enamel.

MATERIALS AND METHODS

1. *The fluoride concentration in the surface layers of extracted teeth.*

Sixteen pairs of freshly extracted teeth were freed of all debris, washed in deionised water and stored at −4°C until the analysis commenced. The method described by McCann (1968) for determining the fluoride in mineralized tissues was employed. Blocks of enamel with known surface areas were prepared and exposed to 1.0 ml of 0.5 M $HClO_4$ for five consecutive etchings; the first two were done for 30 seconds and the others for one minute each.

2. *The fluoride concentration in the surface layers of teeth* in vivo.

An enamel biopsy technique developed by Brudevold, McCann and Grøn (1968) was applied to 50 pairs of teeth *in vivo*. The materials used, silicon carbide, felt cones and cotton wool pellets, were rendered free of Ca and F.

3. *Chemical analysis and calculations.*

Fluoride was determined by means of a fluoride ion activity electrode (Model 94-09)† and a single junction reference electrode (Model 90-01)† coupled to a specific ion meter (Model 407).†

Calcium was determined on aliquots diluted 1:25 by means of atomic absorption spectrophotometry (Carl Zeiss Spectrophotometer, Model PMQ II). The amount of enamel in the sample was calculated on the assumption that its calcium content is 38 per cent.

In the enamel etching technique the depth of etching was calculated as follows:

$$\text{Depth of etch } (\mu) = \frac{\text{Weight of enamel in sample}}{\text{Density of enamel} \times \text{surface area.}}$$

The density of enamel was taken as 2.95 gms/cc (Manly and Hodge, 1939).

RESULTS

The fluoride concentrations in the enamel of the 16 pairs of extracted incisors were determined at five consecutive depths; and its distribution in the surface layers was recorded graphically by plotting the determined fluoride concentrations against the depth of etching (Fig. 2).

†Orion Research Incorporated, Cambridge, Massachusetts, U.S.A.

The fluoride distribution curves followed a similar pattern to that described by Weatherell and Hargreaves (1966). Its concentration was maximal in the outermost layer and fell in a characteristic curve to a plateau in the inferior region. The fluoride concentrations at a depth of 10μ in the different teeth were determined from the distribution curves (Table 1). At this depth they ranged from 180 to 1700 ppm with a mean value of 774 ppm.

TABLE I. The fluoride concentration at a depth of 10 microns.

Tooth		*F ppm at 10 μ*	*Tooth*		*F ppm at 10 μ*
A	R	310	J	R	180
	L	400		L	391
B	R	610	K	R	1570
	L	695		L	1700
C	R	495	L	R	505
	L	565		L	470
D	R	385	M	R	375
	L	440		L	370
E	R	915	N	R	395
	L	760		L	207
F	R	610	O	R	870
	L	685		L	755
G	R	868	P	R	1050
	L	790		L	1300
H	R	627	R	R	890
	L	336		L	900

The fluoride distribution curves of five pairs of central incisors were recorded separately (Fig. 3).

It was not possible to measure the depth of etching when using the enamel biopsy technique because the labial surface areas of the 50 pairs of teeth were not determined. The amount of enamel removed during each biopsy and its fluoride concentration, however, were determined. The relevant data and the number of biopsies in each group are set out in Table II. A histogram showed the frequency distribution of the amounts of enamel removed to vary between 200 μg and 500 μg from the surfaces in 61 per cent of the biopsies (Fig. 4).

DISCUSSION

The fluoride concentration can be determined at different depths in the surface layers of enamel by the enamel etching technique. The application of this method is limited; it can be used only on extracted teeth.

The depth at which the plateau was reached in the fluoride distribution curve

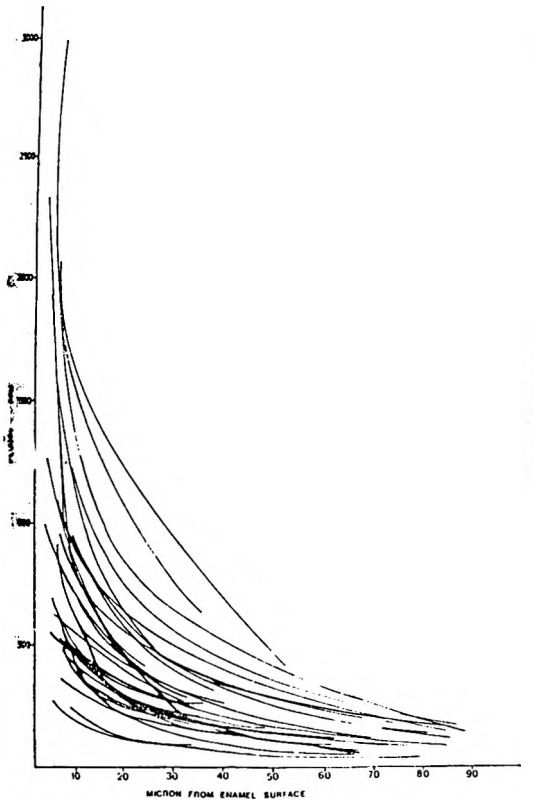

FIG. 2.

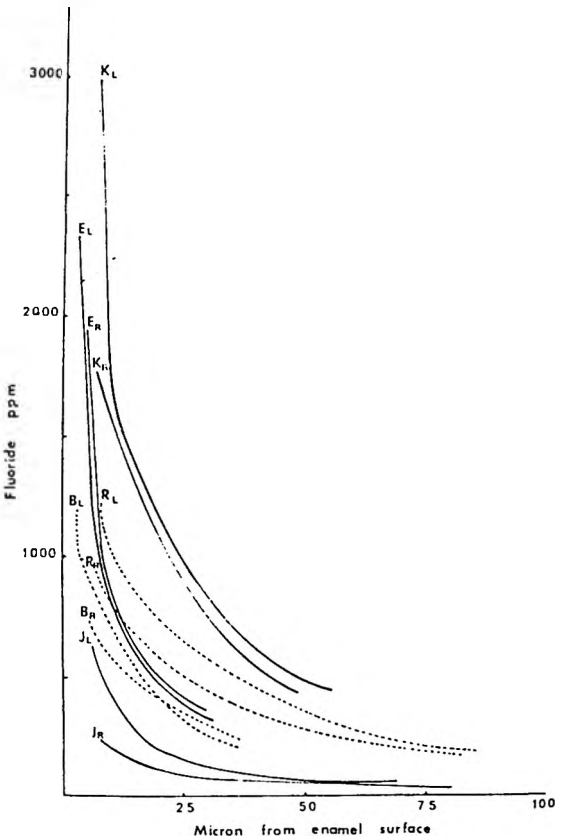

FIG. 3.

FIG. 2. The fluoride distribution curves of the extracted central incisors.

FIG. 3. The fluoride distribution curves of five pairs of central incisors.

FIG. 4. The frequency distribution of the amount of enamel removed during the enamel biopsies.

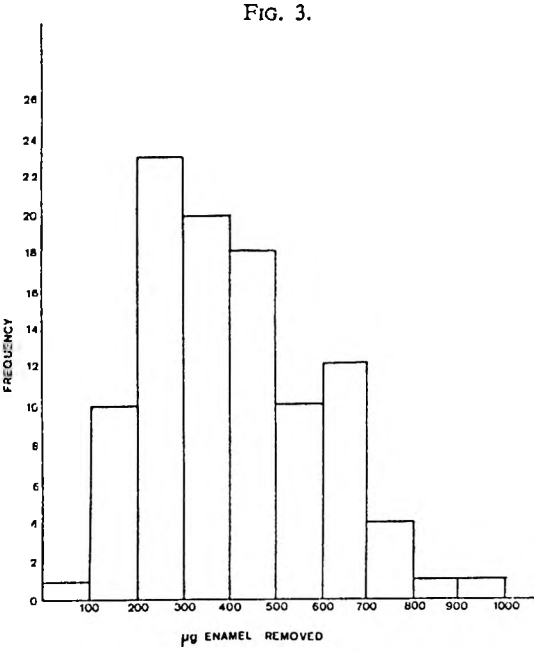

FIG. 4.

varied from one tooth to another. A high fluoride level in a tooth surface was usually associated with a higher level in the interior of the enamel and *vice versa*. This is evidenced by the relatively slight overlap between the individual fluoride distribution curves (Figs. 2 and 3).

Because of the initial sharp drop in the fluoride distribution curves and the differences in the depths of etching obtained, the fluoride concentration at a depth of 10 microns was determined from the fluoride distribution curve of each tooth (Table 1). The results for a pair of central incisors from the same mouth were similar, and so were the fluoride distribution curves (Fig. 3). As the teeth were exposed to the same pre- and post-eruptive environment, these results were expected.

In the 16 persons no correlation between the age and the caries incidence and the fluoride distribution in the superficial layers of the enamel could be established—possibly due to the small size of the sample.

Although the amount of enamel removed in the biopsy technique and its fluoride concentration can be accurately measured, a disadvantage is that the depth of its removal cannot be determined. The only practical way to compare the fluoride concentrations is to group the results of the biopsies together according to the amount of enamel removed (Table II). This is not a very satisfactory procedure because of the sharp drop in the fluoride distribution in the superficial parts of the tissue. The amount of enamel removed varied considerably: from 100 μg to 900 μg.

A new method of enamel biopsy to estimate the fluoride concentration *in vivo* has recently been developed by Hotz, Mühlemann and Schait (1970). It enables the depth of the enamel removed to be determined and controlled within narrow limits.

SUMMARY

The fluoride concentration in the outer layers of enamel of 16 pairs of extracted central incisors was determined by an enamel etching technique. An enamel biopsy method was used to determine the fluoride concentrations in the surface layers of 50 pairs of central incisors *in vivo*. The persons are resident on the Witwatersrand and the average fluoride content of the drinking water in this area is 0.2 ppm. Fluoride distribution curves were prepared for the extracted teeth and the fluoride concentrations at a depth of 10 microns determined from these curves. The depth of enamel removed in the biopsy technique could not be measured and the amount removed varied considerably. No correlation between the age and caries incidence and the fluoride content of the enamel could be established.

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TABLE II: The amount of enamel removed, the mean fluoride concentration and number of biopsies in each group.

Enamel Removed μg	*Number of Biopsies*	*Mean Enamel Removed* μg	*Mean Fluoride conc. ppm*
0—100	1	40	5114
101—200	10	173	2024
201—300	23	261	1372
301—400	20	348	1192
401—500	18	447	771
501—600	10	547	1006
601—700	12	636	786
701—800	4	741	863
801—900	1	868	956
901—1000	1	912	317

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THE PATIENT AS AN INDIVIDUAL*

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"THE human personality is almost certainly the most complex phenomenon studied by science. It is, simultaneously, the most fascinating, at least to many of us. This is not entirely because we egotistically see ourselves mirrored in the intricate architecture of another person's individuality. It is also because, in our daily lives, we must continually meet, recognise, and deal with other personalities, anticipate their actions, understand their feelings." This is a quotation from Ross Stagner's book *The psychology of personality* that seems very adequate as an introduction to the subject that I have been asked to present.

Any classification of patients would go counter to the purpose of this paper. Although culture and personality are intimately related, and we could discuss, in general terms, sets of values or emotional reactions of Scandinavians, Sicilians, or Chinese, this would perhaps give us a general framework or a scale of reference without solving for us the problem of dealing with each person as an individual and unique entity.

We often classify and teach diseases as generalised entities. But even organic disease, to the extent that such things exist, are different from each other, in one and the same group. The complexity and variability of metabolic processes is such, that the interaction between the disturbance of one of these processes with all the others is never the same between two individuals. We often use tests and examinations that should be specific and indicative for a class of diseases. We often find that the results fall within the norm although we, as clinicians, have a feeling that differences are present. The dimensions of the range within the norm are directly proportional to our lack of precise knowledge of the process itself. This may be true on a test for calcium-phosphorus metabolism, or for diagnostic tests for an inflammatory condition of the pulp. It is obvious that the emotional background of the patient will affect not only the physio-pathological processes themselves but also, and still more, the im-

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