J. Dent. Ass. S. Afr. Vol. 29, No. 6, pp. 341 - 350

Fluoridation: Literature Review for 1972

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A survey of the indexed literature relating to all the aspects of fluoridation during 1972, revealed a vast number of publications. This must indicate that there is still considerable enthusiasm exhibited by investigators in this field of dental research. The general trend of the publications appeared to be unchanged from that of the past few years. Fluoridation in its various forms is almost universally accepted, but equally strong and determined opposition continued unabated.

In an attempt to simplify this review I have grouped the reviewed papers under the following headings:

1. Fluoridation of public water supplies.
2. Fluorosis.
3. Metabolism and physiology of fluoride.
4. Medicinal uses of fluoride.
5. Analytical observations of reactions with fluoride.
6. Enamel biopsy techniques for fluoride determinations.
7. Topical applications of fluoride.
8. Conclusion.

1. FLUORIDATION OF PUBLIC WATER SUPPLIES

By far the greatest interest in fluoridation, for both practitioners and the general public, was shown in the large number of publications dealing with the controlled addition of fluoride to the drinking water. Similarly, societies or groups unfavourably disposed to water fluoridation have been extremely active, and to some degree had succeeded in their endeavours.

The Swedish Parliament repealed legislation allowing local authorities to seek approval for water fluoridation (Burt & Petterson, 1972). A most lucid description was given by these authors of how such legislation was passed by 137 votes to 126 with 10 abstentions, whilst almost a quarter of the house was absent. The direct result of this decision was that controlled fluoridation to Norrköping ceased after it had been instituted 10 years previously. This was brought about purely on legal grounds, despite a proven reduction of caries in that town (Melander, 1957a; Melander, 1957b; Sellman & Syrrist, 1968). As a warning to practitioners, it was indicated that the onus lay with the various dental authorities not to be caught unprepared by a more adequately organised anti-fluoridation campaign. It was apparent in the case of the Swedish ruling, that emotional appeals carried more weight than did a rational and well balanced argument.

Similarly, after strong opposition during another anti-fluoridation campaign in the Scottish Burrough of Kilmarnock, the controlled addition of fluoride to the drinking water was stopped (Leading Article, 1972). Prior to this, the area received the benefit of fluoridated water for 6 years. A result of this was that the caries incidence in children's teeth has reverted to that of the prefluoridation levels.

Following a report in Canada, claiming that humans were consuming fluorides in excessive amounts, a brief annotation reaffirmed that fluoridation of public water supplies was compatible with a safe level of total fluoride intake from all sources (Editorial, 1972). This was in agreement with a recommendation by the World Health Assembly, in 1969, that member states introduce fluoridation where the water content of fluoride is below the optimum level of 1 ppm (Filler *et al*, 1972).

The suggested maximum daily intake of fluoride in children is summarized below (McClure, 1970).

1– 3 years of age	= 0,83 mg
4– 6 years of age	= 1,11 mg
7– 9 years of age	= 1,38 mg
10–12 years of age	= 1,73 mg

It has furthermore been suggested that fluoride be regarded as an essential nutritional element (Filler *et al*, 1972).

A questionnaire was prepared by a group of investigators and distributed to dental and medical practitioners, following a claim made by a London anti-fluoridation campaign, which stated:

"A substantial number of authorities in the fields of medicine, dentistry and science in various countries, including certain Nobel Prize winners, have expressed grave doubts concerning both the effectiveness and safety of fluoridation in the long term" (Aslett *et al*, 1972).

Of the 486 questionnaires distributed to the practitioners only 285 were returned and when summarized, yielded the following information regarding the acceptance of fluoridation:

(i) 87.4 per cent unreservedly favoured fluoridation,
(ii) 2,5 per cent disapproved of any form of fluoridation,
(iii) 4,9 per cent were undecided and
(iv) 5,2 per cent favoured other forms of fluoridation, but not that of the public water supplies.

These figures are obviously contrary to the objections quoted by the anti-fluoridation propoganda.

Some of the objections raised against water fluoridation included the following:

(a) that it was a chronic poison;
(b) unproven effectiveness in decreasing caries rates;
(c) that it infringed the rights of people;
(d) that the physiology of fluoride was not understood;
(e) that it created a precedent for mass medication;
(f) that it affected incomes and polluted the oceans.

However, a great deal of information as a result of numerous investigations, has beyond doubt not supported these objections.

Public education was shown to have had some effect, since a survey of British housewives has revealed that 95 per cent of those questioned were aware of the claimed beneficial effects of controlled water fluoridation (Jackson, 1972).

In addition, of those housewives questioned, 33 per cent were undecided about the desirability of water fluoridation for lack of adequate knowledge on the subject while 14 per cent were against it. The remaining 53 per cent were totally in favour of fluoridation. In order to convince the undecided third of the public, dental associations must make full use of the available modern mass media to present the undisputed, proven scientific evidence concerning water fluoridation and the effect this has on caries rates.

Areas which have had controlled levels of fluoride in the public drinking water for many years are invaluable sources of information pertaining to the claimed beneficial effects of water fluoridation. This information may be used to reaffirm the protective effect of the fluoride against dental caries. Furthermore, the results may be used to convince those antagonists of water fluoridation.

Just such proof about the beneficial effects of water fluoridation was made available following an investigation which was carried out in the towns of York and Hartlepool (Jackson & Murray, 1972). These two towns have 0,28 ppm and 1,8-2,0 ppm of fluoride, respectively, in their water supplies. The results have indicated a lower rate of tooth loss in dentate persons resident in Hartlepool, compared with those resident in York. Not only were the differences considerable, but they remained so with increasing ages of the people examined. An extension of this investigation showed that there was no significant clinical difference in gingival recession between individuals living in the areas of high and low fluoride concentrations (Murray, 1972).

Tables have been compiled to indicate the sizes of populations served with controlled water fluoridation Table I (Newbrun, 1972a). Hong Kong, Kuwait and Singapore have 100 per cent of the populations supplied with fluoridated water. Canada and the U.S.A. have 34 and 40 per cent respectively, of their populations receiving fluoridated water. In the U.S.A. an interesting investigation could be undertaken since Columbia has 100 per cent of the population consuming fluoridated water. This is in contrast to Nevada and Utah which respectively have only 3,8 per cent and 2,7 per cent (Table II) of the populations receiving fluoridated water (Newbrun, 1972a). A carefully controlled field investigation in these three states, at all age levels, may reveal some convincing evidence on water fluoridation to add to that documented to date.

2. FLUOROSIS

Chronic fluorosis has often been cited by the antagonists of water fluoridation as another reason for abolishing controlled fluoridation. This may be partially correct, but chronic fluorosis possibly only exists as an occupational hazard for persons subjected to an intake of 20 to 80 mg of fluoride daily for 10 to 20 years. Therefore, this is obviously an avoidable condition (Newbrun, 1972b). However two cases have been described, exhibiting "radiographic evidence" of chronic fluorosis (Juncos & Donadio, 1972).

Case 1 described an 18 year old male with a history of increased urination and thirst since infancy, having consumed water with a fluoride content of 2,6 ppm. Treatment of this case consisted only in a reduction of the intake of fluoride-free water from 2 gallons to 1 gallon daily.

Case 2 described a 17 year old female consuming excessive quantities of water, with a fluoride content of 1,77 ppm, who in addition, experienced several urinary tract infections since childhood. Ten months after surgical intervention she developed progressive renal insufficiency and remained acidotic.

The authors agreed that fluoridated water could not cause renal pathology per se. Chronic fluorosis in the above two instances were claimed to be related to primary diminished renal function, polyuria and polydypsia and excess fluoride in the drinking water with subsequent increased fluoride retention.

Basel is the only city in Switzerland with a controlled level of fluoride in the water (1 ppm). After 5 years of consuming this fluoridated water, 558 school children were examined for signs of dental fluorosis. The result indicated no increase in the frequency or intensity of mottling of enamel (Weisskopf, Gülzow & Maeglin, 1972). A similar study was carried out in Uganda comparing the African and Asian sections of the population (Møller, Pindborg & Roed-Petersen, 1972). In this survey four different areas were chosen where the fluoride content of the water varied from 0,11 to 3,00 ppm. These findings revealed that dental caries increased with age, was higher in females than in males, was higher in Asians than in Africans and decreased with increased fluoride concentration of the water.

PERCENT OF POPULATION SERVED WITH NATURAL AND CONTROLLED FLUORIDATED WATER*
DECEMBER 31, 1971

	Percentage of Population on Public Water Supplies Served with Fluoridated Water	*Percentage of Total Population Served with Fluoridated Water*
United States	58,7	45,5
Alabama	40,6	25,6
Alaska	79,9	44,0
Arizona	19,6	17,3
Arkansas	67,7	36,7
California	19,4	18,2
Colorado	89,5	73,3
Connecticut	90,6	72,6
Delaware	54,3	40,2
Dist. of Columbia	100,0	100,0
Florida	37,4	28,9
Georgia	68,0	47,3
Hawaii	13,2	12,8
Idaho	27,2	17,7
Illinois	98,1	84,4
Indiana	88,9	58,6
Iowa	80,7	55,0
Kansas	58,8	44,8
Kentucky	81,0	46,1
Louisiana	10,4	7,9
Maine	58,9	35,1
Maryland	98,1	76,9
Massachusetts	13,3	12,4
Michigan	90,7	63,6
Minnesota	98,0	73,0
Mississippi	43,6	21,9
Missouri	61,7	45,2
Montana	28,9	19,3
Nebraska	67,2	47,9
Nevada	3,8	3,3
New Hampshire	17,7	11,5
New Jersey	14,8	13,0
New Mexico	53,4	38,9
New York	75,8	66,3
North Carolina	74,9	37,9
North Dakota	91,5	48,0
Ohio	53,5	42,0
Oklahoma	74,9	56,4
Oregon	21,8	16,4
Pennsylvania	52,4	42,0
Rhode Island	90,1	80,7
South Carolina	64,3	36,1
South Dakota	90,6	52,9
Tennessee	67,5	43,9
Texas	63,3	50,8
Utah	2,7	2,5
Vermont	45,8	26,5
Virginia	95,5	61,8
Washington	46,4	38,4
West Virginia	83,0	50,9
Wisconsin	94,8	61,4
Wyoming	40,1	29,7
Puerto Rico	92,4	66,7

*U.S. Dept. of Health, Education and Welfare, NIH, April 1972.

Table I: (Reprinted from Fluorides by Newbrun 1972, with permission of Charles C. Thomas. Springfield, Illinois).

An interesting paper described the results achieved with partial defluoridation in a small community whose drinking water until 1952 had a fluoride concentration of 8,00 ppm (Horowitz & Heifetz, 1972). A defluoridation plant was then put into use which reduced the fluoride content of the water to 1,08 ppm. Initially 96 per cent of the population had some degree of fluorosis, with 49 per cent affected by severe forms of this condition. In 1969, 17 years later, only 18 per cent had some degree of fluorosis, one child having moderate fluorosis and no case being classified as severe fluorosis.

WORLD WIDE WATER FLUORIDATION*

County or Territory	*Year First Project Started*	*Population Served by Fluoride-Supplemented Water*	*Percentage of Total Population Served with Fluoridated Water†*
Australia	1956	5 000 000	41
Belgium	1956	400 000	4
Brazil	1953	2 930 000	3,1
Canada	1945	7 300 000	34
Chile	1953	3 300 000	39
Colombia	1953	2 520 000	12
Czechoslovakia	1958	1 000 000	10
El Salvador	1956	1 380 000	50
Federal Republic of Germany	1952	6 000	0,01
Finland	1959	60 000	1,3
Hong Kong	1961	3 570 000	100
Ireland	1964	1 350 000	47
Japan	1952	—	—
Kuwait	1968	676 000	100
Malaysia	—	3 000 000	25
Mexico	1960	1 750 000	4,4
Netherlands	1953	3 000 000	20
New Zealand	1953	1 205 000	43
Panama	1950	560 000	40
Papua and New Guinea	1966	38 000	1,7
Paraguay	1959	220 000	9
Poland	1967	500 000	5
Puerto Rico	1953	1 820 000	67
Rumania	—	100 000	0,5
Ryukyu Islands	—	740 000	78
Sarawak	—	180 000	—
Singapore	1958	2 000 000	100
Sweden	1952	130 000	—
Switzerland	1960	274 000	5
United Kingdom	1955	2 305 000	4
USA	1945	86 000 000	40
USSR	1960	13 000 000	4
Venezuela	1952	70 000	1

*Based on information supplied by governments, the International Dental Federation, WHO Chronicle, European Public Health Committee, Council of Europe and Dental Section Department of Health Services, Pan American Sanitary Bureau of the WHO.

†The percentage of total population served with fluoridated water refers only to those receiving controlled fluoridated water. Calculation of the percentage of population served by communal water supplies receiving controlled or natural fluoride containing water gives considerably higher values for some countries.

Table II: (Reprinted from Fluorides by Newbrun 1972, with permission of Charles C. Thomas. Springfield. Illinois).

3. METABOLISM AND PHYSIOLOGY OF FLUORIDE

An aspect of fluoridation which has received a great deal of experimental investigation is the transplacental flow of fluoride in animals and man. It was shown that in rats, the placenta acts as a partial barrier to varying doses of injected sodium fluoride (Devoto *et al*, 1972). Increases in the dosage of sodium fluoride caused varying degrees of pathologic changes to the placenta and even to the foetus. This experimental evidence could however not be related to human clinical investigation. This was because the human placenta has a villous-haemo-chorial labyrinthine structure compared to the haemo-endothelial labyrinthine structure in rats. Interestingly however, it has been shown that with 1 ppm of fluoride in the drinking water, the maternal placental blood fluoride level is higher than that of foetal blood (Filler *et al*, 1972).

A histological examination using tritiated thymidine showed that in rats, large doses of sodium fluoride impaired the ability of the ameloblasts to synthesize protein (Kruger, 1972). This was evidenced by distentions found on the endoplasmic reticulum of these ameloblasts. Sub-mottling doses of the sodium fluoride appeared to stimulate the ameloblasts. Furthermore, protein-deficient diets were shown to enhance the injurious effect of excessive amounts of fluoride (Jansen van Rensburg, 1972). As more evidence on mineralization accumulates it may be possible to determine whether there are common effects of fluoride on cells actively synthesizing protein, or whether these effects are dose-dependant.

During the initial mineralization of a tooth, little fluoride is incorporated into the developing enamel (Regolati, 1972). The fluoride levels in developing teeth increased markedly during the time between crown formation and the eruption of the tooth. The next and important phase for fluoride incorporation into enamel occurred during the early post-eruptive phase (Mühlemann, 1972; Regolati, 1972).

An investigation into the mobilisation and mineralization of dental and skeletal elements in rats showed that the deposition of fluoride in bone and enamel probably occurs in different ways (Zipkin, 1972). This may be so since the organic matrix of enamel is neither collagen nor keratin-like in nature. The position of the fluoride ions may also exist in two different forms in teeth and in bones. The fluoride ion may firstly be incorporated as part of the intra-crystalline moiety or the ion may be held to the crystalline surfaces by adsorbed forces. Finally it was postulated that fluoride may in addition be bound to the organic matrices of both bone and enamel.

Fluoride and stannous ions both singularly and together affect the rate of growth of crystals of hydroxyapatite. The stannous ions affected growth by absorption onto the active growth sites of the crystals. The action of the fluoride ion alone was however more difficult to evaluate (Meyer & Nancollas, 1972). A fluoride-rich surface zone in dentine has been demonstrated under arrested caries (Levine, 1972). This condition has not been demonstrated in carious dentine.

Caries reduction in rats has been produced by the addition of bicarbonate and phosphate to the dietary sucrose (Luoma *et al*, 1972). This level of reduction was further reduced by the addition of sodium fluoride to the same diet. It was shown that this effect was the end result of the bicarbonate-phosphate-fluoride combination and not to that of the fluoride alone. This supports previous findings that the addition of 5 ppm of fluoride to the diet of rats significantly reduced the caries rate. However, the same concentration in the dietary water did not produce this result (Hardwick & Bunting, 1971).

An investigation has revealed certain interesting facts concerning the metabolic relationship between aluminium and fluoride (Brudevold, Moreno & Bakhos, 1972). Aluminium proved to be the major complexing element, with minimal complexing occurring with other polyvalent elements such as Fe. Thus the ingestion of aluminium is important in the question of fluoride metabolism. It was shown that the quantity of complexed fluoride increased throughout increases in the gastric and duodenal pH ranges. The amount of complexing increased at the gastric pH from 16 per cent to as much as 60 per cent in the duodenal pH ranges. In addition, it was also shown that aluminium accounted for the greatest degree of complexing of fluoride in the drinking water and not magnesium as was previously shown (Feldman, Marken & Hodge, 1957).

Studies in man, on the fluoride concentration of saliva and urine have been described following exogenous fluoride administration (Capozzi *et al*, 1972; Shannon & Edmonds, 1972). Parotid salivary fluoride levels were highest 10 to 120 min after the fluoride administration. Furthermore, no significant alteration in the quantity of urinary excretion was observed in children with or without renal disease, except that the excretion of fluoride was slower in those children with renal disease.

The *in vitro* action of rabbit muscle enolase and fluoride was shown to occur in two ways (Cimasoni, 1972). In the presence of phosphate the fluoride was bound directly to the protein moiety of the enzyme. Without phosphate however, the fluoride was probably bound to the enzyme-substrate complex. The *in vivo* antibacterial action of fluoride, as an anti-enzyme effect, has not been conclusively proved. Studies of *in vitro* systems have however shown reduced acid activity by salivary micro-organisms in the presence of 1-10 ppm of fluoride.

The physiologic concentrations of fluoride in the surface enamel of individuals of various ages has been investigated (Weatherell, Robinson & Hallsworth, 1972). The fluoride concentrations in individuals over 30 years of age increased from the incisal edge to the gingival margin. This may be attributed to both physiological and pathological wear. In very young children the fluoride concentration increased from the gingival margin to the incisal edge. However in adolescents and young adults up to 30 years of age, the fluoride concentration was greatest in the middle third and decreased towards the gingival and incisal margins. The causative factors in this instance may have been both wear of enamel as well as the post-eruptive deposition of fluoride on to the enamel surface.

Finally, the release of fluoride from disintegrating dental restorations has been examined (Forsten and Paunio, 1972). It was shown that silicates yielded a higher initial concentration of fluoride than did the composites. Further evidence is required to assess whether the fluoride which is released is active or whether it still exists chemically bound and thus not able to perform any anticarious activity.

4. MEDICINAL USES OF FLUORIDE

A paper describing an allergic reaction to high medicinal dosages of fluoride gave some food for thought. Some 1 500 patients were given 40 to 120 mg daily of fluoride for periods up to 4 years. The fluoride was administered in an attempt to induce recalcification in patients with active spongification of the cochlear capsule (Shambaugh, 1972). During the course of investigation 3 patients developed skin rashes. These rashes disappeared with cessation of the treatment, but recurred when the fluoride was again administered.

The prevention of osteoporotic conditions by means of water fluoridation has received interest (Newbrun, 1972b). The N.W. areas of North Dakota have 3,00 to 6,00 ppm of fluoride in the drinking water, compared with 0,1 to 0,3 ppm in the S.E. areas of the same state. A radiographic survey has shown a lowered incidence of osteoporosis in elderly females resident in the high fluoride areas. There was however no difference in the male section of the population. Coincidentally, calcification of the aorta was markedly reduced in both males and females living in the high fluoride areas (Newbrun, 1972b).

Finally, the skeletal uptake of ^{89}Sr has received wide interest in medical science. Experimental evidence has indicated that in rats consuming 50 ppm sodium fluoride, a decreased skeletal retention of ^{89}Sr resulted after 2 months (Light & Stookey, 1972). This result proved to be more effective when the fluoride consumption was continued for longer periods e.g. 6-8 months. Up to a period of 2 months however, there was no appreciable alteration of the uptake of ^{89}Sr in the bones of the experimental animals.

5. ANALYTICAL OBSERVATIONS OF REACTIONS WITH FLUORIDE

In vitro examinations into the effect of stannous fluoride on enamel have continued. Sophisticated analytical methods such as infra-red internal reflection spectroscopy (Krutchkoff *et al* 1972) and single crystal X-ray diffraction (Berndt, 1972) have shown that the major reaction product was $Sn_3PO_4F_3$. In addition soluble calcium fluoride was formed in large quantities as well as varying amounts of other unidentified products.

Powdered enamel, when exposed for 4 min to a 10 per cent stannous fluoride solution produced greater quantities of $Sn_3PO_4F_3$ than did polished enamel. This may be the result of an increased area of available enamel being exposed to the effects of the stannous fluoride solution. Clinically, this may account for the reversal of incipient caries following the topical application of stannous fluoride. The initial demineralization of this form of incipient caries makes available the large surface area for the stannous fluoride activity (Wei & Forbes, 1972). In addition, the possibility of a greater number of phosphate radicals being provided by the demineralization process for reaction with stannous fluoride, has also been postulated (Krutchkoff *et al*, 1972).

Investigations into the actions of polyvalent ions aiding fluoride retention in the surface enamel have been described. An *in vitro* examination has shown that enamel pretreated with titanium tetrafluoride underwent less dissolution in acid than did enamel treated with one of the more commonly used topical fluoridation methods (Shrestha, Mundorff & Bibby, 1972). The precise mode of action of titanium tetrafluoride on the surface enamel was not known. However, it was thought that the titanium was able to substitute with the calcium atoms of the apatite crystals. In addition to this chemical reaction some physical alteration of the surface enamel was shown to have occurred because in bovine teeth a glazed protective layer was produced (Mundorff, Little & Bibby, 1972).

It has also been documented that pretreatment of surface enamel with polyvalent cations e.g. aluminium nitrate prior to stannous fluoride applications, markedly enhanced the resulting uptake of fluoride ions (Gerhardt & Windeler, 1972). The problem however is still whether these polyvalent - bound fluoride ions are mobile enough to be included in the anticarious actions of fluoride. The forces attracting the fluoride ions in these situations are not easily released resulting in a too-firmly attached fluoride complex, which can not be released and act in a protective manner.

6. ENAMEL BIOPSY TECHNIQUES FOR FLUORIDE DETERMINATIONS

Examination of enamel samples to measure the concentration of certain elements such as fluoride, was made possible by enamel biopsy methods. These biopsy methods can be performed either *in vivo* or *in vitro* and each of these can be further subdivided into chemical or mechanical abrasive techniques.
A modification of a long established mechanical abrasive biopsy technique has been described. The purpose of this technique was to facilitate the removal of minimal weights of enamel (Larsen, Kold and Von der Fehr, 1972). A large standard deviation was quoted from the results of this investigation indicating the wide range of results possible with this method.

A further modification of the same abrasive mechanical biopsy technique was described utilizing known areas in an attempt to standardize the results (Aasenden, Moreno and Brudevold, 1972).

An *in vitro* chemical biopsy method has also been described. This technique theorized that the solubility of enamel was inversely related to the fluoride concentration but directly related to the carbonate concentration (Cutress, 1972 a & b). Furthermore, the solubility of enamel was said to be related to the ratio of the fluoride and carbonate concentrations. An *in vitro* technique was described for analyzing thin layers of enamel for fluoride, carbonate and other inorganic constituents.

During the determinations of fluoride values in enamel after topical applications of stannous fluoride, certain potential errors may result (Stearns, 1972). This is so since the major reaction product, $Sn_3PO_4F_3$, is structurally unrelated to fluoro-apatite. In such a case it would be necessary to determine the calcium, fluoride and phosphate concentrations. This, however does not apply to enamel which has been treated with the various sodium fluoride preparations and then tested for fluoride concentrations.

7. TOPICAL APPLICATIONS OF FLUORIDE

Voluminous numbers of papers have been published observing the reduction of caries rates following the fluoridation of teeth by methods other than water fluoridation. A multitude of fluoride-containing products are available for dispensing by trained personnel, and I have subdivided the documented results into:

(a) topically applied solutions and gels;
(b) tablet-administered fluoride;
(c) oral fluoride rinses;
(d) fluoride-containing dentifrices; and
(e) other methods, such as fluoridation of milk or table salt.

A practitioner, as evidenced by the above simplified classification, is confronted with the perplexing problem of selecting the optimum exogenous fluoridating agent and the method of application (Philips, 1972). Likewise, a review of this aspect of fluoridation is the most laborious. Suffice it to say that only a small aspect of the work published has been included, comprising that which I considered to be the most relevant and practical.

(a) *Topically applied solutions and gels*

A clinical investigation was undertaken to compare the effectiveness of 2 fluoride containing gels employing an *in vivo* biopsy technique (Hotz, 1972). One gel consisted of an organo-amine fluoride whilst the second contained an acidulated sodium fluoride. Results 4 days after the application showed that smaller concentrations of fluoride were taken up by the surface enamel subjected to the organo-amine fluoride application. However, 80 days after the applications, it was shown that far greater concentrations of fluoride were retained in the enamel subjected to this organo-amine topical applications.

A fluoride containing varnish was employed to evaluate its effectiveness in prolonging the contact of fluoride to the enamel (Koch & Peterson, 1972). It is well known that greater quantities of insoluble fluoride are produced in the surface enamel after prolonged contact of the enamel with the topical fluoride solutions. The results of an *in-vitro* investigation revealed that after a 6 hour contact period the deeper layers of enamel had significantly-increased fluoride concentrations.

The field of fluoride applications employing adhesive-like materials has become very popular of late. Practitioners would be well advised to continually evaluate the literature relating to the developments in this form of therapy. A flexible polyurethane adhesive containing disodium monofluoro-phosphate (Na_2PO_3F) was found to be effective, *in-vitro*, in reducing the acid solubility of enamel by 37 per cent (Lee, Ocumpaugh & Swartz, 1972). Various other fluoride-containing agents, for example, sodium fluoride, stannous fluoride or acidulated sodium fluoride were tested in this model, but disodium monofluorophosphate proved to be the most efficient. Furthermore, a decreased caries rate varying between 36 and 68 per cent was observed following pretreatment of the enamel with a 50 per cent citric acid. In a subsequent paper the loss of retention of the flexible polyurethane adhesive was discussed (Lee *et al*, 1972a). As a result of this decreased retention, peel forces operated which then tended to lift the film from the shallow and deep fissures.

In vitro results, using X-ray probe analyses, showed a fluoride concentration of up to 4 400 ppm 30 to 45 days following the fluoride applications (Lee *et al*, 1972b). These concentrations were observed despite the flexible adhesive having peeled off. This study confirmed that some degree of remineralization occurred although the enamel had been etched.

A scanning electron microscope study has revealed the effect of conditioning enamel with 50 per cent phosphoric acid containing 7 per cent zinc oxide (Gwinnett & Buonocore, 1972). This showed that etching was almost exclusively limited to the cuspal planes and did not necessarily affect the pits and fissures. These pits and fissures were shown to be filled with certain deposits, which, in addition to air entrapment, did affect the bonding between the adhesive and the enamel.

A rigid adhesive material based on the formulation by Roydhouse, diacrylate monomer and benzoyl peroxide, may be used in preference to the flexible polyurethane adhesive (Lee *et al*, 1972a). With this material it is essential to obtain excellent occlusal coverage. In addition, a film of sufficient strength and thickness is required to bridge the non-adherent regions of the tooth surfaces.

During these investigations it was found that the fluoridation of enamel, either naturally or topically applied, adversely affected the acid etching processes (Lee *et al*, 1972a).

Other independent investigators observed the result of applying fluoride on to pre-etched enamel and the effect this fluoride had on subsequent mechanical bonding and adhesion (Gwinnett, Buonocore & Sheykholeslam, 1972). They have shown indisputable evidence that the physical presence of reaction products on the etched enamel surfaces, following the topical fluoride application, interfered with the mechanical bonding of substances subsequently applied.

Other topical fluoride solutions have been evaluated, amongst which are stannous and sodium fluoride.

Single applications of an 8 per cent stannous fluoride were performed on 1 050 children, aged between 6 and 15 years, living in a non-fluoridated area (Mercer & Muhler, 1972), using a 2 per cent sodium fluoride solution as a control. After two years the results showed a reduced caries rate for both fluoride solutions but the reduced D.M.F. rate was more significant in the cases of stannous fluoride applications. The use of 4,0 or 0,4 per cent stannous fluoride solutions did however not result in similar significant decreased D.M.F. rates.

The findings described above were however not confirmed by other investigators (Jeansonne & Feagin, 1972). They carried out *in-vitro* analyses using sodium fluoride, acidulated sodium fluoride and stannous fluoride. The *in-vitro* analysis was based on the theory that caries susceptibility is related to enamel solubility. Bearing this in mind the investigation showed that sodium fluoride provided the most significant results pertaining to demineralization and remineralization of enamel.

(b) *Tablet administered fluoride*

As an experimental group, children were given daily tablets of 1 mg fluoride, as sodium fluoride, for 3 years. Other children in the control group received no fluoride-containing tablets (Mellberg, Nicholson & Law, 1972). The concentrations of fluoride in the enamel of the experimental group, all at a depth of 5 μm, were 823 ppm and 755 ppm for the anterior and posterior teeth respectively whilst the control group had a mean fluoride level of 675 ppm. These levels may not have been sufficient to afford adequate dental protection, but offered a most suitable adjunct.

A project was described to examine the quantity of fluoride contained in saliva after administration of different types of fluorides (Parkins, 1972). The fluoride was derived from either sodium fluoride tablets, acidulated phosphofluoride tablets or rinsing with acidulated phosphofluoride. The greatest amount of fluoride retained was observed in the subjects who had chewed the sodium fluoride tablets.

(c) *Oral fluoride rinses*

An investigation observed the effect on children who, daily at school, rinsed with an acidulated phosphate fluoride solution. The fluoride rinse consisted of 1 mg of fluoride ion in a phosphate buffer at pH 4,0. A control group of children were not given any fluoride (Frankl, Fleisch & Diodati, 1972). No significant changes in either the control or experimental groups were recorded after 1 year. After 2 years however, the experimental group showed a more favourable decreased D.M.F. rate.

The effect of fluoride on vestibular plaque in children has been investigated (Birkeland, 1972b). The children in the experimental group rinsed with a 0,2 per cent sodium fluoride mouth wash. This procedure was carried out daily for 4 min and observed after 8 weeks. The results indicated a decreased dried plaque weight in the experimental group when compared to the control group of children which had not received fluoride.

In a similar wash used for 1 min only, the results after 9 months showed no significant difference in the amount of plaque formed, nor in the degree of gingivitis (Frandsen *et al*, 1972). The effect of time on the value of rinsing with fluorides was evaluated using a radio-active marker (Birkeland & Lökken, 1972). The results indicated that the longer the rinse remained in the oral cavity, the greater was the quantity of fluoride swallowed. Furthermore, 2-min rinses, in contrast to half-min rinses, showed that greater quantities of fluoride were retained on the enamel surfaces after the longer procedure. This remained so despite several mouth washes attempting to dissolve away the fluoride located on these enamel surfaces.

(d) *Fluoride containing dentifrices*

A decreased D.M.F. rate has been observed after many years of investigation in a most elaborate and detailed caries preventive programme (Marthaler, 1972). This programme was initiated by Professor H.R. Mühlemann and continued by Professor T.M. Marthaler ably assisted by some 15 other dentists with many other para-dental assistants and teachers. The reasons for the decreased D.M.F. rates are adequately described, and in summary may be related to improved brushing with fluoride solutions, general education and oral hygiene improvement, use of fluoridated dentifrices and fluoride tablets and the introduction of fluoridated domestic salt.

A complete statistical breakdown is included to help assess how the various forms of fluoride medication influenced the end result.

The possible reactions of the fluoride present in various dentifrices when dispersed in water were investigated (Hagen, 1972). The fluoride may be inactivated, depending on the constituents of the dentifrice, for example, having combined with the calcium, yielding calcium carbonate or calcium fluoride. In view of this, the basic composition of some dentrifrices was altered when the fluoride was added. When these dentifrices come into contact with powdered enamel the results have shown that greater quantities of calcium fluoride are formed at pH values below 5.5. The structurally more complex compound, calcium-fluoro-phosphate, $Ca_5(PO_4)_3F$, formed at pH values above 5,5.

The use of sodium fluoride-containing dentifrices in students showed an increased fluoride concentration in the vestibular plaque (Birkeland, 1972a). Decreased D.M.F. rates have also been reported in children who brushed with a disodium monofluorophosphate for 3 years (Kinkl & Raich, 1972 a and b). In addition, 12 year old children observed for 2 years also showed a decreased D.M.F. rate when using a non-grinding, potassium fluoride-containing dentifrice (Gerdin, 1972).

(e) *Other methods of fluoridation*

One other important fact emanated from the paper by Marthaler (1972). It showed that 250 mg of fluoride per kg of salt was required to equal the 24 hour urinary excretion of fluoride, comparable to subjects drinking water containing 1 ppm fluoride.

The possibility of employing ordinary table salt as a vehicle for fluoride should not be casually overlooked. The value of this mode of fluoride availability more than adequately overcomes undemocratic features of mass medication claimed by the antagonists of water fluoridation (Mühlemann, 1972).

A subsequent investigation lends support to the beneficial effects achieved by the fluoridation of table salt (Tóth, 1972). This described a 24 per cent reduction of the D.M.F. rate in villagers consuming the fluoridated salt. The results in a control village with no fluoridated salt, indicated a 23 per cent increased D.M.F. rate.

In addition, the value of adding fluoride to milk has again been suggested as another method of countering the opposition to mass medication (Baron, 1972).

8. CONCLUSION

Therapeutic cariology and periodontology cannot slow down the ravages of oral disease in modern man.

However, the preventive value of fluoride has been accepted universally following intensive laboratory, clinical and field studies (Stookey & Katz, 1972). Fluoridation of public water supplies has been the greatest achievement in mass preventive dentistry. Also numerous forms of topical and oral fluoride therapy are available for those persons denied the benefits of fluoridated water. Varying degrees of success rates are claimed for these additional fluoridation methods. One consistent finding is that combinations of these fluoride therapeutic measures provide better results than when used singly (Shannon & Feller, 1972).

Mühlemann (1972) has said that the dental community has been all but hypnotized by fluoride. Other factors such as diet and hygiene must not be neglected. Practitioners too easily accuse patients of poor co-operation. Perhaps greater demands should be placed on the shoulders of practitioners to interest themselves in research in to saliva and non-fermentable carbohydrates. This may reduce the adverse effects of substances like sucrose, whose breakdown products reduce the interdental pH to less than 5,7.

These avenues of research, with continuing investigation of fluoride, have been stated by Mühlemann (1972) as being the two-pronged attack required to provide general oral health.

A practitioner may thus feel confident that he is providing a significant oral preventive programme by advising a combined fluoride, hygiene and diet programme directed by the prevailing local and immediate conditions.

ACKNOWLEDGEMENTS

The constructive criticism expressed by Professor D.H. Retief and Dr. P. Cleaton-Jones in the preparation of this review is gratefully appreciated. Miss B. Slack is sincerely thanked for typing the manuscripts.

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