

From The Department of Operative Dentistry, The Royal School of Dentistry, Stockholm (Dean: Professor G. WESTIN), The School Dental Services, Stockholm (Head: Dr. HELGE BERGGREN).

The plaque test on teeth topically treated with sodium fluoride.¹

By

GUNNAR BERGMAN.

Introduction.

BIBBY (1942) and CHEYNE (1942) were the first to demonstrate that the application of fluoride solutions to the teeth of children may result in a reduction in the caries incidence. Subsequent investigations have in general served but to confirm these findings (KNUTSON and ARMSTRONG, 1943, et al.). If the result of the topical application of fluorides is now fairly established there still prevails some uncertainty about the mechanism underlying the checking of the caries process by fluorine. Two main possibilities have been recognized:

(1) Fluorine enters into combination with the hydroxy apatite in the surface layer of enamel to form calcium fluoride and fluorapatite, compounds which have low solubility and increase the resistance of the enamel to dissolution in acid.

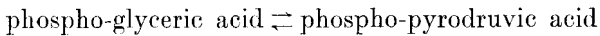
(2) Fluorine checks the formation of acid in the plaque through its antienzymatic effect.

It has been a fairly simple matter to show by *in vivo* experiments that sodium fluoride reduces the solubility of enamel (VOLKER, 1939; BIBBY, 1944; RAE and CLEGG, 1945; PHILLIPS and MUHLER, 1947; et al.). It has also been demonstrated that the supply of fluorides to the plaque *in vivo* restricts the acid fermentation in it (STRÅLFORS, 1950). BIBBY (1941) states that so

¹ This investigation forms part of co-ordinated work on dental caries sponsored by the Swedish Medical Research Council through its Sub-committee for Caries Research.

low a concentration of fluorine as one p. p. m. will arrest the production of acid by oral bacteria. He infers that the caries-inhibiting effect is due in part to the anti-enzymatic influence.

WARBURG and CHRISTIAN (1942) are of the opinion that *enolase*, the enzyme discovered by LOHMANN and MEYERHOF (1934) is the most fluoride-sensitive in the fermentation process. The inhibition of fermentation by fluorides is essentially due to their effect on the enolase. The conversion of phosphoglyceric acid to phospho-pyruvic acid is blocked. At strengths of N/100 to N/200 the fluoride completely checks the reaction



(LOHMANN and MEYERHOF, 1934). This is due to the formation of inert magnesium fluoro-phospho-enolase (WARBURG and CHRISTIAN, 1942). BOREI (1945) provides an interesting survey of enzymes that are attacked by fluorides.

Original investigation.

The object of the experiments.

The aim of the investigation was to determine whether, using STEPHAN'S (1940, 1944) method, it was possible to reveal a difference between plaques on teeth treated and untreated with fluorides in respect of changes in the pH value after rinsing the mouth with a 10 % glucose solution.

The material and method.

The case series comprised 30 children of 12—13 years, 14 of them boys. All were pupils at the Sofia Elementary School in Stockholm and were selected cases of high caries frequency, having carious lesions on an average of 38.6 % of the caries-susceptible surfaces of the permanent teeth.

These 30 children comprised a group from a large case series of 114, of whom on three previous occasions (May and October 1949 and February 1950) the teeth of one half of the dentition had been treated with a 2 % solution of sodium fluoride. For treatment the teeth were isolated with rubber dams. After careful cleansing the solution was applied for five minutes. A year after the beginning of the experiment the fluoride treatment of the 114 children was accompanied by a 50 % decrease in newly appearing caries (BERGMAN, 1951).

The plaque test was performed in the following manner. The subjects were instructed after the third application to refrain from brushing their teeth. After 4--8 days sufficient coating had accumulated on the teeth for the purpose of the tests. STRÅLFORS (1948) used three brushless days previous to the plaque test. This must be considered insufficient in view of the careful cleaning associated with the application of the fluoride. The children were instructed not to eat during the four hours preceding the test.

The apparatus for the pH determinations was in principle the same as that used by STRÅLFORS (1948). The reference electrode was in contact with the floor of the mouth via a transparent rubber tube filled with a saturated solution of potassium chloride. The pH of the plaque was measured in the mouth with an antimony electrode which was placed directly in the plaque. In accordance with Strålfors's analysis (1948) of the potential between saliva and plaque the pH values obtained were increased by 0.1 pH unit. The plaque was blown dry immediately before each determination but between determinations the saliva was allowed to flow freely. All the readings were made for the upper jaw and always on two symmetrically located teeth, one of them on the treated and the other on the untreated side. After measuring the initial pH of the plaque the child was instructed to rinse the mouth with a 10 % solution of glucose (Dextropur) for one minute. Counting from the beginning of the rinsing the determinations were made at the intervals given in the example below (Table 1).

Table 1.

Intervals (in minutes) at which the pH readings were taken in the plaque.

Treated side	Untreated side
2	2.5
5.5	5
10	10.5
15.5	15
20	20.5
25.5	25
30	30.5
40.5	40
60	60.5

In practice it was not possible to take readings on both sides at the same moment, hence the half-minute difference between

them. The example quoted covers one half of the cases. The interval figures for the other half of the case series are obtained by interchanging the column headings.

Results.

Table 2 provides a record of the pH values obtained.

Table 2.

pH values for the plaques after rinsing with a 10 % solution of glucose.

Case	Initial pH		Lowest pH		Final pH	
	treated side	un-treated side	treated side	un-treated side	treated side	un-treated side
1 ♂	7.3	7.4	5.0	5.3	6.6	6.6
2 ♂	6.8	6.8	4.4	5.0	6.0	6.1
3 ♂	6.7	6.6	5.1	4.7	6.5	6.1
4 ♀	6.1	6.1	5.4	5.1	6.6	6.6
5 ♀	6.7	6.7	5.4	5.4	6.5	6.6
6 ♀	6.9	6.8	5.4	5.3	6.8	6.8
7 ♀	5.5	6.1	5.3	5.3	6.5	6.5
8 ♂	6.8	6.8	5.6	5.2	7.3	7.4
9 ♂	6.9	6.8	5.2	5.2	6.4	6.3
10 ♀	6.6	6.6	5.2	5.1	6.1	6.4
11 ♀	6.3	6.7	5.1	5.1	6.9	6.9
12 ♀	7.6	7.7	5.6	5.6	7.2	6.8
13 ♀	7.0	6.9	5.5	5.2	6.8	6.7
14 ♂	6.9	7.1	5.1	5.1	6.8	6.8
15 ♂	5.9	5.9	4.7	4.7	5.4	5.8
16 ♀	6.8	6.8	4.9	4.8	6.8	6.8
17 ♀	6.6	6.5	4.6	4.5	6.6	6.6
18 ♀	6.4	6.5	4.6	4.6	6.1	6.0
19 ♀	7.7	7.5	5.4	5.4	7.5	7.4
20 ♀	7.1	7.1	4.9	4.9	6.6	6.5
21 ♀	6.3	6.3	5.1	5.0	6.2	6.0
22 ♀	7.1	7.0	5.3	5.2	6.2	6.1
23 ♀	6.7	7.0	5.5	5.5	7.0	7.0
24 ♀	6.5	6.7	4.8	4.9	7.1	7.1
25 ♀	6.5	6.5	4.8	4.7	6.3	6.3
26 ♀	6.8	6.8	5.1	5.3	6.7	6.8
27 ♀	7.5	7.4	5.1	5.0	6.9	6.9
28 ♀	6.6	6.4	5.0	5.1	6.8	6.6
29 ♀	6.7	7.1	5.0	5.2	6.8	6.9
30 ♀	6.3	6.3	5.3	5.1	6.6	6.3
Mean	6.72	6.76	5.11	5.08	6.62	6.59

Statistical analysis disclosed no difference between treated and untreated sides. See Table 3.

Table 3.

	n	d_i	S_d^2	t	P
Initial pH	30	-0.043	0.0324	-1.29	∞ 0.1
Lowest pH	30	0.030	0.0381	0.81	∞ 0.2
Final pH	30	0.030	0.0274	0.95	∞ 0.15

d_i is unable to exceed 0.15 (with a probability of 99 %)

$d_i = \text{pH (treated side)} - \text{pH (untreated side)}$ per subject

$$S_d^2 = \frac{\sum (d_i - \bar{d})^2}{n} \qquad t = \frac{\bar{d} \cdot \sqrt{n-1}}{S_d} \text{ (student)}$$

The result certainly does not exclude the possibility that the caries-inhibiting effect of fluorine application might be due in part to a restriction of fermentation. It is manifest, however, that any such effect is not of the type nor of the magnitude that is measurable by the described method.

By way of illustration two curves are reproduced in Fig. 1 referring to one of the children to which the test was applied. (In Figs. 1 and 2 the unbroken line represents the treated side and the broken line the untreated side.)

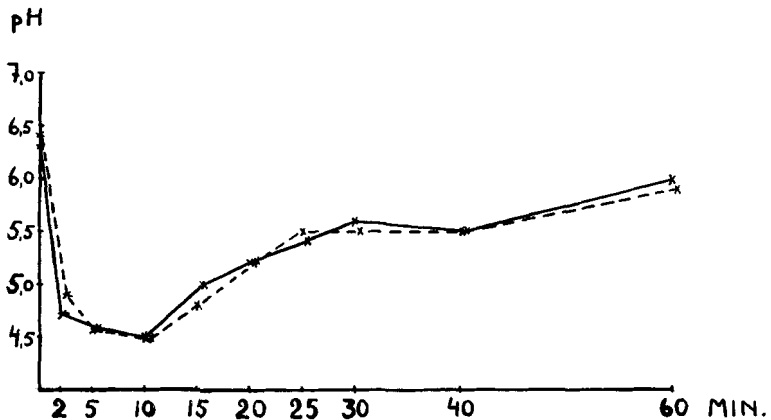


Fig. 1. The plaque test for teeth treated and untreated with fluoride.

If a drop of 2 % sodium fluoride was placed on a plaque on one side of the mouth immediately before rinsing with glucose a clear difference in the curves was evident (Fig. 2). The excess

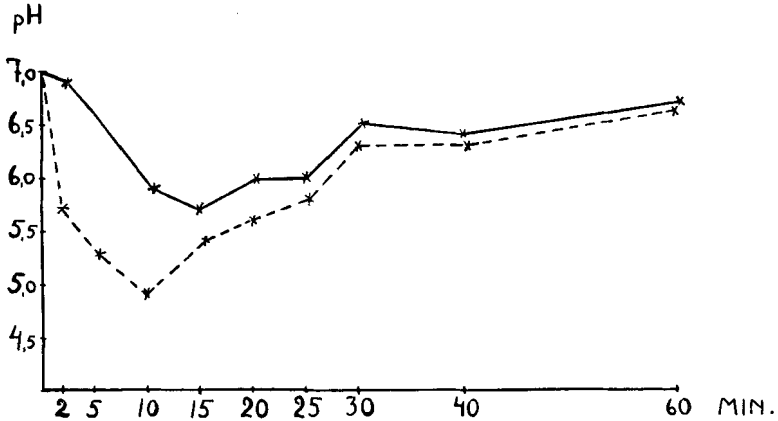


Fig. 2. The effect of one drop of 2 % sodium fluoride placed on a plaque immediately before rinsing with glucose solution.

liquid was absorbed on filter-paper 30 seconds after the application of the drop.

It is evident that the concentration of fluoride in the latter case was so high that it checked the fermentation process in the plaque and gave a flatter Stephan curve.

Summary.

The plaque test with antimony electrodes was carried out on 30 children. A 2 % solution of sodium fluoride was applied topically to one half of the dentition on three occasions. Before the plaque test the children rinsed with 10 % glucose. It was not possible to demonstrate any difference between the treated and untreated teeth in respect of initial, lowest and final pH. The possibility that the caries-inhibiting effect of fluorine application is due to the checking of fermentation cannot be ruled out. It is evident, however, that any such effect would not be detectable nor would it be measurable with an antimony electrode.

One drop of a 2 % solution of sodium fluoride on the plaque immediately before rinsing with glucose resulted in a flatter Stephan curve.

References.

- BERGMAN, G.; 1951. Caries inhibition through topical application of sodium fluoride. Report to the State Medical Research Council (in Swedish).

- BIBBY, B. G.; 1941. Dental Caries. P. 52—53. New York.
- 1942. A new approach to caries prophylaxis. Tufts Dental Outlook, 15: 4. Cit. from BIBBY 1946 (see below).
- 1944. Effectiveness of various fluoride preparations in reducing tooth solubility. Jour. Dent. Res. 23: 202 (Abstract).
- 1946. Topical applications of fluorides as a method of combating dental caries. Dental Caries and Fluorine. P. 93—98, Washington.
- BOREI, H.; 1945. Inhibition of cellular oxidation by fluoride. Arkiv f. Kemi, Miner. o. Geol. 20 A, No. 8.
- CHEYNE, V. D.; 1942. Human dental caries and topically applied fluoride: A preliminary report. Jour. Am. Dent. Ass. 29: 804.
- KNUTSON, J. W. and ARMSTRONG, W. D.; 1943. The effect of topically applied sodium fluoride on dental caries experience. Publ. Health Reports 58: 1701.
- LOHMANN, K. and MEYERHOF, O.; 1934. Über die enzymatische Umwandlung von Phosphoglycerinsäure in Brenztraubensäure und Phosphorsäure. Biochem. Zeitschr. 273: 60.
- PHILLIPS, R. W. and MUHLER, J. C.; 1947. Solubility of enamel as affected by fluorides of varying pH. Jour. Dent. Res. 26: 109.
- RAE, J. J. and CLEGG, C. T.; 1945. The effect of sodium fluoride on the solubility of calcium phosphate, tooth enamel and whole teeth in lactic acid. Jour. Dent. Res. 24: 235.
- STEPHAN, R. M.; 1940. Changes in hydrogen-ion concentration on tooth surfaces and in carious lesions. J. A. D. A. 27: 718.
- 1944. Intra-oral hydrogen-ion concentrations associated with dental caries activity. Jour. Dent. Res. 23: 257.
- STRÄLFORS, A.; 1948. Studies of the microbiology of caries. II. The acid fermentation in dental plaques in situ compared with lactobacillus count. Jour. Dent. Res. 27: 576.
- 1950. Investigations into the bacterial chemistry of dental plaques. Stockholm.
- VOLKER, J. F.; 1939. Effect of fluorine on solubility of enamel and dentin. Proc. Soc. Exp. Biol. and Med. 42: 725.
- WARBURG, O. and CHRISTIAN, W.; 1942. Isolierung und Kristallisation des Gärungsferments Enolase. Biochem. Zeitschr. 310: 384.

Address:

Tandläkarhögskolan,
Holländargatan 17,
Stockholm, Sweden.