AN EVALUATION OF THE EFFECTS OF VARIOUS FLUORIDE PRETREATMENT PROCEDURES PRIOR TO ORTHODONTIC BANDING IN INCREASING THE RESISTANCE OF HUMAN ENAMEL TO DECALCIFICATION

by

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Abstract

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In order to test the efficacy of three fluoride compounds in the reduction of decalcification, each first premolar in twelve orthodontic extraction cases were assigned randomly the following treatments: stannous fluoride (8 percent), amine fluoride ("Elmex Gel"), acid phosphate-fluoride ("Thera-flur"), and no treatment. After receiving three four-minute treatments (during a period of one week), each tooth was banded in a manner conducive to decalcification: the bands were loose-fitting and were not cemented on the buccal surface. As part of the regular orthodontic therapy, the treated and control teeth were extracted eleven weeks later, and the extent of buccal decalcification scored (blindly and independently) by four observers. As indicated by Friedman's blocked, nonparametric analysis of variance, there was a significant ($p < .02$) overall difference among treatment rankings. Specifically, both the amine fluoride and the acid phosphate-fluoride produced a greater resistance to decalcification than did stannous fluoride.

The samples were further analyzed to determine their fluoride content at various levels of enamel. The results of a blocked analysis of variance showed a significant difference ($p < .01$) between treatments. The results of Tukey's omega-procedure appear to indicate that only the amine fluoride produced significantly higher ($p < .05$) fluoride levels in treated teeth than the controls.

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CHAPTER I

PURPOSE

At present, decalcification and decay under and adjacent to orthodontic bands present a very real problem to the orthodontist. Accordingly, a method of prevention is needed to make teeth more resistant to these pathologic processes. In recent years, dental researchers have tested the use of topically applied fluoride solutions in order to reduce the caries susceptibility of human teeth. Stannous fluoride and acidulated phosphate-fluorides are presently being used clinically. These have had limited success, but much of the problem still remains unresolved. Reports by European researchers indicate that organic fluoride solutions such as "Elmex Fluid" (Gaba, Ltd., Basel, Switzerland) may have advantages over the inorganic fluoride solutions, such as stannous fluoride and the acid phosphate-fluorides. The purpose of this study is to test and compare the effectiveness of an organic fluoride to that of an acid phosphate-fluoride or stannous fluoride.

CHAPTER II

REVIEW OF THE LITERATURE

The decay process thought to be fostered by orthodontic appliances has the same pathological and histological characteristics as the decay process seen in the same areas in non-banded teeth. Muhler (1970) noted that it does differ, however, in the location of the pathology. Namely, one finds the greatest increase in dental caries in children with orthodontic appliances to be on the buccal and lingual surfaces of the teeth. In this study of orthodontic patients, Muhler further found that " . . . children receiving stannous fluoride therapy prior to cementation had significantly less dental caries . . . than control groups studied." ($p < .01$)

A number of studies have confirmed the ability of stannous fluoride to reduce dental decay. Muhler (1958), evaluating the effectiveness of a single topical application of ten percent stannous fluoride solution in reducing caries experience in adults, reported a twenty-four percent ($p < .05$) decay reduction when evaluated by the DMFT index. Harris (1963) produced a twenty-three percent ($p<.01$) reduction in caries in children by semi-annual topical application of an eight percent stannous fluoride solution.

There is, however, some controversy in the literature over the effectiveness of stannous fluoride. After one year,

Wellock, Maitland and Brudevold (1965) could measure no reduction in caries in children after a single topical application of eight percent stannous fluoride. Torell (1965) found no caries reduction after two annual applications of ten percent stannous fluoride solution. Similarly, Horowitz and Lucye (1966) found eight percent stannous fluoride to be ineffective when used once annually over a two year period. With such conflicting evidence as this, one cannot immediately infer that stannous fluoride can be relied upon to prevent caries under orthodontic appliances.

Furthermore, stannous fluoride has various inherent disadvantages. It is not stable in aqueous solution at near neutral pH, hydrolyzing to stannous hydroxide and the stannic ion, thus decreasing its effectiveness in reducing caries (Hatton, Nebergall and Muhler; 1955). As its effectiveness is thus decreased, a fresh solution of stannous fluoride must be prepared for each treatment. Stannous fluoride has been occasionally reported to cause gingival irritation and gingival blanching (Muhler, 1957). Therefore, Muhler does not recommend its use where the gingiva is not in a healthy state. The discoloration of teeth has been reported where stannous fluoride has been used, especially in areas of hypocalcification or caries, and around the margins of restorations (Wellock, et al. , 1965; Hyde and Muhler, 1963).

Many of the pitfalls of stannous fluoride have been avoided through the use of the acidulated phosphate-fluorides. Acidulated phosphate-fluoride is stable if kept in plastic

containers, does not cause discoloration of teeth, is non-irritating to the gingiva, and has an acceptable taste (Wellock and Brudevold, 1963; Pameijer, Hunt and Brudevold, 1963).

There is both clinical and laboratory evidence that the acidulated phosphate-fluorides are moderately effective decay-inhibitors in humans. Horowitz (1969), in a two year study on children, produced a thirty-three percent ($p < 0.05$) reduction in DMF surfaces through the use of an acidulated phosphate-fluoride gel applied in wax trays. A reduction of seventy percent new DMF surfaces compared to controls has been reported by Wellock and Brudevold (1963) (see Table 1).

TABLE 1

DENTAL CARIES INCREMENTS IN PERMANENT TEETH OF CHILDREN IN STUDY AFTER A TWO YEAR PERIOD

	Mean DMFT Increment	Percentage Difference	Mean DMFS Increment	Percentage Difference
Control	2.30, S.D.=2.41		5.69, S.D.=4.26	
Test (pH-Fl)	0.77, S.D.=1.29	67	1.72, S.D.=2.06	70

Modified from: Wellock and Brudevold (1963)

In another study (Wellock, Maitland and Brudevold, 1965), two annual topical fluoride applications to children produced

a forty-four percent reduction in new DMF teeth and a fifty-two percent reduction in new DMF surfaces (see Table 2).

TABLE 2

DENTAL CARIES INCREMENTS IN ERUPTED PERMANENT TEETH OF CHILDREN IN THE STUDY TWENTY-FOUR MONTHS POST TREATMENT

	Mean DMFT Increment	Percentage Difference	Mean DMFS Increment	Percentage Difference
Control	1.44, S.D.=1.94	0	4.13, S.D.=4.21	0
Test (pH-Fl)	0.81, S.D.=1.46	44	2.02, S.D.=2.60	52

Modified from: Wellock, Maitland and Brudevold; (1965).

In 1957, European researchers first reported the use of amine fluorides to combat dental caries (Muhlemann, Schmid and Konig; 1957). Wainwright (1954) presented evidence that certain organic molecules diffuse readily through enamel. By using C^{14} to label the urea molecule, he demonstrated a rapid, diffuse penetration of urea into the dentin. He also demonstrated penetration by isotope labeled nicotinamide, thiourea and acetamide. Schmid and Marthaler (Muhlemann, 1967) synthesized a series of organic fluorides to explore the possibility suggested by Marthaler (1959) that they may be used as vehicles to carry fluoride ions into the enamel. Unfortunately, their experimental evidence did not show them to be effective. Muhlemann (1967) suggested that

certain organic molecules with long aliphatic chains (see Table 3) had a great affinity for enamel due to their surface active properties. This, he said, "presented a mechanism whereby fluoride ions could be held in contact with the enamel surface for a prolonged period of time, thus achieving a greater interaction between hydroxyapatite and fluoride ion."

TABLE 3

CHEMICAL COMPOSITION OF VARIOUS AMINE FLUORIDE COMPOUNDS

Amine Fluoride	Chemical Composition
Compound 297	bis -(hydroxyethyl)- aminopropyl - N - hydroxyethyl - octadecylamine dihydrofluoride
Compound 242	cetylamine - hydrofluoride
Compound 335	oleylamine - hydrofluoride
Elmex fluid	1.25% Bis - (hydroxyaethyl) aminopropyl - N' - hydroxyaethyl - octadecylaminum - dihydrofluoricum 3.032% corresp. 0.231% F. - octadecenylaminium - hydrofluoricum 0.287% corresp. 0.0190% F. Natrium fluoratum 2.262% corresp. 1.0% F. Conserv. , Aromatica, Excip. ad Mucilago.

Muhlemann and Schmid (1958) have demonstrated that "amine fluoride 297" (see Table 3) protects enamel from decalcification

better than stannous fluoride. After treated enamel was placed in acid for two hours, the enamel solubility reduction by amine fluoride 297 was 93 percent, while stannous fluoride produced only a 72 percent reduction as compared to the control teeth treated with a sodium chloride solution. These tests have also been comfirmed on uncleaned teeth (Muhlemann, Konig, Marthaler, Schait and Schmid; 1960).

Although no fluoride solution to date has shown one hundred percent retention in the enamel over an extended period of time, Muhlemann (1967) has reported amine fluoride 297 to be superior to the inorganic fluorides such as sodium fluoride, stannous fluoride, and acidulated phosphate-fluoride (see Table 4).

TABLE 4

FLUORIDE CONCENTRATION OF ENAMEL SURFACES AT A DEPTH OF SEVEN MICRONS AFTER A SINGLE FOUR-MINUTE TREATMENT WITH VARIOUS FLUORIDE SOLUTIONS AND SUBSEQUENT WASHING OF THE TEETH FOR FOUR DAYS IN TAP WATER

Fluoride Type	Treatment F%	Fluoride pH	Fluoride Concentration in ppm at 7 microns
$Sn\ F_2$	1.95	2.5	1260
PO_4-F	1.25	3.0	1900
297	1.07	4.4	4520

Modified from: Muhlemann (1967).

After washing previously treated teeth in tap water for four days, or for a short period of time in an ultrasonic bath, Muhlemann (1967) found that teeth exposed to organic fluoride retained two to three times more fluoride than teeth exposed to the above-mentioned inorganic fluorides.

In summarizing his experimental data from animal studies, Muhlemann (1967) stated: "In inhibiting caries amine fluorides were always superior to the frequently co-tested sodium or tin fluorides."

Although certain amine fluorides have been shown to produce and maintain a high fluoride content in enamel, the question to be answered is how effective they are at reducing caries in humans. No evidence could be found in the literature of a long-term, controlled study of supervised topical application of amine fluoride-containing solution or gel. Marthaler (1965), however, in a long-term, unsupervised study where subjects were sent amine fluoride-containing dentifrice and instructions for its use, reported a thirty percent ($p < .001$) caries reduction in children. The amine fluorides in this case were amine fluoride 297 (1.5. percent) and "amine fluoride 242" (0.40 percent) (see Table 3). One would naturally expect a greater amount of caries reduction in a supervised, controlled study.

Muhlemann (1967) has reported the effects of amine fluoride to be threefold. Firstly, fluoride easily reaches the

enamel surface, making it less soluble. Secondly, due to acid formation from plaque, fluoride is released from a resevoir and diffuses into the plaque where sugar fermentation is inhibited anti-enzymatically. Finally, fluoride may catalyze the remineralization of partially demineralized enamel at the plaque-enamel interface.

A number of studies have indicated that certain amine fluorides may have an inhibitory effect on bacterial micro-organisms. Shern (1970), in comparing the ability of cariogenic streptococci to form adherent bacterial deposits on stainless steel wire, concluded that:

> Amine fluoride was observed to be bacteriostatic and to completely inhibit formation of bacterial deposits at an extremely low concentration ($10^{-5}MF^{-}$) where inorganic fluorides were ineffective at inhibiting formation of these deposits.

In this study, Shern found Elmex Fluid to virtually suppress the formation of bacteria at $10^{-5}MF^{-}$ while in contrast, a concentration of $10^{-1}MF^{-}$ was needed when using co-tested stannous fluoride or sodium fluoride solutions.

Similarly, Hermann and Muhlemann (1958) showed that very low concentrations of amine fluorides will inhibit respiration, particularly anaerobic sugar fermentation, by oral micro-organisms. At an amine fluoride concentration corresponding to 3.2 ppm, the inhibition of acid formation was almost total, while a concentration of 100 ppm sodium fluoride was needed to attain the same level of inhibition. These findings have been confirmed

by several investigators (Capozzi, 1967; Bramstedt and Bandilla, 1966).

Human studies have demonstrated the possibility that amine fluorides may interfere with the formation of bacterial deposits on tooth surfaces. The organic cation may be capable of reducing surface tension, thus creating a cleansing effect. Muhlemann and Schroeder (1964), in a clinical study on known calculus formers, produced a reduction in calculus formation by greater than fifty percent (St. Error= 0.054) through the application of fluoride-free amine of the type used in commercial agents which are presently in use.

Marthaler (1960) studied the effects and toxicity of amine fluorides. Their study included a comparison of the LD_{50} level of amine fluoride 297 and sodium fluoride by intraperitoneal injection in Sprague-Dewley rats. The LD_{50} level for amine 297 was 62 mg./kg., while that of sodium fluoride was only 29 mg./kg. Thus the LD_{50} of amine 297 was greater than twice that of sodium fluoride, indicating that amine fluoride is less toxic than sodium fluoride (see Table 5). Marthaler observed that " . . . sodium fluoride killed the rats much faster than the organic compounds."

TABLE 5

A COMPARISON OF THE APPROXIMATE LEVEL OF LD_{50} AFTER INTRAPERITONEAL INJECTIONS OF ETHODUOMEEN . 2HF AND SODIUM FLUORIDE IN SPRAGUE-DAWLEY RATS

Compound	Number of Rats	Whole Compound mg./kg.	Whole Compound millimol./kg.	Fluoride mg./kg.
Ethoduomeen . 2HF (amine fluoride 297)	30	62	0.13	4.8
Sodium Fluoride	44	29	0.71	13.0

Modified from: Marthaler (1960).

In the same study, Marthaler found that by feeding the rats through a stomach tube, he produced no organ weight change or weight gain if the daily dosage of amine fluoride 297 was less than 0.5 mg./kg. Marthaler concluded from his experimental data that, " . . . adverse effects by the use of dentifrices containing amine fluorides may . . . be considered highly improbable." He thus considered amine fluoride 297 safe even for daily, unsupervised use. Furthermore, he compared the dangers of amine fluoride-containing dentifrice to that due to water fluoridation and concluded:

> The danger of intoxication by fluoride dentifrices containing 0.1 percent fluoride is therefore considerably smaller as compared to fluoridated water at 1.0 ppm. It may be concluded that no adverse effects from amine fluorides as described in the present paper have to be expected either, even when limited additional toxic action as in the case of the amine fluorides is present in a dentifrice.

A commercial agent, Elmex Fluid, is presently being sold in Europe for unsupervised home use. It is also distributed in dentifrice form. Elmex Fluid contains 0.925 percent amine fluoride 297 and 0.075 percent amine fluoride 335. The manufacturer lists its complete composition as follows:

> Fluorine content: 1.25% Bis-(hydroxyaethyl) aminopropyl-N'-hydroxyaethyl-octadecylaminum-dihydrofluoricum 3.032% corresp. 0.231% F. -octadecenylaminium-hydrofluoricum 0.287% corresp. 0.0190% F. Natrium fluoratum 2.262% corresp. 1.0% F. Conserv., Aromatica, Excip, ad Mucilago.

As decay and decalcification under orthodontic bands present a very real problem today, some remedy is needed. Though various fluoride solutions are presently being used by the dentist and the orthodontist as preventive measures, none to date has proved totally satisfactory. Clinical and laboratory evidence indicates that certain amine fluoride compounds may have the ability to reduce caries in humans. As an amine fluoride compound, Elmex Fluid, is presently being sold commercially without prescription and has widespread use in Europe, it is only logical that it be compared with the commonly used fluoride-containing agents as to their effectiveness in reducing decay and decalcification under orthodontic appliances.

CHAPTER III

MATERIALS AND METHODS

Sample

Six males and six females, 12 to 16 years of age, who required the therapeutic removal of four first bicuspids, were selected randomly from among 100 patients who presented themselves for orthodontic treatment at Case Western Reserve Department of Orthodontics. The nature of the study, its significance and its potential hazards were explained in detail both to each subject and his or her parents. Permission was, in each case, granted in writing (Appendix I).

The only criteria, other than consent, established for selection were: (1) the absence of restorations or clinical caries on the buccal surfaces of the first bicuspid teeth, and (2) the necessity of first bicuspid extractions as determined by standard diagnostic procedures.

Experimental Design

A table of random numbers was used to assign treatments to the various patients (see Table 6).

Clinical Procedure

Three of four permanent first bicuspid teeth in each patient were treated with one of three topical fluoride solutions;

TABLE 6

TREATMENTS TO PATIENTS DETERMINED FROM TABLE OF RANDOM NUMBERS

Patient	Quadrant			
	Right		Left	
	Upper	Lower	Upper	Lower
1	Control	Stannous Fluoride	Thera-flur	Elmex
2	Elmex	Control	Thera-flur	Stannous Fluoride
3	Control	Elmex	Stannous Fluoride	Thera-flur
4	Elmex	Control	Stannous Fluoride	Thera-flur
5	Stannous Fluoride	Control	Thera-flur	Elmex
6	Stannous Fluoride	Thera-flur	Elmex	Control
7	Control	Thera-flur	Elmex	Stannous Fluoride
8	Thera-flur	Elmex	Control	Stannous Fluoride
9	Elmex	Thera-flur	Stannous Fluoride	Control
10	Thera-flur	Stannous Fluoride	Control	Elmex
11	Stannous Fluoride	Elmex	Control	Thera-flur
12	Thera-flur	Stannous Fluoride	Elmex	Control

the fourth tooth served as a control. The fluoride solutions used were: (1) stannous fluoride (8 percent); (2) "Thera-flur," an acidulated phosphate-fluoride and (3) "Elmex gel," an amine fluoride. For each fluoride, three four-minute treatments were performed within a one week period. Immediately preceeding the first application of fluoride, the teeth were thoroughly pumiced and then air dried. The teeth were also air dried before the second and third fluoride applications, but were not pumiced.

Bicuspid bands (Unitek Corp., Monrovia, Calif.) were cemented on each of the first bicuspids using "Durelon" carboxylate cement (Premier Corp., Philadelphia, Pa.) on the lingual and two proximal surfaces, leaving the band loosely-fitting and cement-free on the buccal surface (Plate I). The intent was to band the tooth in a manner conducive to decalcification on the buccal surface. This technique was suggested by the "gold-plate technique" of von der Fehr (1961), but was designed to approximate closely a usual clinical condition.

Eleven weeks later, the bands were removed, and the teeth extracted using special precautions not to disturb the buccal surface of each tooth (i.e., a 2 x 2 gauze pad was placed over each tooth as it was being removed). The teeth were cleaned with a damp gauze pad and then stored in a humidifier.

PLATE I

FIRST BICUSPID TEETH BANDED IN A MANNER CONDUCIVE TO DECALCIFICATION ON THE BUCCAL SURFACE



Evaluation of Decalcification

The extent of buccal decalcification was scored blindly and independently by four observers.[1] The amount of decalcification was rated from zero to three in half-unit increments.[2] Friedman's analysis of variance was performed to determine whether or not there was a significant difference among the various treatments (Siegel, 1965). Friedman's statistic is χ^2 r, and is calculated according to the following equation:

$$\chi^2_r = \frac{12}{Nk\ (k+1)} \sum_{j=1}^{k} (Rj)^2 - 3N(k+1)$$

N = number of patients

K = treatments

Rj = sum of the rankings for a given treatment

χ^2_r is distributed similar to χ^2_3 if the numbers of rows and columns are not too small.

---

[1] Two graduate dentists and two senior dental students

[2] Examples of scoring were pointed out and quantification procedures explained

Tukey's omega-procedure ("honestly significant difference") was employed to examine contrasts suggested by the data (Steel and Torrie, 1960; p. 109). This statistic, "H.S.D." is calculated from the following equation:

$$H.S.D. = q_{.95} \, {}^{Sp}/ R, \text{ where}$$

q.95 = the 95th percentile of the "Studentized range," for four treatments and 33 degrees of freedom

Sp = the square root of the error mean-square

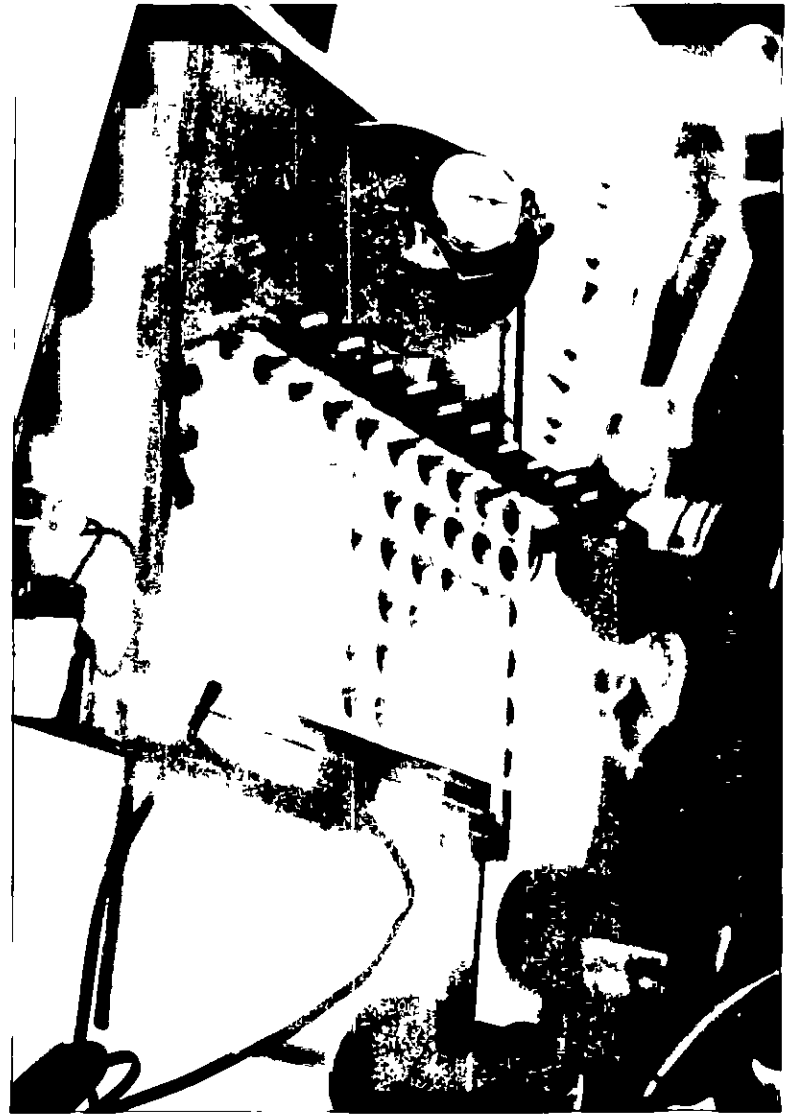
R = the number of patients to which each treatment is applied

Laboratory Phase

Each of the forty-eight teeth were cleaned and sectioned (Figure 1). The cut sections were mounted with paraffin wax on the ends of plastic sticks, exposing only the intact enamel surfaces (approximately 10-25 $mm.^2$). Three thin enamel layers were removed by successively immersing the blocks for 35, 35 and 70 seconds in wells of small plastic trays containing 1.0 ml. of 0.5N $HClO_4$ (Plate II). After o.1 ml. of the solution was removed from each cell, 0.5 ml. of adjusted Tisab

PLATE II

PLASTIC IMMERSION CELLS FOR REMOVING
SUCCESSIVE LAYERS OF ENAMEL



(20.0 g. NaOH to 1000 ml. Orion Tisab [total ionic strength activity buffer]; Orion Research Inc.; Cambridge, Mass.) was added to each cell.

For the determination of calcium, the 0.1 ml. of demineralized samples previously removed were placed in cells along with 1.9 ml. of $LaCl_3$ (500 parts of 1.0 percent $LaCl_3$ plus 400 parts of adjusted Orion Tisab buffer and 0.5N $HClO_4$ [50-50]). The 1.0 percent $LaCl_3$ solution was prepared by adding 50 ml. HCl to 11.75 g. La_2O_3 and bringing it to 1000 ml. volume with 0.5N $HClO_4$. Calcium was determined by the atomic absorption method (DB-G Grating Spectrophotometer [Plate III] and Atomic Absorption Accessory [Plate IV];[Beckman, Fullerton, Calif.] Ca tube: 10 m.a.; Support air pressure: 22 lbs.; Fuel: 4 lbs.). A standard curve for the calcium determinations was obtained from buffered calcium standards.

After the calcium determination was completed, the fluoride content was determined on the remaining solution by transferring it (with adjusted Tisab buffer solution) to electrode beakers and analyzing each sample with a fluoride electrode (Orion Ionalyzer fluoride electrode model 94-09 [Plate V]; Orion Research Inc., Cambridge, Mass.). The millivolt values for a series of fluoride standards (F1=0.00 ppm, 0.01 ppm, 0.02 ppm, 0.05 ppm and 1.00 ppm) were determined with the electrode in order to generate a standard curve for fluoride comparisons.

The thickness of each of the three layers removed was

PLATE III

BECKMAN DB-G GRATING SPECTROPHOTOMETER

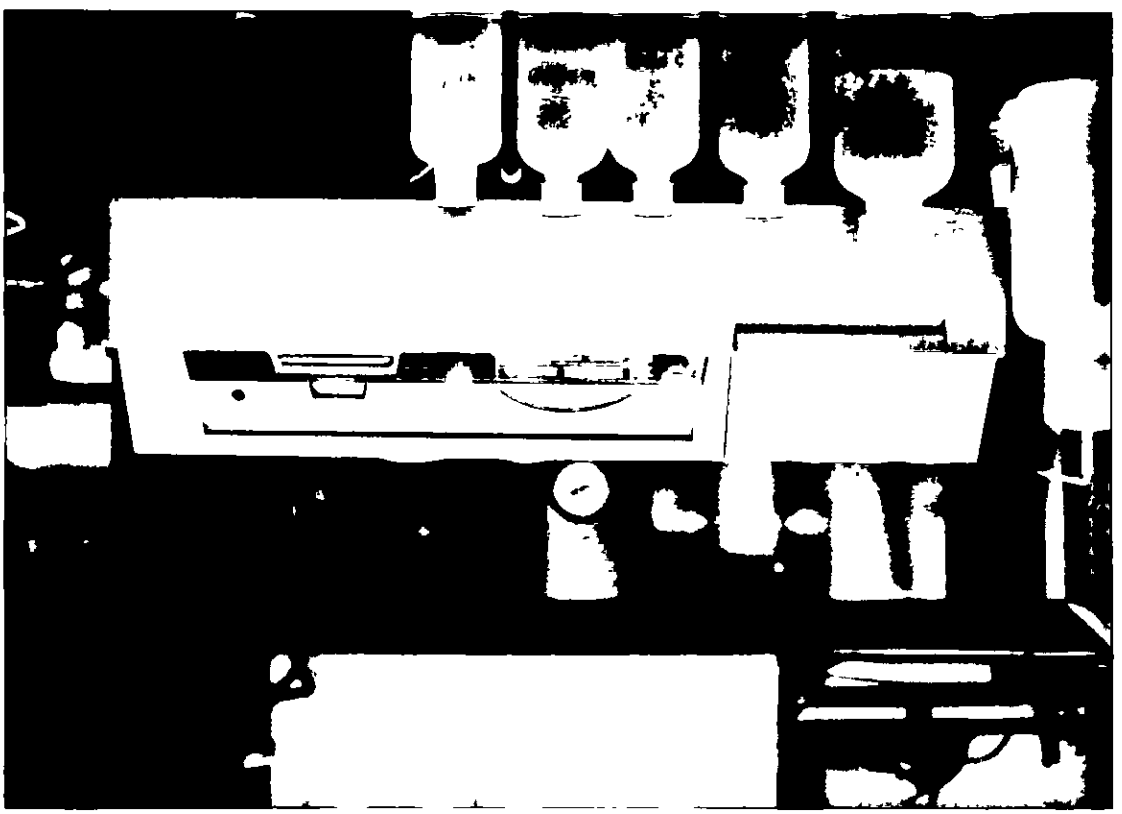


PLATE IV

BECKMAN ATOMIC ABSORPTION ACCESSORY

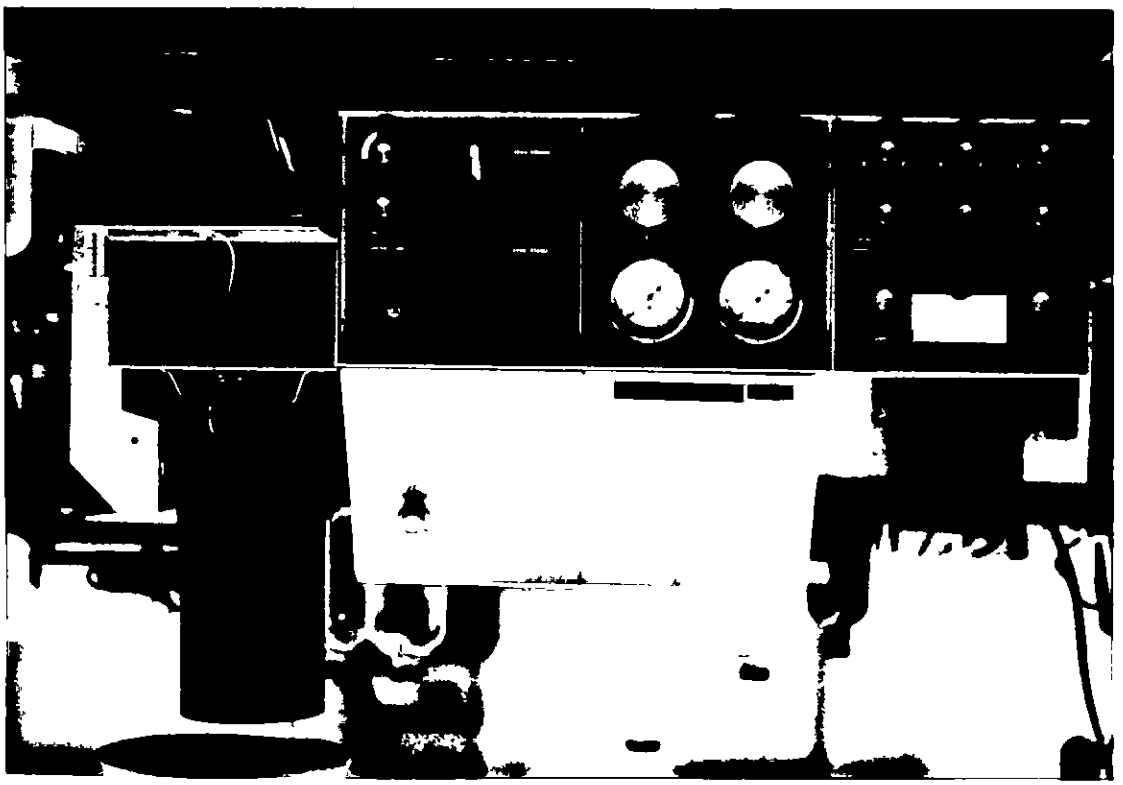
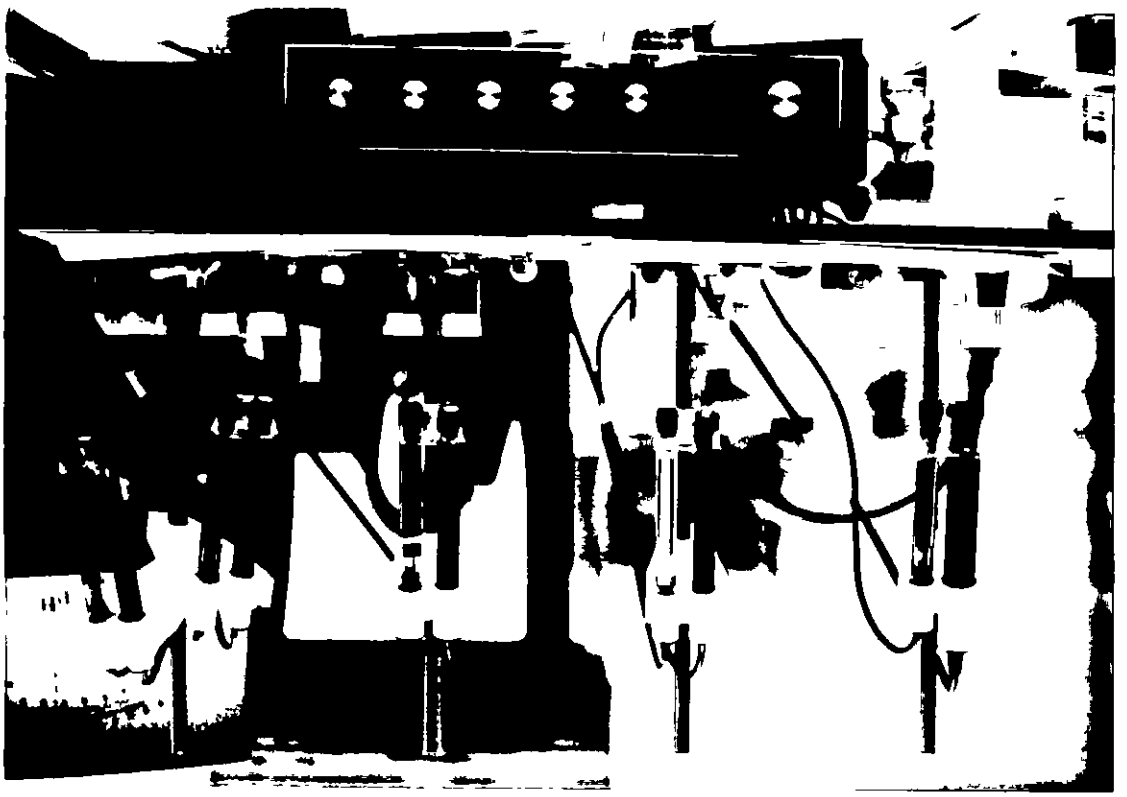


PLATE V

ORION IONALYZER FLUORIDE ELECTRODE



calculated by first measuring the enamel surface area under a dissecting microscope, and then after determining the total amount of calcium removed, assigning a 36 percent calcium content and 2.95 specific gravity to enamel. This method of assaying the depth of etching is described by Mellberg (Heifetz, Mellberg, Winter and Doyle; 1970). Because there is variation in the thickness of the enamel layers removed by this method, the concentration of fluoride found in each layer of enamel were graphed and the values were read off the graph at depths of 5, 10 and 15 microns.

A randomized block analysis of variance was performed to see whether there was a significant difference among treatments: to ascertain whether or not one group had significantly higher fluoride levels than the others (Steel and Torrie; 1960, p. 142). Tukey's multiple-range procedure (also called "honestly significant difference") was employed to examine specific contrasts suggested by the data (Steel and Torrie; 1960, p. 109). Finally, a Pearson product moment correlation procedure was employed to determine whether or not there was a significant correlation between the absolute difference in decalcification rating and the percentage elevation of fluoride content, both measured relative to control (Steel and Torrie; 1960, p. 183).

CHAPTER IV

RESULTS

Evaluation of Decalcification

After the extent of buccal decalcification on each tooth was scored by four observers, the results were tabulated as the sum of the four ratings for each sample. The combined ratings and analysis of variance are shown on Table 7.

Overall differences were significant ($p < .02$) according to Friedman's analysis of variance (χ^2 r= 9.875). Note the similarity between Thera-flur and Elmex, both in terms of total decalcification scores and ranks. Tukey's omega-procedure demonstrated significantly less decalcification ($p < .05$) on teeth treated with Elmex or Thera-flur than on the control teeth.

Fluoride Determination

Mean fluoride concentrations partitioned to depths of 5, 10 and 15 microns are shown on Table 8.

After partitioning the samples according to type of treatment performed, mean fluoride concentrations in the enamel for each type of fluoride treatment (and controls) at each of three depths of enamel are shown on Table 9. Variations in fluoride levels are further illustrated graphically (Fig. 2).

TABLE 7

COMBINED DECALCIFICATION RATINGS AS SCORED BY FOUR OBSERVERS

Patients	Treatments				
	Control	Acid PO_4-Fl	Stannous Fluoride (8%)	Elmex	Ti+
1	6.5 (3)[a]	4.5 (1.5)	7.0 (4)	4.5 (1.5)	22.5
2	7.5 (3)	7.0 (1.5)	8.5 (4)	7.0 (1.5)	30.0
3	9.0 (3)	8.0 (1)	10.0 (4)	8.5 (2)	35.5
4	7.0 (4)	3.0 (1.5)	5.5 (3)	3.0 (1.5)	18.5
5	7.0 (4)	3.5 (1.5)	4.0 (3)	3.5 (1.5)	18.0
6	7.0 (4)	4.5 (1.5)	4.5 (1.5)	5.5 (3)	21.5
7	7.0 (2.5)	7.0 (2.5)	10.0 (4)	6.0 (1)	30.0
8	7.5 (3)	6.5 (1)	7.5 (3)	7.5 (3)	29.0
9	7.5 (4)	5.5 (3)	4.0 (1)	5.0 (2)	22.0
10	7.5 (2)	8.0 (3)	7.0 (1)	9.0 (4)	31.5
11	11.0 (4)	10.5 (3)	10.0 (1.5)	10.0 (1.5)	41.5
12	3.0 (3)	1.0 (2)	4.0 (4)	0.5 (1)	8.5
T+j	87.5	69.0	82.0	70.0	308.5
$\bar{X}$+j	7.3	5.8	6.8	5.8	
Rank Total	39.5	23.0	34.0	23.5	
Mean Rank	3.29	1.92	2.83	1.96	

[a]Numbers in parentheses are rating scores for Friedman Analysis of variance used to evaluate the amount of decalcification.

The results obtained from an analysis of variance, employed to analyze the overall treatment effects, indicated a highly significant overall difference ($p < .02$) among treatments (see Table 10). Tukey's multiple-range procedure, employed to test specific differences suggested by data, indicated that teeth treated with Elmex had significantly higher fluoride levels ($p < .05$) than either control teeth, or teeth treated with Thera-flur or stannous fluoride. Teeth treated with stannous fluoride or Thera-flur did not show a significant increase in fluoride as compared to control teeth ($p > .05$).

A negative correlation ($p < .05$) was demonstrated between the absolute difference in decalcification rating and the percentage elevation of fluoride content, both measured relative to control (see Table 11).

TABLE 8

WORKSHEET FOR FLUORIDE AND CALCIUM COMPOSITION
OF ENAMEL AT THREE LEVELS

Tooth[1]	Ca Ab[2]	Ca[3]	Enam.[4]	X[5]	El[6]	M.V.[7]	F-Cur.[8]	To.F[9]	PPM-F[10]	Microns[11]	Cent.[12]	PPM-F by levels[13]
	105	4.1	228	9		105.0	225	450	1974	8.6	4.3	5 1880
1	100	4.0	222		0	117.5	132	264	1189	8.4	12.8	10 1380
	195	7.5	417	26.5		116.3	140	280	671	15.7	24.8	15 1050
	70	2.5	139	14		112.0	218	436	3136	3.4	1.7	5 1950
2	90	3.5	195		1	118.0	170	340	1743	4.7	5.8	10 1060
	200	8.0	445	41.3		116.0	182	364	818	10.7	13.5	15 740
	90	3.5	195	12		102.0	230	460	2359	5.5	2.8	5 2060
3	100	4.0	222		2	106.0	195	390	1757	6.3	8.7	10 1500
	200	8.0	445	35.4		106.0	195	390	876	12.6	18.1	15 1050
	80	3.0	167	14		102.0	250	500	2994	4.0	2.0	5 1530
4	110	4.4	245		3	112.5	162	324	1322	5.9	7.0	10 1160
	205	8.2	456	41.3		104.5	225	450	987	11.0	15.4	15 990

TABLE 8 - Continued.

	75	2.6	145	15		104.0	290	580	4000	3.3	1.7	5 2320
5	80	3.0	167			114.2	190	380	2275	3.8	5.2	10 1270
	200	8.0	445	44.3		108.0	242	484	1088	10.0	12.1	15 920
	85	3.2	178	14		99.5	285	570	3202	4.3	2.2	5 2550
6	100	4.0	222		0	104.0	235	470	2117	5.4	7.0	10 1400
	220	8.8	489	41.3		105.0	225	450	920	11.8	15.6	15 950
	80	3.0	167	10		123.5	135	270	1616	5.7	2.8	5 1410
7	100	4.0	222		1	125.5	125	250	1126	7.5	9.4	10 1090
	200	8.0	489	29.5		121.0	150	300	613	16.6	21.5	15 840
	75	2.6	145	10		108.0	180	360	2482	4.9	2.5	5 2020
8	105	4.1	228		2	111.0	162	324	1421	7.7	8.8	10 1270
	220	8.8	489	29.5		109.5	172	344	703	16.6	17.0	15 800
	90	3.5	195	10		93.0	355	710	3641	6.6	3.3	5 3100
9	115	4.5	250		3	99.0	280	560	2240	8.5	10.9	10 2240
	240	9.5	528	29.5		95.0	330	660	1250	17.9	24.0	15 1790

TABLE 8 - Continued.

Tooth	Ca Ab	Ca	Enam.	X	El	M.V.	F-Cur.	To.F	PPM-F	Microns	Cent.	PPM-F by levels
	80	3.0	167	13		104.5	285	570	3413	4.3	2.2	5 2820
10	115	4.5	250		4	103.0	300	600	2400	6.5	7.3	10 2000
	200	8.0	445	38.4		102.5	305	610	1370	11.6	16.6	15 1480
	100	4.0	222	13		91.0	390	780	3514	5.8	2.9	5 2700
11	115	4.5	250		0	101.0	255	510	2040	6.5	9.1	10 1920
	205	8.2	456	38.4		92.5	365	730	1600	11.9	18.3	15 1710
	90	3.5	195	14		103.2	310	620	3179	4.7	2.3	5 2300
12	110	4.4	245		1	109.0	242	484	1976	5.9	7.7	10 1820
	200	8.0	445	41.3		100.5	350	700	1573	10.8	16.0	15 1600
	105	4.1	228	17		89.2	390	780	3421	4.5	2.3	5 2600
13	115	4.5	250		2	97.4	275	550	2200	5.0	7.0	10 1780
	240	9.5	528	50.2		91.0	365	730	1383	10.5	14.8	15 1370

TABLE 8 - Continued.

	105	4.1	228	17		99.2	285	570	2500	4.5	2.3	5 2000
14	120	4.6	256		3	106.0	212	424	1656	5.1	7.1	10 1260
	220	8.8	489	50.2		105.0	222	444	908	9.7	14.4	15 870
	60	2.0	111	12.5		117.0	165	330	2973	3.0	1.5	5 1560
15	75	2.6	145		4	125.7	113	226	1559	3.9	5.0	10 1260
	120	4.6	256	37.4		117.5	160	320	1250	6.8	10.3	15 1070
	110	4.4	245	11		100.3	265	530	2163	7.5	3.7	5 2080
16	105	4.1	228		0	108.5	185	390	1711	7.0	11.0	10 1780
	210	8.5	472	32.5		104.2	223	446	945	14.5	21.8	15 1380
	95	3.6	200	13		127.0	120	240	1200	5.2	2.6	5 1100
17	105	4.1	228		1	128.2	115	230	1008	5.9	8.2	10 940
	210	8.5	472	38.4		119.0	162	324	686	12.3	17.3	15 760

TABLE 8 - Continued.

Tooth	Ca Ab	Ca	Enam.	X	El	M.V.	F-Cur.	To.F	PPM-F	Microns	Cent.	PPM-F by levels
	120	4.6	256	17		102.2	230	460	1797	5.1	2.6	5 1400
18	130	4.8	267		2	113.0	150	300	1124	5.3	7.8	10 950
	240	9.5	528	50.2		108.5	180	360	681	10.5	15.7	15 710
	190	7.5	417	18		115.6	145	290	695	7.9	4.0	5 660
19	220	8.8	489		3	116.0	142	284	580	9.2	12.5	10 590
	360	15.5	862	53.1		108.5	195	390	452	16.2	25.2	15 560
	130	4.8	267	12		116.2	172	344	1288	7.5	3.8	5 1200
20	135	5.2	289		4	123.5	130	260	900	8.1	11.6	10 960
	260	10.5	584	35.4		115.5	180	360	616	16.4	23.8	15 800
	40	1.3	72	17		103.0	235	470	6527	1.4	.7	5 1350
21	80	3.0	167		0	115.0	142	284	1700	3.3	3.1	10 1020
	220	8.8	489	50		111.5	165	330	675	9.8	9.6	15 500

TABLE 8 - Continued.

	115	4.4	245	14		100.5	350	700	2857	5.9	3.0	5 2350
22	125	4.7	261		1	113.5	205	410	1571	6.3	9.1	10 1420
	240	9.5	528	41.3		114.2	195	390	739	12.8	18.6	15 930
	120	4.6	256	15		95.2	300	600	2344	5.8	2.9	5 1750
23	120	4.6	256		2	114.0	145	290	1133	5.8	8.7	10 1000
	280	11.5	639	44.3		110.0	170	340	532	14.4	18.8	15 660
	80	3.0	167	14		98.2	290	580	3473	4.0	2.0	5 1450
24	135	5.2	289		3	114.0	155	310	1073	7.0	7.5	10 830
	280	11.5	639	41.3		111.0	175	350	548	15.5	18.8	15 660
	60	2.0	111	15		103.5	290	580	5225	2.5	1.3	5 2600
25	65	2.3	128		4	100.0	335	670	4219	2.9	4.0	10 1100
	260	10.5	584	44.3		105.5	270	540	925	13.1	11.9	15 700
	150	5.8	323	21		85.5	510	1020	3158	5.2	2.6	5 2200
26	155	6.0	334		0	100.2	280	560	1677	5.4	7.9	10 1470
	270	10.9	606	62		95.7	340	680	1122	9.8	15.3	15 1140

TABLE 8 - Continued.

Tooth	Ca Ab	Ca	Enam.	X	El	M.V.	F-Cur.	To.F	PPM-F	Microns	Cent.	PPM-F by levels
	195	7.7	428	18		92.1	500	1000	2336	8.1	4.1	5 2130
27	200	8.0	445		1	106.5	265	530	1190	8.4	12.3	10 1340
	340	14.5	806	53.1		102.2	320	640	794	15.2	24.1	15 1060
	175	7.0	389	18		94.1	360	720	1851	7.3	3.7	5 1640
28	180	7.2	400		2	105.0	225	450	1125	7.5	11.1	10 1180
	320	13.5	751	53.1		99.2	290	580	772	14.1	21.9	15 960
	195	7.7	428	17		88.5	460	920	1495	8.5	4.3	5 1475
29	190	7.5	417		3	99.2	290	580	1391	8.3	12.7	10 1415
	310	13.0	723	50.2		97.0	390	780	1079	14.4	24.0	15 1350
	140	5.4	300	13		98.6	355	710	2367	7.8	3.9	5 2180
30	145	5.6	313		4	109.6	220	440	1406	8.2	11.9	10 1560
	250	10.0	556	38.4		106.2	255	510	917	14.5	23.3	15 1210

TABLE 8 - Continued.

	130	5.0	278	17		——	——	——	——	5.5	2.8	5 2100 est.
31	150	5.8	322		0	103.0	250	500	1552	6.4	8.7	10 1530
	260	10.3	573	50.2		94.5	360	720	1257	11.4	17.6	15 1330
	140	5.4	300	13		107.0	255	510	1700	7.8	3.9	5 1560
32	135	5.2	289		1	117.2	168	336	1163	7.5	11.7	10 1240
	230	9.1	506	38.4		108.0	245	490	968	13.2	21.9	15 1080
	190	7.5	417	16		82.0	580	1160	2782	8.8	4.4	5 2650
33	200	8.0	445		2	94.1	360	720	1618	9.4	13.5	10 1900
	350	15.0	834	47.2		88.8	450	900	1079	17.7	27.0	15 1530
	150	6.8	378	14		94.2	440	880	2328	9.2	4.6	5 2260
34	145	6.2	345		3	104.2	230	460	1333	8.4	13.4	10 1640
	250	10.0	556	41.3		97.2	315	630	1133	13.5	24.3	15 1180

TABLE 8 - Continued.

Tooth	Ca Ab	Ca	Enam.	X	El	M.V.	F-Cur.	To.F	PPM-F	Microns	Cent.	PPM-F by levels
	175	6.8	378	21		87.5	570	1140	3016	6.1	3.0	5 2300
35	190	8.0	445		4	99.4	340	680	1528	7.1	9.7	10 1440
	340	14.5	806	62		92.2	460	920	1141	13.0	19.7	15 1240
	220	8.3	461	18		81.0	610	1220	2646	8.7	4.4	5 2550
36	210	7.8	434		0	93.5	375	750	1728	8.2	12.8	10 1960
	370	16.0	890	53.1		88.0	460	920	1034	16.8	25.3	15 1570
	165	6.9	384	12		112.6	200	400	1041	10.9	5.5	5 1060
37	120	4.6	256		1	124.2	128	256	1000	7.2	14.5	10 1010
	220	8.7	484	35.4		116.5	175	350	723	13.7	25.0	15 980
	110	4.2	234	15		98.7	300	600	2564	5.3	2.7	5 2060
38	120	4.6	256		2	108.0	200	400	1563	5.8	8.2	10 1350
	250	10.0	556	44.2		101.4	235	470	845	12.6	17.4	15 970

TABLE 8 - Continued.

	210	8.3	461	24		86.4	500	1000	2169	6.5	3.3	5 1650
39	230	9.2	512		3	100.5	275	550	1074	7.2	10.1	10 1080
	410	18.0	1001	70.8		94.2	360	720	719	14.1	20.8	15 860
	150	5.8	322	15		95.2	410	820	2547	7.3	3.7	5 2330
40	150	5.8	322		4	105.8	260	520	1615	7.3	10.9	10 1700
	270	11.0	612	44.2		103.1	290	580	947	13.8	21.5	15 1280
	135	5.2	289	18		91.0	410	820	2837	5.4	2.7	5 2330
41	170	6.6	367		0	100.2	280	560	1526	6.9	8.9	10 1330
	350	15.0	834	53.1		94.0	235	470	564	15.7	20.2	15 830
	250	10.0	556	24		91.5	510	1020	1835	7.9	4.0	5 1650
42	250	10.1	562		1	104.5	290	580	1032	7.9	11.9	10 1140
	500	22.5	1251	70.8		97.1	400	800	639	17.7	24.7	15 900
	230	9.2	512	23		77.5	680	1360	2656	7.5	3.8	5 2450
43	230	9.2	512		2	89.6	440	880	1719	7.5	11.3	10 1840
	430	18.8	1045	67.9		84.2	540	1080	1033	15.4	22.7	15 1440

TABLE 8 - Continued.

Tooth	Ca Ab	Ca	Enam.	X	El	M.V.	F-Cur.	To.F	PPM-F	Microns	Cent.	PPM-F by levels
	210	8.3	461	21		85.5	510	1020	2213	7.4	3.7	5 1950
44	200	8.0	445		4	99.0	295	590	1326	7.2	11.0	10 1400
	340	14.5	806	.62		94.2	360	720	893	13.0	21.1	15 1100
	210	8.3	461	24		98.5	400	800	1735	6.5	3.3	5 1280
45	200	8.0	445		4	124.0	120	240	539	6.3	9.7	10 520
	350	15.0	834	70.8		124.0	120	240	287	11.8	18.7	15 350
	115	4.8	267	16		100.0	285	570	2135	5.7	2.9	5 1600
46	140	5.3	295		0	115.4	143	286	969	6.3	8.9	10 880
	250	10.0	556	47.2		117.5	130	260	468	11.8	18.9	15 600
	175	6.8	378	20		124.2	158	316	836	6.4	3.2	5 630
47	175	6.8	378		1	139.4	068	136	360	6.4	9.6	10 350
	320	13.5	751	59		131.3	097	194	258	8.3	17.0	15 270

TABLE 8 - Continued.

	155	5.7	317	16		115.0	145	290	915	6.7	3.4	5	760
48	170	6.7	373		2	127.[illegible]	085	170	455	7.9	10.6	10	470
	290	12.0	667	47.2		123.6	100	200	300	14.1	21.7	15	360

[1]Tooth

[2]Reading from atomic absorption spectrophotometric analysis

[3]Amount of calcium in sample in micrograms as determined from standard calcium curve

[4]Total enamel in sample. Ca is multiplied by .20 because 1 ml. of the sample is diminished by a factor of 10 to 0.1 ml., then added to 1.9 ml. to bring to 2 ml. As human enamel is 36 percent calcium, result is multiplied by 2.78 (Ca x 20 x 2.78 = Enamel).

[5]Tooth area in mm^2 x specific gravity of enamel (2.95)

[6]The number of electrode used in fluoride determination

[7]The millivoltage of fluoride read from the specific ion electrode determination

[8]Estimate of fluoride plotted from standard curve

[9]F.Cur. multiplied by 2 as sample had been diluted one to one with buffer

[10]$\frac{\text{Total fluoride}}{\text{Enamel}} \times 10^6$

TABLE 8 - Continued

[11]Depth of etch for a given sample

[12]Center of etch for sample

[13]Fluoride content in PPM at 5, 10 or 15 microns estimated from fluoride curve

TABLE 9

MEAN FLUORIDE CONTENT OF ENAMEL AT THREE LAYERS
RELATED TO TYPE OF TREATMENT EMPLOYED

Treatment	Number of Subjects	Depth (micra)	Fluoride (PPM)	Standard Deviation
Control	12	5	1823	730
	12	10	1248	512
	12	15	973	409
Thera-flur	12	5	1852	462
	12	10	1261	369
	12	15	1013	354
Stannous Fluoride (8%)	12	5	1758	592
	12	10	1234	402
	12	15	887	311
Elmex gel	12	5	2169	480
	12	10	1506	370
	12	15	1170	329

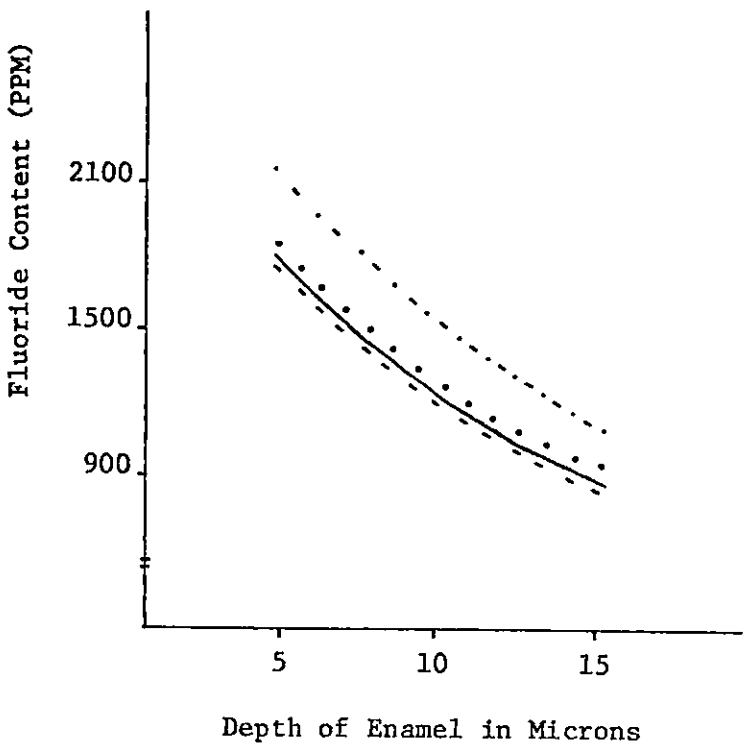


FIG. 2 .--Fluoride levels at depths of 5, 10 and 15 microns in enamel

TABLE 10

ANALYSIS OF VARIANCE FOR FLUORIDE CONTENT IN EACH SAMPLE

Source	Degrees of Freedom	Sum of Squares	Mean Squares
Treatment	3	20,194.80	6,731.60
Levels	2	200,244.01	
Interaction	6	1,277.43	
Subtotal	11	221,716.24	
Patients	11	197,513.91	
Error	121	79,050.51	653.31
Total	143	498,280.6596	

$F = 10.30$

$F.99\ (3,121) = 3.94$

TABLE 11

SCORING FOR DECALCIFICATION WITH THE PERCENTAGE CHANGE OF FLUORIDE CONTENT IN EACH SAMPLE

Patient	D[a]			F(%)[b]		
	E[c]	T[d]	S[e]	E	T	S
1	-2.0	-2.0	-0.5	14.6	13.0	07.0
2	-0.5	0.0	1.0	35.0	46.7	22.5
3	0.5	0.0	2.0	-11.2	-19.6	-11.7
4	-4.0	-4.0	-1.5	47.8	35.2	06.2
5	-3.5	-3.5	-3.0	63.7	69.2	54.7
6	1.5	-2.5	2.5	59.9	16.6	-02.3
7	-1.0	0.0	3.0	09.3	02.9	-14.1
8	0.0	-3.0	0.0	02.2	-14.4	-21.6
9	-2.5	-2.0	-3.5	00.0	-18.1	-16.5
10	1.5	0.5	-0.5	21.2	-30.3	-18.0
11	-1.0	-0.5	-1.0	55.3	20.9	21.7
12	-2.5	-2.0	1.0	93.8	35.7	-21.5

[a]Difference between decalcification rating and control

[b]Percentage change in fluoride content as compared to control tooth in same patient

[c]Elmex

[d]Thera-flur

[e]Stannous Fluoride (8 percent)

$r_{\Delta D \cdot \Delta F} = -.390$

$r_{(34)_{.95}} = .330$

CHAPTER V

DISCUSSION

Interpretation of the results of this study is complicated by the low degree of decalcification, apparently due to the high level of dental care that existed in the sample. Visual inspection of the extracted teeth indicated that significantly less decalcification ($p < .05$) was present in teeth treated with Elmex or Thera-flur than in control teeth. Similar treatment with stannous fluoride, however, did not produce a significant reduction in decalcification.

Although Friedman's non-parametric analysis of variance was used, the scoring system does have some of the obvious characteristics of parametric data--it has a zero point, and decalcification, itself, is quantitative and continuous. If this be granted, Tukey's procedure would be valid for decalcification scoring as well as for fluoride data. It is further noted that measurements of enamel surface area are correct to .5 mm.

Visual scoring may be questioned as the method of choice for generating the most accurate quantification of the existing extent of decalcification, however, it approximates the clinical situation in that evaluations were made on the buccal surfaces of the teeth, which represent the most common site of decalcification in patients wearing fixed orthodontic appliances (Muhler, 1970).

Furthermore, existing methods for an exact quantification of decalcification (i.e., dyes, sectioning) would have made sophisticated fluoride measurements very difficult.

Although Thera-flur significantly ($p < .05$) reduced the amount of decalcification as compared to untreated teeth, no statistically significant difference could be shown by the data as to its ability to increase the fluoride level in the treated teeth. (The author can give no explanation for this result.) Grand means for fluoride level in PPM was 1375 for Thera-flur and 1348 for the controls. However, treatment with Elmex did increase the fluoride level significantly ($p < .05$) as well as decrease the amount of decalcification in treated teeth, supporting the vast number of studies which indicate that increased fluoride levels confer greater protection against decalcification in enamel. This was reinforced by the fact that failure to increase the fluoride level by stannous fluoride was associated with no significant decrease in decalcification.

The negative linear correlation (-.398) between the percentage elevation of fluoride content (relative to control), as compared to the difference in decalcification (relative to control) was relatively low, although statistically significant. It does represent a clinically useful situation, however, because there was a significant decrease in decalcification.

This method would be preferable to measuring total fluoride concentrations, because that method would represent not only

fluoride acquired during treatment, but also, all fluoride that had previously been incorporated into the enamel.

The two reactions that are most likely to take place between applied fluoride and hydroxyapatite are the formation of fluorapatite or the formation of calcium fluoride (Brudevold; Savary; Gardner; and Speirs; 1963). This study does not clarify the nature of the chemical and physical reaction occurring between the fluoride and the enamel crystal.

Frazier and Engen (1966) demonstrated calcium fluoride formation and an increased crystallinity of enamel apatite after treatment with an acid phosphate-fluoride solution. Other investigators (Fisher, Muhler, and Wust, 1954; McCann, 1953) have shown calcium fluoride formation resulting from the application of concentrated fluoride solutions. Furthermore, it is thought (Brudevold, 1959) that the fluoride ion from calcium fluoride can react with the hydroxyapatite in enamel crystals to form fluorapatite.

To avoid any cross contamination from treatments, the teeth were thoroughly isolated with cotton rolls and rinsed immediately after four minutes of application. The probability of contamination was not considered great. Mellberg, Laakso, and Nicholson (1966) found that ten minutes after topical sodium fluoride treatment, only twenty-eight PPM fluoride were found in saliva. Moreover, this was done without precautions.

A direct measurement of total fluoride ion present

at a given depth in enamel does not take into account the way in which the fluoride ion is incorporated into the tooth. The most logical method of correlation estimates the change in fluoride during treatment, rather than the total amount of fluoride in the tooth. It was demonstrated that with a greater percentage increase in fluoride content over the control value, less visible decalcification was evident. This further supports the assumption that protection against decalcification is enhanced by the addition of fluoride by means of topical application.

The results of this experiment support the studies of other researchers who have tested amine fluorides both in vivo and in vitro, and found them to be effective in conferring on enamel properties which make it more resistant to decalcification.

Stannous fluoride has been shown to have many inherent disadvantages. It has a bad taste, poor stability, and is irritating to the gingiva (Muhler, 1957; Hatton, Nebergall and Muhler; 1955). Furthermore, this study does not show stannous fluoride to be effective at reducing decalcification under orthodontic appliances.

Thus, a general class of amine fluorides may be of assistance to orthodontists in the United States; however, it is only marketed abroad. For now, the acid phosphate-fluorides appear to be the best method of treatment, but if the organic fluorides later become available in this country, they may be a better choice.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A study was conducted to test the efficacy of three fluoride solutions in the reduction of decalcification on the teeth of twelve randomly selected patients who presented themselves for orthodontic treatment and who were diagnosed as first bicuspid extraction cases.

The data were of two types:

1. Visual scorings of decalcification rated blindly and independently by four observers.
2. Determinations of enamel fluoride content in PPM at approximated depths of 5, 10 and 15 microns.

A Friedman analysis of variance was performed for the decalcification data, and a blocked analysis of variance was performed for the fluoride data in order to determine whether or not there was a significant difference among treatments. Tukey's multiple-range procedure was employed to analyze specific contrasts suggested by the data.

The visual ratings indicated that both Elmex and Thera-flur reduced the amount of visible decalcification as compared to the untreated teeth ($p < .05$). Treatment with stannous fluoride (8 percent) did not produce a significant decrease in decalcification.

The data from the determination of enamel fluoride content

at various depths indicated that only Elmex produced a statistically significant increase in fluoride content.

As compared to the control value for each patient, significant ($p < .05$) negative linear correlation was found between the percentage increase in fluoride content and the absolute increase in decalcification.

Accordingly, it may be concluded that:

1. Both Elmex and Thera-flur, applied topically, were effective in reducing decalcification of teeth under orthodontic bands.

2. Only Elmex produced a significant increase in fluoride content in the enamel at the depths that were measured.

3. A greater percentage increase in fluoride content in a given patient was found to be associated with a decreased amount of visible decalcification.

APPENDIX II

TEETH OF ONE PATIENT AFTER TREATMENT

PLATE VI

TOOTH TREATED WITH NO TOPICAL FLUORIDE (CONTROL)

DECALCIFICATION RATING: 2.5

PLATE VII

TOOTH TREATED WITH STANNOUS FLUORIDE (8%)

DECALCIFICATION RATING: 2.0

PLATE VIII

TOOTH TREATED WITH THERA-FLUR

DECALCIFICATION RATING: 1.0

PLATE IX

TOOTH TREATED WITH ELMEX

DECALCIFICATION RATING: 0.5

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