

the Journal
of the
American College
of Dentists

Directions for
Dental Education

New Approaches
in the
Prevention of Dental Caries

JANUARY 1968

the Journal of the American College of Dentists

A QUARTERLY PRESENTING IDEAS IN DENTISTRY

T. F. McBRIDE, *Editor*
4236 Lindell Blvd.
St. Louis, Missouri 63108

JANUARY 1968

O. W. BRANDHORST
Business Manager
4236 Lindell Blvd.
St. Louis, Missouri 63108

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Contents for January, 1968

ALBERT LEONARD MIDGLEY, 1878-1967, <i>Otto W. Brandhorst</i>	3
EDITORIAL— EDUCATION AND PREVENTION, <i>T. F. McBride</i>	4
WHICH WAY DENTAL EDUCATION? <i>John Schoff Millis</i>	5
VIEWS ON THE RATIONALE OF TOPICAL FLUORIDE THERAPY, <i>Harold R. Englander</i>	15
A REVIEW OF CLINICAL TRIALS UTILIZING ACIDULATED PHOSPHATE-FLUORIDE TOPICAL AGENTS, <i>Paul F. DePaola</i>	22
RELEASE OF FLUORIDE TO ENAMEL BY AN ADHESIVE BANDAGE, <i>R. S. Manly and Dorothy P. Harrington</i>	34
MASS TREATMENT OF CHILDREN WITH A STANNOUS FLUORIDE-ZIRCONIUM SILICATE SELF-ADMINISTERED PROPHYLACTIC PASTE FOR PARTIAL CONTROL OF DENTAL CARIES, <i>Joseph C. Muhler</i>	45
PRACTICAL APPROACHES TO LARGE-SCALE STANNOUS FLUORIDE APPLICATIONS, <i>Frank D. Grossman</i>	58
ARMY MOTIVATION STUDY, <i>RICHARD L. HOWARD</i>	65
WHAT ABOUT A VACCINE FOR THE PREVENTION OF DENTAL CARIES? <i>Gordon H. Rovellstad</i>	74
THE EFFECTS OF FLUORIDE ON THE PREVALENCE OF MALOCCLUSION, <i>J. A. Salzmann</i>	82
OFFICERS AND REGENTS—1967-1968	92
COMMITTEES—1967-1968	93

ALBERT LEONARD MIDGLEY
1878-1967



ALBERT LEONARD MIDGLEY

D.M.D., Sc.D., F.A.C.D.

Dr. Midgley passed away on October 31, 1967. He was one of the Founders of the American College of Dentists, and for many years was Secretary of the organization.

In 1935-1936 he became President-Elect, and served with distinction as President in 1936-1937.

His activities were not confined to the American College of Dentists. In 1910 he took upon himself the task of laying the foundation for the Council on Dental Education of America and the classification of the dental schools in this country.

No man had higher regard for high professional standards, or the ethical involvements in such standards, than did Dr. Midgley. There were many times when he had to battle for some of these principles but he never wavered.

While his interests were many, his greatest concern had to do with medico-dental relations; toward the improvement of these relations he gave many hours of devotion.

Dr. Midgley was stricken in March 1967, and was bedridden since that time. Even though he could not speak when I visited him in June, I was sure that he understood the discussion which the family and I were carrying on as evidenced now and then by a smile that appeared upon his lips.

The devotion of his daughters during his illness and the loving care which they gave him were a great comfort to him.

Thus another great statesman has gone to his reward. May he rest in peace.

—O. W. BRANDHORST

Editorial

Education and Prevention

Seven years ago *The Survey of Dentistry* noted that "Preventive dentistry offers the most promising solution to the dental health problems of the nation." And further, "The development of effective and widely applied preventive measures is the indispensable approach to ensuring the dental health of the nation."

The eight papers beginning on page 15 were presented at a panel discussion, "Caries Prevention and Control," at the Washington Meeting of the American College of Dentists last October. These papers show the way to a "promising solution" and "effective and widely applied preventive measures." These papers indicate that topical fluoride therapy with large-scale applications, using different fluoride agents in different ways, can lead to control by mass treatment and motivation for preventive self-care. These papers illustrate that rational and practical methods of prevention are now available.

And here Millis, in his paper (page 5), stresses "the translation of the science of knowing into the art of doing." How well that fits in with our current preventive knowledge. He also echoes another statement from *The Survey*: "The first and basic responsibility for progress toward the goal of prevention lies with the universities and the dental schools."

Education and prevention do go hand in hand. It is a happy instance, not entirely casual, that the JOURNAL presents these outstanding discussions in both areas.

The panel papers in this issue indeed point up the ringing challenge stated by Millis that "... dentistry has an excellent chance of being the first health profession to become truly preventive."

T.McB.

Which Way Dental Education?

JOHN SCHOFF MILLIS, PH.D.

I COUNT it a rare privilege, indeed, to have been invited to be a part of this very dignified and auspicious occasion. Further, I count it a particular privilege to have been introduced by my good friend and long-time colleague, Dr. Carl Stark.

I fully realize that my presence here is an act of arrogance for I am a layman. I am not a dentist, I am not a physician, I am not a member of any of the health professions. Therefore, I can by no means be called an expert. I am particularly humble because of an experience ten days ago in Cleveland when we observed the 75th, the Diamond Jubilee Anniversary of the School of Dentistry of my University. Many of you were there to listen and to participate in the symposium, and the ideas which I have to present were so beautifully presented then that I hesitate to proceed. However, as a layman, there is a possibility that I may be able to shed a little light and add some modicum of wisdom to your understanding and to your appreciation of the field, both the practice and the educational component of the health science of dentistry. My only reason for such a hope is that I have spent twenty-five years of my life as a student of education for the learned professions. Perhaps in those twenty-five years, I have gained some insights which are worthy of being shared with you. More especially, I have spent the last five years in an intensive investigation and reflection upon the problems of one field of health education, namely, the graduate phase of medical education. It is on the basis of this experience that I have chosen the topic of my remarks, "Which Way Dental Education?"

I start with what to me is a very clear fact: that is that dental edu-

This address was presented at the Washington, D.C. Convocation of the American College of Dentists, October 29, 1967.

Dr. Millis is Chancellor, Case Western Reserve University, Cleveland, Ohio.

cation, indeed the entire profession of dentistry, is on the move. There are very clear signs of energy and a dynamic desire to improve dental practice, to make substantial increments in the quality of dental education and thereby to serve the American public more effectively than it has been served in the past. A second assumption is that this energy of change, of progress, of inquiry, will continue into the future unabated, or even at an accelerated rate. It is obviously, as we all know, a direct response to energetic and dynamic and sometimes revolutionary forces which affect dentistry, medicine, nursing, technology, science, politics, the social and behavioral studies, the arts and the sciences alike. These forces are both internal within the profession and within the disciplines which are cognate and relevant to the profession, and they are external within the society in which we live and work. They are, I repeat, accelerating in their intensity and in their complexity and, therefore, in their demand for recognition and response. I remind you that we have a choice as to that response. The change which must occur within dentistry and within dental education can be involuntary, that is, a mere adaptation through expediency by following the course of least resistance. Or it can be voluntary, arising out of the will and the determination of man and, therefore, an orderly, effective, and purposeful change. I, for one, strongly urge upon this College that you here and now resolve that this change shall be voluntary, arising from within the wisdom, the experience, the commitment, and the dedication of the profession of dentistry. But a voluntary attack upon the problems of our times as they precipitate the problems of dentistry will require extraordinary voluntary collaboration of the profession and of the educational system. This, experience proves, has not been altogether the easiest thing in the world to accomplish. I am, therefore, directing my remarks to the American Dental Association and to the American Association of Dental Schools alike, and particularly to the American College of Dentists made up, as it is, of the leaders and the most distinguished members, both of the body of practice and of the body of dental education.

I shall try to describe for you a possible strategy, among several alternatives which could be designed, by addressing myself to and answering six basic questions. They are:

1. Where should the responsibility be placed for leadership in and producing and directing change in dentistry?

2. What is the basic strategy for the delivery of the most effective dental health service in the future?

3. What should be the relation of dental education to the university?

4. What policy should be followed in relation to specialization?

5. What basic policy should govern the development of graduate dental education?

6. What basic policy should be followed in the development of postgraduate and continuing dental education?

On the first question, who shall lead, there are obviously two alternatives. First, we could rely upon the field of practice to lead the change in dentistry or, second, we could place that responsibility upon the educational establishment working in close and intimate collaboration with the organized profession. I would urge the second alternative for several reasons which seem to me to be quite compelling. If education follows practice, I think history teaches in all the fields of the health sciences, or all of the learned professions for that matter, that the change is slow and, therefore, our patients receive less than the best possible care in each epoch of time. From the point of view of the educator, we recognize that we should turn out students for practice, not as it is or it has been, but for what it will be. Each Fall, as I have greeted the entering classes in schools of medicine, nursing or dentistry, I have reminded myself of the fact that these young men and women are not entering the world of practice at this time, but are only being prepared for it, and that they will enter it at a time which may be as much as ten years in the future. Therefore, the freshmen who began in the fall of 1967 will not be established practitioners before the year 1975. They will be the leaders of this College in 1990, in the year 2000, and in the year 2010. Further, in the university, we can, if we will but take the time and use the wisdom, dimly see the future which is before us because the research which shapes that future and determines it in a large way is heavily centered in the university. More importantly, the totality of the expanding world of knowledge is located in the institution and there alone. There is no other place where the whole of knowledge, all of the arts, all of the sciences, and all of the skills, is continually reviewed, expanded, amended and applied. Finally, the responsibility for the translation of the science of knowing into the art of doing has been placed upon the institutions of higher

education and particularly upon those institutions engaged in the education of the learned professional.

There will be implications of the decision which I advocate. First and most important, I think, is the relationship between the two bodies of organized dentistry—the American Dental Association and the American Association of Dental Schools—who must determine, I think, a pattern and a mechanism of true collaboration and therefore devise and build a voluntary and truly powerful liaison body. Second, it has an implication for the strategy and the tactics of the further development of research in dentistry. Of course, we must have additional basic research done in the laboratories of our dental schools. But particularly, what we need to do is what no other profession has been able to do, namely, to reap the fruits for dentistry of all the other research which is being undertaken inside the university both in the past and in the present. This would require, in my judgment, the development of a new kind of officer of research, the individual whom I shall describe as a reader, a person whose responsibility is that of reading widely, organizing, criticizing, and collating the results of the research of diverse disciplines. Third, it would also involve the development of a new frontier of research, research at the interface between knowing and doing, between science and art, that is, the translation of knowledge into skill. This would be what we need so very much—research in the delivery of all forms of health care. The decision which I advocate would have a very profound impact on the dental schools, for if they were to assume the responsibility, collectively and in close collaboration with the practicing profession, of charting the future as they are able to predict it with alternative responses to forces of change, they would have to devote a substantial amount of time, manpower, and energy to it. This would require that which we do not now have—a true corporate sense of responsibility as among the totality of our dental schools. This is a strong implication for the American Association of Dental Schools.

I come now to the second question: What is the best possible basic strategy for the delivery of dental care in the future? Again, I see before me two alternatives. One would be a form of dentistry I call disease-oriented, the repair of the results of disease which is after the fact, so to speak. This automatically drives dentistry in the direction of dental surgery; in other words, a surgically-oriented medical specialty. Secondly, we might take, as dentistry is already

giving signs of doing, the alternative of the preventive approach which is before the fact and is obviously more strongly medically-oriented. In a sense, the contrast is between dental medicine and dental surgery.

Now, which alternative? I realize that I have depicted two extremes, neither of which will exist in reality. It is a question of where shall lie the center of gravity in our philosophy, our tactics, and our strategy. Further, I realize, of course, that this is not my choice; it is the choice of the organized body of dentistry. But may I say that I, as a typical patient, do have a strong preference for prevention and for oral medicine instead of oral surgery. My preference relies upon the following reasons. I take it that all of you, committed to the service of your fellow men, recognize and value disease prevention as being a higher moral good than dealing with the results and ravages of disease after the fact. From my meager knowledge, I am convinced that dentistry has an excellent chance of being the first health profession to become truly preventive. I believe that there is an opportunity in our time which makes such a goal practical. In the first place, the oral cavity is biologically, chemically, and physically a relatively simpler body area or system than many others. There are, therefore, fewer parameters for us to deal with than in many other regions of the human biological system. Secondly, I believe that we are at a unique point in the history of science and particularly of the health sciences where we are on the threshold of being able to move from that which has occupied us in research in the past, namely, description of the mechanism of disease and disability, to that which lies behind and to really deal with the cause of disease. As Professor M. M. Payne of Yale has remarked, up to now we have confused mechanism and cause and have thought we knew about the cause of disease when all we were doing was describing, modifying, and dealing with the mechanism of disease. But, if that which I am here predicting should happen, dentistry will increase its research competence by at least 100-fold. Remarkably, this would occur without greater expenditure of manpower or effort.

My third question: What should the relationship of the dental school to the university be? All dental schools but one or two are parts of universities. And perhaps, therefore, this is a silly question, but I do not believe so. For though they are members or parts of, and are located in universities, it has been my observation that they

seem to exhibit a general pattern of isolation from the universities of which they are a part. Conversely, more seriously and more unhappily, the universities appear to draw little sustenance, inspiration, and value from their dental schools. We tend always to think about dental schools and dentistry in an analogy to medicine and, therefore, you probably are asking, "what about the medical schools?" I simply say that their example is bad. Because of the history of the relationship of the medical school to the university over the last sixty years, the medical schools do have, indeed, a very serious problem to solve.

I would remind you that the medical school pattern developed in a totally different era, that of the first two decades of the twentieth century, not in the last third of the century. The schools responded to the basic recommendation of the Flexner Report of 1911 and, therefore, were moved into the university rapidly in the expectation that medical education would become solidly based upon the natural sciences and the other disciplines of the university and that this would automatically elevate the quality of medical education and, therefore, of resultant medical skill. Further, it was hoped that they would be affected by the research environment of the university. This change of environment has produced great progress in medical education as we all know, but it has also produced some very vexing problems which dentistry can and, in my judgment, should avoid. The medical schools were ready for and needed the university in 1911. But may I point out that the universities were not ready for the medical school. In fact, there were only a very few universities, a mere handful, where the disciplinary departments were developed to the true graduate level and competent, therefore, to participate in a graduate professional educational program. The continuing dichotomy between the sciences and the arts, that is, between knowledge, pure and unadulterated, and its purposeful use in the arts, was unresolved. The medical school was mistakenly located physically in or near the hospital rather than in the university itself. There have been some consequent developments. We have seen duplication of departments of biology, physiology, microbiology; duplicated departments of chemistry and biochemistry. Each department and each discipline has become surrounded by an impervious membrane through which neither man nor ideas may flow.

Note that medicine has its present dilemma. It is caught up in

what I call the relevance explosion, the fact that now medicine is becoming dependent, not only upon biology and chemistry, but upon physics, psychology, sociology, and economics, almost the entire spectrum of the university disciplines. It obviously cannot start duplicate departments of psychology, physics, mathematics, sociology, anthropology, and economics, and, therefore, the medical school must fully come into the university, a process which it has resisted for more than half a century. Turning now to the dental school of the university, I have very strong feelings on the subject. Dentistry needs all the support it can get. Every professional discipline requires support, of course. No one can predict with any certainty what the next supporting discipline which we shall require for dentistry is going to be. I consider the task of providing additional basic disciplines in the dental school absolutely impossible. Certainly, the economic cost is completely unjustified. But such a joining of the dental school into the university in a true and viable sense demands that it be a two-way street. Therefore, we must ask ourselves, can the dental school actually contribute in a meaningful way to the university? My answer to this is a ringing yes. The central problem of the university is the interface between science and art, between knowing and doing. It is only in the learned professions that this interface is clear and viable and where the arts and sciences are at peace and not at tension. Further, by being a constant source of ideas for the improvement of education and the learning process, a professional school can be a gadfly and stimulate the production of educational reform.

I come now to my fourth question. That is: What shall be our strategy with reference to specialization? I now show my complete arrogance by daring to undertake this subject after listening to the fine program this morning.* But perhaps I can add a few further ideas. I think that part of our problem in dealing with specialization versus generalization arises out of the use of the word "specialization" itself. I have been suggesting that we stop using that word and use a more meaningful expression, namely, "differentiation." We have taken the word "specialization," which comes from the root "species," and have used it to mean the opposite of generalization.

* This refers to a panel discussion, "Specialties and General Practice," presented at the Sunday morning Meeting of the American College of Dentists, October 29, 1967, Washington, D.C. [Ed.]

It doesn't mean this at all. It merely means that that which is being described is somewhat different from that which somebody else does. This is differentiation, not specialization. And since it is only a difference in species, let's call it a differentiation. But differentiation and further differentiation is inevitable in medicine as the direct consequence of the Flexner Report. For when you place the medical school and later the dental school in the university environment, you let loose the forces of intellectual curiosity; you place upon the medical and dental teacher a responsibility for research. And you trigger the knowledge explosion. Therefore, there is no possibility that we can turn the clock back, that we can reverse the force of differentiation and, therefore, the rise of additional specialization and sub-specialization. But what we can do is to manage that differentiation because it is a selective process of what can and what should be learned. And thus, I say "differentiation," not "specialization." Generalists in a true sense are just as differentiated as are specialists. I point out to you that the basic difference is differentiation by exclusion on the one hand and differentiation by inclusion on the other hand. The real problem here is not differentiation as such, which is necessary, good and proper, but rather the man-created fragmentation of the profession and of professional education which has followed. But I remind you that specialty boards were not appointed by the Almighty; they are voluntary associations of mere men, frail as they are bound to be. But the poor patient has suffered. He is now an individual who must generally resort to self-diagnosis, gets poorer care because on the whole, it is partial care and not comprehensive, and it is discontinuous care rather than continuous care. Further, it has resulted in fragmentation of planning and of control. We see now the primacy of time-serving as the index of competence, a spectacular resistance to change because of vested interests. I have said in some of my articles that if one had started out with malice aforethought to construct a mechanism cunningly calculated to resist all change, he would have developed in the field of medical education the system which we now have.

You may ask, what is the solution? One of the solutions, of course, is group practice. Another is the coordination of service. This requires the active participation of the differentiate whom we call the primary or the general physician or dentist. And it also requires

further institutionalization. But, most important, it requires a truly powerful mechanism to plan for, to promote, to create change within the profession.

My fifth question revolved around the tactics, the strategy, for a policy for graduate dental education. Again, let me look briefly at the situation in medicine, an area in which I have steeped myself for the last five years. I note the fact that the universities over forty years ago resigned from any responsibility for the education of physicians beyond the granting of the M.D. degree at the end of the fourth year. It, therefore, fell by default into the hands of the hospitals. We call them "teaching hospitals"—sometimes a misuse of that adjective. The student has become a renderer of service and the outmoded and outworn system of higher education known as the apprenticeship has persisted.

In my judgment, dentistry at the graduate level must, at all costs, remain in the university to ensure academic responsibility for the highest level of education. This is not higher education; this is graduate education beyond the level of the doctoral degree. There is no education "higher" than that. The university's concern for the future and for the maintenance of the research environment will ensure learning and will resist a tendency to teach by apprenticeship. This will require in our universities and dental schools profound changes, and the consideration of whether we should be offering additional degrees. We shall have to look very hard at our faculty structure in order to produce a true corporate responsibility for graduate education which we do not now have. We shall need a system of collaboration among the dental schools through their association for dental education. Particularly we shall need the development of research as an instructional device and not merely as the producer of new and previously undiscovered knowledge. But the basic revolution which must occur in graduate dental education or graduate medical education alike is to focus upon the interface between science and art, between knowing and doing, between knowledge and skill, and to establish there a true symbiotic relationship. Each must feed and inspire the other. We must come to a recognition that the true definition of a professional is a bivalent individual who is equally at home with knowledge and with skill and, at one and the same time, is both a knower and a doer. This means that we shall have to discard our classical model of health

education which was based upon the assumption that the body of relevant knowledge was essentially static, that the change in that knowledge was relatively slow, so that there will be a generational time lag between the discovery of new knowledge and its appearance in new skills. The model for the educational process has been two years of so-called basic science and an indefinite superstructure of skill capable of unlimited extensibility. They are real and they are present. Now we are struck by a burgeoning knowledge, by an almost instantaneous translation of knowledge into skill, and by the phenomenon of accelerating obsolescence. The requirement of the future for the learned professional and particularly the health professional is that he be equipped both with knowledge and skill indivisibly, and that the university scene become the environment where this becomes possible.

The last question to which I address myself is the policy for postgraduate education, for continuing education. I can treat this very rapidly for I think the same principles apply here that applied in my remarks about graduate dental education. Postgraduate education must become more than simply increments of skill; it must become simultaneous increments of knowledge so that the focus of the continuing educational process is on the interface between these two and the dentist is not asked to deal with knowledge at one time and skill at another time or in a different environment. This means, I take it, that dental schools must take a much larger responsibility for continuing education than they have in the past for it is here that knowledge and skill resides and becomes available for the educational process.

I come now to the "Conclusion." May I simply say that we are at a most significant crossroads in dental education. The problems are complex and difficult. The decisions concerning them and our adaptation to the forces of change must be made voluntarily within the profession, both practice and education, or they will be made for us externally by a society which knows relatively little about it. I view this not as a crisis. I view it rather with excitement, and I think you should, too. It is always exciting to look at opportunities, to have the chance to be statesmen and to be faced with the opportunity of a shared responsibility of colleague among colleagues. In my humble judgment, the next decade can be dentistry's finest hour and can mark its coming of age as a truly learned profession.

Views on the Rationale of Topical Fluoride Therapy

HAROLD R. ENGLANDER, D.D.S., M.P.H.

TODAY, nobody seriously questions the anticaries value of applying fluorides topically to the teeth. There appears to be merit in almost all topical fluoride formulations and techniques of application. To date, topical fluoride therapy has been largely empirical because when clinical trials of topical fluoride measures have been conducted there have been few attempts to measure the fluoride uptake by the enamel or to determine the nature of the chemical reactions that have occurred between fluoride and the enamel crystal. Moreover, the manner in which fluoride "suppresses" dental caries has not been fully understood. Numerous studies have indicated that it probably can exert its effect in one or in several ways: (1) by making the enamel more resistant to acid demineralization; (2) by inhibiting the bacterial enzyme systems which convert sugars into acids in the dental plaque; (3) by a direct antibacterial effect; and (4) possibly by preventing microorganisms in plaque from deriving benefit from the breakdown and invasion of enamel and dentin (1).

Generally, in the prevention and treatment of infectious and non-infectious disease processes with pharmacological agents or when specific physiological effects of drugs are desired, it is necessary to produce effective levels of the active antidisease agent or its beneficial reaction products at the target tissue site. This can be accomplished by direct application of the medicament in question to the tissue for a definite period, or by peroral or parenteral administra-

This paper was presented at a panel discussion, "Caries Prevention and Control," at the Washington, D.C. Meeting of the American College of Dentists, October 28, 1967.

Dr. Englander is Dental Director, Biometry and Field Studies Branch, National Institute of Dental Research, Bethesda, Md. 20014.

tion that first produces an effective concentration of the antidisease factor in the blood. For example, in the control of such infectious diseases as pneumococcal pneumonia, subacute bacterial endocarditis, and lues, prescribed courses of penicillin administration have been developed that can result in optimum beneficial effects. The therapeutic value of such treatment is not merely dependent upon some number of penicillin injections given in arbitrary dosage or the number of penicillin tablets swallowed, per se, but upon rational courses of dosage which establish effective blood and tissue levels of penicillin within at least therapeutic ranges. Indeed, the time-dosage relationship forms the rational foundation of drug therapy and often must be estimated by tedious laboratory and clinical research. The same principle applies in the treatment of noninfectious diseases. An illustration of this is the administration of insulin in the management of diabetes mellitus.

In contrast to pharmacological principles in which attempts are made to achieve the maximum potential benefits from therapeutic measures by systematically establishing effective tissue levels, the history of modern topical fluoride prophylaxis has been fraught with hit or miss clinical attempts to achieve some degree of anticaries effect, often borderline in nature and difficult to observe clinically.

Over the past twenty-five years many researchers have conducted experiments to develop fluoride compounds that are more effective than sodium fluoride. This has seemed premature to me and I raise the question: Have we really learned how to use sodium fluoride to its maximum effectiveness? I think not.

Fortunately most investigators have shown varying degrees of positive benefits with fluorides. Some have advocated sodium or stannous fluoride while others have tried different compounds and formulations administered in various vehicles. Often, high concentrations of fluoride have been applied infrequently to the teeth in aqueous solutions or in prophylactic pastes. There have been many reports recommending that low concentrations of fluoride be applied frequently in dentifrices and mouthwashes. More recent reports have suggested that superiority of combined topical application techniques wherein the infrequently applied stannous fluoride-prophylactic pumice paste is followed by an aqueous topical stannous fluoride application supplemented by daily brushings with a stannous fluoride dentrifice (1-5).

Thus various fluoride formulations have been applied to the teeth in several ways and the effectiveness of the various procedures have been evaluated by comparing increments of crevice and smooth surface dental caries. But basically, just what are we trying to do to the tooth when we apply fluoride topically? It is reasonable to postulate that if fluoride is to exert its anticaries effect it ought to be acquired by the tooth in some sufficiently permanent form. There ought to exist some minimum concentration or range of concentration of fluoride in enamel that we should at least strive to attain in order to achieve an optimum anticaries effect. Perhaps this should be called the "therapeutic enamel fluoride level." If it were possible to obtain this information it would help place fluoride therapy on a more rational basis and would be a step forward in preventive dentistry.

To compare the clinical anticaries effectiveness of various annual and semiannual topical fluoride techniques singly or in combination without first assessing the fluoride uptake in teeth seems naive. As an illustration, how could a yearly prophylaxis with a fluoride-pumice paste followed by an aqueous topical fluoride application produce an additive anticaries effect and be more clinically effective than an aqueous topical fluoride application alone if appreciably greater amounts of fluoride were not acquired permanently by the outermost layers of enamel? The fluoride uptake can readily be assayed *in vitro* in extracted teeth, *in vivo* in exfoliated deciduous teeth after exfoliation, or in permanent teeth that are scheduled for extraction. Such analyses can be conducted before undertaking a long and expensive clinical trial.

For the past several years the National Institute of Dental Research has been directly supporting both laboratory and field studies that have attempted to answer various questions regarding topical sodium fluoride therapy and which provide some insight into the anticaries action of fluoride. The following includes a résumé of some of the more important findings that have emerged together with a mention of fruitful areas needing further investigation.

Under laboratory conditions, using Syrian hamsters infected with caries-conducive streptococcal strains of both human and hamster origin and fed a diet high in sucrose, it has been necessary to apply high concentrations of sodium fluoride to the teeth repeatedly for a few minutes daily to obtain the maximum anticaries effect. It has

been possible to prevent smooth surface caries completely as long as the treatment continued in animals receiving daily applications of water soluble gels containing 1.1 per cent sodium fluoride. Topical fluoride applications have been made effectively in the hamster using small vinyl odontal (mouth guard type) applicators (6-8). In other experiments with hamsters after daily topical treatments with concentrated sodium fluoride-gels had been discontinued, the residual anticaries effect has been good but incomplete (9). These bio-assays suggest that the maximal protection from topical fluoride therapy can be achieved only with repeated topical treatments. Although a fluoride analysis of the enamel from the hamster teeth was not performed in the aforementioned experiments, future studies should include a comparison of the enamel fluoride acquisition in completely, incompletely, and unprotected animals to determine the relation between the degree of protection and the enamel fluoride content.

The laboratory experiments have suggested that the repeated topical sodium fluoride applications have not had a dramatic antibacterial effect in the protected animals since they always harbored large numbers of the caries-conducive streptococcal strains in their mouths and plaque deposits were always present on their teeth. Furthermore, it did not appear that the fluoride treatments permanently affected the virulence of the caries-conducive streptococci because they induced rampant caries rapidly when inoculated into young nonfluoride treated hamsters. During these experiments, tests were conducted to determine whether the fluoride applications prevented the microorganisms in the plaque from producing a high hydrogen ion concentration after the application of sucrose to the plaque. It was found that plaque acidities below pH 4.4 were uniformly and rapidly produced in the plaques of fluoride-protected and unprotected animals (10). Taken together these observations tend to support the postulate that the manner by which fluoride exerts its anticaries effect is by rendering the enamel more resistant to demineralization and that some threshold amount of fluoride must be acquired by enamel, perhaps in the form of fluorapatite, for an optimum beneficial effect. However, this work does not preclude the possibilities that fluoride produces some alteration in streptococcal metabolism, especially at the enamel-plaque interface, or that it may be responsible for undetectable changes in the rate of acid

production of the final concentration of hydrogen ion produced.

Inasmuch as frequently repeated topical applications of sodium fluoride resulted in excellent protection against dental caries in the laboratory, a clinical study was conducted on school children, aged 11-14 years, living in a nonfluoridated area to determine what could be accomplished by a maximum number of repeated topical fluoride applications under supervision. In this study the children applied water soluble gels containing 1.1 per cent sodium fluoride in custom made applicators daily in school for six minutes over a period of 21 months (11). This method of application rather than brushing the gel on as is customarily done when fluoride is applied in dentifrices was chosen because it was felt that the technique would provide for a therapeutically more perfect topical application of fluoride. Namely, that the fluoride-gel could be held in intimate contact with the teeth for the prescribed period, that saliva would be excluded from the teeth after the applicators had been placed by the children, thereby preventing dilution, and that a gentle biting pressure on the applicators would tend to force the gel into the pits, fissures, and proximal areas.

During the course of the trial, the fluoride content in the outer enamel of exfoliated deciduous teeth was compared between the children applying and those not applying the gels.

The results indicated that the children experienced decided benefits from the repeated topical fluoride applications. Accordingly, those receiving an average of 200 topical applications showed about four-fifths fewer newly decayed, missing, or filled tooth surfaces than the group which did not receive the treatments. Very high concentrations of fluoride were acquired by the enamel to depths of about 80 μ , and enamel fluoride concentration varied with the number of topical applications received before a tooth had been shed. Concentrations of fluoride as high as 4,000 ppm were found in the outermost enamel layer, and about 24 daily six minute topical fluoride applications were necessary before an appreciable buildup of fluoride in the enamel occurred. Although the fluoride uptake was assayed in the deciduous teeth there is little reason to believe that the pattern of fluoride acquisition would differ in the permanent dentition. From this one can infer that the fluoride concentration in the outermost enamel would need to be greater than 700 ppm before benefits are attained. Perhaps it should be around 2,000 ppm (12, 13).

There are indications that some of the fluoride acquired by the enamel became fixed in the enamel, possibly in the form of fluorapatite. Tests have shown that very little fluoride could be washed out of the deciduous enamel even in distilled water. Most of the children in the control group who did not receive the repeated topical fluoride-gel treatments had previously received a series of four conventional topical sodium fluoride treatments and many had used a fluoride dentifrice, yet they had relatively low concentrations of fluoride in their enamel.

The repeated topical fluoride-gel applications do not appear to have had an important antiplaque or antibacterial effect. Caries-conducive streptococcal strains have been isolated with about the same frequency from the dental plaque fluoride-gel treated and untreated children (14).

Presently two additional field trials are being conducted in which repeated topical fluoride treatments are being applied in applicators. In one trial, we are trying to determine if the already low dental caries rates of children with a lifetime consumption of fluoridated water can be further reduced, and whether the enamel of the deciduous teeth from these children will acquire appreciably more fluoride. In the other, we are studying the anticaries effect of the applications on the deciduous dentition of preschool children. Since many of the children have entered this study with a caries-free deciduous dentition, there will be an attempt to compare the fluoride levels of exfoliated deciduous teeth from children who remain caries-free and those who develop new lesions. Hopefully, this will provide information about desirable therapeutic enamel thresholds.

If possible, in the future, it would seem reasonable to conduct laboratory and clinical studies with fluorides to determine the optimal enamel fluoride concentration for an optimal anticaries effect. In other words, how much do we need, how do we get it there, and how do we keep it there. It may well be that one or several prolonged applications alone or coupled with periodic fluoride boosters could be as effective as frequently repeated topical applications. In the future, clinical studies could be designed where different groups of children would be subjected to various schedules of repeated topical fluoride applications. Evaluation of caries increments could be compared to the fluoride uptake of the teeth. The chemical analyses

could be supplemented by X-ray diffraction studies of the enamel to clarify the nature of the chemical reaction occurring. Such information could provide a greater rationale for topical fluoride prophylaxis.

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A Review of Clinical Trials Utilizing Acidulated Phosphate-Fluoride Topical Agents

PAUL F. DEPAOLA, D.D.S., M.D.S.

SINCE the development of acidulated phosphate fluoride (APF) some five years ago, this agent has been clinically tested in several forms including topical solutions and gels, prophylaxis pastes, as a dentifrice, as a toothbrushing solution, and as a spray. The purpose of this paper is to review the findings of these clinical trials and to evaluate the different treatment methods as a function of the time and effort required for implementation.

The interpretation of current caries incidence research is made easier if certain considerations are kept in mind. The clinical testing methods available today are relatively unrefined especially when compared to the methods available in the physical sciences. It follows that treatment effects can be estimated only grossly. With proper experimental design and good statistical support it is possible to determine whether a test method is effective or not, or whether several test methods employed in the same investigation differ significantly in effectiveness. An accurate quantitative assessment of caries inhibition, however, seems to elude current testing methods as indicated by the fact that independent tests of the same agent frequently show markedly different percentage reductions in caries. This is because the experimental conditions of different investigations often vary widely, especially with respect to diagnostic criteria. In reviewing clinical findings, therefore, percentage reduction figures should not be interpreted too literally, and reductions from one study should be compared to those of another with cau-

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Dr. DePaola is an Assistant Staff Member, Forsyth Dental Center, Boston, Mass. 02115.

tion in order to avoid unwarranted conclusions. With these considerations in mind we turn to our review.

The most commonly used topical treatment method today is probably the single annual application. Table 1 summarizes the results obtained so far with single annual four minute topical applications of acidulated phosphate-fluoride in children. In each instance the agent contained 1.2 per cent fluoride and had a pH of 3.2. The first two studies were performed by Wellock and produced reductions in new carious surfaces at the end of two years of 70 and 52 per cent, respectively (1, 2). A more recent trial by Horowitz which is still in progress, shows a lesser reduction of 22 per cent at the end of one year (3). Finally, Ship and others are comparing stannous and acidulated phosphate fluoride in a fluoridated community (4). No effect has so far been noted with stannous fluoride, while a non-significant reduction in new DMF teeth of 16 per cent was found with the acidulated solution.

TABLE 1

RESULTS WITH SINGLE ANNUAL 4 MINUTE TOPICAL APPLICATION OF ACIDULATED PHOSPHATE-FLUORIDE SOLUTIONS IN CHILDREN

<i>Investigator</i>	<i>Study Period</i>	<i>% Reduction DMFS</i>	<i>Comments</i>
Wellock '63	2 yrs.	70	
Wellock '65	2 yrs.	52	
Horowitz '67	1 yr.	22	
Ship <i>et al.</i> '67		16% in DMFT (non-significant)	Fluoridated community; 0% reduction in group receiving SnF ₂

It is difficult to interpret the findings shown here (even if they are interpreted loosely) since the treatment effects reported have ranged from negligible to marked. This pattern of results, however, is characteristic of clinical trials involving single annual topical applications, regardless of what agent is used. For instance, of eleven studies employing stannous fluoride once yearly in non-fluoridated areas, five have produced completely negative findings while six have shown reductions in new carious surfaces ranging from 24 to 51 per cent (2, 5-13). It is interesting, however, that results with two annual treatments, whether with stannous or acid phosphate-fluoride, are generally more consistent, in that a fluoride effect has

been noted in every instance but one (3, 9, 11, 12, 14-19). We think that differing techniques of cleaning and drying the teeth and applying solutions has something to do with this. It may be that with single annual treatments stringent clinical techniques are critical to success while with semi-annual treatments, the repeated exposure to fluoride helps to insure an observable effect even with less rigorous methods. At any rate, the results seem to indicate that two treatments per year is a more reliable approach than one per year when applying fluorides topically.

Table 2 contains the findings of studies involving two annual topical applications of APF. Muhler has tested the efficacy of phosphate in combination with stannous fluoride and also of sodium fluoride combined with potassium phosphate (18). The former solu-

TABLE 2
RESULTS WITH TWO ANNUAL TOPICAL APPLICATIONS OF
ACIDULATED PHOSPHATE-FLUORIDE SOLUTIONS IN CHILDREN

<i>Investigator</i>	<i>Agent</i>	<i>Treatment Duration</i>	<i>Study Period</i>	<i>% Reduction DMFS</i>
Muhler '65	SnF ₂ 8% + 8% NaH ₂ PO ₄ , pH 3.0	2 min.	1 yr.	67
	NaF 3.6% + K ₂ HPO ₄ 1.8% pH 6.0	2 min.	1 yr.	52
Horowitz '67	NaF-PO ₄ 1.2% pH 3.2	4 min.	1 yr.	27
Cartwright, <i>et al.</i> '67	NaF-PO ₄ 1.2% pH 3.2	4 min.	1 yr.	50 (in DMFT)
Averill <i>et al.</i> '67	NaF-PO ₄ 2% pH 4.43	Each tooth coated with fresh solution six times	2 yrs.	Non-significant

tion has a pH of 3.0 and contains 8 per cent sodium and phosphate together with 8 per cent stannous fluoride. This mixture forms a heavy precipitate of insoluble stannous phosphate which carries off most of the tin, leaving what is essentially an acidulated phosphate fluoride solution somewhat akin to the more commonly used agent. The caries reduction observed at the end of one year was 67 per cent. The second solution, 3.6 per cent sodium fluoride combined with 1.8 per cent potassium phosphate also performed well, showing a

reduction of 52 per cent. The higher pH of this agent (6.0) indicates that phosphate fluoride combinations in a less acid media are also effective and that further study is needed to determine the optimal pH range for APF solutions. Horowitz is employing the conventional APF solution semi-annually and has found a 27 per cent caries reduction at the end of one year while Cartwright and others, working with orphanage children, have observed a 50 per cent reduction in new DMF teeth at the end of twelve months (3, 18). Finally Averill and associates in a two year study were unable to detect a treatment effect with either neutral sodium, stannous, or acidulated phosphate fluoride, this being the only negative finding in the category of semi-annual treatments.

A particularly suitable method of applying fluoride in private practice is by the use of fluoride prophylaxis pastes. Results obtained so far with APF pastes are summarized in Table 3. The first study involved the semi-annual use of a paste which contains a silicon dioxide abrasive trade-name "Dicalite," and has a pH of 5.0 when mixed with water (20). Whenever rinsing was necessary during the

TABLE 3
12 MONTH RESULTS WITH PROPHYLAXIS PASTES INCORPORATING
ACIDULATED PHOSPHATE FLUORIDE IN CHILDREN

<i>Investigator</i>	<i>Agent</i>	<i>Treatments Year</i>	<i>% Reduction in DMFS</i>	<i>Comments</i>
DePaola '67	NaF-Phosphate + SiO ₂ , pH 5.0	2	31	Teeth sprayed with 10 ml APF sol'n. (.25% NaF, pH 3.8) during cleaning
DePaola '67 (Unpublished)	NaF-Phosphate + SiO ₂ , pH 5.0	2	27	Fluoridated com- munity
DePaola '67 (Unpublished)	NaF-Phosphate + insoluble sodium metaphosphate (pH 5.5)	2	30	Fluoridated com- munity
Peterson <i>et al.</i> '67	Acidulated NaF- Phosphate (2%F) in Lava pumice	1	17	
Peterson <i>et al.</i> '67	Acidulated NaF- Phosphate (2%) in Lava pumice	1	6	Fluoridated com- munity

cleaning procedure the teeth were sprayed by the hygienist with a weak acidulated phosphate fluoride solution and the patient instructed to rinse. At the end of 12 months a 31 per cent reduction in new DMF surfaces was observed. For the next study which was performed in a fluoridated community, the "Dicalite" paste was used semi-annually but the fluoride rinsing procedure was omitted (21). The result was caries-reduction of 27 per cent. In the same community the semi-annual use of a paste containing insoluble sodium metaphosphate as the abrasive led to a 30 per cent reduction (22). In the last two studies, Peterson used a combination of acidulated phosphate-fluoride and lava pumice once a year, in both a nonfluoridated and a fluoridated area (23). Effectiveness as compared to semi-annual treatments in other investigations appears reduced. A 17 per cent reduction was observed in the nonfluoridated area and 6 per cent in the fluoridated. Trials involving pastes incorporating stannous fluoride have shown a similar pattern of results, that is reductions ranging from about 30 to 40 per cent with two treatments per year, and little or no effect with one treatment (13, 25-27). The stannous fluoride pastes tested, however, have either been too high in concentration for general usage, or are unstable and must be freshly mixed prior to each use. The APF pastes shown here may be pre-mixed in manufacture yielding an agent with an indefinite shelf-life and a suitable fluoride concentration. In addition, the practitioner can, if he desires, formulate the paste himself simply by mixing the appropriate abrasive with the APF solution routinely used for topical application.

Although fluoride pastes represent an efficient form of topical treatment it is interesting to note that there may be a definite limitation on their potential for reducing caries. In recent work by Vrbic, Brudevold, and McCann, blocks of intact enamel were given a 30-second prophylaxis in a standardized manner with a slurry of pumice and a fluoride containing solution (28). It was found that a three to four micron layer of enamel was lost as a result of abrasive action, indicating that the enamel was being worn away almost as rapidly as the fluoride was deposited into it. Thus, in order to secure satisfactory abrasive qualities in a fluoride paste it may be necessary to compromise the capacity of the paste for depositing fluoride.

Acidulated phosphate fluoride has also been tested in the form of

TABLE 4
MISCELLANEOUS TREATMENT METHODS UTILIZING ACIDULATED
PHOSPHATE FLUORIDE AGENTS IN CHILDREN

<i>Investigator</i>	<i>Agent</i>	<i>Method</i>	<i>Treatments Year</i>	<i>Study Period</i>	<i>% Reduction DMFS</i>
Brudevold and Chilton '66	Dentifrice containing NaF- phosphate in insoluble sodium metaphosphate	Unsupervised brushing		2 yrs.	26
Bullen, <i>et al.</i> '66	NaF-phosphate (1.2% F, pH 3.2) solution	Supervised brushing	5-1st yr. 4-2nd yr.	2 yrs.	39-1st yr. 15-2nd yr.
Brudevold and DePaola '67 (Un- published)	NaF-phosphate (.25% NaF, pH 3.8) solution	Spray with 10 mls of solution	3	3 yrs.	13-18
Horowitz '67	NaF-phosphate (1.2% F, pH 3.2) gel	Applied in wax trays for 4 mins.	1	1 yr.	14
Englander '67	NaF-phosphate (1.1% NaF, pH 4.5) gel	Applied in polyvinyl trays, 6 mins.	Daily in school	21 mos.	80
DePaola and Lax '67	NaF-phosphate (1 mg F, pH 4.5)	Pill is chewed and "swished"	Daily in school	2 yrs.	26-52

a dentifrice, a brushing solution, a spray, a gel, and a supplement. Results of these tests are shown in Table 4. The first study by Brudevold and Chilton was aimed at comparing calcium-free and calcium containing dentifrices and also at assessing the efficacy of stannous fluoride and sodium fluoride in the formulation (29). The findings after two years showed a significant reduction in DFS only with calcium-free formulations suggesting that the fluoride in these dentifrices was more readily available. The calcium-free sodium fluoride and stannous fluoride dentifrices were approximately equal in effectiveness but it is worthy of note that the calcium-free stannous fluoride dentifrice was stabilized with malic acid which forms a complex with stannous tin so that most of the tin in this dentifrice fails to react with the enamel while the fluoride is readily available.

Toothbrushing four or five times a year with a brush wetted in an APF solution has produced small but significant caries reductions as has a treatment schedule involving three annual sprays with an acidulated solution containing .25 per cent NaF in .1M H_2PO_4 (30, 31). The latter technique which was carried out in school dental clinics represents what is probably the simplest, most rapid clinical method tested to-date since no prophylaxes were given prior to the sprayings and chair time per patient per year was less than five minutes.

Horowitz is presently testing the use of single annual four-minute applications of acidulated phosphate fluoride gel applied in wax trays (3). At the end of 12 months a reduction of 14 per cent was observed, an effect which appears to be smaller than that noted in the same study in children receiving a single annual application of the solution. Theoretically the solution and the gel should be equally effective but if the former does eventually prove superior it could be because the most viscous gel does not penetrate as well into pits, fissures, and interproximal areas, and/or that the tray technique is more subject to salivary contamination. Conclusions regarding the relative merits of the gel and solution must await further testing, however.

A dramatic reduction in caries has been observed by Englander and others from the use of an APF gel and custom-made trays when application was performed six minutes daily in school (32). A neutral sodium fluoride gel performed as well as the acidulated phosphate agent, but chemical analyses of exfoliated teeth showed that considerably more fluoride was deposited in the enamel from the

acid gel than from the neutral, suggesting that fewer treatments would be necessary with the acidulated gel to achieve the same effect.

In the final study shown here DePaola and Lax tested the effectiveness of the daily administration of an APF supplement pill in school children (33). The pills were chewed, swished, and swallowed so that the potential treatment effects were both topical and systemic. An overall caries reduction of 26 per cent was observed but considering separately the teeth which erupted during the course of the study, the reduction was 52 per cent. Although further evidence is needed it appears that supplementation which is ongoing at the time of eruption may provide protection to the erupting teeth which is comparable to that of water fluoridation. Furthermore, a limited frequency of ingestion may be adequate to achieve this effect considering that the treatment schedule in this study was limited to half the days of the year.

Table 5 represents an attempt to summarize the findings to date with acidulated phosphate fluoride and to evaluate different techniques with respect to time and effort required for implementation

TABLE 5
THE RELATIVE EFFECTIVENESS OF VARIOUS TOPICAL TREATMENTS EMPLOYING ACIDULATED PHOSPHATE FLUORIDE

<i>Range of Effectiveness Reported to Date</i>	<i>Method</i>	<i>Approx. Professional Time Required Per Patient Per Yr. (Private Practice)</i>	<i>Degree of Patient Cooperation Required</i>
High (43-80% reduction)	Daily gel and tray (6 min. application)	30 min.	++++
	Chewable F supplements (started prior to eruption)	None	+++
Moderate (28-42% reduction)	Semi-annual topical	90 min.	None
	Semi-annual prophylaxis	40-60 min.	None
Low (6-27% reduction)	Unsupervised brushing	None	++
	Chewable supplements (from mid-childhood)	None	+++
	Three annual sprays	0-5 min.	None
	Single annual gel and tray	30-40 min.	None
	4 annual brushing with APF sol'n.	None	+
	Single annual F-prophylaxis	20-30 min.	None

in private practice. Since acid phosphate fluoride is still relatively new we do not yet have as much information as we would like, so that the present assessment should be considered as an interim report rather than a definitive statement.

The effectiveness in terms of percentage DMF surface reductions for all the different APF agents tested has ranged from 6 to 80 per cent. Dividing this range into thirds, methods producing reductions of 6 to 27 per cent may be considered as having a low order of effectiveness, while 28-47 per cent would represent moderate effectiveness and 48-80 per cent would be high. With this scheme two methods may be categorized as highly effective: the daily six-minute use of a gel and tray and the daily use of chewable fluoride supplements initiated prior to the eruption of the benefiting teeth. The former method requires about 30 minutes of professional time for the fabrication of trays and instruction to the patient. Thenceforth a high degree of patient cooperation is essential to success. The use of fluoride supplements requires virtually no professional time except for instruction but, again, effectiveness depends strongly upon the conscientiousness of the patient.

In the category of moderate effectiveness is the semi-annual topical application and the semi-annual fluoride prophylaxis. In these instances, no patient cooperation is required but professional time is considerable. There is no reason, incidentally, why the APF prophylaxis and topical application could not be combined in an effort to maximize the fluoride exposure of the teeth. Clinical evidence relating to this approach has not yet appeared, but the favorable results obtained from the combined use of stannous fluoride prophylaxis pastes, and topical solutions suggests a cumulative effect with multiple agents (25-27, 34).

A variety of techniques have demonstrated a low order of effectiveness in reducing caries. Unsupervised brushing requires no chair time except for education and is of value to individuals who brush their teeth with some regularity. Supplements instituted in mid-childhood offer some benefit but demand good patient cooperation. Three annual sprays would require no more than a few minutes if administered separately or could be used in lieu of tap water rinsing during operative procedures, without any additional treatment time. Four or five annual brushings, with a solution, would provide limited protection in return for a small amount of patient cooperation,

while a single annual fluoride prophylaxis would do the same at the cost of about 20 to 30 minutes chair time.

It will be noted that the single annual topical application method has been omitted here since its range of effectiveness is difficult to ascertain, as indicated earlier. It is very likely a technique of considerable merit, however, if performed meticulously.

An important point which emerges from this review is that acidulated phosphate fluoride, in all of its forms, has generally performed as well, if not better, than stannous fluoride, the more heavily tested and advertised agent. Compared to the latter it is stable, palatable, and non-staining to the teeth. Furthermore, its formulation permits the use of a gel form which is not possible with a tin-fluoride combination. It is of course, not the last word in topical treatments but laboratory evidence indicates that it is, at present, the most effective means of driving maximal amounts of fluoride into the enamel rapidly and without demineralization (35). It is reasonable therefore to expect the regular and careful use of this agent to be attended by significant reductions in dental caries.

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Release of Fluoride to Enamel By an Adhesive Bandage

R. S. MANLY, Ph.D. and DOROTHY P. HARRINGTON, A.B.

THE recent paper by Englander, Keyes, Gestwicki, and Sultz (1) provides a guide for investigators who seek to improve methods of topical sodium fluoride application. These authors found that an 80 per cent reduction in new caries surfaces took place when fluoride gel was applied daily by subjects over a 21-month period. The gel was applied to the teeth by mouthpieces. The fluoride concentration was determined for each of four successive layers of enamel from teeth receiving from 15 to 221 treatments daily, amounting to a total of 1.5 to 23 hours of contact with fluoride. There was a range in fluoride from 700 to 1,700 ppm in the outermost layer of enamel treated with sodium fluoride gel. Control enamel from the same study averaged 630 ppm in the outermost layer.

This study demonstrated a highly effective means of reducing incidence of dental caries by topical applications. Perhaps there are other means of topical application which could raise the fluoride content of dental enamel to a similar extent without requiring as much cost or effort on the part of the persons receiving treatment.

Our studies were performed on an intra-oral bandage, originally designed as a protective covering for oral mucous surface wounds after dental procedures and manipulations. The sample supplied to us was modified to contain one milligram of sodium fluoride per square centimeter in a gel consisting of polyisobutylene, sodium carboxy-methylcellulose, pectin, and gelatin. A polyethylene backing prevented distortion and fluoride loss to saliva. When this type of bandage is applied to soft tissue it is usually retained for over ten hours. If the bandage containing sodium fluoride could be applied to caries-susceptible surfaces of enamel *in vivo*, high concentrations of fluoride could be kept in contact with the teeth for several hours

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Dr. Manly is President of the Westwood Research Laboratory, Westwood, Mass.; Miss Harrington is a Research Assistant at that institution.

with a single application, without exposing the subject to more than 10 milligrams of fluoride. This low quantity is possible because the film thickness is only 0.8 millimeters. Perhaps four hours' treatment with 1 per cent sodium fluoride in tape would induce fluoride levels in enamel equivalent to 40 daily, six-minute treatments.

Several papers have indicated that fluoride in enamel, especially in the deeper layers, increases steadily with time of contact with sodium fluoride solutions. This was shown by Cooley (2) in 1961 for times up to 16 hours, by Mellberg (3) in comparison of four and ten-minute topical applications, and by Mühlemann (4) for periods from four to 120 minutes. Some of this fluoride was quickly removed by rinsing with water, but when the enamel was protected from the rinsing for a few hours before rinsing started, the fluoride became fixed and less was removed. Brudevold and others (5) showed that protective coatings impeded diffusion of fluoride and permitted fixation of a high proportion of the recently acquired fluoride in enamel. Richardson (6) showed that delay in rinsing allowed some type of chemical fixation of fluoride. Our first approach was to learn whether or not fluoride would transfer readily from tape to tooth enamel *in vitro*. If fluoride concentrations in enamel, similar to those found by Englander and others, could be obtained within a few hours, further study of the tape would be justified. Next some effort was made to learn what conditions are necessary for optimum transfer of fluoride to enamel. There are several testing conditions which might influence the transfer of fluoride to, and retention by, enamel. These conditions were the degree of hydration of the tape, the composition of rinse solutions while the tape was in place and afterward, the number of treatments per day, the number of days of treatment, and the size of tape relative to the enamel piece being investigated. This investigation is concerned with these several factors.

EXPERIMENTAL PROCEDURE

Human enamel for the study was obtained from extracted human molars, refrigerated immediately in water. Cylinders, four millimeters in diameter, were cut from buccal or lingual surfaces of molars with a Horico diamond coring tool, mounted in a drill press. Each cylinder was pressed into a hole drilled in a Teflon block, with the enamel surface raised about one millimeter. The surface was ground parallel with the Teflon by polishing paper of gradually de-

creasing sizes, and finally polished with dentifrice on an Eberbach polisher. This treatment produced a plain surface having a standard smoothness. Treatments with fluoride-containing tape were applied, using either 4.5 or 9.5 mm discs of the tape. Treated enamel was rinsed with liquids of known composition, corresponding to action of saliva in the mouth, both during the period when the tape covered the enamel and for two or twenty-hour periods thereafter. The equipment was modified from a Beckman electrophoresis apparatus. Whatman No. 1 filter paper was used to siphon solutions from an upper vessel directly past Teflon blocks containing the enamel to be rinsed.

After treatment and rinsing had been completed, sampling of layers of the surface was achieved by sequential etching with each of four films containing perchloric acid solution. This is a variation of the method employed by Cooley (2), who recommended a controlled etch with 2M perchloric acid.

Ohmori and others (7) modified Cooley's method essentially by reducing the molarity to 0.5M. Weatherell and Hargreaves (8) increased the concentration to 6N and reported a linearity between etch time and weight loss. They also searched for possible effects of the etch solution beyond the surface layer, but were not able to observe any action. Mühlemann (4) preferred 2N perchloric acid but later, in conjunction with Goldman and others (9), compared grinding and etching with sulfuric acid to establish the similarity between the two methods. Our modification of the Cooley method consisted of using 6.5 mm discs of VM-1 Gelman polyvinyl chloride porous film, soaked for two minutes in the acid and blotted between bibulous paper wet with perchloric acid solution. The moist disc was centered over the enamel and pressed into place for two minutes. Four etches removed about 5-8 microns each of enamel. Each disc was transferred to two milliliters of a solution containing 38 millimolar lactate at pH 4.5 and 0.02 ppm of fluoride. The lactate served to bring the pH into the proper range for analysis and the fluoride brought the concentration of solution into a linear range for the Orion electrode. Extraction of fluoride was achieved through intermittent agitation over a 10-minute period. Then the solution was decanted into a polyethylene vessel. The fluoride concentration was read with an Orion fluoride electrode (Frant and Ross [10]), calibrated with a sodium fluoride standard prepared in the same buffer.

Next the solution was transferred to the small AutoAnalyzer vessel and stored in a refrigerator until analysis was convenient. Analysis was performed by a modification of the N-4b method for inorganic phosphate, eliminating the dialyzer and heating bath. Modified molybdate and reducing reagents were mixed with the sample, and read at 700 millimicrons in the colorimeter.

For conversion of phosphate millimolarity to milligrams of enamel, the phosphorus content of enamel was assumed to be 16.5 per cent (Long [11]). Millimolar phosphate times 0.375 equalled milligrams of enamel per layer. When the fluoride was calculated as nanograms per layer, the ratio of these two values read directly in parts of fluoride per million.

The data to be presented involves a total of 220 tests on 44 enamel specimens. There were four studies. The first was a pilot study with four enamel specimens to evaluate the feasibility of the technique, comparing four enamel layers from molars and premolars, with and without fluoride treatment. When fluoride was absent from the tape, the outer layer of enamel showed fluoride concentrations ranging from 30 to 140 ppm. When fluoride was present in the tape, the outer layer showed concentrations ranging from 330 ppm to over 1,000 ppm in case supernatant liquid was allowed to flow over the tape during the treatment period. This result indicated that considerable quantities of fluoride could pass into the outer enamel layer and suggested that the amount passing into this enamel might be dependent upon the type of solution in contact with the tape, the size of tape, and the extent of hydration of the tape.

This finding offered guidance for the second and definitive study involving 32 enamel specimens. The factors of hydration, rinses, tape size, number of treatments per day, and number of days were studied. Hydration was compared by allowing exposed tape to remain in contact either with room air or with 100 per cent humidity for 24 hours. Rinses were either water or 50-100 per cent supernatant liquid from saliva. The size of the tape was either 4.5 or 9.5 millimeters in diameter. Either one or two days of treatment were applied and the treatments were made either once or twice on each day.

A third study involved another eight enamel specimens that were treated with small pieces of fluoride tape at two levels each for the factors hydration, days, and times. The rinse consisted of KCl and NaCl, both at 17 millimolar, and saturated with CaHPO_4 . This permitted a comparison between the types of rinses.

The final study involved eight enamel pieces and was designed to compare the effect of gel containing 1.1 per cent sodium fluoride with sodium fluoride tape. The other factors were deciduous and permanent teeth receiving either salt or supernatant rinses. In all instances, four etches were performed after each treatment. Each etch layer was analyzed separately for phosphate and fluoride.

RESULTS

Each of the studies was subjected to an analysis of variance. Only statistically significant findings will be reported. A major finding was the importance of hydration of the tape for 24 hours prior to use. The average fluoride transferred to enamel is shown in Fig. 1 for the interaction between hydration and the size of the tape. The effect of

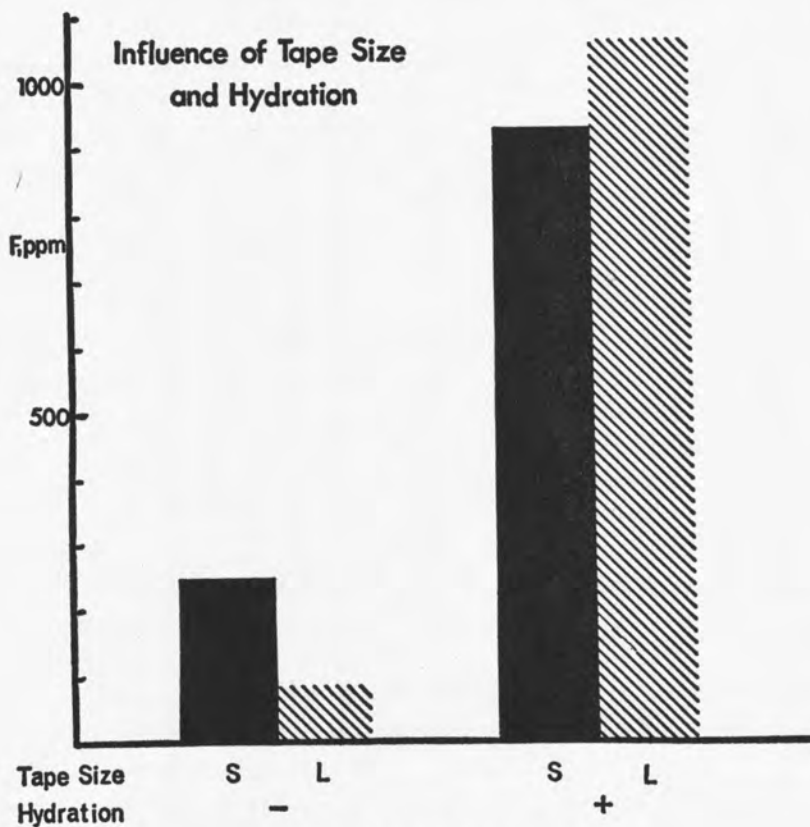


FIGURE 1
Influence of Tape Size and Hydration

size of tape depends upon whether or not the tape was hydrated. Large tape is less effective than small if neither has been hydrated, whereas large tape is more effective than small when both have been hydrated. We assume that the tape becomes partially hydrated at the outer edges during the treating procedure. If the outer edges are over an enamel piece, the uptake of fluoride is improved. This would be the case for small tape, but not for large.

The kind of rinse also affects the release of fluoride to enamel, provided the tape is hydrated. Notice that in Fig. 2 the rinse solution has no influence on the uptake of fluoride if the tape has not been hydrated, but the rinse solution is extremely important if the tape has been hydrated. If supernatant is used as a rinse and the tape is hydrated prior to use, then the average fluoride for the four layers

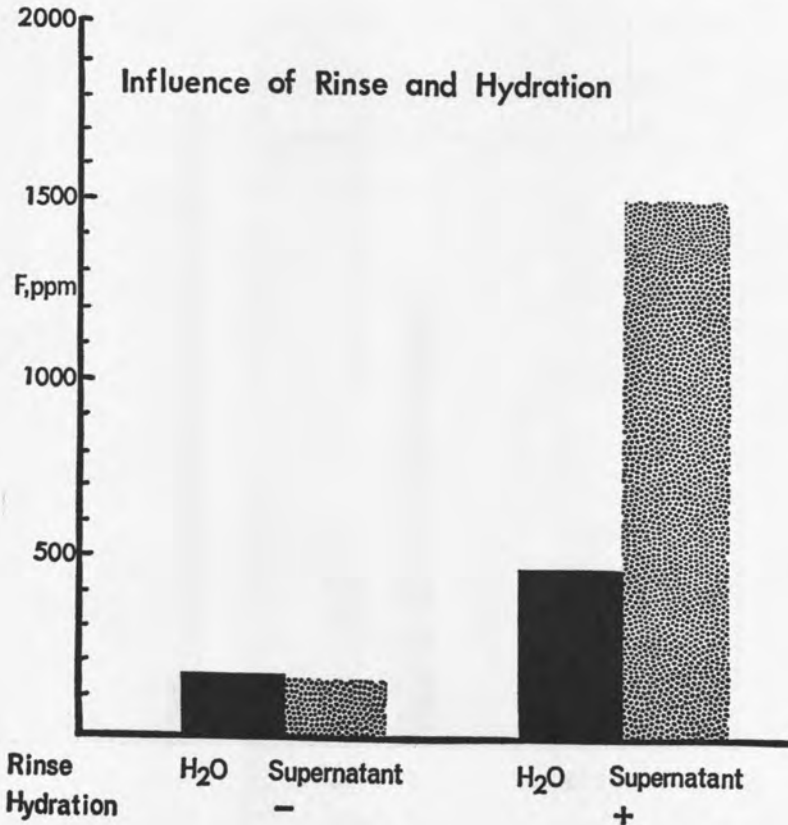


FIGURE 2
Influence of Rinse Solution and Tape Hydration

amounts to 1,500 ppm. Hydrated tape under the appropriate conditions shows nearly ten times the uptake of fluoride by enamel as does the unhydrated tape. Because hydration was so important for fluoride release, there seemed to be no justification in complicating the findings by having any further concern with the unhydrated tape. Data in Figs. 3-5 are all based on hydrated tape.

The fluoride levels among different layers of enamel depended upon the solution used for treatment and rinsing the enamel after fluoride treatment. When the rinse was distilled water (Fig. 3), there was very little difference among the layers—just a suggestion of a downward trend from the outer to inner layer. When salt was present in the rinse in quantities likely to be found in saliva, and when the solution was saturated with dicalcium phosphate similar to saliva, the first layer of enamel retained a fluoride level of over 1,000 ppm. When supernatant was used as the rinse solution, the first two layers

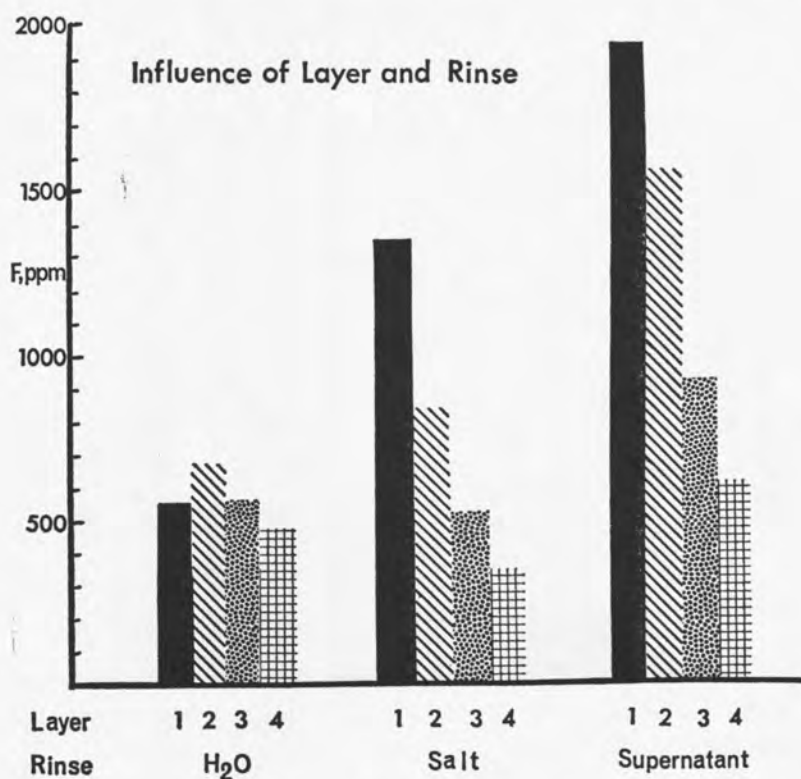


FIGURE 3
Influence of Enamel Layer and Rinse Solution

were above 1,000 ppm. Hence the retention on the first layer depends probably upon the phosphate concentration of the rinse solution. The fixative action of phosphate in the rinse was reported by Mellberg, Laakso, and Nicholson in two papers (12, 13), who observed that a topical treatment for four minutes with 1.2 per cent sodium fluoride gave high values of 4,000 ppm in the outer layer, but was rinsed away to the control within one week. Saliva or metastable calcium phosphate solution kept the first layer fluoride either at 2,300 ppm (12) or 1,600 ppm (13).

Each treatment with tape was two hours in duration. One important question was whether there was a proportionate increase resulting from two and four treatments. The two middle columns of Fig. 4 show the results with two treatments, either when both were given on one day, or when single treatments were provided on two

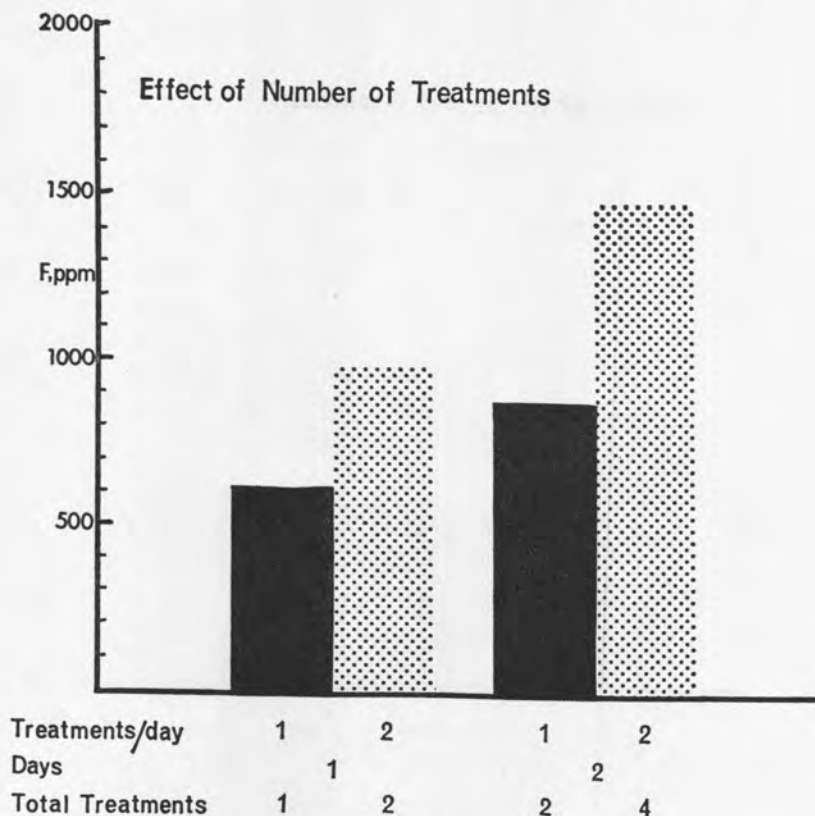


FIGURE 4
Effect of Number of Treatments

consecutive days. The difference between these two columns was not significant. Four treatments produce about $2\frac{1}{2}$ times as much fluoride in the enamel as did one treatment. At first glance, this might appear to indicate a falling off in effectiveness of fluoride with increasing treatments, but since the one treatment produced only 600 ppm, and this is close to the control level reported by Englander, we conclude that the data does not prove that the effectiveness per treatment changes with increasing numbers of treatments. A better comparison of the findings is to note that 370 ppm of fluoride were added by the second treatment on the first day, and 610 ppm of fluoride were added by the jump from two to four treatments on two days. Once again this does not suggest any major loss of effectiveness per treatment as multiple treatments are used.

The final comparison was between the type of applicator, kind of

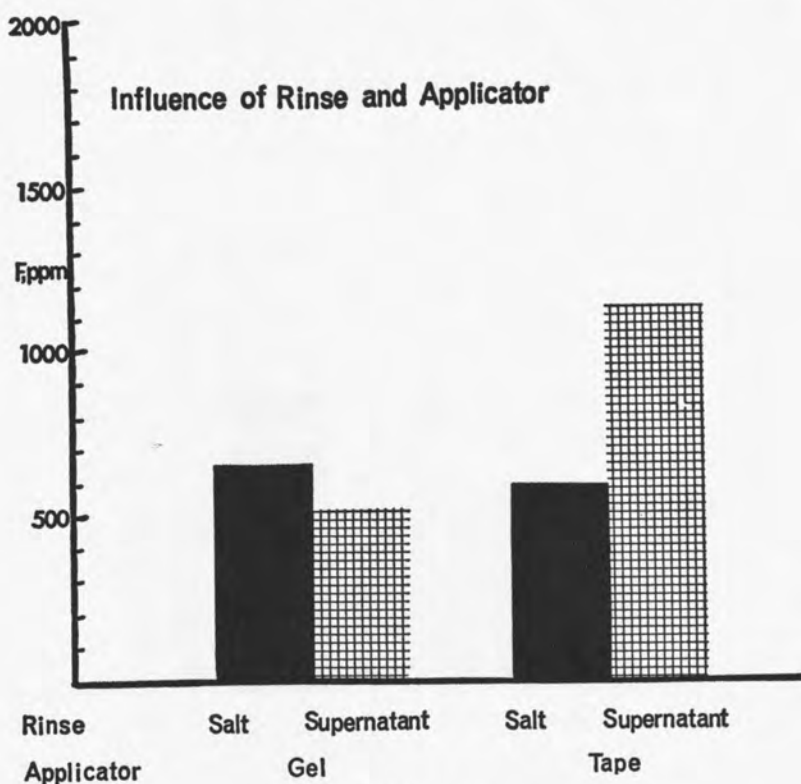


FIGURE 5
Influence of Rinse Solution and Type of Fluoride Applicator

rinse, and deciduous or permanent teeth. Treatments were for two hours only. Here the gel was placed against teeth and covered with a Saran film to make possible a direct comparison between the gel and tape. There was no significant difference between deciduous and permanent teeth. The applicator and the rinse were interacted in a peculiar manner as shown in Fig. 5. Under these conditions there was no difference between enamel treated with gel or tape with a salt rinse, or gel with a supernatant rinse. It was only the enamel treated with tape and rinsed with supernatant that averaged over 1,000 ppm in fluoride content. This finding appears to justify further evaluation of the potentialities of fluoride-loaded tape for clinical use.

SUMMARY

In vitro studies have been performed on fluoride uptake and retention by tooth enamel from an oral bandage containing 1.4 per cent sodium fluoride or one milligram per square centimeter. Best release of fluoride occurred when the tape had been hydrated prior to use and when the rinse solution contained some saliva. When hydrated tape was considered, the fluoride uptake was approximately proportional to the total number of two-hour treatments. Water rinses did not optimize fluoride retention by enamel; more fluoride was found in outer enamel layers when either saliva, or a salt solution resembling saliva, flowed over the enamel during and after the tape treatment. Fluoride transfer from tape to enamel and retention by enamel appeared to be at least equivalent to that obtained from the sodium fluoride gel used in the Englander study.

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Mass Treatment of Children With a Stannous Fluoride-Zirconium Silicate Self-Administered Prophylactic Paste For Partial Control of Dental Caries

JOSEPH C. MUHLER, D.D.S., PH.D.

DURING the past twenty-five years numerous approaches to the prevention and control of dental caries have been suggested. However, only those which involve the use of fluorides have received thorough evaluation and subsequent recognition and acceptance as effective measures. The value of the addition of fluoride to the communal water supply is no longer questioned by reputable scientists, and is a subject which has been reviewed on numerous occasions. Similarly, the dental caries protection afforded by topical fluoride applications is well recognized. All of the various dental caries preventive procedures recognized to date have their obvious limitations. The optimal effectiveness of communal fluoridation is obtained only when the water is ingested during the entire period of tooth formation and subsequent maturation. Also, there is no unanimity of opinion regarding its effectiveness for adults who move into a fluoride area following the period of tooth eruption, nor is there any way that the rural population may benefit. Topical sodium fluoride therapy is effective in children whose teeth developed in nonfluoride areas, but is of limited value in adults or in children whose teeth developed in an optimal fluoride area. The use of stannous fluoride, while overcoming some of the deficiencies of sodium fluoride by showing effectiveness in adults and children living in fluoride areas, still requires a significant amount of time (as do all other topical procedures) on the part of the hygienist or dentist. In addition, all

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Dr. Muhler is Professor of Biochemistry, Indiana University Medical Center, Indianapolis, Indiana.

topical application procedures necessarily require that the subject visit the dentist or a treatment clinic, and it is recognized that a substantial segment of our population never visit the dentist except for the relief of pain.

Three other forms of fluoride therapy have received professional acceptance: the use of stannous fluoride in a compatible prophylactic paste, the use of self-administered fluoride-vitamin preparations, and stannous fluoride-containing dentifrices.

One further problem needs attention if preventive dentistry is to meet the challenge of "mass" treatment of the entire population. This involves the need for dental caries control procedures for the indigent population and the geriatric group. Considerable data are continually accumulating which suggest that many less people see the dentist each year than we originally suspected. In Southern Indiana, for example, a carefully conducted series of studies on low income groups show that from 31 to 74 per cent of the people in this survey have never seen a dentist in their lifetimes (Table 1). In another survey in Southern Indiana, additional information revealed that among 304 subjects over 56 years of age, 249 had never been to the dentist, 3 had dentures, but 166 needed full dentures (Table 2). In a more recent survey in Brown County, Indiana, among 749 children in grades from 1 to 10, 741 had active dental caries, while only 8 were caries-free (Table 3). Of the 741 children with dental caries, 637 had never been to the dentist, and of the 104 who had been to the dentist, 16 received operative treatment while 88 went to the dentist for extractions only. Obviously, if dentistry is to develop effective means of preventing dental caries in such population groups, mass techniques of applying the anticariogenic agents must be developed.

Collectively, these problems, both technically and socially, pose serious problems in preventive dentistry if we are to meet our obligation to bring under control dental caries for all members of the population.

As a result, considerable research in our laboratories during the past several years has been conducted in order to develop a procedure which would: 1—provide maximal dental caries benefits comparable to, or greater than, those obtained with multiple stannous fluoride therapy; 2—obtain this degree of clinical effectiveness using a single procedure; 3—require no professional manpower to

TABLE 1
DURATION (IN YEARS) SINCE LAST VISIT TO DENTIST (1960)
(MONROE, OWEN COUNTIES, INDIANA)

Age	No. of Subjects	Last Year	Last Two Years	Last Three Years	Last Five Years	Last Ten Years	Never no.	%
< 10	85	16	12	2	—	—	59	31.0
10-20	117	9	40	17	30	—	31	73.5
21-35	64	3	35	—	—	—	26	59.4
36-50	69	7	13	2	3	—	44	36.2
51-65	141	2	20	15	15	—	89	36.9
> 65	188	2	31	15	6	9	107	44.0

TABLE 2
DURATION (IN YEARS) SINCE LAST VISIT TO DENTIST (1961)
(BROWN, MONROE, OWEN COUNTIES, INDIANA)

Age	No. of Subjects	Last Five Years	Never		Dentures			
			no.	%	HAD No.	%	NEEDED No.	%
25-40	231	90 (25?)*	116		19		31	
41-55	165	44 (16?)	105		41		58	
56	304	22 (33?)	249		3		166	

* Numbers in parenthesis refer to the number of subjects that are not accounted for among the entire sample in any other category.

TABLE 3
DENTAL CARIES PREVALENCE (1965)
(BROWN COUNTY, INDIANA)
SCHOOL SURVEY

749 children (grades 1 to 10)	
741	8
active dental caries	no caries
637	104
never been to dentist	been to dentist
16	88
for operative	for extraction

produce effectiveness; 4—provide dental health benefits not only with regard to dental caries but to gingival diseases; 5—be low, or without cost, to the patient; and 6—be equally effective for children living in a fluoride or nonfluoride area, and for adults.

Such a program of research has resulted in the development of a stannous fluoride-zirconium silicate prophylactic paste designed for self-application on a mass basis under professional supervision. The laboratory research which led to this development has been summarized in a separate manuscript (1). It is the purpose of this paper to review the available human clinical data.

EXPERIMENTAL

Study I. A total of 100 children, 11 to 13 years of age, participated in this study. The children had resided since birth in a low-fluoride area. All children received a thorough clinical examination independently by two examiners with the use of bitewing radiographs according to techniques which have been previously described in detail (2, 3). The children were divided randomly into two groups according to age, sex, and past dental caries history. The children in Group I received no treatment and served as controls, while the children in Group II received a self-administered stannous fluoride-zirconium silicate prophylactic paste and were provided a stannous fluoride dentifrice* for home use. The children in both groups were reexamined in an identical manner after 6 and 12 months. The children in Group II received a second self-application of the prophylactic paste following the 6-month examination.

Study II. A total of 123 children, 6 to 15 years of age, participated in this study. The children were permanent residents of a natural fluoride area having an optimal amount of fluoride in their communal water supply. All children were selected at the initiation of the study to exclude any child who had not resided in this area since birth. The subjects were given an initial clinical examination with the aid of five- or seven-film bitewing radiographs according to procedures which have been described in detail previously. The children were divided into two groups according to dental age and past

* Crest® dentifrice, manufactured by the Procter and Gamble Co., Cincinnati, Ohio. This same product was used in all subsequent groups where a stannous fluoride dentifrice was a part of the study design.

dental caries experience. Immediately following the examinations the children were given a self-administration with either the stannous fluoride-containing prophylactic paste or a placebo paste of the same composition but which did not contain stannous fluoride. The children were not provided a dentifrice for home use. The examinations and subsequent self-applications were repeated in the same manner after 12 months.

Study III. A total of 395 children, 6 to 15 years of age, residing in a nonfluoride area participated in this study. The procedures employed in this study were identical to those described for Study II except that no radiographs were taken, and two examiners were used. Each dentist examined the same children initially and at the 12-month examination period.

Study IV. Two classes of sixth grade students participated in this study. The children were 11 to 13 years of age and resided in a non-fluoride area. One class, designated as Group I, was comprised of 40 students while the second class contained 31 students and was designated as Group II. All children received a thorough clinical examination with the aid of bitewing radiographs according to techniques previously described. The children in Group I received no further treatment and served as controls, while those in Group II received a self-application with the stannous fluoride-zirconium silicate prophylactic paste and used a stannous fluoride dentifrice for home use. The children in both groups were reexamined in an identical manner after 12 months, and the children in Group II received a second self-application of the prophylactic paste following the 6-month examination.

Study V. A total of 44 children, 11 to 13 years of age, residing in a nonfluoride area since birth were divided randomly into two groups. All children received a thorough clinical examination independently by two examiners, with the aid of bitewing radiographs according to techniques which have been described in detail. The children in Group I received no further treatment and served as controls, while the children in Group II received the self-administered stannous fluoride-zirconium silicate prophylactic paste. The children were reexamined in an identical manner after 12 months, and the children in Group II received a second self-application with the stannous fluoride-zirconium silicate prophylactic paste after 6 months.

Study VI. A total of 150 children, 6 to 10 years of age, participated in this study. The children were residents of a community having an optimally fluoridated water supply and were randomly assigned to one of two groups. All children received a thorough clinical examination independently by three examiners with the aid of bitewing radiographs according to techniques which previously have been described. The children in Group I received no further treatment and served as controls. The children in Group II received a self-administered stannous fluoride-zirconium silicate prophylactic paste and were provided a control nonfluoride, non-tin pyrophosphate dentifrice for daily home use. The children in both groups were reexamined in an identical manner after 6 and 12 months, and the children in Group II received a second self-application of the prophylactic paste after the 6-month examination.

TECHNIQUES FOR ADMINISTERING THE SELF-APPLICATION PROPHYLACTIC PASTE

One of the primary prerequisites for mass treatment is to design and evaluate a technique which the patient can administer the anticariogenic agent himself and one which is very simple to perform and preferably without cost. Obviously, it must produce significant reductions in dental caries. It is our opinion that such a procedure has been developed.

The self-prophylaxis was given in any available space among the school property. Individual class rooms, the gymnasium, and the football field have all been used. Some studies have been conducted in an attempt to determine "optimal size," but from present information it appears possible and feasible to treat up to 1,700 children at a time.

For study purposes, all groups of children are divided into two groups and placed in rows facing either the dentist or hygienist responsible for the brushing supervision. Each child is supplied with a paper dish on which to place two paper cups and the self-administered prophylactic paste. One paper cup contains tap water for rinsing and the other for expectorating the paste and saliva. The child is also given a soft bristle nylon toothbrush (four rows and ten tufts in each row) for applying the anticariogenic paste to the teeth, and a paper napkin. Before the children were given the anticariogenic

prophylactic paste, either the supervising dentist or hygienist conducted a demonstration on a suggested toothbrushing technique (facial and lingual surfaces brushed with a rolling motion, the occlusal surface in a scrubbing motion) and explained to the children the benefit of the self-prophylaxis by the anticariogenic agents in protecting their teeth against dental caries. The children then practiced the brushing procedure in the presence of the dentist or hygienist. No prophylactic paste was used during these demonstration procedures. This brief explanatory demonstration was given at only the initial treatment.

Each child was given approximately 5 grams of the anticariogenic paste. The children were asked not to swallow excessive amounts of the prophylactic paste while brushing and were permitted to expectorate at will. They were not allowed to rinse until the supervising dentist or hygienist asked them to do so after brushing each quadrant had been completed.

The brushing of the different segments was performed in the following order: occlusal surfaces of right maxillary teeth, occlusal surfaces of left maxillary teeth, occlusal surfaces of left mandibular teeth, and occlusal surfaces of right mandibular teeth. The first rinsing was allowed after all occlusal surfaces were brushed. They were asked to brush the facial surfaces of all maxillary teeth, starting from right to left and subsequently the lingual surface of all maxillary teeth from right to left. The second rinsing was allowed after brushing the facial and lingual maxillary surfaces. The facial surfaces of all mandibular teeth and after that the lingual surfaces of all mandibular teeth were brushed in the same way, and the third rinse was allowed. While brushing, the dentist or hygienist counted slowly up to ten for each segment. In between brushings, the children were asked to dip their brushes into the paste in order that they would always have sufficient amounts of the paste on their brushes. In the initial studies following the third rinse each child was examined by the hygienist to see that they had performed a thorough job of removing debris. The time required for the entire procedure was between 20-25 minutes including that time devoted to arrangements, discussions, demonstrations, and brushing procedures. The actual brushing time required about 5 minutes for the entire dentition.

COMPOSITION OF SELF-ADMINISTERED PROPHYLACTIC PASTE

The stannous fluoride-zirconium silicate prophylactic paste is composed as follows: (in per cent by weight) specially prepared zirconium silicate, 48.63; stannous fluoride, 9.00; sodium dihydrogen phosphate, 9.00; tin oxide, 5.40; distilled water, 12.16; humectants, 11.29; binders, 1.78; flavoring and sweetening agents, 2.74. The paste is provided for use in specially lined tubes. Studies concerning the cleaning, polishing, and enamel solubility reduction properties as evaluated in the laboratory are summarized in another manuscript (1). Typical data concerning the stability are shown in Table 4.

TABLE 4

ENAMEL SOLUBILITY DATA OF THE SELF-ADMINISTERED PROPHYLACTIC PASTE AS A FUNCTION OF AGE OF THE PRODUCT

<i>Therapeutic Zircate</i> AGE	<i>Mean % Reduction</i> (RAT E.S.R.)
Fresh	76.4
2 Weeks	82.3
1½ Months	79.2
2 Months	77.3
5 Months	73.5
5½ Months	69.9
7 Months	80.6
7½ Months	70.9
15 Months	75.8

DATA AND DISCUSSION

The clinical data obtained in these series of studies are summarized in Table 5. In Study I, conducted in a nonfluoride area, Examiner 1 found a mean increment of 2.43 DMF surfaces in children receiving the self-administered $\text{SnF}_2\text{-ZrSiO}_4$ prophylactic paste and the daily use of the $\text{SnF}_2\text{-Ca}_2\text{P}_2\text{O}_7$ dentifrice. The control group had 6.63 DMF surfaces, or a dental caries reduction of 63.3 per cent. Examiner 2 found 5.48 new DMF surfaces in the control children and 1.69 DMF surfaces in the children receiving the self-administered prophylactic paste and the $\text{SnF}_2\text{-Ca}_2\text{P}_2\text{O}_7$ dentifrice.

Study II was conducted in an optimal fluoride area by a different examiner than used in Study I. The dental caries reduction at the end of one year was 35.0 per cent over and above the effect produced

by the benefit of the children using the fluoridated water. Assuming a 50 per cent reduction in dental caries from the fluoridated water, the total dental caries effect from the fluoridated water plus the use of the self-administered SnF_2 -prophylactic paste would be approximately 70 per cent. One of the postulates of an effective caries control procedure made by us was that the agent used should produce additive effects in areas in which the communal water is fluoridated. This study demonstrated such an effect, as have other studies using SnF_2 as a topical agent (4), as a constituent of a $\text{Ca}_2\text{P}_2\text{O}_7$ dentifrice (5, 6), when used in a compatible prophylactic paste (7), or when used in multiple SnF_2 therapy (7).

Study III was conducted in a nonfluoride area and consisted of the use of still another independent examiner than used in the previous two studies (VM). This examiner found 3.36 new DMF surfaces in the control group and 1.76 new DMF surfaces in the children using the self-administered prophylactic paste. These differences represent a reduction in dental caries of 47.6 per cent.

Study IV was conducted in a nonfluoride area as a part of a dental health education program. In this health education program the children were given detailed instruction in home oral health care and five dental health lectures in the classroom during the school year. The dental caries examinations and the use of the self-administered prophylactic paste was used to illustrate the effect that possibly could be accomplished by having the children participate in an active manner in such an illustrated dental health education program. The data obtained at the end of one year showed that no new caries developed in the children receiving the self-administered prophylactic paste and who used the SnF_2 - $\text{Ca}_2\text{P}_2\text{O}_7$ dentifrice for daily home oral hygiene.

Study V was also conducted primarily for other reasons than to study the anticariogenic effect of the self-administered prophylactic paste. Its purpose was to determine if the use of a prophylactic paste containing an improved abrasive for enamel polish would have any effect on gingival health. The result of these data will be reported in a separate manuscript. Two dentists were used to evaluate dental caries in the same children, and while the caries increments were different for each examiner, the caries reductions were approximately 70 per cent for each of the two examiners.

TABLE 5
SUMMARY OF CLINICAL DENTAL CARIES DATA USING THE $\text{SnF}_2\text{-ZrSiO}_4$ SELF-APPLIED PROPHYLACTIC PASTE*

Study	Fluoride Water Supply	Exam Period (mos.)	Group†	Examiner	Subjects		DMFT Increment	Mean % Reduction	DMFS Increment	Mean % Reduction
					NO.	AGE RANGE				
I	No	6	C	JCM	40	10-12	2.25	—	3.05	—
			P _f +D _f		38	10-12	0.53	76.4	0.53	80.0
		12	C	JCM	30	10-12	4.80	—	6.63	—
			P _f +D _f		28	10-12	1.64	65.8	2.43	63.3
		6	C	GEK	39	10-12	1.56	—	2.51	—
			P _f +D _f		37	10-12	1.11	28.8	1.62	35.5
		12	C	GEK	25	10-12	3.48	—	5.48	—
			P _f +D _f		26	10-12	1.19	65.8	1.69	69.2
II	Yes	12	C	CWG	65	6-15	0.68	—	1.03	—
			P _f		58	6-15	0.55	19.1	0.67	35.0
III	No	12	C	CWG	112	6-15	0.82	—	1.21	—
			P _f		117	6-15	0.55	32.9	0.80	33.9
		12	C	VM	81	6-15	2.09	—	3.36	—
			P _f		85	6-15	1.34	35.9	1.76	47.6
IV	No	12	C	PDC	40	11-12	2.10	—	3.82	—
			P _f +D _f		31	11-12	-0.35	116.6	-0.80	120.9

V	No	12	C	GPB	19	11-12	3.11	—	8.16	—
			P _f +D _f		19	11-12	1.11	64.3	2.58	68.4
		12	C	NYN	19	11-12	4.95	—	10.84	—
			P _f +D _f		19	11-12	2.05	58.6	3.42	68.5
VI	Yes	6	C	LAL	75	6-10	1.88	—	3.32	—
			P _f +D _c	LAL	70	6-10	1.33	29.3	2.24	32.5
		12	C	LAL	75	6-10	3.40	—	5.57	—
			P _f +D _c		67	6-10	2.06	39.4	3.04	45.4
	Yes	6	C	HGT	75	6-10	1.33	—	2.28	—
			P _f +D _c		70	6-10	0.59	55.6	0.80	64.9
		12	C	HGT	75	6-10	2.61	—	4.00	—
			P _f +D _c		67	6-10	0.85	67.4	1.19	70.3
	Yes	6	C	JAT	74	6-10	1.95	—	3.43	—
			P _f +D _c		70	6-10	1.04	46.7	1.80	47.5
		12	C	JAT	74	6-10	2.91	—	4.22	—
			P _f +D _c		67	6-10	1.36	53.3	1.84	56.4

* The clinical data reported in this manuscript is to provide survey information of the clinical findings. Each of the six studies represent original clinical studies, and will be reported in detail by the respective authors, along with appropriate statistical analysis of the data. All differences between groups as reported in this manuscript are significant at the 0.05 level of confidence. The author of this manuscript appreciates the opportunity to use the data from the different studies in this survey.

† C = control group; P_f = self-applied paste containing 9% SnF₂; D_f = 0.4% SnF₂ dentifrice for home use.

Study VI was conducted in an optimally fluoridated area and consisted of three different dentists each practicing either general dentistry or pedodontics in their community. No "examiner training" was provided any of the examiners, since the object of this study was to determine if a practicing dentist could evaluate the effectiveness of the self-administered prophylactic paste using the same criteria he uses in his office practice to determine the presence or absence of dental caries as well as its progression. In order for any caries preventive procedures to be effective, many workers feel that it must result in caries reductions which are measurable and obvious to the general practitioner using standards known to be effective in his practice. It is of interest to note that each of the three different dentists all reported positive effects, although each found measurable different caries increments. Dentist LAL found 3.04 new DMF surfaces, dentist HGT found 1.19 new DMF surfaces, and dentist JAT reported 1.84 new DMF surfaces in the children using the self-administered prophylactic paste at the end of one year. These represent caries reduction of 45.4, 70.3, and 56.4 per cent, respectively.

These data from ten independent examiners, taken collectively, suggest that the clinical technique of having children administer to themselves an anticariogenic prophylactic paste containing SnF_2 as the active ingredient and which contains an improved cleaning and polishing abrasive may have some usefulness as an anticariogenic procedure to be used on a mass treatment basis. Much, of course, remains to be known about its potential effectiveness, its limitations, its additive effects with SnF_2 dentifrices when used in a superior manner more than once a day, as well as its effectiveness in adults.

Nonetheless, the utility of mass treatment is such a challenging concept that the Fort Wayne, Indiana, community school system considered it of such importance that in May, 1967, 57,000 children performed the self-administered prophylaxis under professional supervision. This number represented 82 per cent of the total children in the Fort Wayne school systems.

CONCLUSION

The profession has accepted the use of fluorides in a variety of different forms for the partial prevention of dental caries. In every use of fluorides, some serious drawbacks to its utility are recognized. In an effort to provide mass treatment for all members of the popula-

tion (children living in both fluoride and nonfluoride areas, and for adults), a new concept in fluoride therapy has been developed which concerns the use of self-application of a new prophylactic paste by the individual patient. This prophylactic paste has been used in study programs in six independent clinical studies and evaluated under a mass treatment basis. The clinical results suggest that this technique is effective in reducing the incidence of dental caries.

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Practical Approaches to Large-Scale Stannous Fluoride Applications

FRANK D. GROSSMAN, D.D.S., M.P.H.

NO matter how much preventive dentistry may add to the quality of treatment, no matter how brilliant its practitioners, and no matter how many individual results can be pointed to with pride, the fact remains that public and professional support of preventive dentistry measures eventually demands economy in the expenditure of time and money in relation to the health benefits derived.

The question today is not whether it is possible to prevent caries. It is how to apply preventive measures most effectively. Perhaps the easiest way of measuring the efficacy of a treatment technique is by comparing its results with those of the technique that it may partially or wholly replace. One may begin by comparing the successor technique with its predecessor, and especially by identifying all significant improvements, such as a reduction in the incidence or prevalence of the disease, and in the time and professional skill and training required for providing treatment; acceptance of the technique by patients; and other interrelated health benefits.

The Naval Dental Corps has for thirty years conducted research and expended great effort on preventive dentistry without marked success in reducing a huge backlog of dental caries. Nowhere is there more striking evidence of the impossibility of meeting dental needs by a conventional approach to preventive dentistry than in the military services. In the Navy, for example, we have one dentist to every 500 troops, a ratio four times as favorable as is found in the civilian community. We devote 67 per cent of all available professional time to restorative dentistry. However, since the end of World War II, naval and marine personnel have had 3 to 4 million unfilled

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Dr. Grossman, Capt. DC USN, is Head, Preventive Dentistry Section, Bureau of Medicine and Surgery, Navy Department, Washington, D.C.

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cavities at any one time, depending on the size of the services at that time. This represents an average of four unrestored teeth per man. Our efforts have not been futile, however. In the four years the average man spends in the naval service, we have restored 81 per cent of the 7.2 carious teeth with which he entered the service plus the eight new lesions he has developed in service. He has left the naval service in much better oral health than he entered it.

In these thirty years we have broadened our concept of preventive dentistry. Today it involves all aspects of comprehensive dental care, including extension for prevention, oral hygiene education, dietary control of caries, early cancer detection, ridge preservation, provision of mouth guards for contact sports, conservative management of the pulp, and fluoridation of water at military installations.

In March 1963, we made a significant finding upon which we have developed a Navy-wide preventive dentistry program that has gained world-wide recognition both within and without the profession.

After two years of careful study at the Naval Submarine Base, New London, Connecticut, we had strong evidence that we could markedly reduce the incidence of caries in a military age population. Upwards of a 70 per cent reduction in carious increment was observed in young adult naval personnel 6, 12, 18, and 24 months after a cario-static treatment procedure that consisted of an annual prophylaxis with a stannous fluoride-special pumice mixture and the topical application of aqueous SnF_2 , followed by the daily use of an SnF_2 dentifrice. We know this treatment procedure as the three-agent stannous fluoride treatment. This study (1) was important for several reasons:

1. It reinforced the findings of other investigators that stannous fluoride is an effective cariostatic agent for young adults.

2. SnF_2 was found to be more effective if used in three agents because each agent has an additive effect, that is:

- a. The SnF_2 prophylaxis paste per se reduced the incidence of caries by 12 per cent.

- b. An SnF_2 prophylaxis followed by the topical application of 10 per cent SnF_2 reduced the incidence by 47 per cent.

- c. When all three agents were used, a 73 per cent reduction was possible.

3. A 15-second topical application per quadrant was found to be as effective as a 4-minute application per quadrant. Thus, the treatment time was reduced by 15 minutes and the whole procedure

from 60 minutes to 45 minutes. Here was a major breakthrough: an effective cariostatic technique for young adults and a 25 per cent reduction in treatment time.

Although we had an effective tool, we were quick to recognize that 67 per cent of our dental manpower was committed to correcting existing caries. We also recognized that the procedure tested required as much professional time per application as is required to correct the condition we were trying to prevent. To make this health benefit available to all would have resulted in the loss of approximately 1,000,000 sorely needed restorations per year. If we had pursued this approach, we would not have made any inroads in the 4,000,000 unfilled carious lesions. We would have maintained the status quo but would not have disturbed the equilibrium in favor of resolving the caries problem. In addition, the possibility of increasing the number of trained dental technicians or dental hygienists to provide this treatment could not be considered because of our increasing commitment to Vietnam. Innovations had to be made, but Where? and How?

The time for topical application had been reduced to 15 seconds per quadrant. Oral hygiene instructions stressing the use of a stannous fluoride dentifrice accepted by the American Dental Association could be presented to groups of men. The problem was the 30 minutes required for a conventional oral prophylaxis. We reasoned that if we could find a quicker way to prepare the teeth effectively for topical application and thus reduce chair time we could prevent a lesion in less time than it takes to restore one. Chrietzberg (2) provided us with the initial clue. In 1951, he had reported that children who brushed their teeth twice a day for two weeks under the supervision of a teacher and then had sodium fluoride topically applied by a dental hygienist had as great a reduction in caries incidence as though a conventional prophylaxis had been given prior to topical application.

We then requested the Naval Dental Clinic, Norfolk, Virginia, to conduct a study to determine whether patients could cleanse the crowns of their own teeth using a stannous fluoride prophylactic paste and do it essentially as well as a dental officer or technician using the same paste applied with an engine-driven rubber cup. Foster (3) conducted this study with great care and found that carefully coached patients could and did get the crowns of their teeth

essentially as clean in 10 minutes using an ordinary toothbrush and the special pumice paste containing SnF_2 as did the average dental technician using an engine-driven rubber cup.

Here we had another major breakthrough further reducing the time required for caries preventive treatment. We named this step "self-preparation for topical application."

Two questions immediately arose: Would such a procedure be acceptable to patients, dentists, and auxiliaries? And if we substituted "self-preparation" for oral prophylaxis, would we still have an effective treatment procedure in the light of our original findings at New London?

The answer to both questions was affirmative. Military personnel on the whole are intelligent, mature, and well-adjusted. They readily understand and accept temporary discomfort when they are taught the reasons for the treatment procedure in relation to their problems and needs. After one year's study, also at the Naval Submarine Base, New London, we found that although the self-preparation procedure is not quite so effective as a conventional prophylaxis, it is still extremely effective. This study, which will be presented in detail at the next meeting of the International Association of Dental Research, shows a 50 per cent reduction in DMFT and DMFS after one year in naval personnel 17 to 24 years of age. This age group represents 60 per cent of naval personnel and is also the age group most susceptible to caries. To implement our findings, we started a centrally directed Navy-wide preventive dentistry program.

We devised a standard preventive dentistry unit consisting of four toothbrushing basins and a dental unit and chair manned by one dental technician or hygienist. We programmed the procedure to a time schedule. Five minutes was allotted to instruction in self-preparation for topical application. In this time frame, the Why? and How? of the procedure were carefully explained, that is, the benefits to be derived and the special brushing technique required. At this time men were provided with a preventive dentistry kit, consisting of an oral B-type toothbrush, a tube of SnF_2 dentifrice accepted by the ADA, and six disclosing tablets. They were also given stannous fluoride paste in a 1-ounce paper cup, a larger cup for rinsing, and a plastic apron. Ten minutes was allotted for accomplishment of the self-preparation procedure. Five minutes was provided for each man to have a 10 per cent topical solution of SnF_2 applied following self-

preparation; then ten minutes for each group of four men to be instructed in good oral hygiene procedures. The total expenditure of time for four men to get a three-agent SnF_2 treatment was 45 minutes.

We found that by this approach 6,220 men could be treated in one year by a dental hygienist or technician vs. 1,500 to 2,000 by conventional methods. By further refinement of method and unit design, plus the use of audiovisual material, we have increased the number of patients who can be treated in this manner to 12,000 per year by one dental technician. This is approximately six times as many as can be treated by conventional means.

How may this new program of caries prevention, applied Navy-wide, affect the backlog of untreated caries among service personnel? And how economical will it prove to be in terms of time and money? The caries increment in naval personnel averages 2+ DMFS per year. Our studies show that we can prevent at least 1 lesion per year. We also know that the average dentist in the military places an average of 200 restorations per month, or approximately 2,000 per year. It can readily be calculated that one auxiliary using the technique described can prevent six times as many carious lesions per year as a dentist can correct in one year if the lesions are allowed to develop. Or we can say that in one year one dental technician can prevent as many lesions as six dentists working full time can correct. Thus, the new program should substantially reduce the backlog of untreated caries. It would also appear to be economical in terms of time and money expended in relation to the health benefits derived.

The concomitant benefits of the program are substantial. For example, the self-preparation technique makes an important contribution toward resolution of the dental health education dilemma. Traditionally, the health education efforts of the profession have been out of proportion to the results obtained. Untold millions of man hours have been expended in giving lectures; preparing tons of posters, booklets, and pamphlets; and making motion pictures and other audiovisual aids—but with little change in the oral health habits of the average American. An essential but missing step in our educational efforts for developing desirable habits and attitudes has been patient involvement. With self-preparation, the patient becomes intimately involved in the treatment procedure. He is told, and can see, what he can do for himself. We sincerely believe self-help is a

great incentive to practice oral hygiene. Self-preparation is by no means the ultimate answer, but it is a step in the right direction.

A study we conducted at the Naval Training Center, Great Lakes, Illinois, a report of which is being prepared for publication, is of great interest in relation to the preceding statement. Recruits chewed disclosing tablets before the self-preparation procedure, and a picture was taken of each recruit with a Polaroid camera that develops pictures immediately. After completion of self-preparation, another picture was taken, and the recruit was able to compare the two pictures. After the initial treatment, he was recalled at intervals of 5 days through 9 weeks of his recruit training. At each appointment another picture was taken and the various pictures were compared in the recruit's presence. The increased thoroughness of oral hygiene was very evident. The resolution of incipient gingivitis has been an important interface benefit.

The idea of self-help was carried forward in the development of a preventive dentistry program for dependent children of active duty naval personnel in 1967. We developed and packaged an abrasive prescription type dentifrice in a $\frac{1}{4}$ ounce tube. Directions were given to parents for the children to accomplish the self-preparation step at home under their supervision. Immediately following self-preparation, children were brought to the Naval or Marine Corps dental clinic for topical application of SnF_2 , at the rate of 10 per hour, and were then given oral hygiene instruction in groups. During National Children's Dental Health Week in February 1967, a total of 260,000 dependent children were afforded an oral examination, a topical stannous fluoride application, an oral hygiene demonstration and lecture, dental health education materials, and a preventive dentistry kit. The children received these benefits on Saturday, Sunday, and week nights of that week to prevent interference with regular treatment schedules.

SUMMARY

The Naval Dental Corps has developed a practical, economical approach to caries prevention through large scale application of stannous fluoride to the teeth. The "three-agent" treatment consists of (1) self-preparation for topical application of a stannous fluoride solution, (2) application of the solution, and (3) regular brushing

with an SnF_2 dentifrice. In self-preparation the individual brushes his teeth for 10 minutes with an ordinary toothbrush and a special pumice paste containing SnF_2 . A study to be presented at the next meeting of the International Association of Dental Research has shown this procedure to be nearly as effective as the conventional prophylaxis in preparing the teeth for topical application of the SnF_2 solution. The same study has also shown a 50 per cent reduction in DMFT and DMFS after one year in naval personnel 17 to 24 years of age receiving the three-agent treatment.

Self-preparation and topical application have been systematized and expedited by the provision of specially equipped rooms in which treatment is given; by a reduction in the time required for topical application of SnF_2 solution; by the use of audiovisual aids; and most significantly, by the substitution of self-preparation for the conventional prophylaxis. Self-preparation has reduced the amount of time that the dental technician or hygienist must spend with the individual patient to the point that he can treat 12,000 patients per year instead of 1,500 to 2,000. In time the new procedure should substantially reduce the amount of caries requiring treatment by the dentist. In the naval service, it additionally provides an important means of patient involvement which stimulates and motivates the practice of better oral hygiene. Through the encouragement of self-help or self-involvement, a significant number of cases of incipient gingivitis have been resolved. This is a step forward in the conquest of our next most prevalent oral disease, "periodontal disease." The parochial school system of Philadelphia, Pennsylvania, the anti-poverty program of Chicago, Illinois, and the Royal Canadian Army Dental Corps represent a small but growing number of organizations that have profited and have put into operation the Naval Dental Corps practical approach to large scale stannous fluoride applications.

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Army Motivation Study

RICHARD L. HOWARD, D.D.S., M.P.H.

PREVENTIVE dentistry was formally introduced to the Army Dental Corps in 1960, as the official philosophy of dental practice. The mechanism for launching this new philosophy was the Army Preventive Dentistry Program. In this program, as is the case with most programs of similar magnitude, there was a myriad of tasks to perform, and few trained people to accomplish them. As a result, each local dental service created its own Preventive Dentistry Program within the guidance provided by Washington. Hard work, ingenuity, and perseverance, coupled with individual perceptions of preventive dentistry, produced programs which were unique for each local dental service.

All local programs, however, recognized that prevention depended upon effective teamwork between the dentist and patient. To accomplish this, patients had to be taught and motivated to accept responsibility for their own preventive self-care, while dentists accepted responsibility for those preventive measures that were beyond the patients' capabilities. The key to teamwork, then, depended upon educating and motivating dentists and patients to assume their proper roles in the team.

In mid-1964, the Army found that its educational efforts toward patients consumed over 2,000,000 man-hours each year. Site visits and on-the-spot observations showed that while the intent of the educational message was reasonably consistent, the techniques used and message content varied widely among Army posts. Those of us who were privileged to see the overall picture were deeply concerned over the effectiveness of the educational effort when viewed in the

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Dr. Howard, Colonel, DC U.S. Army, is Chief, Preventive Dentistry Branch, Office of the Assistant for Dental Services, Office of the Surgeon General, U.S. Army.

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light of its cost in man-hours. This concern resulted in a recommendation to the Chief of the Dental Corps to the effect that the educational effort should be studied with an intent toward improving and standardizing preventive dentistry education Army-wide. This recommendation was accepted, and Medical Research and Development Command accepted responsibility for conducting the study.

Initial examination of the problem immediately produced difficult and nagging questions. How do you measure and document the results of an educational effort? How effective are large group lectures? Small group presentations? Chairside counseling? What should be the content? Is it possible to change the habits of men who have neglected their oral health all of their lives? These, and many more questions with both social science and dental science connotations, would have to be faced by the investigators. Therefore, a decision was made to form a combined team of dental and social scientists who would design and execute the study. The U.S. Army Institute of Dental Research and Decision Research Corporation, a firm specializing in applying social science techniques to measuring and improving communication effectiveness, were selected to conduct the study.

Obviously, all aspects of the educational problem could not be studied simultaneously, for there are many stratifications of people in the Army. It was logical to assume that each stratum might require a different educational emphasis, and a study across this wide range would overtax the resources of the investigating team. Since the large transient military population presented a major problem in education and motivation, and since this population was reasonably available to the investigators, the pilot study was limited to incoming soldiers or recruits. It was further limited to four major Basic Training Centers.

With these decisions, the team began its task of preparing a study design. The objectives were simple and to the point. First, prepare a standardized education program for recruits, and test it. And, second, develop accurate, sensitive methods of measuring the results. In order to continue, the team adopted an assumption and two operating hypotheses.

Assumption: For any selected group there are particular communication methods and certain motivational influences which can be used more efficiently and effectively than others.

First hypothesis: These communication methods and motivational factors can be determined.

Second hypothesis: When properly used in an educational program, they provide optimum results for the time and effort expended.

At this point, late in 1964, a three-stage study design was prepared and approved.

STAGE I—HYPOTHESES

The purpose of the first phase was to develop hypotheses as to the paramount needs, interests, desires, and goals of recruits. We believed that an educational effort keyed to that which is considered important by recruits would be accepted by them. Conversely, if recruits could see no relationship between the educational material and their personal goals, they would not be receptive and would reject the educational effort.

Published material was reviewed again to glean any information which might be helpful. In addition, practitioners in the military and commercial fields were sought out and questioned for their ideas and knowledge in the area of motivating young men. Armed with this information, the social science group began its field work.

Each of the four military posts was visited by a civilian social science team, using a sequential feedback interview technique. Small groups of recruits in their second to fourth week of training were asked to meet with the team for an unknown purpose. Each group to be interviewed was informed that the team was composed of civilians who wanted to talk about the Army, and that any statements made would not be attributed to the persons who made them. All interviews were conducted with a tape recorder in plain sight. Initial interviews were unstructured, and these recruits, still civilians at heart, were most happy to discuss themselves and the Army. Five such interviews were conducted at each installation, with different recruits in each interview group. After each session, the recordings were reviewed for content, which permitted each succeeding interview to be more structured and more dentally oriented. Results from these interviews were made into a questionnaire, which was divided into two parts: Part A dealt with needs, interests, desires and goals, while Part B related to dental knowledge and commitment to oral hygiene practices. Thousands of recruits completed

the questionnaire at the four military installations, and validated the interview findings.

MOTIVATIONAL RESULTS

Information from the interviews and questionnaires was analyzed according to a value system developed by Harold D. Lasswell. In this system, motivating influences are divided into eight general value areas for analysis: Power, Enlightenment, Skill, Well-being, Wealth, Affection, Respect, and Rectitude. Each of these may be viewed as both a base value and a scope value. As base values, they become assets in attaining other values, e.g., enlightenment as a base value to power or respect. As scope values, they are considered as ends in themselves. During our analysis, the motivating values were usually treated as scope values, or ends in themselves.

Respect. This value, in general, ranked at the top of the scale. The reasons given for practicing oral hygiene centered around self-respect and respect for others. Personal pride, appearance, and social acceptance were the most common reasons for brushing teeth regularly.

Recruits have little opportunity for indulgences in this area during basic training, which keenly intensifies the need for respect. Transition from a civilian to a military environment with its inherent insecurities, further intensifies the need for respect. Expressions reflecting the lack of opportunities for respect indulgences were found universally among the interviewees.

Several men mentioned that brushing helps one to "feel like a human being" during basic training. Personal hygiene was seen by many as a means of being able to "feel like somebody for a while—not just a number." Not everyone felt this relationship, but it may be a key to gaining cooperation from many of the men, and particularly from the pace-setters in a unit.

Rectitude. The need to conform to standards becomes important to new soldiers. Early home training in oral hygiene was primarily motivated by this same value, and it can still be effective when handled properly. Many soldiers will accept the fact that oral self-care is "right," because it is their *duty* as soldiers to maintain the best possible health and appearance. They can also accept the fact that they are away from home, and now have the *responsibility* to continue good oral health practices as part of becoming mature.

Recruits, however, regard brushing as a very personal thing and resent non-dental strangers in the Army telling them to brush their teeth.

There are strong feelings of rapidly developing maturity and new found responsibility evident almost universally among recruits. These enhance both self-respect and rectitude, and oral hygiene can be the key to these new attitudes.

Rectitude becomes more important with an increased sense of participation. This may be a key consideration, if men can identify with the purposes of the oral hygiene program.

Well-being. Most men did not see themselves as being in any positive, imminent danger of losing their well-being because of their teeth. The value of a healthy mouth was recognized, but this would become an important motivating factor only if loss of one's teeth were imminent. There was no evidence of a sense of clear and present danger which could serve as an immediate impetus for day-to-day brushing.

On the other hand, a general feeling of well-being and cleanliness was associated with each brushing. This was seen as a way of washing away filth and grime after a day of basic training, just as a shower cleansed the rest of their body. In this context, brushing may be used as a motivating factor in proper oral care.

Affection. Poor oral hygiene was seen as an indirect block to affection by the family, loved ones, and close friends. A bad mouth denied respect from these important people, thereby denying their affection to the soldier. Usually, opportunities for affection indulgences with loved ones are remote until after basic training. Nevertheless, affection is a definite motivating consideration.

Power. Advancement in the military is not a motivating force toward good oral hygiene during basic training. There is some consideration of the relationship between oral hygiene and civilian employment, but no similar relationship is seen in the service. These men are aware that soldiers with sharp military bearing and appearance are in the higher positions, but good teeth are not seen as contributing in any way.

Enlightenment. As a scope value, enlightenment is not a motivating force, because it is not an end in itself to these men. But, as a base value, or an asset in pursuing other values, it is important. Recruits do not feel qualified to make decisions as to proper oral health

procedures. They want to be told how to brush, when to brush, what kind of brush to use, and what kind of dentifrice to use. The principles involved in brushing and self-care can be accepted, if they are related to the values which are important to these men.

Wealth. The probability of successfully using wealth as a motivating factor is very low. Men recognize a connection between this value and oral health habits, but it is tenuous, unimportant, and several steps removed.

Skill. This value is not important in motivating the practice of oral hygiene. There is no reward for a high degree of skill in brushing one's teeth. Feelings of the men toward this value point out a general finding of this analysis: logical, health-associated appeals are relatively ineffective as motives for oral self-care.

ORAL HYGIENE RESULTS

Part B of the questionnaire was a mixture of structured and open-ended questions, some of which related to oral hygiene, dentistry, and the Army Dental Corps. These questions were made from information obtained in discussions with basic trainees, and Part B was designed to test our questionnaire technique as well as validate the questions.

Information gathered by this pilot questionnaire was analyzed by the decision-continuum technique which has six levels of commitment: Not Aware, Awareness, Interest, Involvement, Action, and Habit. Discussion of this technique is a paper unto itself; however, two examples of the findings will serve to illustrate the end product of such analysis. When asked about "Brush teeth well once a day," 7 per cent of the men were not aware that this was a good practice, 26 per cent were only aware of the practice, 23 per cent showed some interest in the idea, 20 per cent were involved to the point of thinking about it but were not doing it, 20 per cent were trying brushing each day, but only 3 per cent had the habit of brushing once each day. Responses were considerably different to a more restrictive question, "Brush teeth after every meal." Some 63 per cent of the men were at the not aware level, 19 per cent were aware only, 8 per cent were interested only, 6 per cent had become involved, about 3 per cent were trying action, and less than 1 per cent had the habit.

Part B did validate the questionnaire technique, and the ques-

tions in it. Thus, the way was open for a large scale questionnaire to gather baseline data. These data will be used for comparison in Stage III, Evaluation.

Having completed the intelligence effort, prepared the hypothesis, and validated the questionnaire technique, the team was ready to begin Stage II.

STAGE II—DEVELOPMENT

Three important functions were to be completed in this stage. First, the large-scale questionnaire had to be administered to the troops, and evaluated. Second, a dental clinical method of measuring the results of changed oral habits had to be developed. And, third, an educational program had to be developed and taught to those dental officers who would use it.

Preparations and administration of the questionnaire were accomplished without any major difficulty. The results have been analyzed and baseline data on the oral hygiene commitment of recruits are now ready for Stage III.

Our dental team developed and tested a method of measuring oral changes related to changes in brushing habits. The team started with the premise that our educational objective was to have each trainee habitually brush his teeth and keep them clean. If this objective could be met, in fact, then it should be possible to measure before and after differences in tooth cleanliness. No attempt was to be made toward relating oral disease and tooth cleanliness.

Frequent observation convinced the team that most recruits could not remove all dental plaque from their teeth with a single brushing, using a commercial fluoridated dentifrice. However, they could keep most of the plaque off by effective, habitual brushing. Therefore, it was decided that measurement of the amount of plaque present on teeth would be used as the intra-oral indicator of oral hygiene habits. From a clinical standpoint, if the soldier failed to brush routinely or brushed in an ineffective manner, the education program would be considered something less than a complete success. It was further decided that the team would search for a method of measuring plaque which was: (a) quick and easy to use, (b) easily taught to other dentists, (c) sensitive to moderate changes in hygiene habits, (d) reproducible, and, (e) subject to statistical analysis.

After many trial designs were tested, a plaque measuring device

was developed which we have dubbed the "plaqometer." It is made from layers of colored plastic that have a consistently uniform thickness, is triangular in cross-section, and has a wire handle. This shape permits placement of a sharp edge against the tooth during measurement.

After the plaque has been stained with methylene blue, its height from the gingival crest is measured and a corresponding number entered on a form. Six specific facial surfaces are measured and an average height of plaque determined. The difference between plaque height before and after an educational effort will be used as one criterion in evaluating effectiveness of the educational program in Stage III.

Preparation of the educational program was completed on time. But, when it was presented to the post dental services, an entirely new aspect of the study came into sharp focus. Dental officers, themselves, proved to be a communication block. Some did not believe that the poor oral hygiene habits of a lifetime could be changed. Others felt that a large-scale educational effort was a waste of time because the men could not understand it. Many felt inadequate in educating patients because they had not been taught how to do it in school. Since these dentists would be delivering the educational effort, this block could not be ignored. The entire study had to be delayed until this problem could be solved.

Sequential feedback interviews were instituted again by the social science team. After determining the primary problem areas among dental officers, a new technique—a decision seminar—was brought into play. This technique develops group participation in understanding and solving problems, and involves each person in accomplishing the group objectives. At post level, the decision seminar has been very effective in reorienting dental officers to preventive dentistry and the study. A number of officers who had been negatively oriented, reversed themselves and developed new and imaginative approaches to patient communication and motivation. At this point the objectives of Stage II were met and the study moved into Stage III in 1967.

STAGE III—EVALUATION

Initiation of this stage was delayed to a considerable extent by administrative problems. Our primary delay resulted from a high

level decision to change the "mix" of people receiving basic training at the four posts. The study, up to 1967, had related to a "mix" of trainees with a preponderance of draftees and enlistees. Early in 1967, the "mix" was temporarily changed to a preponderance of National Guard and Reserve personnel. Since our data showed that these men did not respond to our study in the same manner as enlistees and draftees, the study was delayed until the original "mix" was re-established.

This month, October, our study became active again and is proceeding very well. Baseline data on plaque have been collected and are being analyzed. The education program, called "Fresh Start," is in progress, using four basic study groups. One group will receive the maximum effort, consisting of a large-group lecture, small-group discussion, and chairside instruction. A second group will be exposed to the small group discussion and chairside instruction. The third group will receive chairside instruction, only. And, the fourth group will serve as a comparison group, with no educational effort. All of "Fresh Start" will be completed during basic training.

In December, the trainees will have finished basic and completed about one-half of their Advanced Individual Training. By this time the men will have had an opportunity to lapse into their old hygiene habits, if the education has no lasting effect. The large-scale questionnaire will be administered to these men who have had no previous contact with the questionnaire, and the results will be compared to the baseline data. Analysis will be in terms of how many men moved how far in the six levels of commitment: Not Aware, Awareness, Interest, Involvement, Action, and Habit.

The second dental plaque examination on these same trainees will be accomplished at this time. These results will be compared to baseline data to determine what clinical effect is derived from "Fresh Start."

We hope that our final analysis will shed new light on the problem of educating and motivating young men to accept responsibility for their own oral care. In addition, we believe the results may be useful to administrators who must make decisions relating to the operation of large-scale oral health programs.

What About a Vaccine for the Prevention of Dental Caries?

GORDON H. ROVELSTAD, D.D.S., PH.D.

IN the middle 1800's a French chemist, Louis Pasteur, was the first to associate "germs" with disease. This came about through a problem that arose in the French silk industry, and Pasteur was called in for consultation. During his studies, he saw "germs" through his microscope that were all over the silk worms and the mulberry leaves used for feeding. He recommended the destruction of the worms and the mulberry leaves that were so infected. His recommendations were tried and the silk industry revived. On the basis of this he formulated his well-known "Germ Theory of Disease." This was over 100 years ago and 200 years after Van Leeuwenhoek, the father of the microscope, first described his "animalcules" and "germs" (1).

Robert Koch, a German physician, subsequently developed techniques for the pure culture of germs thereby making it possible to identify specific bacterial infections. With his techniques he was able to isolate a bacillus that caused anthrax, and another that caused tuberculosis. He later formulated what has become known as Koch's postulates, the criteria for establishing the relationship of specific bacteria to a disease (2).

Koch had many students. One of them, W. D. Miller, had dental training and became interested in the microorganisms of the oral cavity and sought a relationship of these organisms to dental caries. He realized that bacteria were associated with this disease, but it required many years of study and experimentation, involving both the chemical and septic theories of "decay," before he completed the first really satisfactory and conclusive investigation of tooth de-

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Dr. Rovelstad, Capt. DC USN, is Officer in Charge, U.S. Naval Dental Research Institute, Great Lakes, Ill.

The opinions and assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

cay. On the basis of his work, summarized in 1890 (3), the "chemo-parasitic" theory of this disease evolved. This included:

1. Microorganisms of the mouth, by the secretion of enzymes or through by-products of their metabolism, fermented food materials to form acids.

2. Carbohydrate food substance, lodging between the teeth was the source of the acid, which in turn attacked the teeth.

3. Further stages of the disease were produced by the penetration of acid into the enamel, progression of microorganisms into dental tubules, decalcification of dentin and destruction of the protein matrix of the dentin.

J. Leon Williams (4) and G. V. Black (5) modified this concept by stating that an essential feature of the disease was the presence of a bacterial plaque on the surface of the enamel.

This was the level of understanding of dental caries at the turn of the century. However, since there were many other widely-held conflicting theories, much controversy raged over the Miller-Williams-Black concept.

DENTAL CARIES AN INFECTIOUS DISEASE

During the past sixty years, many well-known investigators have been associated with the study of the bacteriological characteristics of dental caries and volumes of data have been reported. Although Bunting and co-workers demonstrated a direct association of *Lactobacillus acidophilus* to dental caries in 1925 (6), it was not until 1954 that there was any major evidence supporting Miller's theory.

Orland and his associates, employing "germ-free" animals, developed at Notre Dame University, proved that the disease would not occur in rats in the absence of bacteria (7). Furthermore, they demonstrated a year later that caries could be induced in germ-free animals only by deliberately inoculating the animals with an enterococcus derived from a carious lesion in a conventional rat (8).

Five years later, 1960, Robert J. Fitzgerald and Paul H. Keyes of the National Institute of Dental Research were able to isolate from carious lesions in hamsters a number of closely related strains of streptococci that could produce typical lesions of caries when inoculated into the mouths of caries-inactive hamsters. These microorganisms were not able to produce caries in rats (9).

Fitzgerald and Keyes extended these studies further by demon-

strating that specific streptococci produced caries in hamsters, and that the disease could be transmitted from one animal to another by merely caging infected animals with non-infected ones (10).

Thus dental caries in animals was established as an infectious and transmissible disease, and Koch's postulates were satisfied in relation to dental caries.

Fitzgerald, Jordan, and Stanley then reported that certain streptococci isolated from the rat were cariogenic when mono-inoculated into germ-free rats (11).

Others continued the studies. Zinner and co-workers isolated streptococci from carious lesions in children that produced carious lesions in animals (12). Krasse (13) and Gibbons and his associates (14) have reported that streptococci isolated from human carious lesions were able to produce typical disease in the teeth of rats and hamsters. Shklair has isolated several strains of streptococci from the plaque of naval recruits, one of which has been proven to be cariogenic in germ free rats (15, 16).

In all of these studies, the microorganism isolated has been one that has not been previously classified. One of the unusual characteristics of these streptococci has been their ability to produce a polysaccharide, extra-cellularly, when grown in the presence of sucrose. This is seen in the laboratory as a clear gelatin-like material around the colony.

NAVY "CARIES-IMMUNE STUDIES"

Over the past several years, there has been a study in progress in the Navy known as the "caries-immune" project. Naval recruits having perfect teeth have been selected at time of entrance in the service for participation in this program. Opportunities for these men to serve one year of duty at Great Lakes have been offered to them, during which time they have become subjects of extensive dental studies along with, and in addition to their regular duties on the Center.

One hundred and forty-five such individuals have been included in these studies, although the original studies were begun at Bainbridge, Maryland, in 1955.

These men have come from many parts of the United States. However, since Great Lakes and Bainbridge have served primarily the Central and Eastern parts of the United States, these are the

only areas for which meaningful epidemiological data have been collected.

Only 37 per cent of the 145 studied at Great Lakes originated from areas where optimum amounts of fluorides were known to be present in the water supply.

Of the 145, more than half developed caries while in the study.

During the past year at Great Lakes, only one recruit out of 556 qualified as "caries immune." Twenty-one individuals completed twelve months in the program in 1966. Fourteen, or two-thirds, of these men developed caries in one or more teeth during this period.

From the fourteen who developed dental caries, many different isolates of streptococci were obtained by Shklair which had the ability to form a dextran in the presence of sucrose. These streptococci have been placed in four groups biochemically. To date, one of these streptococci has been inoculated into germ-free rats and found to produce dental caries (17).

Thus, a characteristic streptococcus has been isolated which appeared in the oral cavity of young men who had no previous history of dental caries. However, during a twelve month period of continuous observation, dental caries developed. When the microorganism was inoculated into animals it produced the disease. The same microorganism was subsequently recovered from the animals. Tentatively, Koch's postulates can be said to have been satisfied on these initial experiments with human dental caries.

This suggests the simplest of mechanisms of disease, that of bacterial infection. Previously, disease-free young men, upon arriving at Great Lakes and mixing with many other young men having dental caries, not only develop dental caries, but demonstrate the presence in increasing numbers of a form of streptococci known to produce the disease.

Further studies have shown that those caries-free subjects who remained free from dental caries during the year of observation period, had a higher antibody titer to some cariogenic microorganisms than a group of caries-active subjects (18).

Since a characteristic streptococcus has been implicated, and since the probability of an infectious disease most fittingly describes the situation, then what about a vaccine for the prevention of dental caries?

ANTIGENIC CHARACTERISTICS OF STREPTOCOCCI

Streptococci are complicated microorganisms. Those usually responsible for human infections are designated Group A on the basis of a serologically specific carbohydrate found in the cell wall (19). However, the *types* of Group A are classified on the basis of proteins also bound to the cell wall (20). Each type has a separate antigenic characteristic and produces a separate antibody. Patients develop an immunity to the particular strain that has caused the disease, but not to others. The immunity is type specific. The antigenic component has been designated as "M" protein, and besides being antigenic in character has a role in determining the virulence of the microorganism (21).

Antibodies directed against the "M" proteins are believed to be protective by virtue of their opsonic capacity, that immune factor that stimulates phagocytosis (22). Recent studies have described methods of producing antibodies against purified "M" protein in rabbits (23). On the basis of this, interest in the development of a vaccine against streptococcal endocarditis and nephritis has risen.

Experimental evidence has been reported within the past few months indicating high antibody titers in humans as a result of the administration of a vaccine prepared from the "M" proteins of at least three types of streptococci (24). Thus the vaccine concept based on "M" protein antigens has been found feasible.

PHAGOCYTOSIS—PRIMARY DEFENSE MECHANISM
AGAINST STREPTOCOCCI

Another interesting aspect of this subject is that the protective mechanisms in humans against streptococcal infections is phagocytosis by the leukocytes (25). Antibodies acting as opsonins stimulate phagocytosis and the destruction of streptococci (26). Opsonins are known to be secreted into the saliva (27).

The presence of leukocytes in the oral cavity in a vital state has been demonstrated as well as oral leukocytes engorged with streptococci (28). Additionally, in an experimental situation and with time-lapse motion pictures, the actual phagocytosis of streptococci was demonstrated by leukocytes taken directly from the oral cavity (29). This phenomenon was demonstrated to be possible in the oral cavity where the dental plaque is most common and during the major part of a twenty-four hour period.

SUMMARY

If all of this evidence is put together we have the following:

1. Bacteria have been proven to be essential to the development of dental caries in experimental animals.
2. Characteristic streptococci have been found to be infectious and transmissible in producing dental caries in experimental animals.
3. Streptococci have been isolated from human subjects who developed carious lesions during a twelve-month period of continuous observation. One of these organisms has produced dental caries in the rat.
4. Antibody titers against cariogenic streptococci in individuals developing caries have generally been found to be lower than titers in those who remain free from caries in the caries-immune program.
5. Phagocytosis with destruction of streptococci by leukocytes, is the protective mechanism against human streptococcal infections.
6. Evidence supports the contention that phagocytosis by leukocytes in the oral cavity is an active defense mechanism.
7. Vaccines are being developed which stimulate phagocytosis and destruction of streptococci that cause disease.

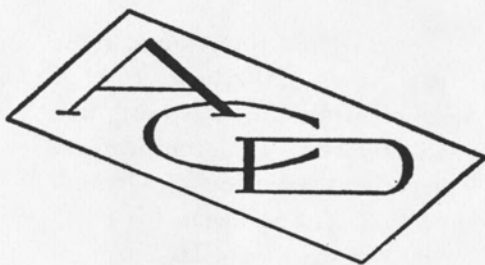
So, therefore, what about a vaccine for the streptococcal infection causing dental caries? Recently Wagner (30) has reported that rats inoculated orally with *Streptococcus faecalis* and parenterally immunized with the homologous bacteria, demonstrated the virtual elimination of dental caries as compared to the non-immunized controls. If recent findings are fully substantiated by investigations in progress in many parts of the country, it would seem that, unlike the thinking of just a few short years ago, a vaccine to prevent dental caries is most certainly a possibility and is worthy of every bit of effort that can be mustered to accomplish it.

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The Effects of Fluoride on the Prevalence of Malocclusion

J. A. SALZMANN, D.D.S.

THE title of my presentation could well have been expanded to include in addition to "The Effects of Fluoride on the Prevalence of Malocclusion," the effects of fluoride also on the practice of orthodontics as a specialty, on the orthodontist as a practitioner of the specialty, on orthodontic education and, indeed, on orthodontics in dental education, and in dentistry in general. The time allotted obviously does not permit a detailed discussion of all aspects of the impact of fluorides on orthodontics in relation to the various phases of dental practice. I shall attempt, nonetheless, to mention these topics in summary.

Orthodontics in general, and the American Association of Orthodontists in particular, have a close historic relationship to fluoridation. Frederick Sumner McKay, who is recognized as the "Father of Fluoridation," was secretary of the American Society of Orthodontists (now the American Association of Orthodontists) in 1906. It was about that time that McKay began his epochal studies on fluorosis and its effect on the dentition. He first discussed the effect of fluorides on the reduction of the prevalence of dental caries in 1908 at a dental meeting in Colorado Springs. In 1956 the American Association of Orthodontists conferred honorary membership on Doctor McKay (1).

Fluoridation has received endorsement from more than thirty world-wide scientific organizations devoted to the life sciences. A large number of communities throughout the United States are fluoridating their water supplies, and a growing number of states are enacting laws that require the community water supplies to be

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Dr. Salzmänn is Attending Orthodontist, Head of Orthodontics and Director of the Cleft Palate Center at the Mt. Sinai Hospital, New York.

fluoridated. However, the trend to fluoridation has from its very inception met with blind opposition from some quarters.

A man is said to be known by the company he keeps, or, to paraphrase the saying, by the friends he has. We can go a step farther and say a man can be judged also by his enemies. The foregoing applies in full measure to the use of fluorides for reducing the staggering amount of dental caries in our population. We shall cite one example only of the type that most frequently opposes fluoridation.

In February, 1966, the United States Public Health Service in conjunction with the American Dental Association sponsored a National Dental Health Assembly in Washington during the National Children's Dental Health Week. A group that calls itself the "National Health Federation" (NHF) chose the same week in the same city to hold its "First National Symposium on Fluoridation." R. L. Smith (2), writing in *Today's Health*, a publication of the American Medical Association, describes the NHF as being composed of "cultists, faddists, and exponents of pseudomedicine who promote questionable and fraudulent medical products." The National Health Federation instructs its members on "How to Fight Fluoridation in Your Area." The special concern of the NHF is evidenced in an article it published on "The Importance of the Health Food Store in the Growing Health Food Movement."

Many of the scientific studies and investigations that were undertaken to disprove the unwarranted allegations made by the enemies of fluoridation actually have added to our knowledge of other benefits accruing from the use of fluorides in addition to their well-known cariostatic effects. The benefits of fluoridation on the developing dentition of children need no special pleading. Not so well known, however, are the beneficial effects of fluorides on the adult dentition and on the reduction of malocclusion.

The effects of fluoridation on the teeth of young adults was demonstrated by Admiral Frank M. Kyes (3) at the United States Naval Academy in a three-step fluoride treatment technic involving prophylaxis with a stannous fluoride abrasive paste, yearly topical application to the teeth of a 10 per cent solution of stannous fluoride for 15 seconds, and daily use of a fluoride toothpaste. A midshipman's expectation of having a new cavity is now about one in 6 years, while the average untreated college student has about two new cavities a year.

The possibility that bones and teeth can be protected through the systemic administration of fluoride, or even through vascular and topical injection of higher concentrations of fluoride than those used in preventing caries has been suggested by Sognnaes (4). Zimmerman (5) found children born of mothers who consumed fluoridated water during pregnancy to have a lower caries attack rate than children whose first contact with fluorides occurred after they were born. The increased fluoride content of deciduous teeth indicates that prenatally administered fluoride can afford them some cario-stasis. Available data do not contraindicate the administration of 1 mg. of fluoride per day to pregnant women (6).

The foregoing findings were followed by the appearance on the market of a number of untested fluoride preparations. The Federal Food and Drug Administration has since banned many of these fluoride-containing drugs that were advertised for use by expectant mothers to prevent caries in their offspring.

The effects of early loss of permanent first molars as an etiologic factor in the development of malocclusion were presented by Salzmann in 1938 (7) in a study of 1,000 boys and girls, age 15 to 19 years, consuming unfluoridated water, of whom 500 had lost one to all four of their permanent first molars, and 500 adolescents in the same age groups who had not lost any of their permanent first molars. The effects of first permanent molar loss were manifested in these children by an increase in caries, almost universal development of malocclusion, traumatic occlusion, changes in facial contour and appearance, and frequent interference with speech and general dental development (8).

Hill, Blayney, and Wolf (9) found the percentage of reduction of first molar extraction in Evanston, Illinois, children who had consumed fluoridated water to be similar to that reported by Arnold (10) who found a 75 per cent reduction.

After approximately ten years of fluoride experience in Newburgh, New York, Ast and co-workers (11) found that the use of fluoridated water by children during their dental development period reduced the loss of permanent first molars to the vanishing point. While almost 7 per cent of the permanent first molars in 9 and 10 year old children in Kingston, New York (with a non-fluoridated water supply), had been extracted, not a single perma-

nent first molar was missing in the Newburgh children drinking fluoridated water.

The cost of providing initial dental care for children 5 and 6 years old in the nonfluoridated area was more than twice as high as the cost of such care in the fluoridated area. The cost for incremental dental care in the nonfluoridated area was double the cost in the fluoridated area (12).

A study was made by Salzmann and Ast in 1955 (13) to determine existing differences in facial growth and development between children consuming fluoridated water and those who drink fluoride-deficient water. The study included 386 children, age 6 through 10 years, in Newburgh, which has a fluoridated water supply, and 373 children of the same age level in Kingston, which had fluoride-deficient water. A total of 759 children was studied. Cephalometric lateral roentgenograms on 8 by 10 inch X-ray films were obtained of these children and tracings were made.

The facial pattern of the Newburgh and Kingston children showed the same range of variation regardless of whether they consumed fluoridated or nonfluoridated water. The children in both cities showed measurements in the maxillofacial area that were similar to the range of values reported independently by Margolis (14), Higley (15), and others. This is an indication that fluoridation *per se* had no effect on the facial growth pattern as such.

However, the Kingston children (with nonfluoridated water) showed consistently higher percentages of malocclusion than did the Newburgh children (with fluoridated water) all of whose permanent first molars were present. The percentage of children with normal occlusion was almost twice as high in Newburgh compared to those in Kingston, although no meaningful differences were found in facial development, or in facial size, between the children in the community with fluoridated water, and those in the fluoride-deficient area.

A follow-up study by Ast and co-workers (16) concluded that their findings "adds further substantiation to Salzmann's previous large-scale study regarding the potential hazard of developing malocclusion as a result of early first permanent molar loss." They point out also that "The benefits which accrue from public water fluoridation programs may be measured not only in terms of significant protection against dental caries but also with respect to a reduced hazard

of malocclusion, especially severe malocclusion which may be regarded as physically handicapping."

Hill, Blayney, and Wolf in 1959 (17) reported 20 per cent less malocclusion among 6 to 8 year old children, and 17 per cent less among 12 to 14 year old children, drinking fluoridated water, compared with prefluoridation findings. In 14 year old children who had been drinking fluoridated water all their lives, they found a much higher rate of normal occlusion and a considerable lower rate of malocclusion than in children on nonfluoridated water.

The reduction of malocclusion in children who consume fluoridated water is not due to any intrinsic osteogenic or osteologic growth changes induced in the jawbones themselves, or to changes in jaw development resulting from the fluoridated water consumed by these children. The reduction in malocclusion in these children can be attributed solely to the decrease in tooth loss and reduction in interdental contact deficiencies caused by severe interproximal dental caries. However, the causes of malocclusion are many, and tooth loss is only one etiologic factor among countless others. The demand for orthodontic service will continue to grow with the increasing appreciation by the public of the benefits of dental care, regardless of the universal use of fluorides.

Douglas and Coopersmith (18), writing on the changes in dental practice due to fluoridation, state that "... the shift away from major attention to caries is leading to greater attention to periodontal treatment and interceptive orthodontics." Douglas (19) further observed, "It seems inevitable, that the present emphasis on restorative dentistry in dental education will slowly be replaced, at least in part, by an increasing emphasis on oral medicine, periodontics, pedodontics, orthodontics, preventive dentistry, and public health."

The increased awareness of the importance of regular dental care brought about by fluoridation, while it decreases the increments of dental caries, actually increases the demand for dental service and the need for additional professional personnel.

The manpower problem in dentistry presents an important block to the increasing demand for children's dentistry and orthodontics. While the population continues to expand, the ratio of practicing dentists to population actually has been decreasing. By 1975 there will be a need for 140,000 dentists to maintain the present dentist-population ratio. To accomplish this, it would be necessary to dou-

ble the present number of 3,300 dentists graduated annually. The first dentists to be graduated from schools built with federal matching funds, provided in 1963, will not enter the profession until 1972.

The American Dental Association now is engaged in studying the use of auxiliary personnel in order to meet the increasing demand for dental service. We must be careful in this connection to avoid the dilution of the professional status of American dentistry and the fractionation of dental practice.

The number of dental specialists has more than doubled in the decade from 1955 to 1965. According to the American Dental Association Bureau of Economic Research and Statistics, there were 88,500 dentists in private active practice in 1965, of whom 6,400 were recognized as specialists. Over one-half of the specialists were in the exclusive practice of orthodontics, and one-fourth practiced oral surgery. There were only a few hundred dentists in each of the other six specialties recognized by the American Dental Association.

The percentage of children with severely handicapping malocclusion has been estimated to be between 15 and 25 per cent of the child population. Orthodontists ratio to child population even in those localities that show the highest concentration of these practitioners indicates a deficiency of professional personnel to cope with the impending potential increase in the active demand for orthodontic treatment under Title XIX of the Social Security Act (Medicaid), and the expanding number of prepaid dental programs. For example, California has one orthodontist to 14,000 children; the District of Columbia has one to 12,000 children; New York has one to 16,000 children, and some states have only one orthodontist to as many as 80,000 or more children.

It should be pointed out that the states mentioned have the highest ratio of orthodontists to their child population. If we accept the conservative estimate that 15 per cent of the child population has severely handicapping malocclusion, the required manpower to deal with the potential case-load of handicapping malocclusion indicates a need for ten times as many orthodontists as are now in practice.

The demand for dental service today is largely initiated by the patient. Oden W. Anderson (20), Professor and Research Director, Center for Health Administration Studies, University of Chicago, speaking before the Federation Dentaire Internationale, at Tel Aviv, Israel, in July 1966, pointed out that close to 90 per cent of the adult

population of the United States believe that they should see a dentist at least once a year, but that only one-third actually do so.

The demand for orthodontic treatment while it is initiated by the patient or the parent is not based on the fact that the patient has an acute attack of "crooked teeth." There are however, subjective determinants on the part of mothers that affect the degree of the utilization of orthodontic service that do not hold for other phases of dental care. These subjective motivations are not necessarily always in agreement with the importance accorded them by orthodontic diagnosis. Prominent among the factors responsible for the increase in the demand for orthodontic care, is the fact that orthodontics still has a sort of status symbol and also, it is there for the asking under Medicaid, fringe benefits, and for very little extra expense under many prepaid dental service and insurance programs.

It is important at this time for dentistry to define on a realistic basis, maximum and minimum standards for the provision of dental care on a population basis in relation to available manpower. We need to establish guiding principles, also to determine the responsibility of government for providing service in the more sophisticated dental specialties. In our affluent society the problem is not the cost of service to government; government can always increase taxes. However, the manpower problem is not so easily or immediately solved.

The need to establish principles for orthodontic treatment in prepaid and in public health programs was recognized by the United States Children's Bureau as far back as 1948 (21). Among the principles adopted at that time was a provision for service programs in orthodontics in which priority was to be given to children with handicapping dentofacial deformities. The questions arise: How do we determine what is a handicapping dentofacial deformity? How do we establish priority for orthodontic treatment?

The American Association of Orthodontists recognized the pressing need for a parameter to be used in assessing handicapping malocclusion as it occurs in the individual child. Such an assessment was needed for determining treatment priority in keeping with the number of children in a community that require orthodontic service because of handicapping malocclusion, in relation to the funds budgeted for orthodontics by the community in question, and the

availability of adequately trained professional personnel to provide the service.

An assessment record form was devised by Salzmann which has been approved by the Board of Directors of the American Association of Orthodontists and has been accepted by the Council on Dental Health of the American Dental Association (22). Copies of the form and instructions for its use are obtainable from the Council on Dental Health, American Dental Association.

By using the "Handicapping Malocclusion Assessment Record" form it is possible to establish priority for treatment according to the magnitude of the score obtained in the assessment of the individual patient, in keeping with the funds budgeted by the community for orthodontic treatment, and in accord with the availability of professional personnel to provide the service. The procedure by which this is accomplished is as follows:

In a community, for example, where there are 3,000 children, a sampling is made in the child population to determine the frequency of handicapping malocclusion and the range of the assessment scores by using the handicapping malocclusion assessment record form. If it is found that there is a potential case-load of 15 per cent of children with handicapping malocclusion, or 450 children out of 3,000, who require treatment, and professional personnel, or available funds, or both, will permit treatment of 250 children only, the cut-off point for acceptance of patients is set at a score that would include 250 children only. These children receive priority according to their individual assessment scores.

There is an urgent need at present also to define, and construct teaching curriculums for the different phases of orthodontic care such as prevention, interception, and full treatment of malocclusion.

In view of the increasing stress placed on preventive orthodontics, it is necessary to define and spell out what is preventive orthodontics, what can we prevent, and how much and what type of patent or impending malocclusion can be intercepted. When these facts are established, we shall be able to avoid entirely the neglect as well as the gratuitous manipulation of children's teeth and expense to the parents, the community, or to any other agency that pays the bill.

The basis of orthodontic service itself should not be predicated on exclusive or non-exclusive practice alone, but on the educational and clinical preparation of the individual dentist for the practice of

orthodontics. All available professional personnel and methods of practice should be employed that will aid in the prevention of malocclusion. The cooperation and clinical efforts of the general practitioner and the pedodontist are required to cope not only with the potential need, but also with the present and immediate active demand for orthodontic treatment.

If the American Dental Association National Children's Dental Program is to become a substantial reality and not remain a paper project, we shall have to find effective means for translating the potential need for general dental and orthodontic care into active demand.

We cannot meet our immediate and future professional obligations by backing into them. We must adapt our thinking and actions to the demands of society while at the same time guarding the scientific progress of our profession.

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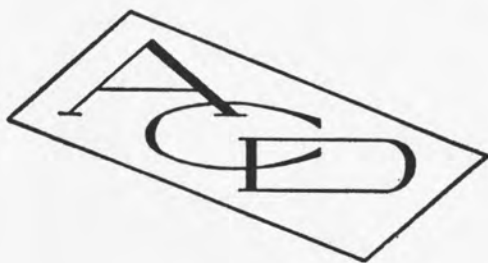
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AUSTIN T. WILLIAMS, 70 Washington St., Salem, Mass. 01970
JOSEPH B. ZIELINSKI, 3147 Logan Square, Chicago, Ill. 60647



The Objectives of the American College of Dentists

The American College of Dentists, in order to promote the highest ideals in dental care, advance the standards and efficiency of dentistry, develop good human relations and understanding, and extend the benefits of dental health to the greatest number, declares and adopts the following principles and ideals as ways and means for the attainment of these goals:

(a) To urge the development and use of measures for the control and prevention of oral disorders;

(b) To urge broad preparation for such a career at all educational levels;

(c) To encourage graduate studies and continuing educational efforts by dentists;

(d) To encourage, stimulate, and promote research;

(e) To encourage qualified persons to consider a career in dentistry so that the public may be assured of the availability of dental health services now and in the future;

(f) To improve the public understanding and appreciation of oral health service and its importance to the optimum health of the patient through sound public dental health education;

(g) To encourage the free exchange of ideas and experiences in the interest of better service to the patient;

(h) To cooperate with other groups for the advancement of interprofessional relationships in the interest of the public; and

(i) To urge upon the professional man the recognition of his responsibilities in the community as a citizen as well as a contributor in the field of health service;

(j) In order to give encouragement to individuals to further these objectives, and to recognize meritorious achievements and potentials for contributions in dental science, art, education, literature, human relations and other areas that contribute to the human welfare and the promotion of these objectives—by conferring Fellowship in the College on such persons properly selected to receive such honor.

This is from the Preamble to the Constitution and Bylaws of the American College of Dentists.

