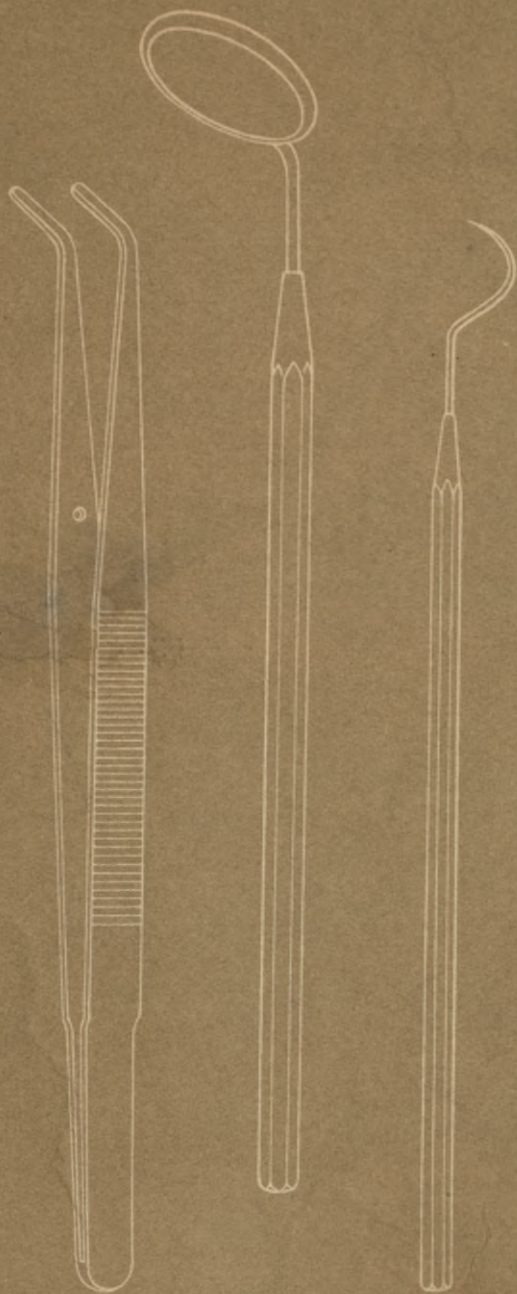


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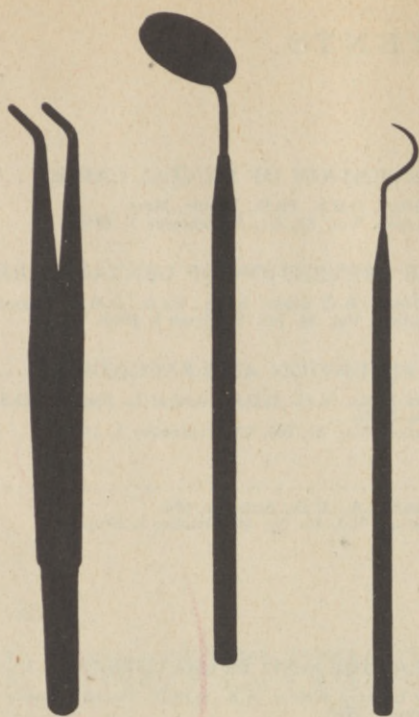
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I. PREVENTIVE DENTISTRY



USE OF FLUORINE IN THE PREVENTION OF DENTAL CARIES

I. RATIONALE AND APPROACH

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MOST of the outstandingly successful methods of preventing disease are those which have had their origins in naturally occurring phenomena of immunity. Vaccination against smallpox, for instance, is a direct outgrowth of the observation that this disease was prevented by infection with cowpox. Immunization against diphtheria is, in a less direct way, an example of the same sort; but, with this disease, practical prophylactic methods could not be established until exact theoretical explanations of the basic reactions between toxin and antitoxin had been worked out.

The story of malaria, pellagra, rickets and many other diseases furnishes further examples of practical methods of control which have resulted from the working out of causal relationships from the study of naturally occurring phenomena of susceptibility or resistance. Indeed, it is seldom that prophylactic procedures can be brought to a practical state without a thorough understanding of the underlying mechanisms responsible for the

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natural immunity. Three steps can generally be recognized in such a development: (1) studies on epidemiology and the phenomena of natural resistance; (2) discovery of the mechanism by which this resistance is brought about, and (3) the working out of methods of utilizing these mechanisms for preventing disease in otherwise susceptible groups. Apparently, this step by step approach has never been fully recognized or conscientiously followed in attempts to work out methods for the control of dental disease. In recent years, sufficient epidemiologic and other evidence has accumulated on the subject of the relationship of fluorine to dental caries to make it profitable to follow the approach outlined above in considering the possibility of preventing caries by some type of fluorine therapy. The remainder of this paper is devoted to such an analysis of our knowledge of the relationship of fluorine to dental caries.

PHENOMENA OF CARIES RESISTANCE IN RELATION TO FLUORINE

The findings in (a) epidemiologic studies, (b) chemical studies and (c)

animal experiments demonstrate convincingly that fluorine acts in some way to prevent dental decay.

Epidemiologic Studies.—For many years, evidence has been accumulating which suggested that, in addition to causing mottling of enamel, fluorine in drinking water also contributed in some way to a reduction of caries. In a series of publications, Dean and his associates have demonstrated that amounts of fluorine below those which cause mottling of enamel would cause a marked reduction in caries activity. The most recent report,¹ which summarizes many of the previous studies, shows that, in twenty-one cities, there was an inverse relationship between the fluorine content of drinking water and the amount of dental caries. Children in cities with one part per million or more of fluorine in the water had only one-third to one-half the caries that children had in cities having a fluorine content of less than 0.5 part per million in the water. It is particularly interesting that this report shows a reduction in caries much more marked in the upper incisors than in other teeth. Communities with fluorine levels above 0.6 part per million had only one-nineteenth of the amount of incisal caries that was present in those using waters with less than 0.5 part per million. In the same groups, the reduction of decay in the molars was only one quarter of that in the incisors. This marked effect on the incisor caries accounts adequately for Arnim, Aberle and Putney's² failure to find a single carious incisor in a thousand Indians examined in an area of endemic fluorosis and, as will be pointed out later, casts light on the mechanism of fluorine action. The low occurrence of dental caries in association with fluorine in drinking water is now a well-recognized clinical phenomenon, noted in many parts of the world. Sognaes' report³ of the dental conditions in Tristan da Cunha is the only one of a situation in which a high fluorine content in

the food (contained in fish, which was the principal item in the diet) has acted to prevent caries.

Chemical Studies.—It has been shown that caries-resistant teeth have a higher fluorine content than do caries-susceptible teeth. Armstrong's figures⁴ for caries-resistant teeth are: enamel, 0.0111 mg., and dentin, 0.0169 mg., per hundred cubic centimeters; and for caries-susceptible teeth: enamel, 0.0069 mg., and dentin, 0.0158 mg., per hundred cubic centimeters. In view of ideas to be developed later in this paper, it is important to note that the principal increase of fluorine in the caries-free teeth was in the enamel and that the increase in the fluorine content of the dentin was negligible.

Animal Experiments.—Although experimental caries in rats bears only a slight resemblance to human dental decay,⁵ it has, until recently, provided the only practical means of studying caries by animal experimentation. Obviously, because of the differences between this condition and human caries, conclusions from this source must be accepted with caution. Nevertheless, the demonstration by a number of workers^{6, 7} that rat caries can be prevented by adding fluorides to the drinking water or food or by intra-oral administration even without ingestion⁸ must be regarded as additional strong evidence that fluorine can protect the teeth against caries. Other studies on rat caries, which will be referred to later, have contributed to an understanding of the mechanism by which fluorine prevents decay.

The foregoing summary of the findings in three different fields of scientific study shows clearly that fluorine acts in some way to prevent caries in man, and that, as a result of this action, a natural resistance to caries occurs in large population groups. Thus, dentistry is presented with a phenomenon of naturally occurring disease resistance and is given an opportunity to interpret this phenomenon

so that it can be turned into an effective and practical method of caries prophylaxis.

MECHANISM BY WHICH FLUORINE
PREVENTS DENTAL CARIES

In considering the possible ways by which fluorine could prevent or limit the progress of dental caries, one has to recognize the views both of those who believe that caries is the result primarily of systemic conditions and of those who believe that changes on the tooth surface are all-important. These possibilities can be adequately dealt with by considering, under three heads, the different mechanisms so far suggested for the action of fluorine: (1) that the systemic effects of fluorine on the erupted or unerupted teeth bring about changes which increase their resistance to caries; (2) that fluorine acts through the saliva to add to the resistance of the teeth or weaken the attack of caries, and (3) that fluorine influences the mechanism of acid production and tooth decalcification at the tooth surface.

The Systemic Effects of Fluorine.—*Unerupted teeth:* Early studies⁹ on rats indicated that animals fed a high fluoride diet before the teeth erupted were less susceptible to "experimental caries" than rats not receiving a fluoride supplement. It was inferred from this that caries resistance in man was also the result of preeruptive changes in the teeth brought about by ingestion of fluorine. There are two reasons for questioning this conclusion: First, as has already been pointed out, "experimental caries" in rats is not completely comparable to human caries and the findings have only a limited significance for man. Second, similar studies¹⁰ have had contradictory results. An indication that fluorine taken during tooth formation may influence caries activity in human beings can be found in Dean's observation¹¹ of an apparent added resistance to decay in children of Bauxite who had used fluorine-contain-

ing water only during the early years of life. The extent of caries reduction resulting from use of fluorides during the first eight years of life (which must of necessity include posteruptive effects on certain teeth) is apparently less than half of that resulting from use extending into adult life.¹² That factors operating after tooth formation are more important than those operating during that period is suggested by the fact that caries reduction in the first permanent molars is only about one quarter of what it is in the incisors¹ despite the fact that the two types of teeth are formed at the same time of life.

Erupted Teeth.—Because enamel and dentin are almost completely inert tissues, it seems unlikely that caries is prevented by metabolic effects of fluorine on the teeth. However, since there is accurate experimental evidence,¹³ obtained by the use of radio-active isotopes, that phosphorus turnover in the enamel is as much as 10 per cent of that in the dentin and 2 per cent of that in the alveolar bone, the possibility of some low-grade metabolic influence must be admitted. Animal experiments¹⁴ have shown that some radio-active fluorine enters the teeth from the blood stream or saliva, but, in addition, they have demonstrated that this element is not concentrated in either the enamel or the dentin in the same way that it is in the bone. Further, because the bulk of ingested fluorine is rapidly excreted in the urine,¹⁴ the amount reaching the teeth is certainly minute enough to have very doubtful significance. This is particularly true when it is recalled that the fluorine would have to be concentrated in the enamel if the distribution of fluorine associated with caries resistance in man⁴ were to obtain. There is evidence⁵ that this does not occur when fluorine is fed to animals. On the other hand, such administration of fluorine to rats does increase the fluorine content of the dentin.¹⁵ (The reduced occurrence of "ex-

perimental caries" in rats associated with this fluorine increase in the dentin is almost certainly explicable on the basis of the difference between "experimental caries" and human caries.⁵⁾

Salivary Effects of Fluorine.—Because it is in continuous contact with the tooth surfaces and because it may reflect systemic conditions, the saliva has to be considered as a possible intermediary agent in the action of fluorine. Studies with partially desalivated rats led Cheyne¹⁶ to conclude "that saliva is of vast importance especially as it acts to transport the caries-inhibitory factor." However, in a reinterpretation of the same experiments,¹⁷ he abandoned this opinion. Sognaes expanded the same experimental approach, using local applications⁸ and stomach tube administration of fluorides, and was able to demonstrate that the presence or absence of salivary glands did not influence the progress of caries in rats, thus indicating that the saliva was not the instrument by which either local or systemic effects of fluorine were brought about. A further indication that saliva is unimportant is found in studies with radio-active fluorine^{14, 19} which revealed that great increases of fluorine in the blood do not significantly change the fluorine content of the saliva. The absence of differences between the fluorine content of saliva of children using fluoride-containing water (low caries) and children using fluorine-free water (high caries) supports this conclusion.²⁰ Finally, the most striking evidence that saliva is of no importance in bringing about fluorine resistance to caries is found in the previously recorded clinical studies¹ that fluorine is four times as effective in reducing caries in the upper incisor teeth, where salivary influences are at a minimum, as in the molars where this effect is maximal. When considered together, these findings establish definitely that caries reduction by fluorine is brought about without the intermediary action of saliva.

3. *Effects of Fluorine on Acid Production and Acid Resistance of Teeth.*—Recent studies²¹ on various aspects of dental caries have greatly strengthened the idea that this disease is primarily the result of the destruction of enamel and then dentin by the action of locally formed acids. It is conceded that a variety of local and systemic conditions modify the speed of tooth destruction, but as yet no mechanism for tooth destruction other than the action of acid has been demonstrated. Consequently, considerations of local factors in caries must deal mainly with the effects of fluorine on the formation of acids, and its possible influence on the resistance of enamel and dentin to acids. A fuller discussion of these questions has been presented elsewhere.²²

Acid formation: Since the formation of acids in the mouth is the result of decomposition of carbohydrates, it is necessary to consider the effects of fluorine on this process. There is no reason to believe that fluorine interferes with the breakdown of starches to sugar. Indeed, McClure²³ has shown that concentrations of fluorine such as might be met with in the mouth cause no limitation of diastatic activity, and that the saliva of children using water with 1.8 parts per million of fluorine does not differ in its ability to break down starch from that of children using fluorine-free water. There is, however, much evidence²⁴ that fluorine can interfere with the later and more important phase of carbohydrate breakdown, the formation of acids from sugar. Fluorine contained in fluorosed teeth has a kindred effect. It is possible, therefore, that this action of fluorine may contribute toward a reduction in the activity of caries.

Tooth resistance: Fluorine might add to the resistance of the teeth by acting in some way to increase the capacity of the teeth to repair themselves. Laboratory and clinical evidence that this type of reaction does not

occur has been offered earlier in this paper.

Again, incorporation of fluorine in the teeth, regardless of its manner of acquisition, might add to their ability to withstand the action of mouth acids. That this is very likely is suggested by the action of fluorine in reducing the solubility of rock phosphate.²⁵ That a similar effect is actually brought about on the teeth by fluorine was demonstrated by Volker.²⁶ When this is considered, in conjunction with the findings⁴ that human teeth with a high fluorine content in the enamel are more resistant to decay than those with less fluorine, we have the strongest kind of evidence that the caries resistance associated with fluorine is primarily the result of an increased content of this element in the dental enamel. Of all the possibilities considered, this seems to be the only one which adequately explains all of the clinical and laboratory findings. The increased fluorine in the teeth could delay caries either by adding to their acid resistance or, to a lesser extent, by limiting acid production in the immediate vicinity of the enamel.²⁴ We must conclude, then, that this is the principal way in which fluorine acts to reduce dental caries.

Manner of Acquisition of Fluorine by the Teeth.—Since the evidence offered so far indicates that salivary action and preeruptive or systemic influences on the teeth are relatively unimportant in influencing fluorine resistance to caries, the conclusion just reached is essentially a negative one, unless an explanation of how the fluorine reaches the enamel is provided. Fortunately, a satisfactory answer can be supplied.

For some time, there has been evidence in the literature that bone combined actively with fluorides. Half a century ago, Carnot²⁷ demonstrated that the fluorine content of bone was increased by immersing it in fluoride solutions. This reaction between fluorides

and bone phosphates is apparently a very active one because contact with bone²⁸ or hydroxylapatite²⁹ will remove fluorine from drinking water. That the chemically similar phosphates of tooth enamel and dentin react similarly was demonstrated by Volker, who, using radio-active isotopes and solubility tests, showed that a short exposure of enamel and dentin to fluoride solutions resulted in a rapid reaction with fluorine,³⁰ causing a marked reduction in their solubility in acid.³¹ Recently, this key finding that fluorine combines actively with the teeth has been confirmed by chemical analysis of teeth immersed for short periods of time in sodium fluoride solutions³² or brushed with fluorapatite.³³ From this evidence, it may be concluded that a lowered acid-solubility of the teeth results from an increased fluorine content of the enamel and dentin, which is brought about principally by a direct reaction between the fluorine of fluoride-containing water and the tooth enamel, independently of the ingestion of fluorine or its absorption into the system. Additional support for this conclusion can be found in the experiments of Perry and Armstrong³⁴ and Sognaes.⁸ The former showed that increases in the fluorine content of the enamel of rats' teeth resulted from direct contact between the teeth and fluoride-containing drinking water and not from passage of the fluorine into the system. The latter demonstrated that caries in rats could be prevented by direct applications of fluorides to the teeth even when none of the fluoride was swallowed.

This explanation of the mode of action of fluorine is in complete accord with clinical findings. If a direct combination takes place between the fluorine of the water and the tooth enamel, the degree of protection accorded to the different teeth should be proportionate to the extent of their contact with the water. Thus, the upper anterior teeth which come in greatest contact with the

fluoride-containing water during the act of drinking should be most benefited, whereas other teeth, such as the molars, which have less contact with the water, should show less caries reduction. The clinical studies¹ quoted at the beginning of this paper show that this is the case, the reduction of caries in the upper anterior teeth being more than four times greater than that in the molars.

Conclusion.—The contents of the foregoing section can be briefly summarized by stating that attempts to explain the action of fluorine in preventing dental caries on the basis of its effects on tooth formation, tooth metabolism or salivary action were unsuccessful, but that a satisfactory explanation, which is supported by all existing laboratory and clinical evidence, is provided by postulating that the increased resistance to caries is the result of a direct acquisition of fluorine by the tooth enamel from fluorine-containing waters or foods. This is apparently the result of a peculiar affinity which exists between calcium phosphates of the sort occurring in bones and teeth and fluorine, which results in a rapid reaction between fluorides of the water and the teeth. When fluorine combines with enamel or dentin, it greatly reduces their solubility in acid. This increased resistance to the action of acid is probably the primary cause for the reduction of caries in teeth which have come in contact with fluoride-containing waters.

UTILIZATION OF FLUORINE IN THE PREVENTION OF DENTAL CARIES

It seems that the simplest and most direct approach to the use of fluorine to reduce caries would be an increase of the fluorine content of the water supplies in caries-susceptible areas so that it would be the same as that of communities with little decay. If there were no complicating factors, which there almost certainly would be, this could be accomplished by adding fluorides to the

water to bring about a fluorine content of one part per million. Such concentrations of fluorine should reduce caries activity without causing mottling of the enamel. The use of fluorine supplements in water supplies has been advocated by Cox³⁵ as a means of combating dental decay. Experimental tests of this procedure are under consideration at this time.

One disadvantage of adding fluorine to the water supply is that there is reason³⁶ to believe that a fluorine supplement in a soft water would be absorbed to a different extent from that present when the same supplement was added to hard water or occurred naturally. Further, individual variations in water consumption, diet or metabolism would probably produce uneven results in different children. These factors make it difficult to establish a universally satisfactory level of fluorine intake which will confer the advantages of caries prevention without the risk of producing mottling of the enamel or other as yet unknown undesirable effects which may result from continuous ingestion of fluorine. Another disadvantage of this approach is that the greatest caries reduction which could be expected to result from using drinking water containing 1 part per million of fluorine, a concentration which produces sporadic mild mottling of enamel, would be no greater than the approximately 50 per cent reduction shown to result¹ when like concentrations of fluorine occur naturally in the water. A reduction of caries to one-half is, of course, no more the desideratum than the direct infection with cowpox was the ultimate achievement in the prevention of smallpox. The aim in programs of caries prophylaxis should be to reduce caries in all teeth at least to the extent to which fluorine reduces decay in the anterior teeth; namely, by from 90 to 95 per cent of its normal incidence.¹ To accomplish this, it seems obvious that more refined methods of use than simple

addition to the drinking water must be worked out.

In consideration of the mode of action of fluorine, it was concluded that the anterior teeth showed their phenomenal resistance to caries because they alone came into repeated direct contact with fluorine-containing water. Therefore, because the reaction between fluorine and the enamel is a very rapid one, it seems likely that direct applications of fluorine-containing fluids to the teeth would reduce caries. Moreover, if our conclusion on the mode of action of fluorine is correct, the extent of the reduction should be approximately equal in all teeth.

This possibility has recently been tested in a clinical study in Brockton.³⁷ ³⁸ Three times a year for two years, applications of 1/1,000 sodium fluoride were made to the teeth of one of the four quadrants of the jaws of a group of 100 children, and the progress of caries was compared with that in the opposite (control) quadrant of the same jaw. Re-examination at the end of the first and second year showed a striking reduction of caries in the treated quadrants. In the test quadrants of eighty patients completing two years of treatment, eighty-three new cavities appeared; whereas, the corresponding untreated control quadrants in the same jaw, but other side of the mouth, there were 124 new cavities. There was less difference in questionable caries (fillings, questionable caries and cavity enlargements), the test and control figures being 90 and 115. The reduction of caries in the molars (40 per cent) and bicuspid (33 per cent) was essentially the same as in the anterior teeth (34 per cent).

These results, which have received confirmation in a more limited study,³⁴ not only prove the correctness of our general conclusion regarding the mode of action of fluorine and the accuracy of our explanation of the different degrees of caries reduction in incisors and molars when fluorine is taken in the

drinking water, but also show that application of fluorine directly to the teeth will reduce caries, even though it is not taken into the system. There is no reason to believe that the caries reduction brought about in our study represents the best result obtainable by this general method. Since contact with fluorides in the drinking water reduces caries in the anterior teeth by as much as 95 per cent,¹ it is not unreasonable to expect that a similar reduction could be brought about in all teeth when improved methods of making local applications are worked out.

It is possible that this end could be accomplished either by giving more frequent fluoride treatments or by increasing the reactivity of the fluorides. The former could be accomplished (a) by having dentists or dental hygienists give frequent treatments, or modified treatments, of the kind given in the Brockton experiment; (b) by having patients apply fluoride-containing preparations to their own teeth as part of their regime of oral hygiene, or (c) by subjecting the teeth to a concentrated series of fluoride treatments during a period of a few days. All these methods are now being investigated in various parts of the country, and the relative effectiveness of each approach should soon be known. We have been able to make some progress in the latter direction⁴⁰ and will report progress toward increasing the solubility reducing effects of fluorides in another paper.

The foregoing represent only a few of the possible ways in which fluorides can be used to control caries. It is likely, for instance, that the reaction between fluorine and the teeth could be increased by means of electrophoresis, thereby bringing about a greater reduction in tooth solubility. It is also probable that a prolonged contact of fluorides with the teeth and a resultant increase in the solubility-reducing effect could be brought about by incorporating fluorides in such materials as celloidin, which would adhere

to the teeth for long periods of time. These represent only some of the methods which could be used to bring about solubility-reducing effects on the teeth. Until these and other approaches have been thoroughly investigated, it will be too soon to conclude that it is impossible, by means of direct fluoride treatments of the teeth, to reduce caries in all teeth to the extent that fluoride impregnation from the drinking water reduces it in the anterior teeth.

GENERAL SUMMARY AND CONCLUSIONS

The thesis is advanced that the most profitable approach to disease prevention is through the study and interpretation of natural phenomena of disease resistance.

Evidence from clinical studies, chemical analyses of teeth and animal experimentation is quoted to show that a naturally occurring phenomenon of resistance to dental caries is associated with the action of fluorine.

The evidence relating to the possible ways in which fluorine could act to prevent dental caries is examined. It is concluded that its action is principally the result of an increased fluorine content of the tooth enamel which is not brought about by preruptive or subsequent systemic effects on the tooth. This fluoride increment in the enamel makes the teeth less soluble in acids and may also exert a minor secondary effect by reducing acid production by bacteria in its immediate vicinity.

On the basis of geologic data and laboratory experiments with teeth, it is shown that the enamel can acquire fluorine after the teeth are erupted through the medium of direct external contact with fluoride-containing waters. This is offered as the mechanism by which the teeth acquire fluorine and an added resistance to caries.

From this conclusion, it is postulated that treatments of the teeth with fluoride-containing solutions would reduce dental caries. Clinical tests are quoted to show

that caries can be reduced by at least 30 per cent by such a procedure.

In a discussion of possible methods of using fluoride therapy to prevent dental caries, it is concluded that the addition of fluorine to water supplies will probably yield a smaller reduction in dental caries than it will ultimately be possible to bring about by refinement of the general method of direct application of fluoride to the teeth.

CONCLUDING COMMENT

The work of establishing the influence of fluorine in controlling dental caries which has been summarized in this paper may well come to be recognized as the most important series of investigations in the recorded history of dentistry. Whether this turns out to be the case or not will depend on the course of research on the subject in future years. At worst, attempts to produce a significant reduction of caries by practical measures of fluorine therapy may fail or produce undesirable results of an unpredictable sort. Disappointment or reaction might then lead to a premature abandonment of this approach to caries control. At best, a number of effective ways of controlling caries by fluorine therapy may be worked out; or information obtained from such studies may lead to effective chemical therapy by agents other than fluorides.

Since it is unlikely that even at its most effective level fluorine therapy will entirely prevent tooth decay, other approaches to caries prevention should be continuously explored. Progress toward prevention can undoubtedly be made by furthering our knowledge of the effects of selection of carbohydrates which do not readily undergo fermentation, or which are rapidly eliminated from the mouth. Initial work in these fields gives great promise and, if fully exploited, might provide successful methods of caries prevention. The immediate possibilities for the control of caries are extremely bright. It is more than likely

that, in the near future, really effective procedures for caries prevention will be available, methods which will make such low demands on time and money that they will be attractive and profitable for patients, dentists and public health organizations alike. That such possibilities are now within our reach should serve as a challenge to all who are able to carry out or support work in the field of dental caries or public health.

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THE USE OF FLUORINE IN THE PREVENTION OF DENTAL CARIES

II. EFFECT OF SODIUM FLUORIDE APPLICATIONS

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IN two previous papers,^{1, 2} the available information touching on the action of fluorine in preventing dental caries was analyzed, and the conclusion was reached that the caries-preventing effect of fluorine is principally the result of a direct reaction between the external surfaces of the erupted teeth and fluorides in the drinking water or food. In these papers, it is suggested that the fluorine content of the teeth and their consequent resistance to caries could be increased by bringing them in contact with solutions of fluorides or other fluorine-containing preparations. If actual clinical test proved that this was the case, not only would convincing proof of our conclusion on the mode of action of fluorine be provided, but also a new and important approach to caries prevention could be established. For these reasons, it became important to make a clinical study of the effect of applications of fluoride on the activity of dental caries.

STUDY GROUP

Through the assistance of Dr. Florence Hopkins, of the Dental Unit of the Mass-

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achusetts Department of Health, and Mr. John Miller, then superintendent of the Brockton Schools, it became possible to carry out a study on the children attending Brockton Schools and to use the facilities of the school dental clinic. Because more new caries appears immediately after the eruption of the second molars, cuspid and bicuspids, and because the appearance of these teeth provides a new "caries-susceptible population" in the mouth, children from 10 to 13 years of age were chosen as most likely to reveal any caries-preventing effects from our treatments. A group of 100 children in this age group were selected by Miss Marie Blake, dental hygienist in the Brockton Schools, on the basis of willingness to cooperate, parental consent and, when there was one, the approval of the family dentist. At the beginning of the experiment, the age distribution of children was as follows: 10 to 10.5 years, 15; 10.5 to 11 years, 10; 11 to 11.5 years, 21; 11.5 to 12 years, 15; 12 to 12.5 years, 12; 12.5 to 13 years, 3; 13 years, 4. The group was of mixed racial and national background, nineteen claiming American parentage,

fourteen Italian, eleven Irish, ten French, seven Syrian, three Swedish, three Lithuanian and two Polish, with single representatives of other groups or national mixtures.

Most of the children were receiving regular dental treatment at the school clinic, but some were ineligible, others would not submit to dental care and a

health manifested themselves, but an unexpectedly high percentage showed microscopic hypoplasia of the teeth (Mellanby) or other signs of malnutrition. Largely as a result of changing conditions associated with defense employment, a number of children were lost during the period of the study. Ninety of the original 100 children were exam-

TABLE 1.—CARIES INCREASE BETWEEN FIRST AND SECOND EXAMINATIONS

No. of Patients Reporting for Both Examinations	Fluoride Treated Quadrants					Untreated Control Quadrants				
	First Examination			Reexamination		First Examination			Reexamination	
	Quadrant	No. of Teeth	No. of Affected Surfaces	New Caries	Questionable Change	Quadrant	No. of Teeth	No. of Affected Surfaces	New Caries	Questionable Change
27	UR	144	69	7	16	UL	145	69	21	17
17	LR	100	32	8	11	LL	97	29	12	21
24	UL	139	74	8	19	UR	139	88	13	21
22	LL	117	37	10	16	LR	115	38	15	17
90		500	212	33	62		496	224	61	76

TABLE 2.—CARIES INCREASE BETWEEN FIRST AND THIRD EXAMINATIONS

No. of Patients Reporting for Both Examinations	Fluoride Treated Quadrants					Untreated Control Quadrants				
	First Examination			Third Examination		First Examination			Third Examination	
	Quadrant	No. of Teeth	No. of Affected Surfaces	New Caries	Questionable Change	Quadrant	No. of Teeth	No. of Affected Surfaces	New Caries	Questionable Change
24	UR	132	56	21	34	UL	133	54	46	31
17	LR	100	41	14	15	LL	97	40	15	30
21	UL	133	51	22	26	UR	133	64	40	29
18	LL	99	52	26	15	LR	97	41	23	25
80		464	200	83	90		460	199	124	115

few had their own dentists. The state of the teeth was not considered in choosing the experimental group. The children evidenced considerable variation in caries-susceptibility, three showing complete absence of caries and two having cavities or fillings in virtually every existing tooth. The remainder had between one and five affected permanent teeth. The usual variations in physique and

ined at the end of the first year, and only eighty were available at the end of the two-year study.

FLUORIDE TREATMENTS

Fluoride treatments were given in only one quadrant of each mouth. Different quadrants were selected and treated in different patients, so that an approximately equal number of each quadrant

(upper left, lower left, upper right or lower right) were used for test purposes. The quadrant on the opposite side of the same jaw was used as a control. Because laboratory study had shown that 1/1,000 sodium fluoride solution was almost as effective in reducing the solubility of enamel and dentin as were higher concentrations, an aqueous solution of this strength was chosen for use in the mouth. A routine dental prophylaxis with pumice and peroxide was given by the dental

with cotton swabs, alcohol and air. Thereafter, all surfaces of the controlled teeth were kept wet with the 1/1,000 sodium fluoride solution for seven or eight minutes by means of repeated applications of the solution on cotton wool. In some instances, the fluoride solution was worked into tooth fissures by means of an explorer. On completion of treatment, the excess fluoride was removed with the absorbent roll or cotton swabs and the mouth thoroughly rinsed with

TABLE 3.—CARIES INCREMENT DURING TWO YEARS OF FLUORINE THERAPY

Test Period	Number of Children Completing Period of Study	Test Quadrants			Control Quadrants		
		New Caries	Questionable Change	Total Caries Increase	New Caries	Questionable Change	Total Caries
1 year	90	32	69	101	59	82	141
2 years	80	83	90	173	124	115	239

TABLE 4.—CARIES INCREASE IN VARIOUS TEETH IN EIGHTY PATIENTS

Tooth Group	Procedure	New Caries	Questionable Change	Total Caries	Percentage Reduction
Incisors and Cuspids	Test	12	14	26	26
	Control	23	12	35	
Bicuspid	Test	12	18	30	25
	Control	14	26	40	
Molars	Test	59	58	117	29
	Control	87	77	164	

hygienist to all the teeth in the mouth from two to twenty-four hours before the fluoride treatment was given.

The procedure employed was as follows: Both the test and control quadrants were swabbed with hydrogen peroxide to remove any adherent debris and, as far as possible, to clean out tooth crevices and interproximal spaces. The mouth was then washed out with water. The test side was isolated with cotton rolls and the surfaces of the teeth were dried

water. Treatments of this sort were given at intervals of approximately four months during the period of the study, and thus each patient received six treatments prior to the final examination.

CARIES EXAMINATION

The amount of caries in each mouth was determined by means of a mirror and probe. Graphic recordings were made of each tooth, showing the extent of the caries present and the size and

location of any fillings. Extracted, unerupted or erupting teeth were recorded as such. As in all examinations of this kind, many areas were found that could not be definitely called either carious or caries-free. Such areas were listed separately under "questionable change." The second examination was made after a period of one year, immediately before the fourth fluoride treatment. The third examination was carried out after a two-year period, at the termination of the experiment. Changes in the condition of the teeth were observed for each patient

surfaces that were carious in the corresponding control quadrants, and seventy-six caries-free surfaces in the control quadrants that were carious on the test side. In view of the normal symmetry of the attack of caries, this may be taken to indicate that there would be a slightly greater predisposition to caries in the test as compared with the control quadrants.

RESULTS OF FLUORIDE TREATMENTS

The results of the examination of the ninety patients who completed the first

TABLE 5.—LOCATION OF NEW CARIES AND QUESTIONABLE AREAS

	Total for Teeth		Percentage of Total Occurring in Different Locations											
	New	Questionable	Occlusal		Mesial and Distal		Buccal		Lingual		Bucco-gingival		Linguo-gingival	
			New	Questionable	New	Questionable	New	Questionable	New	Questionable	New	Questionable	New	Questionable
Molars Treated	59	58	61	71	17	10	10	7	0	3	3	9	8	0
Control	87	77	59	68	16	9	8	16	5	0	7	6	6	1
Bicuspids Treated	12	18	50	67	50	28	0	0	0	0	0	6	0	0
Control	14	26	50	65	43	26	0	0	8	0	0	8	0	0
Incisors and Cuspids Treated	12	14	0	0	100	93	0	0	0	7	0	0	0	0
Control	23	12	0	0	92	92	0	8	4	0	4	0	0	0

showing any new caries or questionable changes on previously intact tooth surfaces, increases in the size of existing cavities and new fillings placed in areas previously recorded as sound. In the original examination, the amount of caries in the test and control quadrants was about the same, the test quadrants having 212 affected surfaces that were carious and the corresponding controls on the other side, 224. In the test quadrants, there were ninety-one caries-free

year and the eighty who completed the second year of treatment are given in Tables 1 and 2. In these tables, questionable new caries, areas previously caries-free that had been filled and cavities that had shown a definite increase in size are grouped under "questionable change." The increases in caries during the first year and during the two-year period are summarized in Table 3. The three tables show that the caries increase in the quadrants treated with sodium

fluoride is considerably less than that in the untreated or control quadrants. At the termination of the study, the former showed an increase of 173 definite and questionable cavities as compared with 239 in the latter. The striking aspect of the findings is that the greatest reduction was in the new caries. Over the two-year period, there were only eighty-three definite new cavities in the treated, as compared with 124 in the control, quadrants. During the first year, the relative decrease in new caries was even more marked. Table 4 shows that the action of fluorides was effective on all types of teeth. Clinical observations seemed to indicate that the fluoride applications were particularly effective in controlling smooth surface caries, especially that occurring about the gingival margins in very susceptible patients. However, Table 5, which compares the caries-reducing effect on different surfaces of the teeth, does not offer any support for this impression.

DISCUSSION

The findings just presented offer definite proof that the activity of caries can be reduced by application of sodium fluoride to the surfaces of the teeth. Thus, support is given to our previously stated conclusion^{1, 2} that fluorine acts to prevent caries principally by combining directly with the enamel surface to increase its resistance to the action of acid. More important than this is the possible bearing of these findings on the prevention of dental decay. The fact that such a marked reduction in caries can be produced by as few as three treatments³ with the fluoride solutions indicates the great potentialities of fluorine-containing reagents in the field of preventive dentistry. It seems obvious that if infrequent treatment can cause such definite changes in the progress of caries, more frequent treatment, the use of improved technics of application or treatment using a more active fluorine reagent might accomplish

a great deal more in the control of dental decay. Even if the results obtained in these experiments are not improved upon, an important practical step toward caries prevention has been made.

Topical application of fluorides to the teeth represents only one of many ways in which fluorine therapy could be used to prevent dental decay. An earlier paper² mentions a number of other possibilities, some of which are already on trial. Because improvements in methods of fluoride therapy will come only with time and continued experiment, there is a question as to how long dentists should wait before they put fluoride treatment into general use for caries prophylaxis. There is little doubt that if this procedure is not utilized fairly quickly by the dental profession, it will be presented to the public by other agencies. Provided suitable precautions are taken to prevent the swallowing of fluoride solutions, there seems to be no reason why dentists should not begin to use fluoride treatments of the sort described above on the teeth of caries-susceptible patients. Largent⁴ has indicated that such sodium fluoride treatments "can be carried out without appreciable systemic absorption of the material."

SUMMARY

Experiments on eighty children over a period of two years showed that six topical application of a 1/1,000 sodium fluoride solution reduced dental caries by somewhat more than one-third as compared with results in the corresponding untreated quadrants in the same mouth.

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RAMPANT DENTAL CARIES: PREVENTION AND PROGNOSIS

A FIVE YEAR CLINICAL SURVEY

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INTRODUCTION

THE prevention and prognosis of rampant dental caries have long been two of the most important and baffling problems confronting the dental and medical professions. In spite of recent developments in the field of preventive dentistry, the concept still prevails that the control* and prevention of dental caries rest entirely with operative procedures. This purely symptomatic treatment of filling cavities is used with-

out consideration of etiologic factors. Consequently, the disease continues to occur, often with increasing frequency. The present war emergency is bringing out with striking emphasis the fact that mechanical means alone are inadequate to meet this problem, especially since the dental manpower of the nation is insufficient to take care of the reparative needs of both the armed forces and the civilian population. It is urgently neces-

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*In the past, the term "control of dental caries" has had the misfortune of a wide variety of interpretations. These ranged from the concept that "control" was achieved by repair of affected areas, to the attitude of mind which considered "control" as concerned with the correction of the fundamental etiologic factors. Because of its possible misinterpretation, the term "control" has been avoided in this report.

sary, therefore, to explore the possibilities of prevention.

Several procedures have been suggested in the past. Some had as their main aim the removal of acidogenic micro-organisms from the mouth, which, since the time of W. D. Miller, have been suspected of being responsible for the production of this disease. Most of these procedures have been found to be impractical and disappointingly unsuccessful owing largely to the necessity of waiting for a period of from six months to a year to test the effectiveness of any correction. The many changes that occur during such a long period of time greatly obscure the accuracy of observations. However, the introduction of an immediate quantitative laboratory test by Hadley, Bunting and Delves in 1930¹ provided a mechanism to determine caries activity at any given time by the presence of *Lactobacillus acidophilus*. Its application was first tested by Bunting, Jay *et al.*^{2, 3, 4, 5, 6, 7, 8} and confirmed by Becks,⁹ Enright, Friesell and Trescher¹⁰ and Thompson.¹¹

These preliminary studies offered great possibilities and it became increasingly apparent that this concept should undergo a thorough testing on a sufficient amount of material to determine its validity and practical value. For this purpose, a program was developed in 1937 which had as its objective answers to the following questions:

1. Is *L. acidophilus* consistently present during dental caries activity and absent during caries inactivity?

2. Is the reduction of refined carbohydrate intake effective in reducing the *L. acidophilus* index?

3. Is the reduction of a high *L. acidophilus* index accompanied by a reduction in dental caries frequency?

MATERIAL AND PROCEDURE

The project was divided into two parts:

1. A study of the association of dental

caries and *L. acidophilus* indices in two groups: (a) Individuals with rampant dental caries. (b) Individuals who are completely caries-free.

The rampant caries group comprised 1,250 individuals, 572 males and 678 females, who had applied for preventive service during the last five years and ranged in age from 4 to 60 years. Approximately half were 18 years or younger. For purposes of standardization, only individuals who developed ten or more cavities within the preceding year were accepted as having rampant dental caries.

The group completely caries-free was obtained from the student body of the University of California in Berkeley, comprising 265 individuals between the ages of 18 and 54 years, including 170 males and ninety-five females. A preliminary report on some of these individuals has been made by Henningsen¹² and Collins, Jensen and Becks.¹³ Their selection was based on clinical and roentgenographic oral examinations. The *L. acidophilus* indices were made for both groups on each of two successive days in order to determine whether a definite relationship exists.

2. A study of the effect of reducing the intake of refined carbohydrates on the *L. acidophilus* index and subsequent caries experience in a large number of individuals with rampant dental caries.

For this purpose, a five-year study was planned and the interval of one year was selected as the basic observation time. When the periods between the dental examinations varied from the one-year standard, the record was allocated to the nearest unit of one year. Through the cooperation of dentists and physicians who referred their most problematic cases, more than a thousand individuals with rampant caries were served in this five-year interval. From these, a total of 790 one-year observations were made, 499 being observed for one year, 111 for two, fifteen for three and six for four years.

Their ages ranged from 4 to 60 years in 272 males and 359 females. Since each one-year observation represents the experience of one individual during that period, for simplification reference will be made to individuals rather than to one-year observations.

In order to recognize and evaluate the activity of dental caries accurately, it was necessary to follow meticulously a standardized plan of examination so that all findings would be comparable. For this purpose, a staff of instructors and clinical assistants were assembled and trained. The standard method adopted included:

1. Clinical and roentgenographic oral examinations.
2. *L. acidophilus* index determination.
3. Evaluation and change in food intake.

In order to familiarize the referring dentist or physician with the procedure, complete sets of instructions were sent on request.*

Clinical and Roentgenographic Oral Examinations.—In order to enable the examiner to compute the caries experience from successive examinations over an extended period of time, it was necessary to establish a systematic procedure of dental examination and an exact system of recording. For this purpose, all filled and unfilled carious areas were charted. The Bodecker Caries Index¹⁴ was used to express the total carious areas involved, and any change found on a subsequent examination was similarly recorded. This readily allowed the observation of primary (new) or secondary caries (new involvement of areas previously restored). For purposes of consistency and accuracy, each case was followed through by a team of examiners. From the standpoint of roentgenographic interpretation, the slightest observable nick or break in the regular contour of the enamel was noted and charted for

each area. Even though it was desirable to have an entire denture roentgenogram available, posterior bite-wing films were accepted as the minimum requirement and were retaken once a year. The clinical oral examinations were repeated at least once a year and in many instances semiannually.

L. Acidophilus Index Determinations.—The method employed for the determination of the *L. acidophilus* index was that described by Hadley.¹⁵ Initial saliva specimens were obtained on two successive days, again one week after the change in food intake and monthly thereafter unless lack of response necessitated more frequent checks. These specimens were collected in the morning before breakfast and before brushing the teeth. The patient was instructed to chew vigorously a 1-gm. piece of paraffin 100 times on each side of the mouth and to expectorate all accumulating saliva into a sterile bottle. Mailing containers with detailed instructions, paraffin and sterile bottle were provided. Immediately upon receipt of the specimen, the saliva was plated, and incubated for four days. The colonies were then identified and counted. Routine reports were forwarded to both the referring dentist or physician and the patient.

Evaluation and Change of Food Intake.—For purposes of listing the food taken, a record form was made available to the patient with careful instructions to record food intake for a typical one-week period. Times of unusual activity, such as vacations, trips and holidays, were avoided. Indications of food preferences and dislikes were made, on both the basis of taste and the allergic reaction. Each patient was questioned as to the condition of physical health, recent illnesses or any systemic disturbances of which they were aware. This was done to facilitate collaboration with medical counsel as well as to avoid interference with any recommendations concerning food intake.

*These are available by addressing the Division of Dental Medicine, University of California, Medical Center, San Francisco, Calif.

In evaluating these records, the amounts of refined carbohydrates were estimated and sugars and concentrated sweets were expressed in equivalents of teaspoonfuls of sugar.¹³ The totals for the week were then averaged for daily consumption. The value of such records is, of course, open to question for at least the following reasons: 1. Difficulty in securing a record that is a typical sample of food intake. 2. Incomplete recording of kinds and amounts of foods eaten. 3. Variation in sources and preparation of foods affecting the amounts of nutrients. 4. Individual variations in efficiency of digestion, assimilation and utilization.

In the future, quantitative analytic methods of determining the amounts of various nutrients in tissues and body fluids will possibly replace the present rather inadequate methods of assessing the food intake. However, until such methods have been satisfactorily established, it is necessary to resort to evaluations which give at least an index to the trend.

When the patient was first referred, arrangements were made to secure the salivary specimens, a record of the food intake for a period of seven days and entire denture or bite-wing roentgenograms. After an interval of approximately ten days, in which time these data were received and the *L. acidophilus* index determined, the patient was recalled for a detailed oral examination and consultation:

The first recommendations for a change of food intake were based on the number of *L. acidophilus* present and the amounts of refined carbohydrates consumed. In general, this required restriction of the following foods: sugar in and on foods; all concentrated sweets such as jam, jelly, syrup, honey, raisins, dates, figs, prunes, currants and canned fruits, and candy, chewing gum, confections, pastries and sweet beverages. The patient was also counseled to minimize

prepared breakfast cereals and other highly refined cereal products. The extent and severity of restrictions were found to be a highly individual matter, in that some patients had to be much more strict than others. In some instances, excesses of fresh fruits had to be curtailed for a time in order to bring about a reduction of the *L. acidophilus* index. To make up for the loss in calories, the patient was advised to increase the intake of other foods; for instance, meat, eggs, vegetables, milk and milk products. In the majority of cases, such a recommendation resulted in an improvement over the previous régime of food intake. In observing the individual patient's response, a check on any fluctuation in body weight was made. Height, weight and age standards, correlated with width measurements at chest and lilac crest, were used.^{16, 17} It was noted that there was frequently a loss of from 6 to 8 pounds in the first month or two of this régime, especially in individuals who were overweight at the start. In view of the wide range of variation in individual response, other measures used may be demonstrated in hypothetical cases.

1. The *L. acidophilus* index dropped from high to zero or within a range of from 300 to zero:

The patient was then advised to stay strictly on this régime for the next three months, on the assumption of a favorable prognosis. Additional specimens were taken each month, and if the index remained zero for three months, the patient was allowed one or two servings of a sweet dessert per week. The analysis of subsequent monthly specimens of saliva determined whether this was permissible.

2. The *L. acidophilus* index was reduced to a small fraction of its initial high level.

The patient was encouraged to continue strictly on this régime since, in some instances, the complete change re-

quired a longer period of time. If a zero index was obtained in the next monthly check, the patient was instructed to proceed as under (1). If the index did not drop within the 300 to 0 range, an additional consultation was arranged.

3. The *L. acidophilus* index was reduced only 50 per cent or remained high.

This condition suggested three possibilities: (a) The patient had failed to understand details of the nutritional recommendations and continued to include foods that were favorable to the

were checked at additional interviews.

5. The *L. acidophilus* indices fluctuated from high to 0 intermittently.

Here caries was found to be largely eliminated or reduced to a very low frequency and additional consultations were highly effective.

6. The initial as well as subsequent *L. acidophilus* indices were 0 despite the fact that the dental examination revealed extensive decay.

This indicated the possibility that the cavities present were the result of a previous period of caries activity and that the disease was inactive at the time.

TABLE 1.—*L. ACIDOPHILUS* INDEX IN RAMPANT DENTAL CARIES AND CARIES-FREE GROUPS

Groups	Number of Cases	<i>L. Acidophilus</i> Index				
		1	2	3	4	5
		0-299 0	300-999 +	1,000-9,999 ++	10,000-49,999 +++	50,000+ ++++
I. Rampant Dental Caries	1,250	111 8.9%	43 3.4%	232 18.6%	392 31.4%	472 37.7%
Total	1,250	154=12.3%		1,096=87.7%		
II. Caries-Free	265	208 78.5%	10 3.8%	34 12.8%	10 3.8%	3 1.1%
Total	265	218=82.3%		47=17.7%		

growth of *L. acidophilus*. (b) The patient did not cooperate through lack of self-discipline or because of an environment incompatible with such change. (c) Certain undisclosed constitutional factors interfered with the normal response.

In such instances, additional consultations were necessary to determine the actual situation.

4. The *L. acidophilus* index fluctuated from high to low intermittently.

In such cases, it was observed that caries was apt to persist, but usually at a much lower rate than previously. Variations in cooperation or other causes

For a correct interpretation, these cases required a check on the technic of supplying the specimen. In many instances, the patient had previously been counseled to reduce the intake of sweets. The initial indices, therefore, were actually representative of the effectiveness of corrective procedure.

7. The initial *L. acidophilus* index was 0 and subsequently rose to a high or fluctuating value. This occurred in a very small percentage of cases that presented the same possibilities as examples 3, 4 and 5.

The question arises as to whether the elimination of excessive sweets and other

refined carbohydrates is permissible from a general health and nutritional point of view. The current emphasis in popular advertising on the energy value of the many products predominantly containing refined carbohydrates must be regarded as distinctly biased. It is recognized that glucose is metabolized in the cell to produce energy with carbon dioxide and water as the final waste products. However, this is not a simple one-step process. There are a number of sequential steps and, for several of these, a specific catalyst must be present. If the catalyst is not available in adequate amounts, the reaction for which it is responsible slows down, the rate of energy production is reduced and the cell is faced with detoxification of waste products other than carbon dioxide and water. Each of these catalysts is in itself a complex organic compound and its presence depends on sufficient amounts of the many necessary nutrients. Thus "energy" depends not only on a generous supply of sources of glucose, but also upon an adequate supply of other nutrients. The body is in no way dependent on refined carbohydrates for the insurance of a smooth and efficient operation of such energy affording mechanisms. Actually, it can operate just as efficiently, if not better, on naturally occurring unrefined sources of glucose, which has the additional virtue of supplying many other nutrients. It might be added that fats, proteins and all other carbohydrates, as well as sugars, are also sources of energy. Thus, the recommendations set forth for dental caries prevention are not only permissible, but also highly desirable from the standpoint of energy, health and nutrition, and are entirely in accord with the summary of the Council on Foods and Nutrition on some nutritional aspects of sugar, candy and sweetened carbonated beverages.¹⁸ Great difficulties were often encountered when therapeutic recommendations were made for an increased intake of these refined carbohy-

drates. This practice frequently resorted to by internists, pediatricians and obstetricians is regrettable because of the sequence of a state of rampant dental caries.

RESULTS

In discussing the results of this five-year survey, reference is made to the problems stated previously:

1. *Is L. acidophilus consistently present during dental caries activity and absent during caries inactivity?*

In Table 1, it is seen that a total of 1,250 patients with rampant dental caries (Group I) and 265 individuals completely caries-free (Group II) were studied for the presence or absence of *L. acidophilus* in order to explore the significance of the wide numerical range of *L. acidophilus* indices. An arbitrary classification of 0-299 (0), 300-999 (low), 1,000-9,999 (high), 10,000-49,999 (high) and 50,000 (high) and over was used. Since numerical bacteriologic counts are not mathematically exact, the ranges were also expressed as 0, +, ++, +++ and ++++ respectively (Table 1).

The observations on the group of 1,250 patients (Table 1, Group I) revealed the striking picture of a strong relation between high *L. acidophilus* indices and rampant dental caries. In fact, 1,096, or 87.7 per cent, had indices over 1,000, while only 154, or 12.3 per cent, were between 999 and 0.

In contrast to this, of the 265 caries-free individuals (Table 1, Group II), 218, or 82.3 per cent, had indices below 1,000, while the remainder, or 17.7 per cent, were over 1,000. (It is notable that these findings are almost identical with those of smaller caries-active and caries-free groups previously reported.¹³) Many of this caries-free group with high indices, observed for a period of one, two or three years, developed caries in this later period, which indicates that these cases, though

TABLE 2.—L. ACIDOPHILUS INDEX RESPONSE AND DENTAL CARIES EXPERIENCE IN 790 RAMPANT CARIES CASES DURING ONE YEAR FOLLOWING NUTRITIONAL CONSULTATION

Group	L. Acidophilus Index Response	Total		Group Per Cent of Total	1 0 Caries		2 1-2 Cavities		3 3-5 Cavities		4 6-9 Cavities		5 10+ Cavities	
		No.	%*		No.	%†	No.	%†	No.	%†	No.	%†	No.	%†
I	(a) High to 0	246	31.1		219	89.0	21	8.6	4	1.7	2	0.82	0	0
	(b) High to low	120	15.2	69.8	68	56.7	37	30.8	12	10.0	3	2.5	0	0
	(c) High to 0, fluctuating	110	13.9		70	63.6	19	17.3	13	11.8	6	5.5	2	1.8
	(d) High to low, fluctuating	76	9.6		27	35.5	24	31.6	17	22.3	7	9.2	1	1.3
II	(a) 0 to 0	44	5.6		36	81.8	6	13.7	2	4.5	0	0	0	0
	(b) 0 to low	32	4.0	14.3	26	81.3	5	15.6	1	3.1	0	0	0	0
	(c) 0 to low, fluctuating	37	4.7		27	72.9	3	8.1	5	13.5	2	5.4	0	0
III	(a) 0 to high	12	1.5		8	66.7	3	25.0	0	0	0	0	1	8.3
	(b) 0 to high, fluctuating	20	2.5	4.0	3	15.0	10	50.0	5	25.0	1	5.0	1	5.0
IV	High to high	93	11.8	11.8	8	8.6	12	12.8	23	24.7	29	31.2	21	22.6
	Total	790			492		140		82		50		26	

*Percentages calculated for the entire group of 790 individuals.

†Percentages calculated for each of the ten groups.

clinically caries-free at the time of initial observation, were actually caries-active. Their exclusion from the caries-free group would, therefore, improve the already significant figure of 82.3 per cent. Thus, the presence and absence of *L. acidophilus* is indicative of caries activity and inactivity, respectively.

2. *Is nutritional correction with special regard to reduction of refined car-*

typical response was obtained in this group which represents 69.8 per cent of the total, with indices dropping from high to o or low (Group I, a, b) and at times showing fluctuations (Group I, c, d). It may be noted that in approximately one-third of all cases (Group I, a), *L. acidophilus* was eliminated completely (o index) for an entire year. In most instances, the response was abrupt

TABLE 3.—*L. ACIDOPHILUS* INDEX RESPONSE IN 438 RAMPANT DENTAL CARIES CASES FOLLOWING NUTRITIONAL ADVICE THROUGH REFERRING DENTIST OR PHYSICIAN

Group	L. Acidophilus Index Response:	Total		Group Per Cent of Total
		Number	Per Cent	
I	(a) High to 0	151	34.5	70.0
	(b) High to low	25	5.7	
	(c) High to 0, fluctuating	83	18.9	
	(d) High to low, fluctuating	48	10.9	
II	(a) 0 to 0	21	4.8	6.9
	(b) 0 to low	6	1.4	
	(c) 0 to low, fluctuating	3	.7	
III	(a) 0 to high	8	1.8	2.0
	(b) 0 to high, fluctuating	1	0.2	
IV	High to high	92	21.0	21.0
	Total	438		

bohydrates effective in reducing the L. acidophilus index?

The answer to question 2 is shown in Tables 2 and 3. In reviewing the records accumulated over the five-year period, considerable variations in *L. acidophilus* response were noted. The 790 individuals were segregated into four groups (Table 2), which showed typical patterns of reaction to nutritional régimes recommended (Table 2).

Group I: The most favorable and

within a few days, following the restriction of refined carbohydrate intake. In addition to this group with the classical response, better than one-third more showed a marked reduction of the index, which reached the o or low levels, but was not maintained consistently throughout the year (Group I, b, c, d).

Group II: The initial indices of this group (14.3) were o, which is atypical for rampant dental caries. Reference is made to the experience shown in Table

1, Group I. Some of these remained 0 (Group II a) and others rose to low and fluctuating levels (Group II, b, c). As mentioned previously, many of these initial 0 indices were due to the fact that the patient had received advice to reduce the refined carbohydrate intake before the first specimens of saliva were taken. Therefore, in the majority of these cases, their initial indices do not represent a state of caries activity, but rather the result of corrective measures. Their reaction for the remainder of the year compared favorably with that of Group I. Thus, by combining these two groups, it can be seen that in 84.1 per

cent of these 125 patients, 15.8 per cent of the total, gave questionable cooperation. (Table 2.)

During the five-year period, *L. acidophilus* indices were made for an additional 438 individuals (Table 3), who received their nutritional advice from the Division of Dental Medicine through their dentist or physician without direct consultation with staff members. The changes in the *L. acidophilus* index of this group were similarly favorable, although a somewhat higher percentage failed completely to respond (Group IV). The other group percentages tally closely with

TABLE 4.—SUMMARY OF DENTAL CARIES EXPERIENCE FOLLOWING NUTRITIONAL CONSULTATION

Total Number of Rampant Caries Cases	Caries Experience During One-Year Observation Periods									
	0		1-2		3-5		6-9		10+	
790 (Table 2, Groups I to IV)	492	62.3%	140	17.7%	82	10.0%	50	6.3%	26	3.3%
Total	632 = 80%				158 = 20%					
665 (Table 2, Groups I and II)	473	71.7%	115	17.3%	54	8.1%	20	3%	3	0.45%
Total	588 = 88.4%				77 = 11.6%					

cent of all cases, the *L. acidophilus* index was effectively reduced by the reduction of refined carbohydrate intake.

Group III: This group comprised only 4 per cent of the total and, similarly to Group II, started with atypical 0 indices. During the year of observation, the individuals of Group III responded unfavorably and rose to high and fluctuating levels (Group III, a, b).

Group IV: In contrast to Group I, a, which is classical for a complete response, this group (11.8 per cent) did not evidence any favorable reaction to corrective measures.

The reasons for the lack of response in Groups III and IV were evaluated indi-

vidually, and repeated interviews showed that the majority of these 125 patients, 15.8 per cent of the total, gave questionable cooperation. (Table 2.)

A total of 1,228 individuals thus received recommendations for corrections (Tables 2 and 3) and 1,004, or 81.7 per cent, responded, with a significant reduction in the *L. acidophilus* index.

3. *Is the reduction of a high L. acidophilus index associated with the reduction of dental caries frequency?*

The results of the annual dental examinations were checked against the *L. acidophilus* index response of Groups I to IV of Table 2. Dental caries experience was expressed as 0, 1 to 2, 3 to 5, 6 to 9 and 10 and more cavities per year. As shown

under question 2, Groups I and II responded most favorably in the reduction of *L. acidophilus* indices after curtailment of the intake of refined carbohydrates. A striking parallel is seen in the decrease of dental caries activity for the same groups, as well as the continued caries activity in Groups III and IV with persistently high *L. acidophilus* indices. A summary of the findings in Table 2 is given in Table 4 for the entire 790 individuals (Group I to IV) and separately for the 665 (Groups I and II) which give the affirmative answer to the foregoing question. (Table 4.)

If a preventive procedure aims at complete elimination of dental caries in one year's time, it can be seen from Table 4 that such a result can be achieved to the extent of 62.3 per cent of a group of 790 patients suffering from rampant dental caries, or 71.1 per cent in a selected group of 665 individuals who had a more favorable *L. acidophilus* index response. If, however, the development of only one or two cavities is accepted as a good clinical result for individuals previously having rampant caries (ten or more cavities in the preceding year), these percentages of prevention rise to 80 per cent and 88.4 per cent respectively.

COMMENT AND CONCLUSIONS

The many theories and concepts of the etiology of dental caries have never been substantiated by clinical investigations of sufficient scope and duration to establish their general acceptance. Probably the greatest advance in the prevention of this disease is due to the earlier writings of Bunting and Jay. Their efforts revived interest in Miller's concept and supplemented it by the introduction of a quantitative bacteriologic test that made it possible to evaluate critically the merits, practicability and effectiveness of corrective procedures.

The present investigation had as its main objectives to determine: the relationship of *L. acidophilus* indices to den-

tal caries activity and inactivity; whether a high *L. acidophilus* index can be effectively influenced by reducing the excessive intake of refined carbohydrates and whether such a reduction would be accompanied by a decrease in caries frequency.

The findings may be summarized as follows:

1. Caries activity and caries inactivity were found to be accompanied by positive and negative indices respectively. In a group of 1,250 rampant caries cases, 1,096, or 87.7 per cent, had *L. acidophilus* indices over 1,000. The reverse picture was found in 265 caries-free individuals, 218, or 82.3 per cent, of whom had *L. acidophilus* indices below 1,000. This contrast between the two groups demonstrates a definite relationship between the presence and absence of *L. acidophilus* in caries activity and inactivity respectively. Although there are other acidogenic micro-organisms which may play a similar rôle, *L. acidophilus* is consistently found whenever a state of rampant caries exists and is absent during caries inactivity. Therefore, the presence of *L. acidophilus* constitutes a significant index and establishes this index as a qualified laboratory indicator for diagnosis and prognosis of this disease.

2. In 1,004 (81.7 per cent) of 1,228 rampant dental caries cases, a reduction of the *L. acidophilus* index was obtained within a period of a few weeks by reducing the intake of refined carbohydrates and replacing the calories derived from these foods by increasing the intake of meat, eggs, vegetables, milk and milk products. The comparatively small remaining group either manifested insufficient cooperation or were influenced by undisclosed factors. This high degree of success established the reduction of the intake of refined carbohydrates as at least one effective means of reducing the *L. acidophilus* index.

3. The reduction of the *L. acidophilus* index resulted in a drastic decrease in

dental caries frequency. In a group of 790 rampant caries cases (ten and more new cavities in the preceding year), the prevention of new cavities was achieved along with the reduction of the *L. acidophilus* index to the extent of 80 per cent. Of these, 62.3 per cent were arrested completely, while an additional 17.7 per cent developed only one or two cavities during the following year. In the 665 cases with a favorable *L. acidophilus* response, no new cavities developed in 71.7 per cent and cavities were limited to one or two in 88.4 per cent. This incidence of favorable response establishes the definite relationship between the reduction of the *L. acidophilus* index and the reduction of dental caries activity.

From the experience gained in the last five years, it has become evident that a program of dental caries prevention based on *L. acidophilus* indices and corrective procedures could be entirely practical and effective in private practice, institutional work and public health service. Even though the introduction of the laboratory procedure in individual private offices may not be economically feasible as yet, the establishment of clinical laboratory facilities in certain centers could make such a service readily available to a large surrounding area. It is encouraging to note that some state health departments already offer this laboratory service. One of the distinct features of this test is that analysis of the sample can be delayed for several days after it is taken, permitting transportation across the country if necessary. The entire procedure wherever applied need not interfere with other routine treatment because it can be accomplished within a few minutes. The effectiveness of correction can be determined within one week, and the time, effort and cost in these preventive procedures are only a fraction of those necessary for repair.

Significant as the reported figures may appear, it must be realized that results will vary with the interest, experience

and skill of the individual practitioner, clinical group or public health worker. The reduction in intake of refined carbohydrates may have good clinical results, but it does not explain the cause of the disease.

For instance, occasional observations were made to the effect that some individuals consumed large amounts of sugars without developing decay and others with a low sugar consumption developed rampant dental caries. This suggests that in addition to excessive refined carbohydrate ingestion, other factors have a bearing on the course of this disease. In other words, it is not possible to state that ingestion of refined carbohydrates or sugars or foods containing sugars results in decay. It is, of course, conceivable that the formation of lactic acid is the result of local fermentation of sugars and concentrated sweets. However, the extensive inclusion of these foods may impose a burden on various metabolic processes or accentuate a lack of other nutrients. The establishment of the *L. acidophilus* index as a qualified laboratory test may greatly facilitate further investigation of these unknown factors.

For the successful application of these procedures, dental teachers and students of dentistry must acquire a sound understanding of the fundamentals of nutrition and many other factors in physiologic well-being. The problem of dental caries prevention thus evolves from treatment at the hands of highly skilled technical dental experts alone to include considerations of all factors in a sound dento-medical approach.

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GINGIVITIS AND VITAMIN C

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INTRODUCTION

DURING the past few years, some reports in the literature^{1, 2, 3} indicate a conflict of opinion regarding the use of ascorbic acid in the treatment of gingivitis. From a clinical point of view, it must be said that the only known uses of vitamin C are the prevention of scurvy and the treatment of scurvy.^{4, 5} The possible exception to this, the action of the vitamin on the

intermediary metabolism of aromatic amino acids in premature infants,⁶ is interesting, but requires further investigation. The use of the vitamin in gingivitis is based on the assumption that this process is either due to a scorbutic process or that it is improved by the administration of extra ascorbic acid. It appears, therefore, that much of the confusion is based on evaluation of the local lesion in relation to a vitamin deficiency. It is therefore the purpose of this communication to present certain data and considerations which might clarify the problem.

At first glance, the problem resolved itself into placing in categories the various bases for the existence of gingivitis, and secondly into accepting certain defi-

The material in this article should be construed only as the personal opinions of the writers and not as representing the opinion of the Navy Department officially.

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nitions for the various pathologic processes. Within certain limitations, gingivitis can be classed broadly as follows:

1. Gingivitis based on a great variety of mechanical, pathologic and constitutional conditions not related to vitamin C economy.

2. Gingivitis based on an active scorbutic process wherein there is a marked tissue deficit of the vitamin and a resulting change in collagen formation.

3. Gingivitis as a disease resulting from a one-time scorbutic process, but where the subject is at present

(a) Consuming a maintenance intake of vitamin C.

(b) Consuming less than the maintenance requirement of vitamin C.

(c) Consuming more vitamin C than is necessary for maintenance economy, but having a deep seated gingival lesion which transcends the original defect.

These, then, are the essential possibilities. It is obvious that any lesions described in Section 3 may very well belong in Section 1 or be concurrent with any of the processes mentioned in the other sections. The advent of pocket formation and the presence of exudate superimposes a new disease, and should the subject be scorbutic, this process must require specific dental therapy as well as the systemic care given to the patient.

In order to clarify the following discussion, it may be well to define the terms used.

Gingivitis: Any inflammatory process involving the gums.

Periodontal disease: Pyorrhea alveolaris, *Schmutz* pyorrhea, diffuse atrophy, paradentitis, periodontoclasia, Riggs' disease: Disease processes involving the supporting structures of the teeth.

Scurvy: A clinical entity dependent on a prolonged depletion of ascorbic acid in animal tissues, with a resultant morphologic change in the intercellular substance of certain mesenchymal derivatives. As a result, hemorrhages occur and the gums, lacking intercellular sub-

stance, become boggy and swollen. According to Hess,⁷ absolute reliance must not be placed on gum changes for an early diagnosis, as usually they do not appear until late in the disease. The early signs of perifollicular hemorrhages and petechial spots are much more characteristic. In 1940, when Crandon⁴ induced scurvy in himself, there were no gum changes whatsoever, but all other signs and symptoms of scurvy were present and tissue biopsies revealed little or no collagen. However, it is well to bear in mind that stress modifies and at times determines the site of gross lesions. Thus, the gums are often subjected to trauma by chewing, etc., and separation may occur on a mechanical basis, promoting periodontal disease.

Maintenance Intake of Ascorbic Acid.—The amount of ascorbic acid, either synthetic or derived from food, needed to prevent scurvy and which maintains a sufficient and a somewhat constant content of the white-cell tissue layer of the blood or other tissues is the daily minimal requirement. This may be related to time and function, so that sporadic increased intakes of the vitamin may compensate for periods of inadequate intake.^{5, 8} Such an intake averages about 25 mg. of ascorbic acid a day for a twenty-one month period in the normal adult subject.⁵

At other times, subjects consuming large doses of ascorbic acid become saturated, and protection against scurvy for a period of from four to six months exists even though the subject consumes none or little of the vitamin.⁴ This is evident in natives consuming fruits high in ascorbic acid in season, and relatively little at other times.⁹

Therapeutic or Curative Intake of Ascorbic Acid.—An undramatic and slow response occurs when the small maintenance dose of ascorbic acid or slightly more is administered to the scorbutic subject. Relatively small doses may take weeks to have the necessary therapeutic

effect. Thus, large doses of the vitamin, of 150 mg.-1,000 mg., should be given daily. After treatment, the patient can be placed on a maintenance dose. Some investigators¹⁷ have confused the maintenance minimal intakes with optimum therapeutic doses of the vitamin.

Criteria for the Evaluation of Scurvy.—The diagnosis of this disease must be based on the clinical picture, which has been amply discussed elsewhere.^{4, 5} The use of the saturation tests and urinary excretion tests, as well as plasma as-

whether ascorbic acid economy is disturbed in gingivitis, thus requiring an increased intake of the vitamin for therapeutic purposes. In regard to the first problem, it seems unlikely that the cases of gingivitis ordinarily seen are in any way related to scurvy. Ungley¹³ and King¹⁴ clearly showed that administration of vitamins in large doses failed to exert any beneficial effect on gingivitis. Ralli¹⁵ pointed out some time ago that gingivitis may, in general, have a multiplicity of causes other than scurvy, and

CERTAIN FINDINGS RELATED TO SCURVY AND GINGIVITIS* IN SIX ADULT SUBJECTS ON A SCORBUTIC REGIME†

Subject	Age	Sex	Ascorbic Acid							
			Initial Values		2 Months		4 Months		5-6 Months	
			Plasma‡	Plasma & White Cells#	Plasma	Plasma & White Cells	Plasma¶	¶Plasma & White Cells	Plasma¶	Plasma & White Cells
J. K.	26	♂	1.1	30.0	0.2	20.0		11.0		Trace
M. W.	42	♂	0.96	32.0	None	18.0		6.0		None
T. L.	38	♂	1.0	32.0	None	18.0		8.0		Trace
C. L.	64	♂	1.2	28.0	0.1	22.0		10.0		None
A. M.	36	♀	0.96	30.0	None	20.0		10.0		4
C. A.	26	♀	0.96	26.0	None	16.0		7.0		None

*Initially, the gums were negative (no scurvy). The tests at two months continued negative. At four months, there was still no scurvy, and the gum condition was negative, except for soreness in subject C. L. and questionable findings in M. W. At five-six months, the gums were negative except for swelling, tenderness and bleeding in subject M. W. The scorbutic findings were positive at this period except in subject A. M.

†The teeth were carefully brushed, the subject using a fine castile soap morning and night.

‡Milligrams per hundred cubic centimeters.

#Milligrams per hundred grams.

¶None.

corbic acid values, do not contribute to the diagnosis of scurvy.^{5, 11, 12} If, on the other hand, the blood tissues, i.e. the white-cell platelet layer, values are low, or zero, the diagnosis of scurvy will receive adequate laboratory confirmation.^{4, 5, 11}

THE PROBLEM: THE RESULTS

The problem resolves itself into two phases: (1) to ascertain whether gingival disease parallels a depletion of ascorbic acid, and (2) to determine

Crandon⁴ failed to develop gingival lesions during his experience as a scorbutic. On the other hand, numerous investigators^{18, 19} have combined vitamin C therapy with dental hygiene and dental procedures and have reasoned that such a form of treatment gave satisfactory results. Since gingivitis is a disease with various manifestations and etiology, the conclusions drawn were unwarranted. In some reports, the assumption that subclinical scurvy existed was based on the saturation test with vitamin

C. This test is dependent on urinary elimination of a large amount of a test dose of ascorbic acid. It has been supposed by some that if no ascorbic acid is eliminated after such a dose, the subject is deficient in this vitamin. This has been shown⁵ not necessarily to indicate scurvy. Others¹⁶ assumed that low plasma vitamin C values were indicative of scurvy. The plasma vitamin C is always zero in scurvy, but it can also be so in non-scorbutic states, since it is the presence of the vitamin in the blood tissues (white-cell platelet layer) that is significant.^{4, 5, 10, 11}

Six subjects, volunteers, after saturation with vitamin C, were placed on an ascorbic acid free régime (Table 1).

The diet consisted of eggs, cheese, cooked cereals, a variety of beans, bran flakes and debittered yeast and contained all vitamins with the exception of ascorbic acid. A variety of dishes were prepared from the above and numerous seasoning adjuvants were used. On the whole, the diet was well tolerated.

The diagnosis of scurvy during the fifth and sixth months was based on the appearance of perifollicular hemorrhage and petechiae. Some had moderate and diffuse cutaneous hemorrhages over the thigh. None of the subjects objected to these findings. Lassitude and fatigue took place during the fourth month. After the advent of scurvy, treatment was immediately instituted with 1 gm. of ascorbic acid a day and a regular diet.

It would be difficult to say what gum changes might have occurred if the patients had been maintained on this régime. It is highly probable that gingivitis would have manifested itself. On the other hand, the data indicate that a shortage in the vitamin (in this case, a lack of it) does not readily lead to gingivitis. With the exception of one subject none had any noticeable changes in the gum tissues. It is well to point out that the diet was essentially a bland one, and that if more active chewing had taken

place, the gums might have been more easily injured. The fact that pressing and scraping the papillae in an occasional test did not bring about a marginal gingivitis supports the view that gingivitis is a late manifestation of scurvy and that it is not easily induced by a scorbutic régime. At least, the evidence suggests this concept.

Concomitantly with this study, a series of patients were chosen in whom the actual pyorrhea was minimal, but gingivitis fairly pronounced. Out of a group of about sixty subjects with pyorrhea and gingivitis, only eighteen could be placed in this category. The others had deep seated pocket formation and exudate. The plasma ascorbic acid levels in these eighteen subjects varied from 0.2 to 0.6 mg. per hundred cubic centimeters. The white-cell platelet values varied from 16 to 24 mg. per hundred grams. These determinations were carried out at intervals of four days for three separate tests. On the whole, the values remained approximately within the range of the initial ones, and since the values were nowhere in the limits of scorbutic values, a positive state of ascorbic acid economy existed. The use of 1 gm. of ascorbic acid and 3 glasses of fresh orange juice daily for three weeks failed to alter the condition in any way. No dental hygiene was used. A group of twenty cases with a much more advanced pyorrhea process and with a somewhat similar ascorbic acid economy of the blood tissues, but who received no ascorbic acid whatsoever (placed in the diet of the six subjects studied), showed the usual variable improvement with local therapy. In about one-third, there was definite improvement; in one-third, no change, and in one-third, the results were equivocal. All of these subjects were hospitalized. It was, furthermore, the impression of the dental consultants that a bland diet contributed to the treatment of pyorrhea and gingivitis, the gums being subjected to less trauma.

There is no way to exclude the possibility that gingivitis in some cases may have been due to some early scorbutic process and, with chronic infection and pyorrhea, the dental condition persists regardless of subsequent ascorbic acid intake. It is our impression that such an etiology is unlikely.

CONCLUSION

The assumption that gingivitis, with or without pyorrhea, is on a scorbutic basis is unwarranted unless there is antecedent or present clinical evidence of scurvy. The only laboratory confirmation of the diagnosis being a depleted white-cell platelet ascorbic acid content, no other test with the exception of the index gained by whole blood values is reliable.

Gingivitis and its periodontal manifestations is, in most instances, a local lesion, and its connection with systemic processes requires considerable additional study.

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II. PROTECTIVE DENTISTRY



THE LOCAL USE OF SULFANILAMIDE AND SULFATHIAZOLE IN EXTRACTION WOUNDS; A PRELIMINARY REPORT

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I. INTRODUCTION

THE local application of sulfanilamide in tooth sockets is being practiced empirically by many men in dentistry today. This paper is a preliminary report on the use of sulfanilamide and sulfathiazole prophylactically and therapeutically. The reports on the local use of sulfanilamide are very promising. Jensen, Johnsrud, and Nelson¹ applying it locally in 39 compound fractures found all healing by primary intention; whereas in another series of 94 cases of compound fractures 20% became infected, though

the treatment remained precisely the same except for the use of the powdered sulfanilamide. The authors found that administering the drug orally produced a blood level of 10-15 mg% while the local implantation gave a concentration of 800 mg% in the area; a concentration which lasted for 36 hours. According to Key and Frankel² at this concentration the drug is no longer bacteriostatic but is rather bactericidal. Of the local use of sulfathiazole Spink and Hansen³ say "results have been highly satisfactory and merit further investigation." It is on

the basis of such reports that this attempt to evaluate the effectiveness of these chemotherapeutic agents in dentistry is made.

II. THE LITERATURE

The sulfonamides and their derivatives have been reported to be effective in varying degree for a large number of organisms, including pneumococcus,^{4,5,6,8} streptococcus beta hemolyticus^{4,5,6,8} meningococcus, Lancefield's Group beta hemolyticus streptococcus A, D, and G,^{4,8} staphylococcus aureus,^{4,7,8,9} Bacillus proteus^{3,4,7} gonococcus,^{7,8} streptococcus faecales,⁷ aerobacter aerogenes,⁷ streptococcus alpha hemolyticus,^{3,7} and staphylococcus albus.⁷ Since the bacteria cultured from post-operative dental infections are to be found among these organisms, it seemed only reasonable to assume that these drugs would be effective in dental septic conditions. Spink and Hansen³ using powdered sulfathiazole topically in 36 patients with staphylococcus sepsis found the results to be "highly satisfactory," while Edwards¹⁰ concluded that "sulfanilamide is definitely of value in the treatment of streptococcal infections of the mouth and jaws." Lockwood¹¹ however says that sulfonamide "is probably of limited value in bone foci." Spink and Paine¹² in a small series of cases report that wound infections seem to heal more rapidly when sulfathiazole is applied locally. It is of especial value in the treatment of chronic osteomyelitis. Hubbell and Austin¹³ however found no difference between the healing of control sockets

and that of sockets containing therapeutic dressings (one of the dressings was sulfanilamide in lanolin). Lawrence⁸ reports the bacteriostatic action of sulfathiazole in vitro to be greater than that of sulfanilamide for beta streptococcus Group A. Long and Bliss⁴ think that sulfathiazole is fully as bacteriostatic as sulfanilamide in vitro for the particular group of organisms with which they worked. Archer¹⁴ found that sulfanilamide reduced the time of treatment of a "dry socket" by 50 per cent.

III. METHODS

No attempt was made to select the patients except that as many subjects as possible were those who had multiple extractions in which three or more teeth were extracted at a single operation. In these patients one socket was filled with sulfathiazole, a second with sulfanilamide, the third was kept as a control. Thus in these cases of multiple extractions which constitute 30.14% of the 1,065 extractions performed, all systemic factors remained constant for the individual patient except the agent used. The drugs were obtained in tablet form, but were broken into small pieces before they were packed into the socket. No curettage was done previous to the insertion of the drug nor was any attempt made to use sterile drugs. Key and Frankel² recommend that the drugs be sterile before using them locally. The patients, save in some few isolated instances, were followed daily for about a week. All teeth were extracted under conditions of as complete

asepsis as possible. Following the extractions sedatives were prescribed. Almost all of the hospital patients entered the institution for reasons other than dental, 25.7% being classified as poor risks due to their systemic conditions.

Therapeutically in the two cases which entered the hospital with an already diagnosed condition of localized osteomyelitis or "dry socket" and in those sockets which became infected

those in which sulfathiazole was used. None of these showed any of the clinical signs of the "dry socket."

Two facts are notable:

First, that each of two patients had two sockets which became infected; agreeing with Hubbell and Austin¹³ in whose experimental animals such "dry sockets" as did occur were in a single animal.

Second, that all the post-operatively infected sockets occurred in the mandi-

TABLE I
EXTRACTIONS*

Sockets	Teeth		Total	Number infected		Per cent
	upper	lower		upper	lower	
Control	201	142	343	0	5	1.46
Sulfathiazole	169	212	381	0	1	0.26
Sulfanilamide	177	164	341	0	0	0.00

* 631 of the extractions were performed on hospital patients.

post-operatively, the following procedure was adopted:

1. Take culture from socket
2. Débridement of socket
3. Irrigate socket thoroughly with warm saline solution
4. Pack socket carefully with sulfathiazole

There were only three patients who showed the clinical symptoms of the so-called "dry socket" or alveolalgia,¹⁴ or localized osteomyelitis; of these, two had had the diagnosis made by their dentist before entering the hospital. The third occurred in one of the control sockets of a hospital patient who was considered to be in good health. In addition to these, four of the control sockets became infected as did one of

ble, where drainage is not as good as in the maxilla.

IV. RESULTS

A. Prophylactic Use of Drugs

A total of 1,065 extractions were performed; of these 343 not given chemotherapy were controls, 381 were packed with sulfathiazole, and 341 were treated with sulfanilamide. Five infections developed in the controls, one of these progressing to the point where it showed clinical manifestations of the "dry socket." Of the 381 prophylactically treated with sulfathiazole but one case of infection occurred, and this in a man who also had a control socket which became infected. No infections followed the prophylactic use of the sulfanilamide.

B. Therapeutic Use of the Drugs

In treating the infection therapeutically the drug chosen was sulfathiazole for the reasons that it is less toxic than sulfanilamide and for many types of organisms more effective. Also the small number of cases rendered it advisable to better test the efficacy of a single drug rather than two and obtain no indication of either's true ability to abort the infection.

Case 1

J. R., a 25 year old male, had his lower left premolars extracted by his dentist on November 2. Pain was not severe on the 3rd, but grew worse on the 4th. He returned to his dentist on the 5th, who gave him a sedative tablet. The pain did not abate, rather becoming more severe, so that he revisited his dentist on the 7th, on which date a partly exfoliated sequestrum was removed. He entered the hospital on the evening of the 7th to have a hemorrhoidectomy performed. He was seen by the writer about two hours after admission who informed the patient's surgeon of the oral condition and on whose advice the anesthetic agent was changed from one of inhalation to sodium pentathol. His condition consisted of a slightly swollen left mandible with severe pain. Pressure along the margins of the sockets was extremely painful and caused pus to well out. A culture was taken, then the sockets filled with sulfathiazole, but no débridement was performed. For sedation he was given 1/6 grains of morphine sulfate. The hemorrhoidectomy was performed on

the 8th and the patient was seen by the writer on the evening of the same day. His dental condition was slightly better, the ache being dull rather than sharp, though pus was still present. On the 9th the sulfathiazole was again put into the sockets, pain and pus still present. Sedatives were given daily. The report of the culture taken on the 7th showed:*

1. Streptococcus—beta hemolyticus type, 2+
2. Streptococcus—alpha hemolyticus type, 2+

On the 11th there was no apparent pus, but the dull ache was still present. On the 12th, the sockets were very slightly curetted, irrigated, and sulfanilamide packed into them. On the 13th there was no pain, no sign of infection, and a culture then taken proved negative. In the treatment of this case the failure to irrigate the sockets when the patient was first seen may have prolonged the infection. Lockwood¹¹ has shown that the presence of peptones in the necrotic tissue inhibits markedly the ability of the sulfonamide derivatives to be bacteriostatic.

Case 2

E. D., 20 year old female, had her lower right second premolar extracted on October 19 by her dentist. The pain was quite noticeable on the 20th, but circumstances prevented her seeing her dentist again until the 23rd, at which time he applied local medication. She revisited him on the 24th when he

* Cultures were examined only for streptococci and staphylococci.

curetted and placed a drain into the socket. On the 25th he changed drains and irrigated the socket. She entered the dental clinic on the 26th with sharp "shooting" pains. Removal of the drain revealed pus in the socket. A culture was taken, the socket curetted slightly and then filled with sulfathiazole. Seen again on the 27th she said there was little pain, while a swab put into the socket brought forth only a slight purulent odor but no pus. The socket was again irrigated and packed with sulfathiazole. Revisiting the clinic on the 29th, the patient reported that the pain had ceased to trouble her on the evening of the 27th. The original culture revealed:

1. Staphylococcus albus, 2+
2. Streptococcus—beta hemolyticus type, 1+
3. Streptococcus—alpha hemolyticus type, 2+

A final culture taken on the 29th was negative for these organisms.

Case 3

P. D. C., 21 year old male had his lower left first molar extracted on the 29th of the month. He had some pain on the 30th, but no swelling. Curettage of the socket showed pus to be present. In this instance no therapeutic treatment was carried out. Aspirin was prescribed for sedation. On the 31st the patient reported that the pain at night was such as to prevent restful sleep. No swelling or pus was evident. Codeine in $\frac{1}{2}$ grain doses every four hours was given in addition to the aspirin. On the third day, the patient

was still in pain and unable to sleep. No pus was seen nor was there any soft tissue swelling. For sleep $1\frac{1}{2}$ grains of phenobarbital was prescribed at bedtime. The status quo did not change for the 4th, 5th, or 6th days. On the 7th day treatment was instituted because the patient was suffering from intense pain. A culture was taken, then the socket was carefully freed of debris and pus was obtained. The socket was then irrigated with warm saline which was followed by filling it completely with sulfathiazole. The patient complained of pain on the following day despite the continued sedation. No free pus was apparent. The socket was again very slightly curetted, irrigated, and packed with sulfathiazole. He was also given the drug orally, 105 grains per day. On the 9th day he reported less pain and that he had slept most of the night. Upon examination no pus was evident. Treatment of the previous day was repeated. On the 10th day he reported no pain and the socket did not appear infected. A culture was taken.

The culture taken on the 7th day revealed:

1. Streptococcus—beta hemolyticus type, 3+
2. Streptococcus—alpha hemolyticus type, 2+

The final culture proved negative for these organisms.

In the above three instances the diagnosis of localized osteomyelitis was made. In the following cases none of the clinical symptoms of the "dry socket" were so well established. Hence

the diagnosis is merely post-operative infection.

Case 4

F. C., 25 year old male, complained on the third day following the extraction of his lower right second molar of slight pain in the area. A culture was taken, which was followed by débride-ment, irrigation, and sulfathiazole. At the end of 24 hours he said that he no longer had any pain. The report of the original culture showed:

1. Streptococcus—beta hemolyticus type, 1+
2. Streptococcus—alpha hemolyticus type, 1+

No final culture was taken.

Ten days later a second tooth, the lower left second molar, was extracted and this socket, although prophylactically treated with sulfathiazole, became infected and slightly painful on the 5th day after the extraction. The same treatment that had been followed for his other tooth was instituted. Pain and signs of infection disappeared in 48 hours. The bacteriological report:

1. Streptococcus—alpha hemolyticus type, 2+

No final culture was taken.

Case 5

B. D., a 29 year old male, had his six lower anteriors extracted at a single operation. He complained of a dull ache on the third day following the extraction but was not seen until the 7th day, due to circumstances beyond his control. On examination pus was found in the lower left cuspid socket. This socket was irrigated and filled

with sulfathiazole. He reported that he was free from pain and needed no more sedative after 24 hours. Cultures were not taken in this case.

Case 6

K. P., a 24 year old male. On the second day after extraction of his lower right first and second premolars he complained of pain. Examination of the sockets revealed the presence of pus but no soft tissue swelling. No cultures were taken in this case but otherwise the treatment was that used in Case 4. After 48 hours he no longer complained of pain, nor was there any sign of infection.

In all of the above cases sedation was continuously given during treatment.

V. SUMMARY

In a group of patients 1,065 teeth were extracted; 343 being controls, 381 being followed by the insertion of sulfathiazole into the sockets, and the remaining 341 extractions by the placing of sulfanilamide into the sockets. Of the controls 5 developed post-operative infection, an incidence of 1.46%. Of those extractions in which sulfathiazole was used, only one became infected or 0.26%. None of the sockets in which sulfanilamide was used became infected.

Sulfathiazole was used in the treatment of the post-operatively infected sockets.

VI. GENERAL COMMENT

The incidence of infection among our controls was 1.46%. Considering the

TABLE II
TREATMENT AND RESULTS

Patient	Age	Tooth	Pre-treatment interval	Treatment	Duration of symptoms	Culture* Reports
F.C.	25	7	3 days	culture curettage irrigate sulfathiazole	24 hours	strep. alpha 1 ⁺ strep. beta 1 ⁺ (1)
		7	5 days	as above	24 hours	strep. alpha 2 ⁺ (1, 2)
K.P.	24	4, 5	2 days	as above	48 hours	(3)
B.D.	29	3	7 days	as above	24 hours	(3)
E.D.	20	5	8 days	as above	48 hours	staph. albus 2 ⁺ strep. alpha 1 ⁺ strep. beta 2 ⁺ (4)
P.D.C.	21	6	7 days	as above sulfathiazole also given orally	72 hours	strep. alpha 3 ⁺ strep. beta 2 ⁺ (4)
J.R.	26	4, 5	5 days	sulfathiazole curettage and sulfanilamide	8 days	strep. alpha 2 ⁺ strep. beta 2 ⁺ (4)

* Thanks are due Miss Mary Leary for the bacteriological work.

1. No culture taken at end of treatment.
2. Previous prophylactic treatment with sulfathiazole.
3. No culture taken.
4. Final culture negative.

systemic condition of many of our patients this compares quite favorably with Archer's findings,¹⁴ who in 23,886 extractions found that "alveolalgia" or septic socket developed in 226 cases 00.95%. All of the infected sockets occurred in the mandible, which is not what Archer found. He reported 79% in the mandible and but 21% in the maxilla. But our series is much too small to warrant a conclusion.

The data seem to indicate that the use of sulfanilamide or sulfathiazole prophylactically is advisable, especially in mandibular extractions. It is also well worth while to use the drugs in

the treatment of "alveolalgia" or "dry socket."

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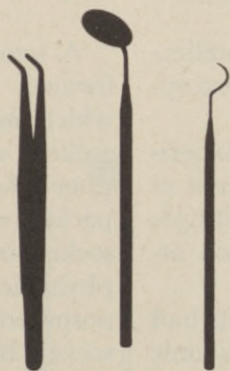
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LOCAL USE OF SULFANILAMIDE AND SULFATHIAZOLE IN EXTRACTION WOUNDS

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IN a preliminary report,¹ the data presented were indicative of the fact that sulfanilamide and sulfathiazole should be used prophylactically after the extraction of teeth. However, owing to the small number of cases presented, 1,065 extractions, the data were not conclusive. This paper presents additional and similar data which, when combined with those previously published, permit such conclusions.

the extractions were performed aseptically. The rest were carried out under field conditions, often in a combat area. In the field, antiseptics and cleanliness rather than asepsis were the rule.

4. Owing to primitive conditions and the unavailability of laboratory facilities, no material for culturing was taken from the sockets, clinically diagnosed as infected. Bacteriologic studies could not be made.

TABLE I.—PRESENT DATA

	Extractions			Infected Teeth			
	Upper	Lower	Total	Upper	Lower	Total	Per Cent
Control	220	247	467	0	5	5	1.08
Sulfathiazole	222	211	433	0	0	0	0.00
Sulfanilamide	198	242	440	0	0	0	0.00

The methods were those of the preliminary report with the following exceptions:

1. Whereas, in the original experiment, an attempt was made to secure as many patients as possible with multiple extractions, in this instance no such attempt at selection was made.

2. Previously, most of the patients had entered the hospital because of systemic disease rather than oral disease, with the result that 25.7 per cent were poor surgical risks. In the present series, almost without exception, the patient was in excellent physical condition.

3. In this report, only 60 per cent of

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A total of 1,340 extractions were performed. Of these, 467 were controls in which no sulfonamides were used; 433 sockets were packed with sulfathiazole after the extractions, and 440 were packed with sulfanilamide. None of the sockets in this series that were given prophylactic chemotherapy became infected postoperatively, while five of the control sockets became infected, though not in a single case did the infected socket reach the condition clinically recognized as alveolalgia, or "dry socket."

CONCLUSIONS

1. The use of either sulfanilamide or sulfathiazole prophylactically is of defi-

nite value in the prevention of postoperative infection in the extraction wound.

2. Owing to the extremely low incidence of postoperative infection in extraction wounds in the maxilla, none in

agents should be based on the area of the operation, the type of extraction, the amount of trauma, the systemic condition of the patient and the degree of infection present before the operation.

TABLE 2.—PRESENT AND PREVIOUS DATA

	Extractions			Infected Teeth			
	Upper	Lower	Total	Upper	Lower	Total	Per Cent
Control							
Previous report	201	142	343	0	5	5	1.46
This report	220	247	467	0	5	5	1.08
Total	421	389	810	0	10	10	1.23
Sulfathiazole							
Previous report	169	212	381	0	1	1	0.26
This report	222	211	433	0	0	0	0.00
Total	391	423	814	0	1	1	0.12
Sulfanilamide							
Previous report	177	164	341	0	0	0	0.00
This report	198	242	440	0	0	0	0.00
Total	375	406	781	0	0	0	0.00

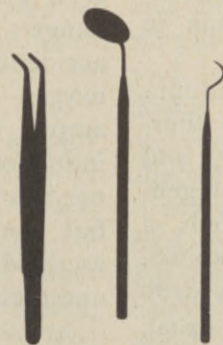
this series and but one in every 503 extractions in Archer's² series were infected. It is inadvisable to routinely use sulfonamides prophylactically in the maxilla.

3. In every instance, whether in the mandible or in the maxilla, the use of sulfonamides prophylactically should not be routine. Rather, the use of these

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USE OF VINETHENE AS AN ADJUNCT IN NITROUS OXIDE-OXYGEN ANESTHESIA FOR DENTAL SURGERY

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GENERAL anesthesia for general dental practice has been shunned by most practitioners as involving too much risk, with the feeling that the results do not warrant the effort expended. Too many men simply refer cases requiring general anesthesia to specialists, not realizing that alleviation of pain is probably the most important single factor in building up a patient's confidence in the dentist.

We do not say that every patient desiring a general anesthetic should be given one in a private office without any further consideration. Most dental surgical procedures can be performed under local anesthesia, but it should be possible for the adequately trained general practitioner to care for those few selected cases in which general anesthesia is indicated. Besides the contraindications for general anesthesia in office practice, which have been so thoroughly discussed in many other articles and texts, there are several other points that must be taken into consideration in the administration of this type of anesthesia in general practice.

First and foremost, the person administering the anesthetic should be thoroughly trained, both theoretically and clinically, in the administration of general anesthesia. Since Horace Wells, a dentist, introduced general anesthesia, we must not lose our heritage and drop

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out of this field because of inadequate training. Many dentists have adjacent offices, and there is no reason why one cannot anesthetize while the other extracts. Since the general practitioner is not so well trained in dental surgery as the specialist in this field, he should not attempt involved procedures which would consume a great deal of time, under general anesthesia. The necessary equipment for administration, emergencies and recovery should, of course, always be present.

The main reason for this fear of general anesthesia in general office practice is the untoward reaction of patients during the induction phase. Attempts to shorten this period, which is the bugaboo of so many men, have led to the so-called rapid-induction method. With this technic, the amount of oxygen administered is cut down to almost nothing, in some cases to nothing. The patient then receives 100 per cent nitrous oxide. Many men still use this method in spite of a great deal of evidence as to the dangers involved. Courville¹ has reviewed accidents occurring with nitrous oxide-oxygen anesthesia and has shown examples of fatal results with the rapid induction technic. True, many men still use this method with comparative safety, but the absence of ill-effects may be ascribed to the short duration of the anesthesia.

Arrowood² states, "Since it takes ten to fifteen minutes for full saturation with a given mixture of nitrous oxide, oxygen deprivation during these short pro-

cedures is not often sufficiently severe to be fatal." But it takes only one minute of oxygen lack to produce histologic evidence of permanent damage to the brain cells.⁸ Although the residual air present in the alveoli of the lungs contains oxygen, we cannot afford to work with such a low margin of safety as is afforded by the so-called rapid-induction method. Another point against this technic is that a false excitement phase may occur during the first stage of anesthesia owing to the increased sensation of suffocation experienced by the patient.

Opposed to this method is the so-called "slow-induction" technic. With this method, an adequate supply of oxygen is always being administered to the patient. Chapman, Arrowood and Beecher³ state that ". . . none of our patients retained consciousness beyond 75% nitrous oxide (with 25% oxygen), and most of them lost consciousness at 60% (with 40% oxygen)." Arrowood,² however, says:

Some, but by no means all, patients can be adequately anaesthetized without premedication with this mixture (80% N₂O, 20% O₂) for simple extractions, if sufficient time is taken to saturate the patient. If this cannot be accomplished, nitrous oxide should be supplemented with a more potent agent in preference to further reducing the oxygen content of the mixture. Ether, vinethene, or pentothal is suitable for this purpose and selection depends upon conditions in each individual case. When it is recognized beforehand that the patient is likely to be resistant, premedication may make the difference between a stormy course and an uneventful one.

Most dentists are loath to employ premedication because of their fear of "hangover" effects. We deal with ambulatory patients, and depressant drugs are not generally used in ambulatory practice. How, then, can we obtain a safe, smooth, yet relatively rapid induction in an office patient without premedication? The slow-induction method offers a safe and fairly smooth induction, but the

full effects may not be felt until saturation is reached (after from ten to fifteen minutes). Some patients cannot be anesthetized with nitrous oxide and oxygen alone unless the oxygen supply is cut dangerously low. Then, as Arrowood has suggested, we must use a more potent anesthetic agent as an adjunct. She suggests ether, vinethene (divinyl ether) or pentothal. The use of ether, because of its relatively slow excretion and untoward after-effects, is not feasible for office patients. Pentothal sodium has been recommended for dental office use by Hubbell,⁴ but the relatively long recovery time and incipient dangers associated with its use have caused Mecca⁹ and others to discourage its use for general office practice. Perhaps in time it will be developed into the ideal office anesthetic.

Vinethene, in my opinion, is an excellent adjunct to nitrous oxide-oxygen. It is quick-acting, relatively safe and rapidly excreted, with little or no after-effects. Wellman, Kable and Livingstone⁵ found that only 2.6 per cent of patients vomited after its use, in contrast to the 57 per cent with ether.⁶ Vinethene is, of course, not perfect. It is highly inflammable, cannot be stored indefinitely, causes increased salivation and may be dangerous in the hands of the inexperienced. Liver damage has been produced experimentally with vinethene anesthesia by Goldschmidt *et al.*,⁷ but this has occurred only after prolonged anesthesia (two hours or more) and in the presence of anoxia. Wellman, Kable and Livingstone⁵ list the following contraindications for vinethene anesthesia: "known or suspected hepatic damage; operations lasting over thirty minutes; the presence of a flame or sparking device; anuria, uremia or marked disease of the kidneys; paralysis of the vocal cords; ankylosis of the jaws; goiter; extensive disease of the lungs; diabetes; cyanosis; intestinal obstruction, and advanced debility."

Vinethene has been administered by the open drop method at Lincoln Hospital Dental Clinic since 1937 to an average of fifteen patients a week, mostly children. All induction for open drop ether anesthesia in the operating rooms is carried out by the use of open drop vinethene. We have noted a typical sequence of clinical signs in induction with open drop vinethene. The patient, usually a child, breathes the mixture according to the anesthetist's instructions for about a minute ("blow it away"). He then holds his breath for about ten or fifteen seconds. This is followed by a short period of slight hyperpnea, after which the patient lapses into the smooth regular breathing characteristic of vinethene anesthesia, third stage, first plane. The eyelid reflex is still present at this point. The patient is then ready for operative procedures.

For some time now, we have used vinethene together with nitrous oxide-oxygen for induction and maintenance in general anesthesia for exodontia and minor oral surgery at the Lincoln Hospital Dental Clinic. We use a Gwathmey model machine. This machine is not equipped with dials or gages, but with a wash bottle into which perforated metal tubes are inserted. The number of perforations through which the bubbles of the gases emerge into the water of the wash bottle denotes the proportion of the mixture being administered. We start with five "holes" of nitrous oxide and two and one-half "holes" of oxygen. A small wash bottle, into which one third of a bottle of vinethene is poured, is attached to the system. As the patient starts to breathe the nitrous oxide-oxygen mixture, the "dial" on the vinethene wash bottle is turned on and off two or three times, to allow vinethene to bubble through the water into the mixture. The patient's reactions are observed. One application of vinethene to the mixture is usually sufficient for induction.

Occasionally, the patient may react to this bubbling of vinethene by coughing slightly. In this case, we wait a little longer before applying the vinethene admixture. The anesthesia can be maintained for as long as is necessary, which is usually not more than from ten to fifteen minutes, on this mixture of nitrous oxide-oxygen, with an occasional bubbling of vinethene.

We have used the same general method for major surgical procedures, such as appendectomy or hysterectomy, for induction in obstreperous patients. Here, a Waters' model is used. Ether is placed in the wash bottle and about 15 cc. of vinethene is placed in the drip apparatus. As the mixture of 750 cc. of oxygen and 7 liters of nitrous oxide per minute is administered, vinethene is dropped into this semiclosed system at the rate of about 40 drops a minute. Induction is usually sufficient by the time the vinethene is used up to switch to ether without any of the signs of pharyngeal irritation which usually accompany induction with ether. The induction is smooth, rapid and uneventful.

SUMMARY

Most general practitioners are reluctant to employ general anesthesia in their offices because of possible untoward effects during the excitement stage.

The rapid-induction method of reducing these occurrences is too dangerous for widespread use.

The slow-induction method is not always feasible with obstreperous patients without premedication.

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PHYSICS AND MECHANICS INVOLVED IN SERVICEABLE PORCELAIN JACKET CROWN RESTORATIONS

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PRESERVATION or restoration of the integrity of the dental arches is of paramount importance if gross disfigurement, impaired efficiency, negative esthetic values and local and systemic disease are to be avoided. Prevention of all dental disease or disorders should be the ultimate aim of the dental profession, and every form of treatment accorded a patient should be preventive in character.

At the present time, we have not attained the ideal of complete prevention of dental disease, and even if there were means whereby the absolute prevention of dental caries or irregularities could be accomplished, there would always be a large percentage of people who would not avail themselves of the treatment any more than they now avail themselves of other established and proved preventive measures for other systemic disorders. In addition, there are the increasingly large

number of accident and injury cases which require restorative measures.

With this situation in view, the profession should, while applying all the known means of preventing dental disease, focus its attention on the best possible means of restoration that will promote health, comfort, function and esthetic appearance.

A question that might well be asked is: "What individual restoration is an ideal one, or what qualities go to make up an ideal individual tooth restoration?" and "Is there such a method that can be universally used in the restoration of any or all broken down teeth in the absence of disease that warrants the retention of such a tooth in the dental arch?"

There is such a method. The degree of perfection attained is in direct proportion to the accuracy of technic, judgment and skill of the operator, during both preparation and restoration. The form and color can be so developed that the artifice can be detected only by the

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closest inspection. Functional activity can be restored and the health of the environmental tissues can be protected. Could anything more be required of any restoration?

The porcelain jacket crown, which is such a replacement medium, has the advantage of being indicated on either vital or non-vital teeth, anterior or posterior, of either arch. Crown work is rather a radical procedure when we consider the amount of tooth structure removed during preparation, but the results obtained more than justify the amount of tooth structure lost during the preparation, provided it is conservative.

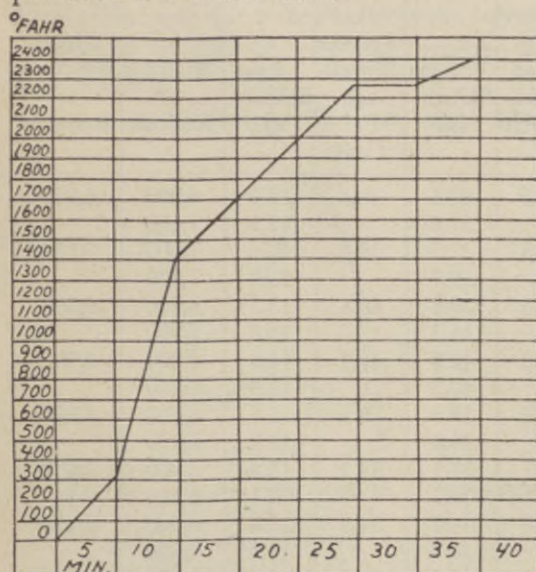


Fig. 1.—Graph showing time and temperatures employed in baking specimens.

The history of a high percentage of the teeth which, owing to caries, must be replaced by means of porcelain jacket crowns seldom varies, particularly in the anterior teeth. The beginning is usually incipient decay in the region of the contact point, which, if properly treated by means of a gold foil filling with margins extended to immune areas, would call for a small, almost unnoticeable and permanent restoration. Such treatment is preventive in the highest degree. This form of treatment is the exception, rather than the rule, at the present time.

Instead, a cement filling is usually placed which, in varying lengths of time, disintegrates and washes out, being repeatedly replaced with larger and deeper fillings of the same kind until one or both incisal angles become weakened and are fractured off. Some optimistic operators even attempt restoration of the angles with the same type of filling.

Obviously, such a practice is wrong, and if such possibilities were explained to the patient, there would be no question as to the type of service which would be most acceptable. No individual wants temporary work, which must be done over at varying intervals, when one permanent and satisfactory method is available. Incidentally, all of the damage following such a procedure is not at the expense of tooth structure, for, as fillings wash out, the contact is lost, which permits packing of food particles into the interproximal space, resulting in soft tissue irritation and destruction. Then follows loss of the normal interproximal space owing to drifting of teeth mesially to take up the space occupied originally by the normally contoured tooth.

This is the history of a large number of cases requiring porcelain jacket crowns in the anterior part of the mouth, a progression of disastrous conditions prevention of which in the beginning would have made the porcelain jacket crown unnecessary, as well as relieving the patient of the added trouble and expense.

Many of the profession are under the impression that porcelain jackets are limited in their application to the six anterior teeth, because it is in this location that they are most necessary for esthetic purposes and most appreciated by the patient. In general, they are equally useful on any tooth whether vital or non-vital, in either arch, where access and the operator's skill are such that adequate preparation is possible.

In particular, they are indicated in

(1) teeth badly broken down from either accident or caries, (2) hypoplastic teeth, (3) peg-shaped lateral incisors, (4) badly discolored teeth or teeth with mottled enamel, (5) badly eroded or abraded teeth and (6) widely spaced or poorly alined anterior teeth (within reasonable limits), and (7) for increasing the vertical dimension in reconstruction cases and, (8) with certain modifications, as bridge abutments. So we see that it is practically universal in its application.

but nothing definite that could be duplicated or proved from the data supplied. Nothing of definite value was found regarding volumetric change, specific gravity, modulus of rupture, impact tests or porosity. This is one reason that porcelain has not been more generally used. Next, the successful application of porcelain jackets requires a thorough knowledge of dental anatomy and histology. In no other type of operative procedure is this more necessary. In addition, accurate preparation is an absolute neces-

TABLE I.—RESULTS OBTAINED FROM TESTS

Specimen	Method of Condensation	Mix	Appar-ent Specific Gravity	Mean Specific Gravity	Volume Shrink- age	Mean Volume Shrink- age Per Cent	Linear Shrink- age	Modulus of Rupture	Mean Modulus of Rupture
C 1 A	Mechanical vibration	Wet	2.39	2.35	38.6	38.1	12.9	6,800	6,950
C 1 B	Mechanical vibration	Wet	2.31		37.6		12.5	7,100	
C 2	Poured and vibrated	Very wet	2.37	2.33	37.7	38.4	12.6	7,000	7,150
C 2 A	Poured and vibrated	Very wet	2.30		39.1		13.0	7,300	
C 3	Gravitation	Wet	2.33	2.36	39.8	40.5	13.3	4,700	5,300
C 3 A	Gravitation	Wet	2.39		41.3		13.8	5,900	
C 4	Poured, no vibration	Very wet	2.40	2.38	42.8	41.5	14.3	4,200	4,900
C 4 A	Poured, no vibration	Very wet	2.37		40.2		13.4	5,600	
C 5*	Poured, no vibration	Very wet	2.29	2.25	37.5	38.5	12.5	6,100	6,100
C 5 A*	Poured, no vibration	Very wet	2.21		39.6		13.2	6,100	
C 6*	15-minute vibration	Medium	2.20	2.27	37.1	38.2	12.4	5,700	5,050
C 6 A*	15-minute vibration	Medium	2.35		39.3		13.1	4,400	
C 7	Vibrated	Dry	2.30	2.28	34.2	34.3	11.4	6,300	7,250
C 7 A	Vibrated	Dry	2.26		34.4		11.4	8,200	
C 8	Poured, no vibration	Very wet	2.32	2.32	48.2	47.4	16.1	8,400	7,250
C 8 A	Poured, no vibration	Very wet	2.32		46.7		16.0	6,100	

*Glycol specimens.

Why, we might ask at this point, if they are so adaptable to the foregoing conditions, are they not more generally used? There are a number of reasons. First, until recently, there was little known of the physical properties of porcelain. In 1934, I began research on the physical properties of baked porcelain. In a review of the literature, virtually nothing of a scientific nature was found. There were a great many articles on porcelain technics and empiric statements regarding the physical properties,

sity if physical or mechanical failure is to be avoided.

The technic of preparation is so standardized that there is little use of repeating it. The main objectives in the preparation are the protection of the pulp, the peridental membrane and the gingival tissues and conservation of tooth structure.

Before any operative steps are taken, a careful study must be made of the position and size of the pulp, extent of caries or depth of previously placed fill-

ings, as well as the condition of the apex of the root and investing tissues, with the aid of recent roentgenograms. Many pulps that have the appearance of vitality in an x-ray film will be found to be either dead or degenerated when tested by means of electrical current or thermal change. Accurate study casts will permit a much more detailed examination of the occlusion than is possible in the mouth. All of this information is necessary for an accurate preparation and a minimum of injury to both hard and soft tissues, as well as a preparation that, owing to its form, will meet and supplement the physical limitations of the baked porcelain when subjected to the stresses and strains of mastication.

Baked porcelain, while an ideal ma-



Fig. 2.—Ideal preparation embodying shoulder cut at right angles to long axis of tooth and tapering toward incisal aspect approximately 1 degree.

terial for restorations in the mouth because of its esthetic possibilities, the tolerance of soft tissue which contacts it when the porcelain is highly glazed and its insulation properties, has, when adequately supported, a high resistance to direct force, but low resistance to impact force or to torque. The latter weakness implies the necessity of proper occlusion in all masticating movements to prevent trauma or sudden impact.

While a certain amount of bulk is advisable and desirable, from the standpoint of color reproduction, it is unwise to depend on bulk of porcelain for strength. From practical experience, it

has been observed that a moderately thin, well-supported mass of porcelain will tolerate greater stress than will a much thicker unsupported mass of the same material.

It is difficult or virtually impossible to observe and measure accurately the forces acting during mastication. The test which most closely approximates these forces is the "modulus of rupture" test. This is made to determine the force in pounds necessary to fracture a transverse section of a material and is used principally in testing brick, tile, terra cotta and glass. This test combines shearing stress, compressive stress and tensile stress all in one operation. The measurements made in inches give a result in pounds per square inch required to fracture the specimen. Such a test approximates the forces in mastication to which



Fig. 3.—Slightly concave lingual surface of preparation area.

practical porcelain restorations are subjected better than any other static test known.

The size of the specimen used for this and other tests as shown in the accompanying table was $5 \times 5 \times 31$ mm. before firing, with a volume of 732 cc.

The tests made upon these specimens determined the specific gravity, or density, the volume and linear shrinkage and modulus of rupture. High-fusing porcelain was used, all specimens being subjected to the same firing technic. (Fig. 1 and Table I.) These results indicate that, regardless of the method of condensation on the consistency of the mix, there was less than 0.1 difference in the

specific gravity or density, while the volume shrinkage varied as much as 10 per cent, depending on the method of condensation. So far as the modulus of rupture test is concerned, the tests showed that the greater the shrinkage, the less the transverse strength.

The condensation or density of the unfired mass affects shrinkage during firing. Clarke¹ claims that, for practical work, the amount of linear shrinkage varies from 9 to 20 per cent. Felcher² states that high-fusing porcelain shrinks from 14 to 18 per cent. Gill³ states that certain high-fusing porcelain shrinks from 15.3 to 23 per cent. All three authors agree that the degree of condensation of the plastic unfired mass plays a very important part in the shrinkage during firing and that condensation

strains set up in the finished product and the form of the prepared tooth that receives the applied stresses at various angles to afford maximum direct resistance, shearing resistance or wedging resistance, as well as close adaptation of the porcelain to the preparation area. Much of the success of the restoration in overcoming these conditions lies within the control of the operator in so shaping the prepared tooth that it offers the maximum resistance to and proper distribution of the applied stresses.

Resistance and retention form is an established principle in any cavity preparation for the reception of any type of filling in order to insure permanence of the restoration. For the same reasons, the preparation of a tooth for the reception of a porcelain jacket crown must em-

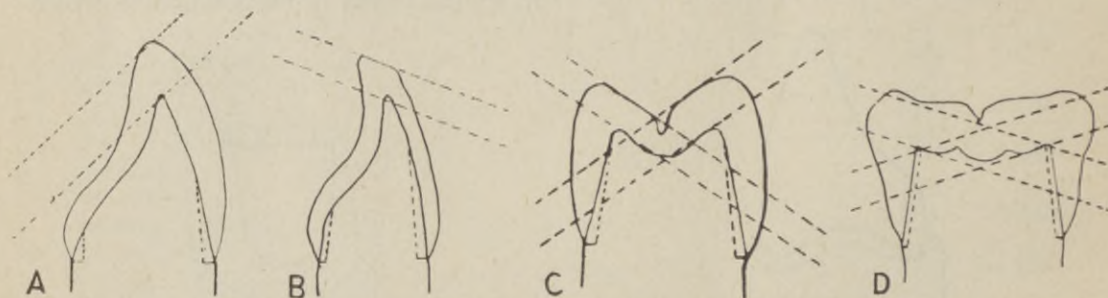


Fig. 4.—Worn bevel of incisal edge or cusps of teeth, which are best guide in making this portion of preparation, stress being delivered at right angles to preparation area at that surface.

produced by vibration causes the greatest degree of density and consequently the least shrinkage.

The amount of stress, as indicated by the modulus of rupture tests conducted by Fitzgerald,⁴ Moldal⁵ and myself,⁶ show that certain high-fusing porcelain tolerates from a minimum of 4,200 to a maximum of 9,556 pounds per square inch transverse stress, the test that combines shearing, tensile and compressive stress. This would indicate that, under normal conditions, the material would have adequate strength.

There are, however, other conditions that affect the strength or durability of baked porcelain restorations in the mouth: the matter of impact force,

body principles which will not only prevent the dislodgement or loosening of the crown, but will also embrace features, in the form of the prepared tooth, that will take into consideration the limitations of the material used in constructing the crown, and, in producing this form, combine the resistance and retention form to meet and overcome the stresses to which the fused porcelain restoration will be subjected.

When considering the resistance form necessary for a satisfactory porcelain jacket crown, we must be fully aware of the limitations of the material, its friability as compared to any of the metals and the effect of both direct and leverage forces, which it must tolerate

if it fulfils its purpose in the dental arch.

In considering the friability of porcelain, the resistance form of the preparation area should be such that the maximum strength of the porcelain is insured under stress. In order to accomplish this in the preparation, all planes should be so prepared that they receive the applied stress at right angles; which means that the force in the direction of the long axis of the tooth would be received by a shoulder cut at right angles to the long axis of the tooth. This applies more particularly to the labial and lingual portions of the shoulder, rather than the proximal, as these present sloping surfaces. (Fig. 2.)

The form resistant to direct stress applied to the lingual surfaces of the upper anterior teeth should present a

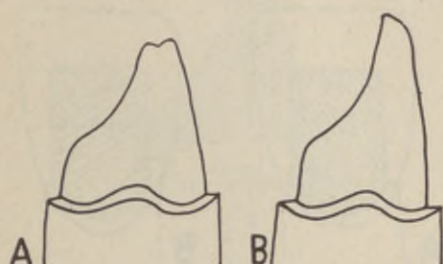


Fig. 5.—A: Preparation of anterior tooth for end-to-end bite. B: Incisal bevel on upper central incisor reversed for crossbite.

broad, slightly concave surface to offer the maximum of resistance and support of the porcelain. (Fig. 3.) While the incisal portion of the preparation area, which is subjected to the forces generated by the protrusive movement of the mandible, can best be made by preserving the worn bevel which is found upon the natural tooth before the preparation is begun (Figs. 4 A, 4 B and 4 C), this varies according to the inclination of the condyle path and the position that the teeth occupy in the opposing arches, varying between a deep overbite, end-to-end and crossbite. (Figs. 5 A and 5 B.)

The resistance form of the posterior teeth is regulated by the cuspal inclinations. Here also, the natural wear in-

fluences the preparation, varying from acute to obtuse angles upon the occlusal surface. (Figs. 6 A and 6 B.) In general, if an even thickness of tooth structure is removed from the occlusal surface of the posterior teeth to allow for an adequate thickness of porcelain, we can be assured that the resistance form of that occlusal surface will be correct. The amount and location of tooth structure removed should be determined with the idea of supporting the porcelain, leaving as little unsupported or overhanging porcelain as is possible, rather than depending on the bulk or mass of material for strength or resistance to stress. In short, the resistance form is the shape or form given to a tooth preparation that will enable it best to withstand the stresses of mastication. It is important in direct ratio to the exposure of the

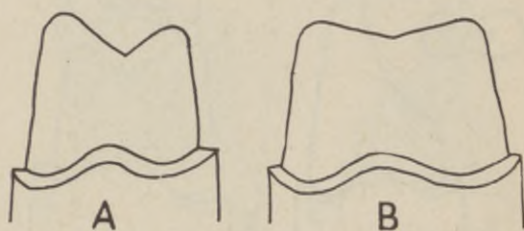


Fig. 6.—A: Preparation where little occlusal wear has taken place, cusps are high and grooves are deep. B: Preparation of posterior tooth where occlusal surface is worn to practically flat plane.

crown to the force exerted in bringing the teeth into any of the movements or positions during occlusion.

Retention form is so closely associated with resistance form that there is little difference so far as the preparation is concerned. Convergence toward the incisal or occlusal surface should not be more than 1 degree from the right angle shoulder at the gingival surface; merely enough to allow removal of the impression of the preparation area without distortion. If the shape of the preparation area results from removal of an even thickness of tooth structure or its equivalent in a gold casting, this form will be

adequate to prevent a tendency toward displacement by rotation, which would certainly be the case if the preparation area were cylindrical or cone-shaped.

Although it must be recognized that there are variations from the foregoing to meet certain definite requirements, the farther we depart from the ideals before mentioned, the more we court disaster. There are a few variations that merit mention: first, the shoulderless crown, used principally in the lower central and lateral incisor locations and occasionally on bicuspid where the gingival portion of the root is extremely narrow mesiodistally and presents concave surfaces upon these areas. Coupled with a well-crowned coronal portion of the tooth, it presents a very serious problem in a conventional type preparation without in-

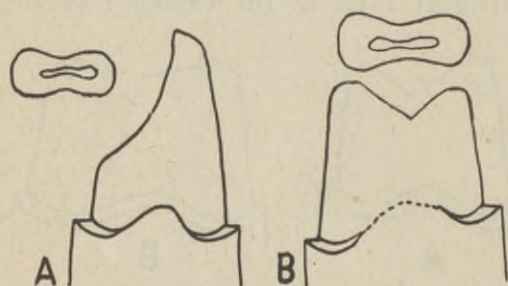


Fig. 7.—A: Preparation for lower anterior tooth in younger person when gingival portion of root is constricted. B: Preparation for upper bicuspid with root constricted mesiodistally.

volvement of the pulp. In such cases, the crown portion of the tooth is tapered at a 1 degree angle to the long axis of the tooth to a point just beneath the free gingival margin, as much tooth structure as possible being preserved mesiodistally to protect the pulp as well as to support the porcelain, the feather edge of which extends just beneath the free gingival margin.

From the standpoint of resistance or retention, the shoulderless crown can meet these requirements, as explained by Grubb⁷:

Considered from the viewpoint of func-

tion alone, a jacket crown in a preparation without a shoulder on any surface offers ample resistance. There is less overhang of unsupported porcelain. Moreover, the pressure developed by a slight deformation of the prepared tooth due to the compressibility of the dentin would be transmitted to and be absorbed by the entire crown.

However, from the standpoint of future disease of the surrounding soft tissue, this type of preparation is far from ideal. A feather edge of porcelain is always sharp and rough and, owing to the inherent qualities of the porcelain material, these thin edges are friable and easily fractured, sharp, angular irritating surfaces resulting which not only damage the soft gingival tissue, but expose to the fluids of the mouth a portion of the dentin of the prepared tooth.

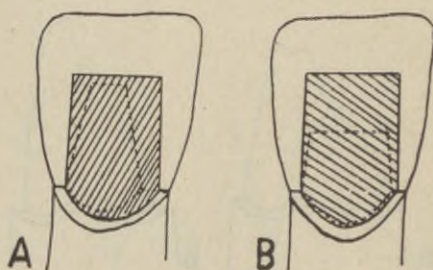


Fig. 8.—A: Gold casting that prevents unsupported bulk of porcelain at proximal aspect. B: Insufficiency of tooth structure remaining to properly support porcelain. The tooth must be built up with gold casting to ideal form.

On the other hand, if a blunt, rounded edge is made, contour of the gingival portion of the crown is exaggerated, and this is damaging to the gingival tissues and, in addition, adversely affects the appearance by providing an inharmonious tooth form.

There are, perhaps, cases wherein the conformation of the crown and root portion of the tooth is such in relationship to the pulp that it would be advisable to have a shoulderless portion upon the prepared root. This would be true in a younger person in whom the pulp is extremely large and the mesiodistal di-

ameter of the root portion is extremely narrow. In such a case, the prepared tooth could have a properly prepared shoulder on the labial and lingual aspects, tapering out and terminating just beyond the angles proximally. (Figs. 7 A and 7 B.) While such a preparation is not ideal, it is protective to the pulp of the tooth and, at a later date, when the pulp has receded sufficiently to permit the formation of a proximal shoulder, such a preparation should be made, the original restoration being considered as a temporary expedient.

So far, we have considered teeth having abundant tooth structure in which to make an ideal preparation. Unfortunately, there is not always a sufficient amount of tooth structure remaining

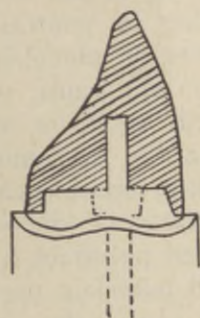


Fig. 9.—Gold core made to build up pulpless tooth to ideal form to support porcelain and prevent fracture of root due to leverage.

after all carious and weakened areas have been removed to permit such a preparation, and if we would have adequate support for a jacket crown, it is necessary to reproduce the lost tooth structure by means of a gold casting, regardless of whether or not it is a vital or pulpless tooth. If the tooth is vital, the preparation is made so that a wax pattern (Figs. 8 A and 8 B) of proper form and retention can be made and duplicated in gold. In pulpless teeth, a gold core with a dowel extending into the root canal for retention can be made, the prepared area being formed in such a manner as to prevent splitting of the root under stress. (Fig. 9.) These are cemented to place and treated, so far as

further construction is concerned, as tooth structure.

This method of making use of a gold core can also be used in certain cases (Figs. 10 A and 10 B) wherein, for esthetic effects, it becomes necessary to use a jacket crown as a bridge abutment. The gold core can be constructed with a proximal extension which will afford a soldering joint for the bridge attachment.

While, from a mechanical standpoint, it has been shown that proper form must be obtained in the preparation to prevent overhanging or an unsupported bulk of porcelain to insure a durable and satisfactory crown, it must be kept in mind that handling of the porcelain material itself during the building up of

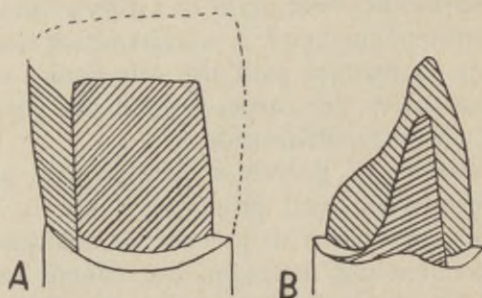


Fig. 10.—A: Labial view of gold casting with proximal extension for soldering, making possible use of porcelain jacket as bridge abutment. B: Proximal view of casting.

the porcelain plays an important part in the strength of the finished crown.

There has been a general belief in the profession that there is a great variation in the strength of high, medium and low fusing porcelains. This has not been borne out by the investigations of Fitzgerald,⁴ who found that in strength each was comparable to the others, although, in general, the high fusing porcelains have the highest modulus of rupture, and the low fusing, the lowest modulus of rupture; but the variation was so small that the indications were that it is not necessary to use high fusing porcelain to have adequate strength for restorations.

There are other factors in the strength

of the finished porcelain product besides the fusing point. The constituents of porcelain include flux, which has the lowest fusing point of all of the ingredients and which, upon fusing, forms a bond that unites the higher fusing materials. Searle⁸ writes:

The nature and amount of the bond largely determines the strength of ceramic materials at various temperatures. In conjunction with the bond, particle size and shape are to be considered. In ceramic materials, the maximum strength is obtained by the use of irregular, angular grains of numerous sizes which interlock freely.

Clark¹ found that the texture and strength of porcelain was at its greatest at the point where vitrification is complete. In order to produce the necessary translucency and glaze to satisfy esthetic requirements, and a non-irritating surface in contact with the soft tissue, we must carry the fusion beyond the point of complete vitrification.

Fusing of porcelain permanently affects its physical properties; that is, it does not return to its original condition upon cooling, as metals do. Metals can be fused repeatedly and, upon cooling, each time revert to their original condition. Porcelain, subjected to repeated firing, begins with the condition that was produced by the previous firing and progresses from that point. With each successive firing or with increases of heat, the pores or blebs enlarge, owing to the formation of gases; the translucency increases; the strength decreases and a colorless, glassy, highly vesicular mass results, tending toward the spherical. Therefore, if it were possible to produce an accurately fitting and contoured crown in one bake, stronger restoration would result than one subjected to several firings. There is one other consideration which, if neglected, often results in failure of the crown. That is the provision necessary to accommodate the crown for the normal occlusal wear.

Contact with highly glazed porcelain causes almost no wear or abrasion upon human enamel. There is always occlusal or incisal wear on natural teeth, at varying rates in the mouths of different persons. If no provision is made upon the glazed porcelain for restoration of the wear, it soon results in traumatic occlusion with a labial displacement of the entire root and crown in the case of the upper anterior teeth, or a fracture of the crown due to impact force, or a breaking down of the investing tissues.

All of the foregoing results can be avoided by etching slightly the highly glazed portion of the crown that contacts the opposing teeth during any of the movements of mastication as disclosed by the use of carbon paper. This etched surface, in contrast to highly glazed surfaces of porcelain, is highly abrasive and will cause wear of the opposing teeth equal to the wear of attrition upon the the natural teeth in the arch. These areas, incidentally, are the only surfaces of the entire crown where unglazed porcelain is permissible.

If unglazed porcelain touches the approximating teeth, the interproximal wear, which is constantly progressing, soon destroys the normal contact point, rendering it flat and allowing the impaction of fibrous foods, with its attendant damage to the interproximal tissues. If unglazed or etched porcelain touches the soft tissue of the gingivae, an irritation and inflammation results, and if the labial or buccal glaze is destroyed, the translucency and color are destroyed and there is an accumulation of stain and débris.

To those who are seriously interested in the improvement of their knowledge and technic upon this subject, I can only recommend that they read and reread the literature I have referred to in this paper, and to those who are inclined toward research, I can suggest that there still exist a great number of unsolved problems regarding baked porcelain.

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A NEW TYPE OF PORCELAIN BRIDGE AND THE TECHNIC FOR ITS CONSTRUCTION

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JACOB A. SAFFIR, D.D.S., Kew Gardens, L. I., N. Y.

FOR more than sixty years, porcelain has been employed in dental bridge prosthesis. A period of such length has provided an unusual opportunity to study and evaluate this material.

A number of years ago, Albert L. LeGro wrote, "The practitioner of today is gradually coming to realize that porcelain in dentistry, aside from being exceedingly artistic, is rapidly taking its rightful place as a restorative material, second to none."¹

Recently, Stanley D. Tylman² competently observed that "the biological compatibility and the esthetic qualities of glazed porcelain have directed the attention of the dental profession for many years toward the possibility of constructing serviceable bridges made entirely of baked porcelain."

The porcelain bridge has always been popular with men who understood its indications. In the main, there are two types of porcelain bridge in use. One, of all porcelain, has its place where the span is short and biting conditions are

extremely favorable. The second, used where the span is longer or the biting more severe, is the reinforced porcelain bridge, built around a strong metallic bar. This type, by far the most practical, when used under proper conditions, has proved stronger and more satisfactory.

Despite the frequent indications for its use and its many well-known advantages over other prostheses, the reinforced porcelain bridge is not commonly employed. Perhaps this is as much due to the specialized skill and the amount of laboratory time required for its construction as it is to the expense involved. Also to be taken into consideration are the work and expense that face the dentist and the patient when a broken pontic is to be replaced, since this procedure necessitates the removal of the bridge and often the remaking of all the pontics.

The advent, about three years ago, of a pin pontic tooth with a porcelain incisal edge and gingival border made possible the construction of a porcelain bridge closely similar, in esthetic values, to the all-porcelain reinforced bridge and with the following decided advantages over it:

Read at the Eighteenth Annual Midwinter Meeting of the Chicago Dental Society, February 22, 1944.

1. Broken pontics can be easily replaced without necessitating the removal of the bridge, as new pontics can always be ground in and fitted to the bridge structure.

2. Special skill in ceramics is no longer required because of the ease of assembly and construction by the use of these pontics.

inforced with strong metal, which will add protection to the porcelain in this region.

5. The teeth may be glazed or changed in any way, individually, and the entire bridge is not subjected to the danger of the furnace for any adjustment to one of its pontics.

6. The pontics can be replaced even after the bridge has been in the mouth for several years, should the color, size or any other condition demand it.

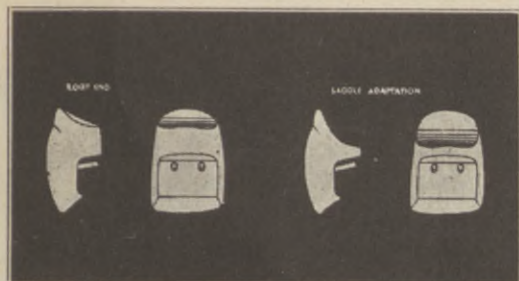


Fig. 1.—Lingual and proximal view of pontics, showing pin recess, root end (left) and saddle (right) type.

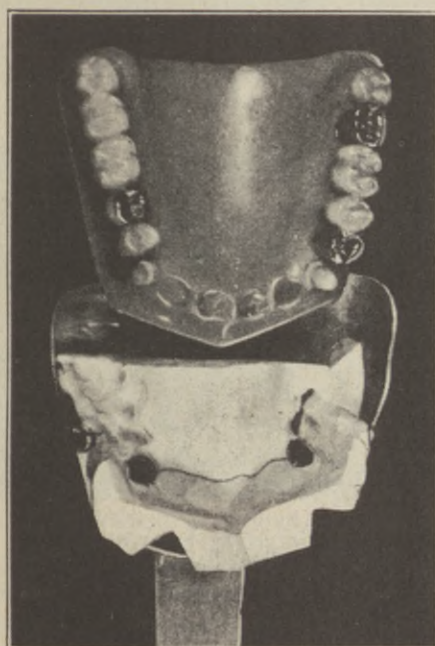


Fig. 2.—Model showing six-tooth anterior bridge using porcelain veneer jacket crowns as abutments; also impression for construction of all-veneer bridge.

3. The results are just as esthetic and yet the cost no longer is a factor.

4. If the case indicates, the dentist can have the biting portion of the pontic re-

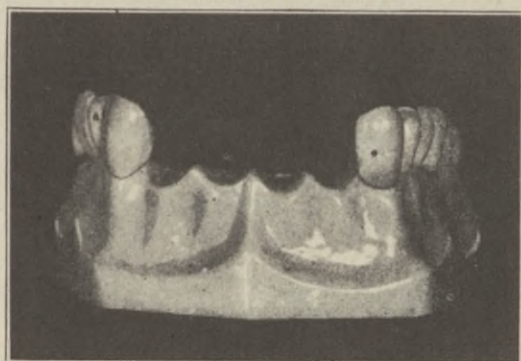


Fig. 3.—Model with abutment in place using porcelain veneer crowns as abutments.

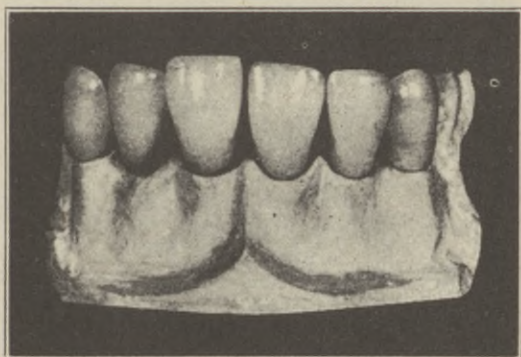


Fig. 4.—Labial view. The teeth chosen for the case were the right width, but longer than in the completed case.

7. Replacements and repairs can be made by a dentist wherever teeth are purchasable; thus the bridge does not have to be sent for these services to a city where there is a competent ceramist.

The teeth described in this paper, for pontic uses, are all porcelain, except for the two platinum pins in a recess on the lingual surface. (Fig. 1.) This recess is

above the incisal edge of the tooth, to leave a translucent incisal edge in the finished bridge, and is a short distance below the gingival border of the lingual surface, so that when the casting, which will serve as a reinforcement, is made, it will not impair the translucence of the tooth any more than the reinforcing bar which is present in all reinforced porcelain bridges.

We see, therefore, that in this bridge

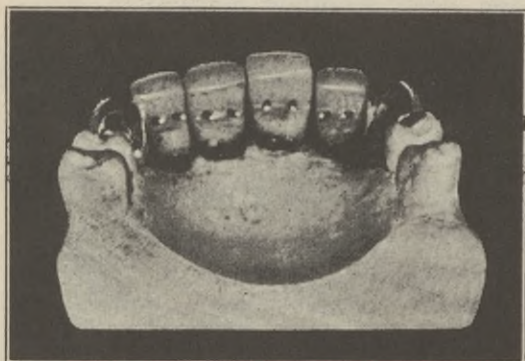


Fig. 5.—Lingual view of teeth chosen for case, showing ample room to grind root ends for adaptation.

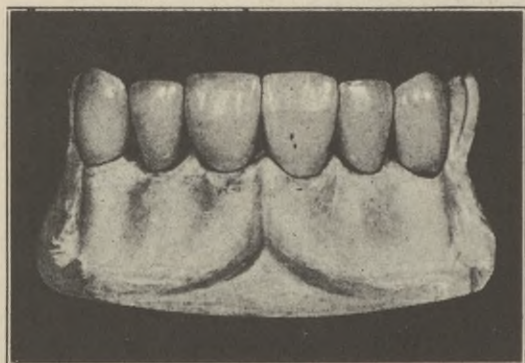


Fig. 6.—Teeth arranged and held in place by sticky wax, while plaster index is made on labial aspect.

the reinforcing bar is on the lingual aspect instead of being embedded within the porcelain as it is in the all-porcelain reinforced bridge.

Chosen here for illustration is a case requiring the replacement of the central and lateral incisors, using the cuspids for abutments. This is shown in Figure 2, which also shows the impression of the

case. Porcelain veneer jacket crowns were used as abutments in this case and these are shown on the model in Figure 3.

In choosing pontics, the procedure is as follows:

After the width is determined, the length is so approximated that one will not have to cut away much or any of the translucent incisal tip. The teeth chosen for this case are shown in Figure 4.

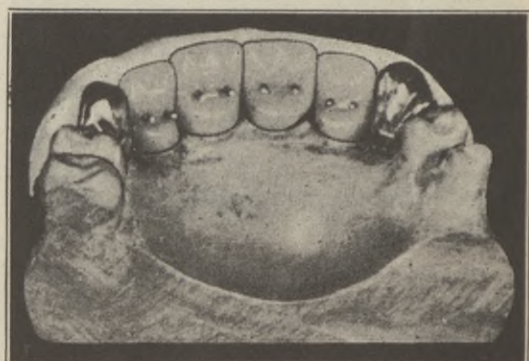


Fig. 7.—Labial index in place holding pontics in correct position, while being waxed on lingual aspect.



Fig. 8.—Reinforced pontics waxed and ready for casting; showing two central incisors with added reinforcement.

Second, one should so choose the length that the pins will come at about the cingulum area of the tooth. This may require some adjustments of the root end area of the pontic to permit proper adaptation of the root end. In Figure 5 is shown the lingual aspect of the teeth chosen and illustrated in Figure 4.

It is best to select a facing from 1 to 2

mm. longer than is necessary, to permit a good gingival adaptation, as is shown in Figure 4. After the teeth have been properly adjusted gingivally, their incisal edges should be in the approximate position that they will hold in the finished bridge and they also should be prepared on both the mesial and the distal aspect to assume, in all respects, their final shape and form.

The preparation on the lingual surface of the pontic comprises the beveling of all the margins. Where it has been ascertained that there is to be undue stress on the incisal edge, a triangular groove having a slightly flattened apex is cut in the center of the lingual surface starting from the incisal portion of the pin recess and continuing incisally to within



Fig. 9.—Cast backings showing slot cut to connect with pin holes; also lingual castings for abutments with pin holes to accommodate porcelain facing.

from 0.5 to 0.75 mm. of the incisal edge.

It can be seen that the casting which extends up into this groove, as well as the extensions upward along the mesial and distal bevels, will act as a guard for the incisal portion against stresses which porcelain, by itself, usually does not have the strength to withstand without fracture.

One must be sure to use for backing material a suitable extremely hard casting gold. Such gold is generally labeled by the manufacturer "extra hard," having a Brinell hardness from 148 upward when bench cooled.

After the lingual portion has been prepared, the teeth are completed. The next step is to properly aline the teeth on an articulated model of the mouth, then to secure the teeth to each other and to the model on the lingual aspect by any of the well-known means, such as sticky wax, soft wax or modeling clay.

While teeth are thus being held, as shown in Figure 6, a small amount of plaster of Paris is placed on the labial

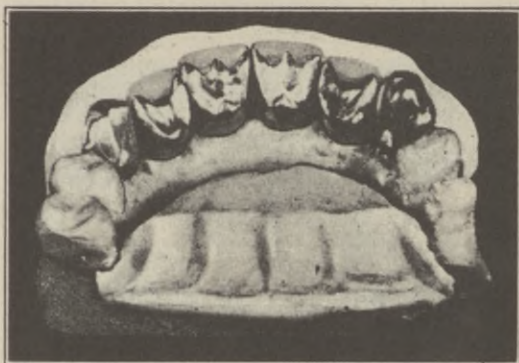


Fig. 10.—Labial index in place with pontics, and castings in place with lingual index relined for soldering.

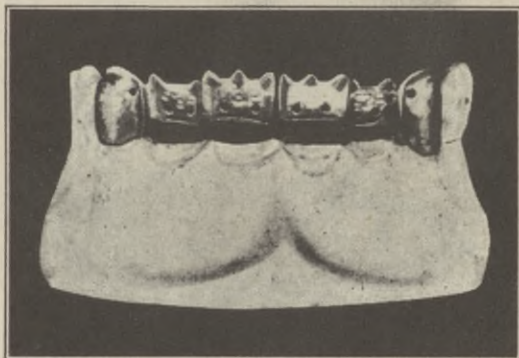


Fig. 11.—Pontics and abutments on model soldered except in median line, which is soldered later.

surfaces of the teeth and on a small labial portion of the model, including the labial portion of the cuspids, so as to furnish, when set, a means for accurately holding the teeth in their proper places on the model. This step is shown in Figure 7, and this is the place where the teeth will be in the finished case when placed in the mouth.

This holding or retaining means of the teeth is hereafter referred to as an index, for it enables the proper indexing of the teeth in respect to the model.

We can now work freely on the lingual portion and proceed by treating the lingual recesses in the porcelain with a separating medium which will not permit wax to stick to the porcelain, inasmuch as we are to take wax impressions of the lingual recesses on these pontic teeth. It is not considered advisable to

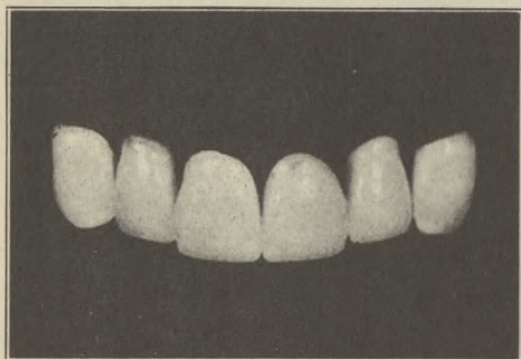


Fig. 12—Labial view of completed bridge.

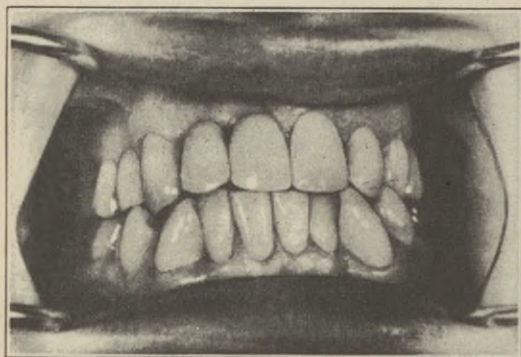


Fig. 13.—Labial view of practical case replacing upper right central and lateral incisors.

make more than two backings in one casting. In fact, it does not require much more time to construct individual backings.

After the wax has been placed in the recesses, it is properly carved to reproduce the form desired for the lingual surface, as shown in Figure 8. It is then removed, invested and cast.

There are various methods of reproducing the pin holes during the casting operation. The wire in a No. 3 paper clip is of the same diameter as the pin and the wire in a No. 4 Puritan bank pin is of the same gage as the pin. Either of these can be placed in the hole, and, after casting, be removed by dissolving in nitric acid.

A carbon point may also be used for this purpose, but this is the least desirable of all of the methods because it frequently leaves gas bubbles in the gold around the carbon points. The preferred method is to carve a small groove on the gingival aspect of the wax, deep enough to reach the ends of the pin holes, as shown in Figure 9.



Fig. 14.—Lingual view of practical case restoring upper right central and lateral incisors with added reinforcements of pontics.

This procedure gives three worth while results:

First, the investment can run right through the pin holes, with practically no danger of trapping air, and with a good opportunity for a fine casting of the pin holes.

Second, there is a slight saving in gold.

Third, proper cementing is simplified and more or less assured because the cement runs right through these holes.

One of the difficulties in properly cementing this type of pontic where no opening into the pin holes has been created lies in failure to force the air out

of the pin holes, thereby allowing the cement to completely fill the pin holes.

Another method, of course, of constructing this type of bridge allows the pins to go right through the backing and come out on the lingual surface. This method also permits proper investment and simplified cementing and has its advantages in these respects.

The backings, having been cast, are fitted to the pontics. Then, by use of the index again, the pontics are realigned, as shown in Figure 10.

At this point, it is necessary to take a lingual impression of the bridge with the backings in their proper position, pour this impression with soldering investment and proceed with the soldering operation.

It is preferable not to solder the entire bridge in one operation, but to solder it in small sections, making new indices after each soldering operation. It is also desirable to solder first the pontics nearest to the abutments and then the intermediate pontics. In Figure 11 are shown the central and lateral pontics soldered to an abutment. They will next be soldered to each other.

Although the entire bridge may be soldered on the model, it is preferable to leave one joint open until the final fitting in the mouth, where an impression is taken and poured in soldering investment. When the bridge is then finally soldered, one is assured of the maximum in accuracy of assemblage.

When soldered and assembled, the finished bridge, as will be noted, has the same appearance as in Figure 6, when the teeth were completed and assumed

the shape and position that had been anticipated for the finished bridge.

Figure 12 shows the completed and assembled bridge off the model. Figure 13 shows the labial appearance of another bridge, using these pontics and this type of construction in the mouth of a patient in whom the right central and lateral incisors were restored. Figure 14 shows the lingual aspect of this same bridge.

The same indications and contraindications that are present in porcelain bridge work in general are applicable to this type of bridge as well. For example, a very close bite, especially if it is an end-to-end bite, is frequently a contra-indication. If employed in the average mouth, however, where conditions are fair, a completely satisfactory bridge, both esthetically and functionally, can be produced.

Upon viewing the esthetic and satisfactory results with porcelain bridge work, one must concur with the observation of J. L. Loop,³ professor of ceramics at the University of Southern California, that "restorative dentistry which, after all, comprises by far the major portion of the dentist's ministrations, finds its most finished form of expression in porcelain work."

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COMPLETE DENTURE IMPRESSIONS BASED UPON THE ANATOMY OF THE MOUTH

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THE objectives of complete denture impressions are: (1) retention, (2) stability, (3) support, (4) esthetic values and (5) preservation of the alveolar ridges. Success in attaining these objectives depends on the dentist's knowledge of the anatomy of the mouth, and his skill in the use of an impression technic to establish the desired relationship between these objectives and the anatomic structure of the mouth.

Retention of a denture is based on its resistance to forces that tend to remove it from the normal close contact with the mucous membrane. It is the most spectacular and probably the least important of the objectives. It is spectacular to pull on an upper denture without its becoming loose. Likewise, it is good showmanship to be unable to dislodge the lower denture by means of an instrument placed against the lower incisor teeth. But these are not functional forces. A denture that would withstand this kind of test might be a failure under functional conditions. Also, it might not meet the other objectives of complete dentures. Overextension or an extremely tight peripheral seal would develop this type of retention. Retention attained by these means would be only temporary. Stability and support would be lost with the destruction of the supporting structures. Esthetic values would be lost and the retention itself would become ineffective when the mouth is open wide or when the jaw is moved from side to side

or the tongue is manipulating food in the mouth.

Retention is attained by the forces of adhesion, cohesion and atmospheric pressure and the plastic molding of soft tissues around the polished surfaces of the dentures. Adhesion and cohesion are effective when there is perfect apposition of the impression surface of the denture to the mucous membrane surface. These forces lose their effectiveness if there is any horizontal displacement of the dentures that breaks the continuity of this contact. Atmospheric pressure is effective primarily as a rescue force when extreme dislodging forces are applied to the denture. It depends on a perfect peripheral seal to keep the pressure applied on only one side of the denture. The presence of air on the impression surface would neutralize the pressure of the air against the polished surface. Since each of these forces is directly proportional to the area covered by the dentures, the dentures should be extended to the limits of the oral cavity.

The plastic molding of the soft tissues around the polished surfaces of dentures helps to perfect the peripheral seal. Also it forms a mechanical lock at certain locations on the dentures, provided these surfaces are prepared for it. This lock is developed automatically and without effort by the patient if the impression is built with an understanding of the anatomic possibilities. An example of this lock can be seen at the distobuccal angle of the lower denture, where the suctoral pad in the cheek folds over it.

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Stability is based on the resistance to horizontal movement of the denture. Retention is lost when the limit of stability is exceeded by forces applied to the denture. Horizontal movement of the denture takes the denture out of contact with the mucous membrane and breaks the peripheral seal. Therefore, it may be said that stability is more important than retention. Stability is necessary to resist the forces of occlusion, both centric and eccentric. It is attained by utilizing the surfaces of the maxilla and mandible that are at or near right angles to the

Support for a denture is based on the resistance to forces at right angles to the occlusal surface of a denture. A favorable supporting structure is one that does not permit an appreciable change of position of the denture under varying pressure. The quality of the support depends on the thickness of the soft tissues over the bone and the way in which the impression materials are carried against them.

The esthetic value, or appearance, of the denture is dependent in no small way on the impressions. The denture borders

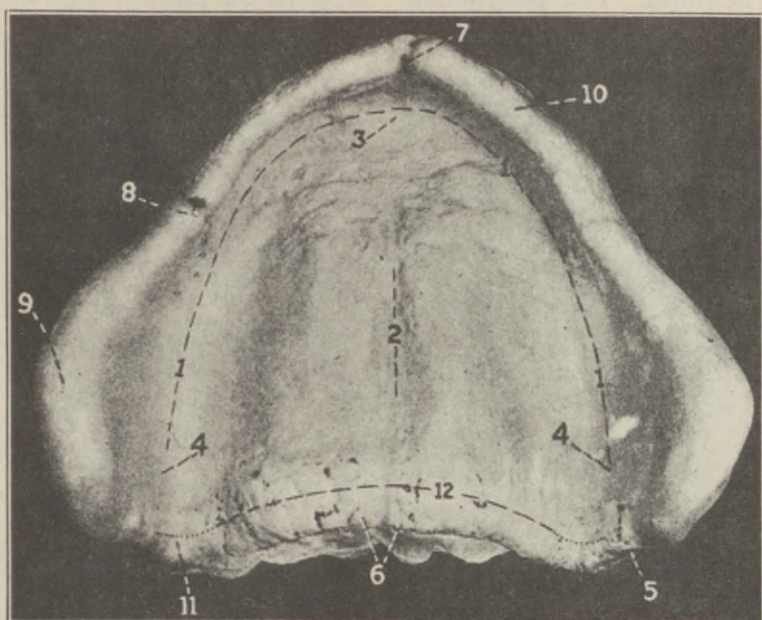


Fig. 1.—Plaster wash impression taken in modeling compound tray. The maxillary groove (1) gives support for the denture and is recorded with the tissue at rest. The median groove (2) and the incisive fossa (3) are to be relieved in the denture to balance pressures and protect the blood and nerve supply. The maxillary tubercular fossa (4), together with areas on the buccal and lingual aspect of the maxillary groove (1), gives lateral stability. The masseter groove (5) provides space for the masseter muscle and ramus in function. The labial notch (7) and buccal notch (8) provide space for the labial and buccal frenula (9). The buccal flange fills the buccal vestibule, attaining maximum tissue coverage, and together with the labial flange (10), pterygomaxillary postdam (11) and the palatal postdam (12), forms a complete peripheral seal. The labial flange (10) is adjusted for thickness to support the lip for improvement of the appearance.

occlusal plane. These surfaces might not be at a favorable angle, and the soft tissue over them might be too soft in many cases for ideal results. It is the dentist's responsibility to know where these areas are and how to make the best use of them.

support the reflection tissues when necessary. The shape of the mouth and the fulness of the lips depend on the proper support of these tissues at the periphery, and by the thickness of the labial flange. The effectiveness of the peripheral seal

and stability is reduced if the impression is constructed with a labial flange that is too thick. The flange must then be reduced in thickness, the tissues thus being permitted to drop back away from the denture. Overextension of an impression will reduce the amount of vertical opening possible for a case. Then when overextension is corrected, the tissues will not be properly supported and the vertical dimension will be reduced too much.

The preservation of the alveolar ridge is the most important objective of impressions for dentures. The destruction

than impressions in this tissue loss, or softening, but improper placement of pressure by an impression can interfere with the blood and nerve supply to the tissues; and will cause its destruction.

The foregoing remarks briefly outline some of the problems involved in developing an impression technic. How these objectives are to be attained will be indicated. (Figs. 1-2.)

Effective adhesion and cohesion can be attained for an upper denture by use of a plaster wash impression, if the wash is taken in a tray that properly supports the plaster. The tray must carry



Fig. 2.—Anatomy of upper jaw. For retention, the denture is limited by the labial frenum, labial reflection, buccal frenum (1), buccinator muscle (2), masseter muscle (17), ramus, hamular notch (7) and vibrating line (9). Stability is attained by contact with the buccal and lingual side of the alveolar ridge when the median raphe (15) is relieved. The lip must be supported by the labial flange for the sake of appearance. The blood supply is protected by relief of the incisive foramen (16) and by the thickness of the palatal glands (14) covering the greater palatine foramen (12).

of ridges will carry with it the loss of retention, stability and support of the dentures and will ruin the finest esthetic effect of the restoration. Discomfort and inefficiency will replace the comfort and efficiency that were attained along with the other objectives, when the ridges shrink away. There may be factors other

a minimum bulk of plaster into a definite contact with the tissue. Excessive bulk of plaster causes distortion through its expansion. The tray must not contact the tissue as it carries the plaster to position, because this would distort the tissue surface. This distortion would cause injury to the tissue or soreness by

interfering with its blood supply. Moreover, the distorted tissue would tend to resume its normal form, thus exerting a force to dislodge the denture. From this, it can be seen that it is desirable to record the tissue surface in its relaxed form.

A good peripheral seal may be obtained in plaster if it is properly supported by a tray, which must have sufficient width at the periphery to support the plaster and must have sufficient height to carry it to within 1.5 mm. of the reflected tissues, at rest. A larger amount of plaster than this on the periphery will not carry it to certain contact with the peripheral

the soft tissues of the palate in relation to their thickness. It is necessarily located in the hamular notches and just anteriorly from the vibrating line. It is along this line that the tissues will tolerate additional pressures. A postdam located too far anteriorly will be placed on tissues with extreme variation in thickness, and if placed too far posteriorly will be ineffective because it will be in contact with the movable soft palate, which, under certain conditions, will rise up out of contact with it.

Stability is attained in this impression by the definite contact of the buccal and labial flanges with the buccal and labial

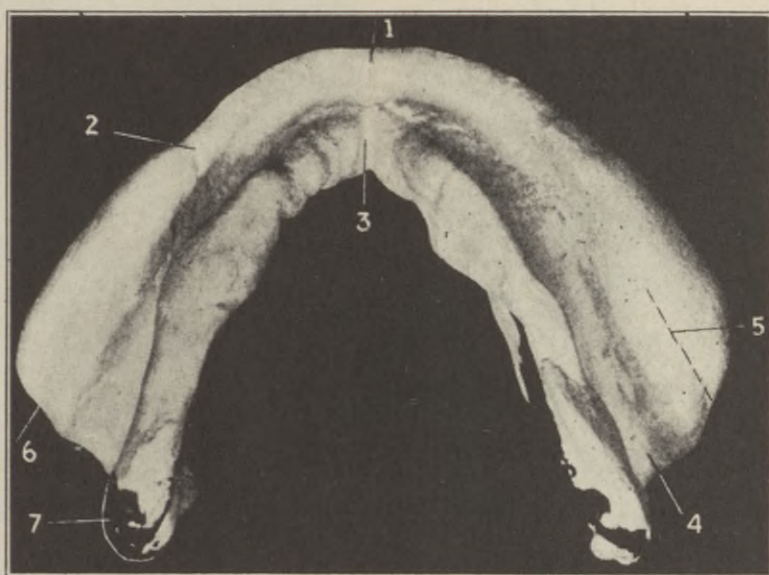


Fig. 3.—Lower plaster wash impression taken in modeling compound tray, used to record tissue surfaces of stress-bearing areas at rest and to make vulcanite tray. The landmarks are the labial notch (1), buccal notch (2), lingual notch (3), retromolar fossa (4), external oblique groove (5), masseter groove (6) and retromylohyoid eminence (7).

tissues. The flanges of the tray, if too high, will interfere with the tissues as they are muscle trimmed. The structures that limit the extent of the denture, such as the labial frenum, buccal frenum, buccinator and masseter muscles, and the ramus must have freedom for action. The tray must not be too large or too small. The peripheral seal is maintained at the distal border of the denture by means of a postdam. The postdam places a uniform pressure on

surfaces of the alveolar ridge; and by the definite contact of the palate with the anterior third of the vault and with the lingual slopes of the alveolar crest.

The alveolar ridge is the area which furnishes the primary support for the denture. However, a hard area in the median line, the median raphe, must be relieved to make this effective. This is done by adding metal to the cast before processing the denture. The amount of relief to be given to the cast depends on

the relative hardness of the tissues over the alveolar ridge and over the median raphe. The extent of the relief depends on the size of the hard area.

The esthetic values are preserved by the well-rounded periphery in the anterior portion of the impression and its thickness, which is regulated according to the amount of shrinkage that has oc-

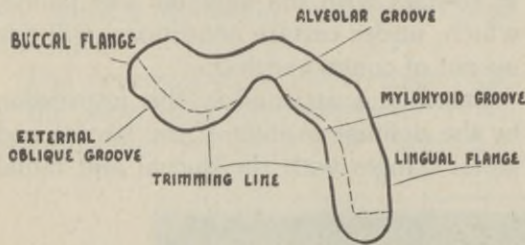


Fig. 4.—Cross-section through final impression. The form of alveolar groove is recorded in plaster. The remainder of the tissue surface is developed in modeling compound.

face of the mouth, by the thin plaster wash. The blood and nerve supply in the anterior third of the palate is protected by extending the relief anteriorly to cover the incisive papilla. The blood and nerve supply to the posterior two-thirds of the palate is adequately protected by the thick palatal glands which cover the greater palatine foramen.

Adhesion, cohesion and atmospheric pressure are all less on the lower denture than on the upper, because of the difference in the area covered by them. All of the tissues of the lower jaw, within the limits of the functional area, should be covered by the lower denture, to develop the maximum effect of these forces. (Figs. 3-4.)

Adhesion and cohesion in the lower denture are attained by the accurate record of the form of the soft tissues

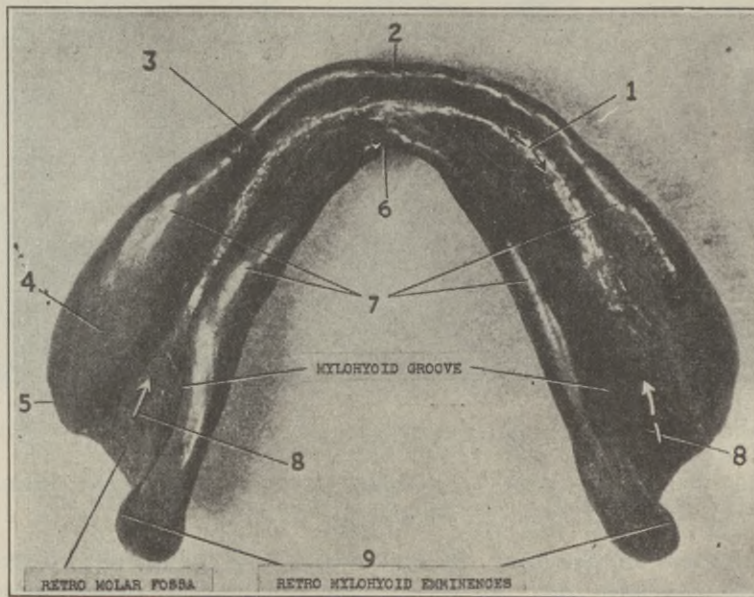


Fig. 5.—Landmarks on final lower impression: alveolar groove (1), which is recorded in plaster, reproduced in vulcanite tray and formed in cast; labial notch (2); buccal notch (3); external oblique groove (4); masseter groove (5); lingual notch (6); retromolar fossa (8), and retromylohyoid eminences (9). The slopes of the alveolar groove and the entire periphery are developed in modeling compound.

curred and according to the amount of support needed by the lips.

The health of the ridges is provided for by a minimum amount of pressure applied to the mucous membrane sur-

when they are at rest. Their form is recorded by a thin plaster wash impression, taken in a modeling compound tray. The issues of the crest of the ridge are not distorted by a resistant impres-

sion material. A cast is formed in this impression, and a vulcanite tray is processed over this cast. The bottom of the alveolar groove in the vulcanite tray has the same form as the plaster wash impression. This form is carried through to the completed denture. The periphery of the tray is cut until it is 1 mm. short of the reflected tissues. Also, 0.5 mm. and all undercuts are removed from

the slopes of the alveolar groove in the tray.

Modeling compound is added to the cut surfaces of the tray to restore the contact with the slopes of the ridges, and to perfect the peripheral seal. This compound is heated and inserted in the mouth in such a way that the excess will flow over the crest of the ridge and out over the periphery. When it is removed from the mouth, the compound that has moved down into the bottom of the alveolar groove on to the uncut vulcanite is removed. This process is repeated until no compound moves into the bottom of the alveolar groove, and



Fig. 6.—Anatomy of lower jaw. For retention, the denture makes continuous contact with structures that limit it: the labial frenum, buccinator muscle (1), masseter muscle (2), anterior border of ramus, temporal tendon (7), retromylohyoid curtain (5) and superior constrictor muscle, which is backed up by internal pterygoid muscle (3), mylohyoid muscle (9) and lingual frenum. The lingual flange lies between the alveolar ridge and the sublingual fold (10), the lingual nerve (8) and the anterior tonsillar pillar (4). The denture must cover the retromolar pad (6). Stability is attained by contact with the slopes of the alveolar ridge. Support is given by the alveolar ridge and the buccal shelf medially from the external oblique line. The appearance is improved by supporting the lip. The health of the ridge is preserved by limiting pressure on the crest of the ridge, placing the heaviest pressure on the buccal shelf.

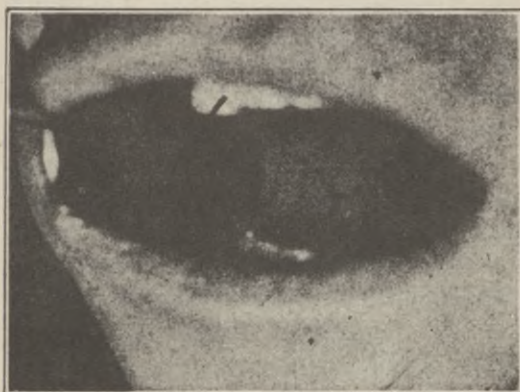


Fig. 7.—Suctorial pad (indicated by arrow) in cheek, which folds over distal-buccal angle of denture to make perfect peripheral seal, and automatic soft tissue lock on lower denture in that area.

until the junction between the uncut vulcanite and the compound is smooth, with no ledge either way. This restores the form of the slopes of the alveolar groove and controls the amount of pressure upon it. (Figs. 5-6.)

Atmospheric pressure is effective as a retentive force because of the peripheral seal developed by the muscle trimming in modeling compound. The seal is developed as a plastic record of the structures that limit the extent of the impression. These structures are the labial frenum, the reflected labial mucous membrane, the buccal frenum, the buccinator muscle and reflected area of the

cheek, on the labial and buccal aspect; the masseter muscle, the anterior border of the ramus, the pterygomandibular raphe, the superior constrictor of the pharynx and the retromylohyoid curtain, on the distal aspect; the mylohyoid muscle, the soft tissues in the floor of the mouth and the lingual frenum on the lingual aspect. The controlled plasticity of the modeling compound makes it possible to vary the amount of tension on each of these structures. There are a few areas which require special attention. The masseter muscle and the internal pterygoid muscle are brought into approximation with the impression only when under contraction. Therefore, a downward pressure should be exerted on the impression tray in muscle trimming these areas. The mylohyoid muscle and the tissues supported above it vary greatly in their form and position with different tongue positions. The lingual flange must be extended downward far enough to maintain a continual contact with the floor of the mouth under all conditions. Also, the lingual flange of the denture must slope toward the tongue at such an angle that these structures will be free to move into all positions. The floor of the mouth in the region from bicuspid to bicuspid is relatively closer to the cast of the ridge than it is posteriorly from that point. The lingual flange in this region must maintain a continual contact with the floor of the mouth without limiting the action of the tongue. It must be possible for the patient to protrude the tongue far enough to wet the lips without interference. The suctorial pad in the cheek folds over the distobuccal angle of the denture. (Fig. 7.)

Stability against forces tending to move the denture horizontally is attained by the modeling compound record of the slopes of the alveolar ridge. Modeling compound heated to 135 degrees is less plastic than plaster of Paris. The modeling compound will, therefore, exert

a slightly greater pressure on the slope of the ridge than the plaster. This will assure a definite resistance to horizontal forces applied to the denture. The area lingually from the bicuspid is particularly effective in this respect. It is anteriorly from the sharp mylohyoid ridge and therefore can be made to fit the mandible very closely.

The most favorable areas for support of the denture are on the crest of the alveolar ridge and on the buccal shelf. The crest of the ridge is cushioned by soft tissue, which is not displaced or distorted by the impression and which is completely at rest when no pressure is being exerted upon the denture. The buccal shelf, the area between the crest of the ridge and the external oblique line, consists of smooth cortical bone and is covered by the attachment of the buccinator muscle. It is nearly horizontal except at its anterior end. It is one of the most nearly ideal surfaces in the lower jaw that can be used for the support of a denture. The modeling compound record of this form is developed in such a way as to place the heavy masticatory load on this surface. This area carries more of the pressure than does the crest of the alveolar ridge.

The form and thickness of the labial flange of the lower denture affect the appearance in the same way as in the upper.

The conditions that tend to preserve the lower ridge and maintain its health are related to the preceding objectives. The tissues on the crest of the ridge are protected by their automatic relief. The plaster impression that determines their form is taken while they are at rest. The modeling compound on the slopes of the ridges relieves the pressure on the tissues of the crest. The heavier pressure is transmitted first to the buccal shelf, which is ideally situated to resist these forces. The denture is stable and therefore horizontal movement is re-

duced to a minimum. Horizontal movement causes much of the destruction of ridges. The compound on the slope of the ridges is handled in such a way that it cannot cause a gripping of the ridge. It must be heated to a temperature that will cause it to exert more pressure than plaster of Paris, but not enough to form a ledge on the inside of the denture. If this surface is formed in such a way as to cause no ledge to appear on the slope of the denture, the pressure is properly balanced between the crest and the slope. This develops the most favorable protection for the blood and nerve supply to the tissues, and facilitates repair of damage done by the denture.

It is obvious that there are factors

other than impressions in successful denture construction. Occlusion, arch form, leverages, tooth color, size and form are a few of the varied problems that affect the retention, stability, support and appearance of the denture, and the preservation of the alveolar ridge. Each step in the construction of complete dentures has its own responsibility for the end-results. Good impressions are necessary to success because all the other problems are dependent on their success for their solution.

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A PRELIMINARY REPORT ON PENICILLIN IN DENTISTRY

LEO STERN, D.D.S.¹

Penicillin has already produced an impressive literature, but it has yet to be evaluated in the treatment of diseases of the mouth. As it may soon be available to the profession, it seems desirable to describe some personal observations dealing with its use in dentistry.

Penicillin has properties that offer many advantages over the sulfonamides in the direction of range and potency. These were recently described from the point of view of the bacteriologist by Bartels (1). Interpreted in clinical terms of dental interest they may be restated as follows:

1. Its high solubility in water indicates the probability of increased local effectiveness by rapid absorption into underlying tissues. Conversely, this quality carries the disadvantage of requiring more frequent application to open surfaces such as are encountered in lesions of the mouth, where it may be washed away too quickly. For such cases a relatively insoluble and tenacious base is indicated. However, absorption is not too rapid when it is injected into closed cavities such as root-canals, infected cysts and suppurating sinuses. The agent itself is non-irritating.

2. Penicillin is bacteriostatic in high dilution towards many, but not all strains of staphylococcus aureus. Lower dilutions appear to influence streptococcus viridans recovered from cases of subacute bacterial endocarditis (2). Reported cures of this disease (3) should be accepted with extreme reserve at this time, but it seems beyond question that penicillin is able to eliminate those organisms that are freely floating in the bloodstream. This quality may prove of value in the treatment of dental periapical infections.

3. Because the potency of penicillin is not inhibited by peptone, tissue secretions or pus, as are the sulfonamides, it is useful in such dental lesions in which pus has formed, as abscess cavities and osteomyelitis.

4. Penicillin is more effective in the treatment of chronic infections than the sulfonamides.

5. When properly diluted with pyrogen-free distilled water the more recent samples exert no toxic effects on blood cells, excretory organs, or on tissue to which it may be applied locally (4).

This report deals with the application of penicillin in fusospiral gingivitis, putrescent root-canals, and in one case of severe post-extraction infection. The number of cases in this series is far too small to justify the drawing of conclusions, but a brief statement of methods and findings may be of assistance to others when the agent becomes generally available.

FUSOSPIRAL GINGIVITIS

The preparation used in this series was a cream-cellulose-base, soluble in water 1:12, containing penicillin to the value of 250 Florey units per cubic centi-

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meter. Six patients were treated, each with the typical history and symptomatology of fusospiral gingivitis. The onset was sudden, ushered in by sore and bleeding gums, and a moderate degree of malaise. There was a putrid odor to the breath, hypersalivation, frank gingivitis with necrotic ulcers, and lymphadenitis. Blood counts were normal in four patients; one showed a leucocytosis (13,500 w.b.c. per mm.); and in another, there was a slight qualitative anemia with occasional abnormally large red cells. A profusion of fusospirochetes was demonstrated in the smears. Each patient was given a small quantity of the preparation and instructed to apply it to the gums every three hours. Nothing was to be taken by mouth for an hour afterward, and no supplemental treatment was prescribed. Results are summarized in Table I.

Cases 1 and 4 responded extremely favorably. After two days, although smears were still positive, bleeding was almost completely controlled, many ulcers had resolved, lymphadenitis was reduced and the patients stated that they felt much better. After four days, clinical improvement seemed complete in both patients and routine periodontal treatment was substituted.

TABLE I

CASE NO.	BLOOD COUNT	GINGIVAE, 2ND DAY	4TH DAY	6TH DAY
1	Normal	+	++	++
2	Qualitative anemia	-	+	++
3	Normal	-	-	-
4	Normal	+	++	++
5	Leucocytosis	-	-	-
6	Normal	-	-	-

-, indicates no change; +, improvement; ++, marked improvement.

This course was paralleled in Case 3 after the fourth day. No improvement was noted after six days in Cases 5 and 6: thereafter the patients were treated in the routine manner with good results. It seems a conservative comment that if fusospiral gingivitis is a local infection, some strains of the exciting organisms appear to be influenced by penicillin. Unfortunately the fusospirochetes cannot be cultured as a group and as yet no "in vitro" method is available for testing their sensitivity.

THErapy OF PUTRESCENT ROOT-CANALS

The preparation used was penicillin dissolved in distilled water to the value of 250 units per cubic centimeter. Five patients were selected for this experiment, each complaining of subacute pericementitis in an anterior tooth, associated with loss of viability and a putrid odor to the pulp. The following criteria were used in selecting cases: sudden onset of severe pain, marked tenderness to percussion, and negative response of the affected tooth to the Faradic current. In each case distinctly putrescent pulps were uncovered and preliminary cultures were made after isolating the tooth, gaining access to the pulp chamber, and removing

the coronal half of pulp debris. Penicillin was injected into the canal, using a Luer syringe to which was attached a silver lachrymal needle having a wrapping of rubber dam to serve as a washer. The degree of pressure employed in the injection was just sufficient to elicit a pain response. Cavities were sealed with gutta-percha. The results of cultures during the course of treatment are given in Table II.

At the second visit each patient gave a story of early relief from pain with gradually receding tenderness. Cultures were negative in two cases after three days, and remained so on the sixth and twelfth day, when the root-canals were filled with Callahan's resin solution and gutta-percha points. Another patient responded in like manner on the sixth day. In Cases 2 and 5 there was seepage present in the canals after twelve days and a persistent moderate tenderness. The apices of these teeth were resected and the root-canals filled; the periapical tissues appeared normal.

TABLE II
Putrescent canals treated with penicillin

NO.	TOOTH	CULTURE	CULTURE 3RD DAY	CULTURE 6TH DAY	CULTURE 12TH DAY
1	UL2	Str. Viridans	+	-	-
2	UR3	Str. Viridans Staph. Albus	+	+	+
3	UR5	Staph. Aureus	-	-	-
4	UL2	Str. Viridans	-	-	-
5	UL1	Str. Viridans Staph. Aureus	+	+	+

Although the results of these experiments were equivocal, penicillin appeared to be effective in three cases. It remains to be demonstrated in a large series whether it will prove superior to currently used agents.

POST-EXTRACTION INFECTION

On March 14th, M. W., a 28 year old housewife, previously in good health, complained of pain and swelling on the left side of the jaw and neck. Four days earlier, an unerupted 3rd molar had been removed under local anesthesia. Reaction was not severe until the third day, when a shaking chill was experienced in the morning, followed by a rise of temperature to 102.2°F. The tissues of the neck and over the jaw began to swell considerably and there was severe pain in the jaw, radiating to the ear. Another brief chill occurred the next morning, followed by a fever of 103°F.

The patient appeared acutely ill. The skin covering the mandible and submaxillary area was red and diffusely swollen, exquisitely tender to pressure, but not fluctuant. Trismus was noted and the floor of the mouth on the left side was somewhat edematous and tender. A gauze dressing removed from the socket of the 3rd molar was stained and had a foul odor. No other significant clinical signs were found. A blood culture and complete count were ordered, a boric acid dressing applied externally, and intra-oral irrigations of hot saline solution prescribed, together with aspirin and codein for sedation.

There was no improvement nor did a fluctuant point develop during the next two days. The temperature rose to 103.4°F. The blood picture was normal excepting for a white cell

count of 12,000, but the blood culture showed many colonies of staphylococcus aureus. The laboratory reported this strain to be sensitive to 5 units of penicillin.

Treatment with penicillin was begun on March 16th at 5 p.m., with 10,000 units injected intramuscularly every 4 hours. The following day the maximum temperature was 100.8°F. and the patient felt decidedly better. On March 18th the temperature remained below 100°F, the external swelling was considerably reduced and the edema in the floor of the mouth had resolved. Therapy was discontinued after 120,000 units had been injected. There was no evidence of spontaneous discharge of pus and the patient made an uneventful recovery. A follow up examination on April 3rd showed a nicely granulating socket, with neither tenderness nor swelling externally.

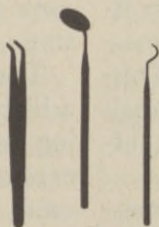
COMMENTS

Taken individually, none of these cases followed a pattern of improvement that is not often observed with other forms of therapy. However, the percentage of favorable responses suggests therapeutic benefits at least equal to that of currently approved agents. A considerably larger number of dental case reports covered by adequate clinical and laboratory controls must be accumulated before the value of penicillin can be measured.

It seems reasonable to conclude, however, that considerable variation exists in the sensitiveness to penicillin among the many strains of organisms found in dental infections. Fortunately a convenient laboratory technic is available for measuring this quality. It is recommended that this method be used as an "in vitro" control to clinical experiments.

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ROOT-CANAL THERAPY AND THE USE OF SULFONAMIDES

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IN root-canal therapy, we have to contend with an infectious condition of the pulp caused by the invasion of either staphylococci or streptococci, or both. In 1935, Domagk demonstrated that mice could be protected against fatal doses of streptococci with prontosil.¹ This discovery was the forerunner of the use of the sulfonamide group of drugs, and a new weapon had been evolved to combat infection from these organisms.

The mode of action of sulfonamides is thought to be primarily bacteriostasis. Long and Bliss, in 1936, found that the drug acted directly on the bacteria, destroying the capsules of these microorganisms and rendering them more susceptible to destruction in this avirulent state by the defense mechanism of the individual.² It has been observed further by Lockwood³ that any product of protein digestion, such as is found in a necrotic area, will inhibit this bacteriostatic activity of the sulfonamides. This action is explained by the close similarity of the chemical structure of the drugs of this group and that of para-aminobenzoic acid, a product of protein hydrolysis. One competes with the other in bacteriometabolism.⁴ This fact is very important, as it tells us that, before an infection is ready for chemotherapy, all necrotic material and débris must be removed. This precaution is as necessary in root-canal therapy as it is in any other form of surgical procedure.

In dentistry, the sulfonamides commonly used are sulfanilamide, sulfathiazole and sulfadiazene. In root-canal therapy, we are concerned with the

same drugs. The specific action of these drugs on certain organisms has been determined,^{2, 5, 6, 7, 8} and it is advisable to choose the drug on the basis of the organism present. This effect has been interpreted by the reaction of the drug and the enzyme secreted by the bacteria. The enzyme of one type of bacteria may be interfered with by one of the sulfonamides, while that of another remains unaffected.

When to use the drug, and which one to use, therefore depends on the type of infection present. Sulfanilamide has been found to be more efficacious against streptococcal infections; sulfathiazole against staphylococcal infections, and sulfadiazene against mixed infections, especially in the presence of *Streptococcus viridans*. From these facts, we may deduce that for an acutely abscessed and purulent pulp, the staphylococcus being the chief offender, we should employ sulfathiazole. Chronic abscesses, such as are seen with granulomas, generally reveal a streptococcal infection in which the use of sulfanilamide would be more efficacious. Sulfadiazene, being used where mixed infections are present, may be applied in either case. It is permissible, however, to interchange these drugs in some instances, since the line of bacteriostatic action is not definitely drawn.

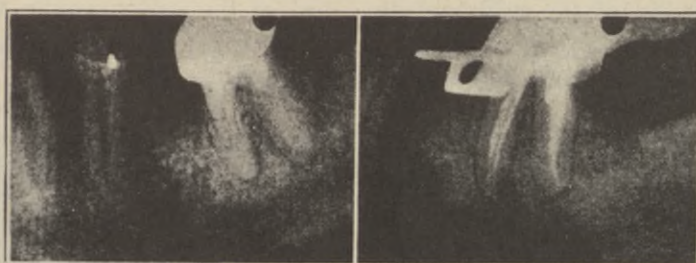
The sodium salts of these drugs have a high degree of alkalinity, the pH ranging from 9 to 11. They are, therefore, extremely irritating and should not be used. When in saturated solutions, they have been known to coagulate human serum.^{9, 10}

The bacteriostatic and the bactericidal

properties of the sulfonamides have been demonstrated by many investigators. Adams¹¹ states that "the hot sulfanilamide solution is bacteriostatic after 60 seconds' contact with the growth, but continued contact with the drug after the first immersion is bactericidal." Other investigators, such as Goodman and Gilman,¹² have shown this effect *in vitro* and reached the same conclusion when they applied the drug to open wounds or infections.

The local application of the sulfonamides, although it had come into use

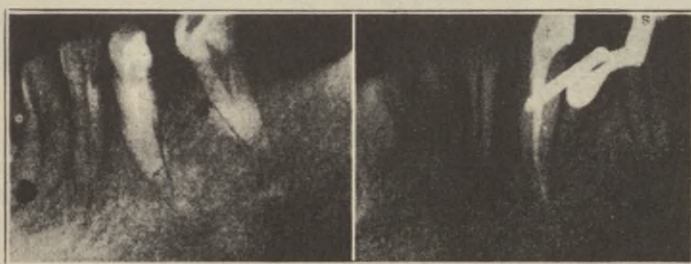
the treatment of wounds by adequate early cleansing followed by débridement and dusting into the wound of a sufficient quantity of sulfanilamide or sulfathiazole. McGehee¹⁵ has reported a series of 407 cases of perforated appendix wherein sulfanilamide was employed locally with a mortality of 6.2 per cent. Previously, in a control series, the mortality had been 41.5 per cent. It has been further observed that local application in wounds may produce as much as from 10 to 20 times higher concentration of the drug in the area than can be



A

B

Fig. 1.—Case in man aged 35. The patient complained of a dull ache in the area. A, appearance in February 1941; showing improper treatment rendered a number of years ago in Greece. B, tooth properly treated and filled. The symptoms have subsided.



A

B

Fig. 2.—Case in woman aged 43. A, appearance November 1939; showing faulty treatment. The patient complained of sensitivity of the tooth. B, condition after root-canal therapy had been repeated.

after the method of oral administration, has shown outstanding results. In the military field, this has been taken advantage of to the extent that every American soldier who goes into action is provided with 5 gm. of sulfanilamide powder, which is to be implanted immediately in any wound.¹³ Moorhead,¹⁴ in reporting an extensive military experience following the Pearl Harbor disaster, stated that he obtained good results in

obtained by systemic administration. This high has been as much as 500 mg. per hundred cubic centimeters of local tissue fluid with a blood level high of approximately 2 mg. per hundred cubic centimeters, a quantity well under the level of toxicity.² The quantity of sulfonamides used in root-canal therapy is even smaller and their local application is, therefore, not great enough to affect any systemic disorders.

There has been considerable discussion of the efficacy of the local use of sulfonamides in the mouth after extractions. The results may be questioned by the fact that the drug, incorporated by the tissue fluid of the wound, is constantly exposed to the action of saliva and the contamination of the mouth. In surgical procedures involving a closed cavity, as in abdominal operations, as well as root-canal therapy, outside contamination does not exist and the action of the sulfonamides is left unimpaired.

From the foregoing facts, it can be seen that I have given a brief résumé of the basis for the use of the sulfonamides in root-canal therapy. At this point, I shall describe my method and use of these drugs and certain principles that

subjective symptoms of discomfort were called to my attention by the patient, and disappeared after proper treatment and root-canal filling.

I use the sulfonamides (1) whenever infection of the pulp or periapical area is suspected and (2) only when these drugs can be applied so as to come in contact with tissue fluid.

Vital pulps obviously do not need comparable chemotherapy; therefore, these drugs are unnecessary. If there is pulp degeneration, with a loss of the germicidal blood supply, or infection has progressed beyond the apex, I utilize the aid of the sulfonamides to eliminate infection and so assist the body in its work of repair.

The sulfonamides when in contact



Fig. 3.—Case in girl aged 13. The pulp of the tooth had become acutely abscessed as the result of a blow. A, condition March 1941 before treatment; B, October 1941. The tooth had been rendered comfortable soon after treatment, which was completed in six visits. Orthodontic treatment was instituted soon after.

I adhere to in treatment. To begin with, chemotherapy is just part of a technic of root-canal treatment. It is necessary to supplement this at the outset with proper and sterile instrumentation as well as to complete the treatment with the correct filling of the canal. Figures 1 and 2 illustrate cases of which one might say that failure in root-canal work was due to a faulty method of therapy in more than one phase. In both instances,



Fig. 4.—Case in boy aged 19. The tooth had become abscessed as the result of carious exposure. Treatment was completed in five visits. A, condition November 1941, before treatment; B, April 1942.

with tissue fluid are readily absorbed. The method of use of these drugs is therefore based on this principle. Because of their high degree of diffusibility, they may, through absorption, attain a wide area of distribution in the body.¹⁶ In root-canal therapy, the drugs are applied, therefore, in a manner to make contact with tissue fluid, in order to cause absorption.

Sulfanilamide and sulfadiazene are used in solution form as irrigants. Sulfathiazole, although more difficult to obtain in solution, is applied as a powder

or made into a paste with glycerin and mixed with the purulent exudate in the canal of a tooth. In this form, it may be used as a dressing. Sulfanilamide, having the greatest solubility of the group, is dissolved in sterile water or saline solution. Although it is soluble to the extent of 1.46 per cent in water at body temperature,¹⁷ solubility is increased to more than 6 per cent at 60° C. (140 F.),¹⁸ at which temperature it is applied. The use of a warm solution enhances the bactericidal action. When it is injected locally, 1.97 per cent will be soluble in human serum at body temperature.¹⁷

Sulfadiazene, like sulfathiazole, has a low solubility, but recently has been com-

strains of bacteria react in such a way as to lose their virulence or their ability to become virulent. Since the type of tissue involved in such infections is similar to those tissues in the root canal, the mixture can be similarly used for such treatment. I have applied it to the canal as sulfanilamide is applied, as an irrigant, after the solution has been heated.

If the sulfonamides are used in the sterile crystalline form, there will be little, if any, interference with the healing process. Since the primary aim in any treatment is to permit Nature to set up her healing mechanism quickly, by controlling infection with a sulfonamide we obtain this objective. This fact has been substantiated by many investigators,

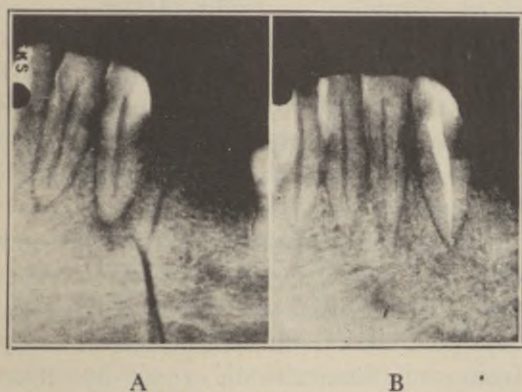


Fig. 5.—Case in woman aged 56 A traumatic abscess developed, with acute symptoms. A, condition November 1941; B, July 1942. Treatment called for six visits.

pounded in a solution of 2.5 per cent sulfadiazene in 8 per cent triethanolamine. This mixture has a pH of about 8.7, is not toxic and is readily absorbed by the tissue. Its use has been determined by a group of investigators^{19, 20} from the Department of Otolaryngology at the Johns Hopkins University and Hospital and found successful in controlling the growth of pyogenic organisms in the upper air passages, with a marked decrease in the incidence of sinus, ear, pharynx and bronchial infections. Their deduction was that, although these areas were not sterilized, the clinical results suggest that certain

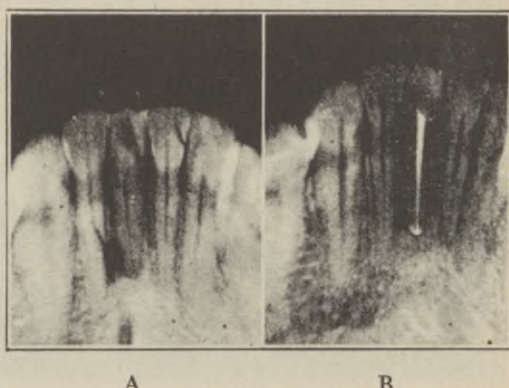


Fig. 6.—Case in woman aged 32. The patient was referred for root-canal therapy after a prolonged attempt at treatment by another dentist. The symptoms had become acute. A, condition February 1943; B, June 1943. Six visits were necessary.

among them Colebrook, Francis,²¹ Tafel, Harvey²² and others.²³

Bacteriologic examination will determine primarily when a canal is ready for filling. For this purpose, a culture of a medium of glucose-ascites broth or brain-heart infusion broth, or the like, may be used; or the findings may be determined by a smear through microscopic examination. For accuracy, the culture is the more precise method. However, although the bacteriologic examination of root canals will serve as a valuable guide, as well as lead the oper-

ator to preserve a sterile technic, it is still debatable whether absolute sterility is possible or necessary before a canal may be filled. As Cahn²⁴ states: "Surgeons do not wait for negative cultures until they close a wound. If they did, most patients after a laparotomy would be lying around with their entrails hanging out."

If the total number of bacteria can be reduced or even kept constant, the white blood cells can be relied on to eliminate them. The trouble is that bacteria multiply exceedingly fast, it having been estimated that under proper conditions a single bacterium produces one billion descendants in fifteen hours; hence, the need for such deterrent agents as the sulfonamides. In the past, I have used the culture method at the start of

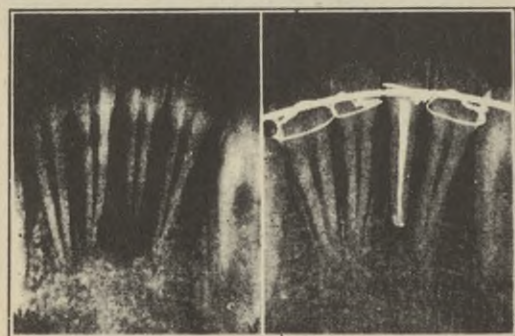


Fig. 7.—Case in boy aged 13. An acute abscess developed from a blow. The patient was having orthodontic care at the time. A, condition November 1942; B, April 1943. Treatment called for six visits, after which orthodontic treatment was resumed.

chemotherapy with the sulfonamides mainly to determine the time of treatment. At present, I have discontinued the use of cultures, but still resort to smears as a guide to therapy. I have found the average number of visits in most cases to be five or six. Adams reports that the average for fifty-two cases is 3.18 treatments.²⁵

I had previously confined my treatment in root-canal therapy to the orthodox medicaments, namely eugenol, beechwood creosote, cresatin and tri-

formocresol, using as well electrosterilization. By this method alone, I found that purulent and acutely infected teeth required a dozen or more treatments before a negative culture or smear could be obtained. Since the use of sulfonamides, the number of such treatments in practically all cases has been reduced at least half. I still, however, use the above-mentioned drugs in conjunction with sulfonamide therapy because of tissue tolerance of repetitious application of the same drugs, and because some of these conventional drugs assist in the elimination of the products of protein hydrolysis, thereby enhancing the action of the sulfonamides.

The accompanying roentgenograms show examples of results of the method of root canal treatment just described. Figures 3 to 7 indicate the condition of teeth before treatment and the results of healing processes as shown by these teeth in roentgenograms taken approximately six months later.

The use of sulfonamides may be further superseded by the newer developments of such bactericides as gramicidin and penicillin. Gramicidin was obtained from soil bacteria in 1939 by Rene Dubos, of the Rockefeller Institute of Medical Research. Although it is highly insoluble, its use after operative procedures locally has greatly lessened post-operative complications and discomfort. As its name implies, it is bactericidal primarily against gram-positive organisms.²⁶ Penicillin, the byproduct of a fungus, *Penicillium notatum*, was discovered by Alexander Fleming, an English bacteriologist, in 1928. This drug has added advantages in that it is soluble and therefore may penetrate tissue to a greater extent, with the further advantage of being neither toxic nor irritating. It is exceedingly effective in combating staphylococcal infections and is equally effective against the aerobic and the anaerobic streptococcus and the pneumococcus.²⁷ Neither of the drugs, however,

has been marketed, although indications are that they may be released in the near future. It is hoped that their application will meet with similar success in root-canal therapy, as well as in other fields of dentistry.

CONCLUSIONS

From a theoretical, experimental and clinical point of view, it is rational to conclude that in root-canal therapy the sulfonamides aid in eliminating infection.

In root-canal therapy, these drugs must be employed with two important facts in mind: 1. They may be used only in direct contact with tissue fluid through irrigation or by mixture of the powder, such as sulfathiazole, with tissue fluid in the canal of the tooth. 2. They are used only when infection of the pulp exists and especially when the infection has progressed to the periapical region.

Chemotherapy with the sulfonamides alone is not a panacea in root-canal therapy, but must be supplemented by an aseptic root canal technic.

Gramicidin and penicillin may prove even more effective substitutes for the sulfonamides as bacteriostatic agents. Their use in root-canal therapy remains to be developed.

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