# Clinical Observations On Cementation

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A survey of the literature reveals a relatively small number of contributions on the subject of cements and cementing procedures, particularly in the field of orthodontics. Yet, of all the routine operations which we as orthodontists are called upon to perform, probably none is more fundamental or fraught with greater potentialities for success or failure than the seemingly simple act of cementation of bands or other appliances. This apparent lack of interest in a subject which should be of paramount concern to us in our field might result from a belief that it is essentially a simple, fool-proof procedure, well understood by all practitioners of dentistry; in short, something with which we are so familiar that we are apt to regard it with contempt. If this is true, it is contempt which is unjustified. It shall be the purpose of this essay to explore some of the avenues of thought relating to cements and their manipulation, but it must be emphasized that these remarks are in no sense to be construed as truly scientific or definitive, except as they refer to work of others in this field. Rather they represent the result of clinical observation over a period of years in the practice of general dentistry as well as orthodontics.

It might be well at the outset to give some consideration to the two types of cements most commonly used in our field; namely, zinc phosphate cement (also known as crown and bridge cement), and copper cement.

Zinc oxide is the principal ingredient of zinc phosphate cement powder and may comprise, roughly, from 85% to more than 99% of its composition. The remaining constituents may be such materials as magnesium oxide, bismuth oxide, silica and pigments. The differences in cement powders are due to processes of manufacture and to variations in the ingredients used, other than zinc oxide.

Phosphoric acid is the chief constituent of the liquids. The acid is modified by presence of the phosphates of one or more metals, as aluminum and zinc, and is adjusted to the correct specific gravity. The specific gravity of the liquid and the nature and amount of modifiers vary in the different cements.

The properties of a cement are controlled by the manufacturer through composition and processing of the powder, and through adjustment of specific gravity and modifiers of the liquid. Much depends upon proper coordination between powder and liquid. Painstaking work and care are involved in routine processing, as well as in original development, to convert these common chemicals into a usable dental cement. Essential clinical advantages in dental cements must not be sacrificed by the manufacturer for certain physical properties which bear too limited a relation to the requirements of their use. Some properties of cements can be improved only at the expense of other properties of equal or greater importance. Clinical merits, mixing and working qualities, and physical properties must be held in equal balance. Precedence should be given to clinical values rather than to physical properties.

Two distinct types of zinc phosphate cements are on the market today. One type embraces all those products which comply with the requirements of the

American Dental Association's specification No. 8 for dental zinc phosphate cement. The other type is represented by what is commonly known as crown and bridge cement. The difference in the two types of cements lies mainly in the composition of the powders, although the liquids vary also. The powders of those cements which comply with specification No. 8 contain about 8 to 10% magnesium oxide; the zinc oxide powder of crown and bridge cement contains no addition of magnesium oxide.

The zinc oxide cements are characterized by clinical qualities which cannot readily be represented by physical data from the testing laboratory. This is the type which contains no magnesium oxide in the powder. As a result the powder has a greater density. The zinc oxide cements require more care in the making of a good mix. They set more slowly, but the setting may be controlled to a greater extent by varying the technique of mixing. The mix is stickier and seems more adhesive, in contrast with the more fluid or "watery" mix of the zinc-magnesium oxide cements. The sticky texture of the mix results in a low powder-liquid ratio when determined by the standard consistency test. For best results with a zinc oxide cement a larger powder-liquid ratio must be used than that indicated by the standard test.

It might well be that a discussion of the mixing and setting of cement presented to a group such as this should come under the head of "carrying coals to Newcastle". However, the fact that an operation is performed daily many times does not preclude the possibility of our becoming careless in our technique. With your indulgence I will touch upon a few of the highlights.

The slab used for mixing dental cements should have a temperature preferably between 65 and 70 degrees F. The chemical reaction between the basic powder and the acid liquid is best controlled within this range. The reaction is accelerated by higher and retarded by lower temperatures. Nevertheless, in warm, humid weather the slab should never be cooled to a temperature at which moisture condenses on it.

Any increase in the temperature of the slab effects a decrease in the amount of powder which can be incorporated into the mix. For this reason mixing on too warm a slab tends to produce an inferior cement. If the temperature of the slab is too high, the result may be a clotty or uneven mix and too fast setting; if it is too low, setting may be retarded unduly. The liquid should not be dispensed on the slab until the moment the operator is ready to proceed with the mix.

Heavy glass slabs in which thermometers are incorporated are available for those who wish to have an exact check upon the temperature of the slab at the time the mix is made; thus one important factor relating to the production of a standardized mix may be consistently employed.

Small portions of powder should be added to the liquid in the early stages of the mix, gradually neutralizing the acid liquid. Subsequent larger portions of powder will work smoothly, a lumpy or clotty condition will be avoided, and a normal setting will be obtained. If the first incorporations of powder are too large, chemical reaction will proceed too rapidly. This may result in a coarse uneven mix, generation of heat, and too fast setting. (These suggestions, incidentally, are at variance with those advanced by an orthodontist in the Bay Area who has done considerable experimental work in the field of dental cements; his conclusions will be discussed later.)

One should spatulate thoroughly after each incorporation of powder. The mix must be smooth and uniform before powder is added. The mix should be spread over a reasonably large area of the slab during spatulation, dissipating into the cool slab any heat generated by the chemical reaction.

Setting properties of a cement can be controlled by spatulation. Rapid addition of powder with rapid spatulation and short total time of mixing produces an accelerated setting. Slow addition of powder with more spatulation and longer total time of mixing produces a retarded setting. The mix should be made in from a minute to a minute-and-a-half as the needs of the situation indicate.

The best consistency for the mix may be obtained by incorporating all the powder possible without exceeding the state of plasticity indicated for proper seating of the appliance at hand. The desired consistency should always be attained by adding more powder, never by allowing a thin mix to stiffen. The larger the ratio of powder to liquid in the mix, the more the acid is neutralized, and the safer and stronger the cement will be, factors which are of primary significance in our field. Theoretically the ideal practice would be to weigh the powder and measure the liquid for the mix, as is done in scientific testing of dental cements, a procedure which has been worked out by the orthodontist mentioned above and which will be touched upon subsequently.

Seasonal changes in weather affect the mixing of dental cements, a fact of which we in Southern California should not be unmindful; in fact we should be cognizant of daily fluctuations. In cold, dry weather it is easy to make a good mix. On hot, humid days the mixing of cement is more difficult and requires special care with regard to points mentioned in the foregoing paragraphs. Most difficulties arise during the spring and fall, in the periods of transition between extremes of weather.

Setting time should not be judged by the behavior of the surplus cement on the slab. All cements are made to set in the mouth at approximately 99 degrees F. The chemical reactions involved in setting will proceed considerably faster in the warm mouth than on the cool slab. Of course it goes without saying that the setting cement should be protected from moisture, dryfoil generally being the agent of choice.

The three most common causes of cementation troubles are:

1) Use of a liquid which has become changed by exposure to the atmosphere or by contamination.

2) Improper technique in mixing.

3) Failure to give attention to the temperature of the slab.

Proper care of the liquid is essential for best results in cementation. The liquid is the vulnerable part of any dental cement. If exposed, it evaporates in dry atmosphere, and absorbs moisture from the air on warm, humid days. For this reason the liquid should not be placed on the slab until the moment we are ready to proceed with the mix.

The cap should be replaced on the bottle immediately after withdrawing the liquid, and screwed down tightly. The neck of the bottle should be kept clean and the inside of the cap free from accumulated liquid. Agitation of the liquid by shaking the bottle is unnecessary; squeezing the dropper bulb several times will provide sufficient agitation.

It has been generally thought that dental cement powder keeps indefinitely without change, but there are some who feel it, too, may be contaminated by excessive exposure to air, as will be subsequently discussed.

Drying the tooth with alcohol is inadvisable, I believe, on several counts. Preferably it should be dried with cotton or gauze and a sparing application of warm air. Zinc phosphate cements adhere better to a normally dry tooth structure than to one which is artifically dehydrated, and in addition, acid from the fresh cement is more likely to penetrate a severely dehydrated enamel surface.

Some men prefer the darker shades of cement because they believe them to be stronger. Laboratory tests fail to confirm this belief, although clinical evidence seems to bear it out. However, the darker shades' it seems to me, do render a definite service to the orthodontist in that they make it easier to check on proper cementation of bands by virtue of their contrast in color with the enamel.

Since the copper cements exert a greater power of retention to tooth and metal surfaces, there are occasions when their use becomes advisable. The color, particularly of the black copper cement, is objectionable, but other advantages more than offset it. In general, the mixing of this type of cement is a less exacting procedure than the mixing of a zinc phosphate cement. The powder should be added to the liquid rapidly until the consistency of a thick cream is reached, followed by a thorough spatulation. The slab should be at approximately 70 degrees F. A stiff mix should not be made as the cement will set too fast to be usable. The same precautions mentioned above relating to freedom from moisture and avoiding excessive dehydration apply with this type of cement, although in general it is less affected by unfavorable conditions of moisture than is the zinc phosphate cement.

In this connection, Dr. Cecil Steiner has made some observations which are of interest. In using black copper cement on teeth which may present decalcified areas either inherent in the tooth's formation or caused by extraneous factors, one should always coat the tooth surface with Copalite or some kind of tough varnish. Black copper cement has a tendency to stain decalcified tooth structure and if this varnishing precaution is taken, subsequent embarrassment may be avoided. He also mentions that painting the tooth surface with straight liquid or with a thin mix of cement prior to cementing with a thicker mix often increases the success of the operation. The setting time may be materially decreased by the application of heat either by a jet of warm air or by holding a previously heated burnisher or other instrument against the band or onlay for the first few minutes.

Dr. John H. Parker of Alameda, California, has, perhaps, made one of the most comprehensive scientific studies of cements and their manipulation of anyone in this general area, the results of which have been embodied in his essay entitled: "A COMPARATIVE STUDY OF THE MIXING TECHNIQUE OF A ZINC OXIDE CEMENT." One of his salient conclusions, it seems to me, is that "by changing the mixing technique of all widely used crown and bridge cements, better results can be obtained."

His paper deals with history, composition and requirements of cements in thorough fashion. He then comes to the matter of the mixing technique. "In the usual specification for mixing, portions of the powder are incorporated into the liquid slowly over a period of one minute and twenty seconds. In direct opposition to this practice is Dr. Joseph Mitchell's fast mixing technique which consists of incorporating the whole of a measured amount of the powder into the liquid as rapidly as possible.

"Before comparing the consistency and workable time of the cement tested (1) by slow incorporation, and (2) according to Dr. Mitchell's fast mixing technique, the following tests were made to determine the amount of powder which could easily be incorporated in a fast mix in 15 seconds. Differences in consistency and setting time were also noted and recorded. Tests using the same amounts of powder mixed in one minute and twenty seconds were used for comparison.

"First, five mixes of the crown and bridge cement were made in which 20 grains of cement to a proportionate amount of liquid, were mixed as rapidly as possible. It took approximately one minute to mix this amount, the bulk of powder being difficult to incorporate as a whole due to the mechanical limitations of instrumentation. The consistency was creamy and the mix set in 7½ minutes from the start of the mix. The five mixes of 20 grains mixed slowly, in 1 minute 20 seconds gave a creamy consistency and set in approximately 8 minutes.

"The same tests were then made using 10 grains of powder to a proportionate amount of liquid, and it was found that the setting times were almost identical, but that the fast mixing time was cut to 35 seconds. In these fast mixes it was noticed that there was considerably more fluidity of the mix following the incorporation period.

"In the final five mixes, 5 grains of powder and a proportionate amount of liquid (3 drops) was used. A fast mixing time of 15 seconds was attained. Following the mixing period, this mix literally flowed from the end of the spatula. The setting time was 4½ minutes. In the five mixes of 5 grains mixed slowly, a creamy mix was obtained which set in the same time of 4½ minutes.

"In the foregoing tests, the workable times of the two mixing techniques are readily compared. In the first test the workable times were approximately the same. In the second test, there was approximately 30 seconds more workable time using the fast mix. In the third test, the workable time of the fast mix was almost double that of the slow mix. Thus by using the fast mixing technique, the orthodontist has an appreciably longer time to work before the cement sets, and the cement a greater fluidity."

Dr. Parker then describes tests for consistency which were made by placing various mixes on a glass slab and covering them with another glass slab of known weight at intervals of 10 seconds, 20 seconds, and 30 seconds, giving a general idea of the circular spread or fluid consistency. Charts are submitted based on these tests. These, again, demonstrate an apparent greater amount of workable time.

Tests were then made to correlate adhesive properties or seal under varying conditions, but the author adjures us to remember that these are somewhat questionable. In brief, these tests consisted in cementing 24 identical copper blocks to the sand blasted surfaces of glass slabs. Weight testing scales registered the pounds necessary to break the seals. The sand blasted surfaces, incidentally, were variously treated in this series as follows: (1) with distilled water and dried cotton; (2) with isopropyl alcohol and dried with cotton; (3 with saliva; (4) with orthophosphoric acid; (5) surface not treated previously, but cement burnished to place with spatula; and, (6) surface not treated, but cement powder used in the mix which had been exposed to air for 28 hours. This was to simulate in some respects the last portions of powder in the bottle following frequent cementings in which excess powder had been poured back.

The following conclusions were reached in this series:

"(1) From a purely mechanical viewpoint there is little difference whether a surface be cleaned with alcohol or distilled water.

(2) The saliva in the slow mix apparently acted as a media producing a greater fluidity. The more fluid cements

uncontaminated by saliva afforded a better seal than the creamy mix, and when allowed to harden over a period of time gave the highest recordings.

(3) Additions of neutralized orthophosphoric acid will greatly reduce the sealing quality of a cement.

(4) Pressure, or burnishing, the cement to the surfaces helps to a certain extent in the creamy mix, but does not have any advantages in the fluid mix.

(5) There is some evidence that powder exposed to air for any length of time will give a consistently poorer mix."

Further tests of adhesion were made in which a series of mixes were immersed in saliva solution for 24 hours and tested for seal 48 hours later, and another series which was immersed 3 days and tested 48 hours later. These experiments seemed to show that the fluid mix was more resistent to saliva and that the sooner cement is exposed to saliva, the poorer the seal will be.

Dr. Parker's over-all conclusions are:

"(1) A fast mix of a known ratio of powder and liquid of the cement tested results in —

(a) more fluidity following the mixing.

(b) longer workable time.

(2) A semi-fluid mix is preferable to a creamy mix for adaptation and seal to roughened surfaces.

(3) Cleansing a roughened surface with isopropyl alcohol or distilled water makes little difference in the resultant seal if the surfaces are wiped dry.

(4) In the tests with saliva, the creamy mix apparently became more fluid resulting in a favorably high reading, while saliva in the fast mix caused almost a complete failure of the fast mix. The results of the immersion test are not conclusive but apparently the longer the cement can harden within limits, the more impervious the cement will be to dissolution.

(5) Burnishing cement to the surfaces will help to form a better seal.

(6) The practice of pouring excess cement back into the bottle will eventually weaken the cement mix. This will be proportionate to the relative humidity of the atmosphere and $CO_2$ present in the individual office."

Of the advantages of the fast mix as applied to orthodontics, Dr. Parker has this to say:

"Two, three or four bands according to size are the limit that can safely be cemented and sealed with the fast mix, but with the advent of dryfoil these teeth can be sealed from saliva, the cement slab reversed and a new mix made within a matter of seconds. A whole segment of the mouth can be cemented and sealed from saliva in a matter of minutes and the patient allowed to close the mouth and swallow in a normal fashion. This seal of foil sprayed with alkaline liquid prior to cementation can be retained over the tooth for approximately 40 minutes to an hour at which time the excess cement can be trimmed and then the patient dismissed. With several spatulas and cement slabs, and slight imposition upon the patient, the entire operation of cementation can be accomplished in one appointment.

"It is recognized that the orthodontist cannot stop and weigh out 5 grains of powder for every cementation, so it is proposed that this cement be placed in capsules. Filling #5 gelatin capsules full will give a semi-accurate measure of powder. By using three funnel-shaped ear viewers, bought from any medical supply house, a simple instrument for rapidly filling the capsules can be made. These capsules can be filled, and packed fifty to a bottle in approximately 20 minutes."

He then proceeds to give a detailed

description of the construction and operation of the cement filler, which I will not attempt to delineate at this time, but for those wishing this information I am sure Dr. Parker would be more than happy to furnish it.

Dr. Parker's supplementary observations are:

"The spatula as well as the slab must be cooled. Any small particles of cement from the previous mix that may be left on the spatula should be cleaned off by a drop of the cement liquid and then the spatula wiped clean. The cement slab should have a smooth, highly polished, unscratched surface.

"The author has found that by breaking the five grain capsule of powder directly onto the liquid and mixing immediately, the powder is much more readily incorporated into the liquid.

"This entire cementing technic has been used in this office since 1941 with outstanding success, but I have hesitated to present it beyond the two or three men who are now using this method because of the arguments that often develop when anything not conforming to the conventional is brought out.

"If I have seemingly favored any one cement it is only because I feel that as long as one can see the cement color at various points around a tooth, the band itself will be well sealed, but when it is not distinguishable the band should be recemented.

"All cemented bands are covered with dry foil made in the office, and sprayed lightly just before adaptation. This dry foil is left on for one hour and then removed and the teeth cleaned. (Dry foil developed by Dr. George Grover, San Francisco.)

"Just before cementation, all bands are etched on the inner surface with a #507 dentate bur. Small stones seem to leave a residue of the material."

I am indeed grateful to Dr. Parker for his kindness in permitting me to quote from his splendid essay and for forwarding to me samples of the cement capsules to which he refers.

An article entitled "EFFECT OF ZINC OXYPHOSPHATE CEMENT ON ENAMEL" by Drs. Castello, Massler, Monteleone and Suher of the University of Illinois, College of Dentistry, was published in the March, 1948, issue of the American Journal of Orthodontics. The authors remark that only two references pertinent to this problem were found in the literature—Lefkowitz and Bodecker, 1938, and Lefkowitz, 1940.

In this series of experiments 36 recently extracted adult teeth were used. The teeth were cleaned by hand brush with soap and water, then wiped with cotton moistened with alcohol and ether; 13 of the teeth received no further preparation; the other 23 were ground and polished, then cleansed by soap and water, followed by alcohol and ether. One-half of the selected enamel surface was covered with a 50% solution of collodion which was allowed to dry thoroughly. This collodion film served to protect the covered portion of the enamel from the action of the cement. The action of cement liquid alone was studied on the enamel of two teeth. On all other teeth 3 different mixes of cement (Stratford-Cookson) were used: namely, thin medium and thick. The enamel surfaces were examined by direct obesrvation and with a binocular dissecting microscope using deflected light.

The summary and conclusions of the authors of this article are:

"(1) Cement liquid alone etched the enamel markedly and homegeneously.

(2) All enamel surfaces exposed to the action of various mixes of cement were more or less affected.

(3) The etching was more prominent on the ground surface than on the unground surface. This might indi-

cate the presence of a "protective film" on the surface of the intact enamel.

(4) The etching was spotty or circumscribed, indicating a partial adherence of cement to enamel surface.

(5) The degree of etching did not seem to increase after the cement was completely set.

(6) The cement liquid alone and the cement mixes did not affect the enamel surfaces covered by a film of collodion."

In view of these findings, and since the problem of etching of enamel is related to the general subject of this essay, I have taken occasion to make inquiries of various members of our specialty with reference to clinical observation on enamel etching as a result of cementation, and to the use of Copalite or other protective media prior to cementing procedures.

Dr. Wendell Wylie writes: "I have never heard of painting teeth with Copalite or any material similar to it prior to cementing bands. Since the principal function of cement is, first, to seal off fluids of the mouth from the teeth, and, second, to hold the bands securely in place, it seems to me filling up the minute irregularities in the enamel of teeth with a material like Copalite would defeat the cement in its latter purpose, since it is only through that mechanism that cement has any retentive power at all.

"Your other question concerning the possibility of a good mix of cement etching sound enamel reminds me of a paper published by Lefkowitz and Waugh, which reported through microscopic study a slight decalcification of enamel through the action of the free acid left in orthophosphoric acid cement. The severity and extent of this etching, however, was such that it required microscopic study to demonstrate it, and I concluded from reading the article that it had no great clinical importance.

"Some of the men in the Bay Area are painting the crowns of the teeth with 2% sodium fluoride solution prior to cementation, perhaps on the theory that like a glass of orange juice every day, it can do no harm and might do some good. Some dry the teeth with alcohol before cementing, and others argue that since alcohol precipitates proteins that would only guarantee that soft debris remaining on the crowns of the teeth would be fixed in place before the bands went over it. Others, less preoccupied with biochemistry, contend that carbon tetrachloride is a better drying agent anyway, and use it."

Dr. C. F. Stenson Dillon reports that experiments he has made with Copalite showed that it could be peeled off teeth very easily. He therefore concluded that it would make bands less stable when cemented. He is also opposed to excessive drying of teeth with alcohol or other agents. He feels that such procedure renders teeth more absorptive and since after cementation the only moisture they can pick up is the free acid in the cement, they thereby become better candidates for etching. He is convinced that cases which show definite clinical evidence of etching are the result of partial loosening of bands and of consequent disintegration of the cement. He believes that cement disintegrates less under chrome bands than under precious metal ones owing to the ductility factor or "flowing under stress" of the latter. He does, however, concede that the cement may occasion an indistinguishable etching or change in the enamel surface, and cites as an example the case of the band which will not remain in place on, say, a very pointed cuspid, the first time it is placed; on the second cementing it frequently adheres securely. He is of the opinion that some change in the enamel surface as a result of the first operation has made it possible for the second cementation to be successful.

In this connection Dr. John Parker

writes: "There is one phase of cementation that has intrigued me ever since the advocacy of flourine therapy. It is my belief that in certain cases following the removal of the cement, some protection to enamel or of intercementing substance has also been removed. Although I am not too optimistic over the use of flourine, this is one phase where the application may be warrented before saliva can reach these newly exposed areas."

Dr. Dallas McCauley has had no experience with Copalite or other varnishes in connection with cementation. He feels that any etching which occurs is due to cement disintegration under bands. Some time ago he conducted a series of experiments with various brands of cement to try to determine superiority from several points of view. He correlated careful records of his cases with reference to specific bands coming loose, consistency of saliva, tendency toward caries, etc, but concluded that there was no appreciable difference and no positive evidence of superiority among the various brands.

Dr. Betty Selmer states that she has had no experience with the use of Copalite. She did, however, call my attention to an article in a recent issue of Collier's, on Dr. Bernhard Gottlieb's theory of dental caries and his impregnation treatment, written by J. D. Ratcliff under the title, "HAS THE TOOTHACHE BEEN STOPPED?" She suggests that if there is real merit in this therapy it might have its significance for us in connection with cementing operations. She adds that it differs from sodium fluoride therapy in that it is claimed to be as efficacious for adults as for children.

Dr. Howard Lang has not made use of Copalite or any type of varnish; like many of the others queried, he feels that direct contact of the cement with the clean enamel surface is better.

To my knowledge, Dr. Carl Brugeman is the only one who has had experience with the application of Copalite. He reports that he feels it protects the enamel surface, but adds that the advantage gained in this security is somewhat offset by the bands coming loose more frequently.

The only instance in which I have had personal resort to the use of Copalite was in the case of areas of erosion which seemed to be sensitive to direct application of cement, but which subsided after the band was removed, Copalite painted on, and the band recemented.

An almost universal comment by those polled was to the effect that they were not much worried over the areas covered by the bands, but were definitely concerned over those areas between the bands and the gum margins. One or two commented that they were looking toward the day when a technique for cementing attachments directly to the teeth without the intervention of bands should arrive and I am of the opinion that such an eventuality is not beyond the realm of possibility. As to the presence of a protective film or substance which might be deleteriously affected by the acid in cement, I confess I cannot figure out what it could be. According to Oppenheim, Nasmyth's membrane disappears as soon as the tooth erupts and comes into function, and even in some cases where we feel that the membrane is intact it is no guarantee against etching of the enamel, as witness those instances in which high cuspids show evidence of decalcification even before the teeth are brought down into function.

Thus we find that in almost any phase of our professional endeavors there is no unanimity of opinion, a condition which, by and large, reflects a healthy intellectual atmosphere. A universal adherence to precepts and techniques would be stultifying and certainly would give cause for alarm. Only by disagreement, sound argument, scientific investigation, clinical trial and error, and eventual reconcilement of opposing views can we arrive at secure and trustworthy methods of precedure.

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