A CLINICAL INVESTIGATION ON THE GENERAL
DISINTEGRATION AND STRENGTH CHARACTERISTICS
OF FOUR TEMPORARY FILLING MATERIALS

By
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INTRODUCTION

The exact date of the first attempt to use a temporary filling material is uncertain. However, it may be traced back to the first century when Galen recommended the filling of large cavities temporarily with lint, beeswax, and other substances before extirpation, in order to preserve the brightness of the teeth under the extirpating force.

According to Courteille, a recent proposed of marvel and also was used by the Egyptians in the seventh century, is the costume and honey candy. A similar filling of wax and impressing the wax into the tooth by calendation, after the seventeenth century. Of considerable interest in this regard is his statement that such a filling is preferred to gold since it since the latter is "more in keeping, as it entirely covers the tunneling of matter." However, it was not until 1807 that the tin-cementation method was first announced by Scalia, a French architect, who invented a cementation of gold filling material in the setting of metallic walls.

The clericality, conscientiousness, and impossibility led him to recognize it as "a stopping for hollow teeth." The interest came to Notice (noticeably) in such a restorability material led to a search for specifications of formulation and compositional test particularly for those tin-cementation methods with reasonable evidence. As a filling compound for the different limitations of that element, their evaluation in metry.

Courteille pointed out that the bone and hide had an indifferent effect, as for his reason plastic, and was substituted. The
The exact date of the first attempt to use a temporary filling material is uncertain. However, it may be traced back to the first century when Celsus\(^1\) recommended the filling of large cavities temporarily with lint, lead, and other substances, before extraction, in order to overcome the brittleness of the teeth under the extracting forces.

According to Guerini\(^2\), a cement composed of mastic and alum was used by Abu Bakr Rhazi in the seventh century, to fill cavities and arrest decay. A similar filling of mastic and turpentine was used later by Soolingen, during the seventeenth century. Of considerable interest in this regard is his conception that such a filling is preferred to a metallic one since the latter is "never so perfect as to entirely impede the penetration of moisture."\(^2\)

However, it was not until 1855, when the zinc-oxychloride cement was first announced by Sorel\(^3\), a French architect, who formed a combination of zinc chloride useful in the setting of mosaic tile. The plasticity, adhesiveness, and impermeability led him to recommend it as "a stopping for hollow teeth."\(^4\) The interest shown by dental practitioners in such a restorative material led to a series of modifications in formulation and compounding that perhaps may place the zinc-oxychloride cement, with reasonable evidence, as a mother compound for the different varieties of zinc cements that evolved in dentistry.

Bremner\(^4\) pointed out that the zinc chloride had an irritating effect, so for this reason phosphoric acid was substituted. The
rapid setting of the mix was corrected by the addition of sodium phosphate that later developed into cement of fair quality.

Molnar traced the evolution of zinc oxide-eugenol from the zinc oxychloride cement and found that there was a substituting of the liquid, first by creosote, later by oil of cloves, and finally by eugenol which was introduced in 1894 by Wessler in Sweden.

The apparent opacity of these early restorations and their incapability of withstanding the oral conditions urged the profession to continue the search for another restorative material having the same ease of manipulation but with superior physical properties.

The first translucent cement was introduced by Fletcher of England, in 1871. The earliest type of silicate cement consisted of powdered silica and a cement liquid composed of sodium tungstate in a gelatin solution. The early silicate cement was claimed to be damaging to the pulpal tissues, due to the prolonged acidity following its placement in the cavity and its possible arsenic content. These factors limited the use of silicates for sometime. In 1904 there was a renewal of interest in silicate cement by its reintroduction by the German chemist Steenbock and the German dentist Asher as "Asher's Artificial Enamel". Since then there has been a gradual improvement in the quality of the material and manipulative techniques which has lead to its wide-spread use.

According to Anderson and Paffenberger, the silico-phosphate cements have been used in dentistry since 1878. It was claimed
that such a combination produces a material having the optical qualities of the silicates and the lower solubility in distilled water exhibited by the zinc phosphate cement. At the present time there is evidence of growing interest in these materials.

The introduction of the different types of temporary restorative materials into the dental profession seemed to answer a tremendous demand. This fact seems apparent because of their widespread use. The results of the survey done by Brekhus and Armstrong\textsuperscript{13} led some authorities\textsuperscript{14} to predict the probability that the dental cements as used today constitute from 40 to 60 per cent of all restorations. Such a high percentage would suggest the need for the dental profession to perfect these materials to meet the different purposes of their use.

The primary indication for a temporary filling, as the term implies, is when it seems inadvisable or impossible to fill a cavity at the initial visit\textsuperscript{15}. They can also be used when the number of the cavities is great and the time of the patient or the dentist is limited. Lack of dental manpower and auxiliary personnel is a reality in some situations today. Rapid rehabilitation by caries removal and filling the cavities with temporary materials until the treatment schedule permits more adequate and complete treatment must often be the procedure of choice. Such conditions are frequently encountered in the military service and wherever a limited dental staff is responsible for providing dental care for institutionalized masses\textsuperscript{16}. 
Treatment of rampant dental caries may necessitate gross removal of the caries and the insertion of a temporary material that permits the formation of secondary dentin. Short life expectancy of a tooth also may be an indication for a semi-permanent filling as in the case of deciduous teeth during the late childhood period or in permanent teeth that are to be extracted for orthodontic purposes. Temporary filling materials are used sometimes to provide a coverage and seal in dressings for pulp treatment. They are also used as vehicles for anodyne drugs.

The physical properties of a temporary filling material and the possible variations in the consistency of its mix may sometimes determine its usefulness as either a protective base or luting substance.

Not long after the introduction of these different dental cements it was realized that the available materials and technics did not meet the requirements for the ideal restoration. The ideal requirements at that time were arbitrarily established. However, it may be possible to say that the requirements of an ideal temporary filling material are nearly the same as those of the ideal permanent one except that a shorter life span and less durability would be acceptable. Also ease of removal is desirable in a temporary filling material. However, the use of the modern equipment and technics seems to relegate this property into a place of secondary importance. Since temporary filling materials
are usually replaced, they should not require a special type of cavity preparation. It is agreed that it is important that the materials be easily recognized from the permanent16.

Probably, it was only the biological aspects of such materials, that is, their effect on the vitality of the pulp and their germicidal potency, that were of main concern to most of the early investigators7,9,10,20-26. However, in addition to the biological aspects, it was recognized that in order to achieve the best results from the materials, they had to be used with the greatest possible skill and knowledge27. This trend was a stimulating factor which lead to the study of the physical properties of these materials. Today knowledge of the physical properties of materials is of the major concern to the dental practitioner if he is to perfect his skill in their use, predict the clinical behavior, and judge their value.

The first milestones along the route of the systematic studies of the physical properties of dental cements were undoubtedly marked by the work of Crowell28 in 1927 and Paffenberger and his associates at the National Bureau of Standards between 1933 and 193829,30,31. They provided the sound line of investigation to be followed. These methodical series of studies as well as the continuous efforts for standardizing testing conditions undoubtedly resulted in the era of specifications. These specifications, though they help in evaluating many of the measurable physical
properties, fail to give absolute information on the clinical behavior of the material.

It is true that the reproduction of the oral conditions is a difficult problem. The complex factors involved in the mouth are difficult to isolate, reproduce, and hence standardize. On the other hand, clinical trials are long and arduous to interpret. Nevertheless no true evaluation of any restorative material can be achieved nor the clinical significance of its properties as measured in the laboratory be understood except after a series of systematic clinical trials under carefully controlled conditions.
In spite of the multiplicity of factors apparently involved, in one way or the other, in the general disintegration of the temporary-filling materials in the mouth, there is universal agree-
ment that solubility and strength properties of these materials
are considered as the most eminent factors.

In view of the overwhelming amount of literature dealing
with the entire studies of these two properties, a full treatise of
the laboratory aspects of the subject would certainly be a redundant
statement. This fact, together with the obvious limited number of
in vivo studies, accounts for the superficial character of the
review that follows.

In reviewing the literature, it is apparent that the solubility
and strength properties of temporary-filling materials are greatly
influenced by their composition and manipulation, to a degree that
dictated the need to refer to them, at least in substance.

In 1951, Frankel published a detailed discussion indicating
the nature of the reaction between the liquid and the powder of
dental powders. The conclusion brought out by this paper was a
strong definitive support to the fact that mixing technique has a
great effect on the solubility of the composite also on its
strength characteristics and its solubility. Implicitly this research
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variables involved including the liquid powders ratio, the rate
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REVIEW OF THE LITERATURE
In spite of the multiplicity of factors apparently involved, in one way or the other, in the general disintegration of the temporary filling materials in the mouth, there is universal agreement that solubility and strength properties of these materials are considered as the most eminent factors\(^{29,30,31}\).

In view of the overwhelming amount of literature dealing with \textit{in vitro} studies of these two properties, a full treatment of the laboratory aspect of the subject would certainly be a redundant endeavor. This fact, together with the obvious limited number of \textit{in vivo} studies, accounts for the superficial character of the review that follows.

In reviewing the literature it was learned that the solubility and strength properties of temporary filling materials are greatly influenced by their composition and manipulation, to a degree that obviated the need to refer to them, at least in abstractness.

In 1927, Crowell\(^{28}\) published a detailed discussion explaining the nature of the reaction between the liquid and the powder of dental cements. The conclusion brought out by this paper was a strong scientific support to the fact that mixing technic has a great effect on the workability of the cement and also on its strength characteristics and its solubility. Probably this research stimulated the interest of many investigators to study all possible variables involved including the liquid-powder ratio, the rate with which the powder is incorporated into the liquid, composition
of both the powder and liquid and their effects on the setting time. All the factors that have been mentioned have a bearing on the proper manipulation of dental cements, and development of desirable properties.  It has been found in these studies that the set cement is powder particles held together by a binding matrix.  This matrix is considered to be responsible for undesirable physical properties such as high solubility, weakness, shrinkage, and staining.  The goal of nearly every step in manipulation is to keep this matrix to a minimum and still maintain a workable consistency.  This is achieved by the incorporation of an optimum amount of powder.  It was found that there is a certain limit beyond which more powder particles will have no liquid with which to react.  Therefore sufficient matrix to bind the mix is not formed and the material will be weak. The use of quantitative measures of the liquid and powder have always been advocated. Maximum amounts of powder can be incorporated as long as the setting time is delayed by decreasing the reaction rate.  It has been proved that the latter is influenced by the climatic conditions, temperature and moisture. Cooling the environment combats the exothermic character of the reaction and allows longer mixing time especially in the case of the zinc-phosphate cement. A cool dry slab is a prime requisite for incorporation of maximum amount of powder.  Protection against moisture serves the same purpose.  Water contamination during
mixing accelerates the setting time in both acid liquids and eugenol\textsuperscript{19}. It has also been found that premature exposure of the unset cement with water affects the surface texture of the cement\textsuperscript{31}. In the case of the zinc oxide eugenol cements, contaminated with moisture, some of the particles may wash out, or immiscible water droplets may form minute defects in the set structure. In the case of the acid liquid cements, the acid will leach out leaving a defective surface\textsuperscript{19,31}.

The surface texture, the optical qualities, and durability of the silicate cements are considered of extreme clinical importance. This fact, besides the foregoing explanation accounts for the great attention given by the investigators to the manipulation of silicate cements.

The hygroscopic character of the liquid and the desire for a low rate gel formation at low temperature led some authorities to advocate the mechanical mixing using the rubber balloon method in crushed ice\textsuperscript{47,48}. Later, others advocated using the Wig-L-Bug mechanical amalgamator\textsuperscript{49}. There are claims that these methods result in improved physical properties. The end result may be a more homogeneous mix but the actual effect on the physical properties, especially the solubility and compressive strength, is still debatable\textsuperscript{19,47,48,49,50,51}.

The fact that the physical properties are greatly affected by composition and manipulation caused the materials to be subjected to a series of modifications in compounding and formulation. An
example of these materials is zinc oxide-eugenol. Its apparent biological superiority over other cements and its superior sealing properties resulted in numerous modification of formula. Water, chlorides, nitrates, acetates, resins, hydrogenated rosin, polystyrene, and dicalcium phosphate as additions to zinc oxide and eugenol have been tried and tested individually and in combination. The importance of water and zinc acetate as accelerators, rosin for a smooth homogeneous mix and polystyrene for strength have been emphasized. After the zinc eugenolate was demonstrated to be a chelate compound by Copeland, additions became more selective. The works of Brauer, et al. and Phillips and Love brought forth more promising additions that may have a successful effect in combination with the O-ethoxybenzoic acid (EBA), a chelating agent which seemed to be the most effective in improving the strength characteristics.

Along the same line, current investigations have been carried out to improve the qualities of the silicate cement. The addition of oily materials to decrease shrinkage and glass fibres have been attempted in efforts to improve the strength. These, for the most part have not been successful.

It has been found that there is only a very narrow range of compositions containing the three component systems silica, alumina, and lime, which can be fused into clear glasses and which when powdered and mixed with a cement liquid will produce the desired
setting time\textsuperscript{36}. It does not appear likely that there will be any drastic change in the basic formulation of silicate cements. The basic formula of zinc phosphate cement has not undergone any significant change or modification. The addition of amalgam alloy to zinc phosphate cement has been reported to improve the strength characteristics and decrease the solubility of this cement\textsuperscript{63}.

A hybrid type cement resulting from the combination of zinc phosphate and silicate cement powders is known as silico-phosphate cement. It is reported to be stronger and less soluble than the zinc phosphate cement\textsuperscript{31,64,65}.

The strength characteristics of dental cements have been shown to be influenced by factors such as composition, manipulation, and solubility as well as all variables involved\textsuperscript{28,29,30,44}. It is then logical to assume that the strength of the set cement is a property of the matrix. Mahler\textsuperscript{66} pointed out that the strength of the restoration is lowered by the discontinuity of the structure such as internal porosity, voids, surface scratches, grooves and pits. He stated that these defects increase stress concentration playing an important role in raising the magnitude of the internal stresses within the structure. A structural failure results from these internal stresses combined with forces applied during oral activity.

Swartz\textsuperscript{67} showed that even after brushing, a rough abraded surface retains greater numbers of bacteria than a highly polished surface.
The observations that areas of stagnation undergo more dissolution than areas subjected to the washing action of saliva and the possibility that surface roughness and pitting may act as potential areas of stagnation, would logically lead to the assumption that internal porosity and inclusion of air bubbles, that may arise from faulty manipulation, affect the strength characteristics. The end result may be weakness in the structure followed by chipping, fracture and disintegration. The continuous abrasion probably exposes such porosity as surface voids enhancing accumulation of factors responsible for dissolution.

In another study by Swartz, it was shown that the hardness and abrasion resistance of the dental cements seem to follow the compressive strength. The stronger materials are usually the hardest and exhibit greater resistance to abrasion. Silicate cements, followed by zinc phosphate cements, were the strongest and hardest, and exhibited more resistance to abrasion. Zinc oxide-eugenol was the least hard and least resistant to abrasion.

It was noticed early that there exists a relation between the strength characteristics of a cement and its solubility. Paffenberger pointed out that when the material is stored in a solution such as distilled water, the compressive strength decreases with time while storage in a liquid petrolatum in which the cement is insoluble does not affect its strength. Since the oral fluids are believed to produce dissolution of cements, it is reasonable
to assume that the more soluble materials will suffer a continuous loss of strength. These two factors probably, plus others, are acting within the complex system of the oral cavity undoubtedly lead to general disintegration of the material.

There is general agreement that all temporary filling materials are comparatively weak as restorations. They have low compressive strength, are brittle, cannot resist impact forces, lack edge strength and cannot maintain sound marginal integrity.

In order to meet the American Dental Association specification number 8, zinc phosphate cement must exhibit a minimum compressive strength of 12,000 lbs./sq. inch under the specified conditions. According to specification number 9, the silicate cement must exhibit a minimum compressive strength of 23,000 lbs./sq. inch under the specified conditions. There is no specified compressive strength for zinc oxide-eugenol or silico-phosphate cements. However, the former has been reported to reach 5500 lbs./sq. inch and the latter reported to reach 29,500 lbs./sq. inch.

The average tensile strength of zinc phosphate cement, according to Bowen and Rodriguez, is 350 lbs./sq. inch and that of silicate is 500-1000 lbs./sq. inch.

Literature on different restorative materials seems to relate the gross fracture and marginal breakdown of any restorative material to a number of speculations grouped under three major factors: physical properties of the material, operative procedures, and oral conditions.
Since it is not the purpose of this work to study these factors individually or pinpoint the effect of each, it may suffice to mention them in generalized terms.

The physical properties that probably have a bearing on the gross fracture are the strength characteristics, known as compressive strength, brittleness, the ability to resist shear stresses, and impact forces. The same strength characteristics can be related to the marginal disintegration, however, the edge strength, adhesive properties, dimensional changes and solubility of the material may also be involved. All temporary filling materials are known to be lacking in edge strength. There is no clear cut data on edge strength. However, compressive strength, tensile strength, and impact strength together may give a comparative idea on the edge strength of different materials.

A true adhesive property is not found in any of the temporary restorations, however, when the term is used to denote the mechanical interlocking between two surfaces, they all have it to a certain degree. Dimensional changes are said to affect the margins of the filling. In case of expansion, overlapping margins of the filling break under masticatory forces. Shrinkage may lead to unsupported margins of both the filling and the tooth structure that often results in marginal break-down. Moreover, leakage through
the resulting space may permit more chance for dissolution agents to cause further disintegration and deterioration of the filling. However, all cements are reputed to shrink on setting. Drying of the restoration results in further shrinkage.14,42.

The operative procedures have been always stressed as important factors in gross fracture and marginal break-down of restorations. Some studies have been conducted to reveal the relation between the cavity design and the gross fracture of any restoration.6,77,78. One aim in the design of the cavity is to decrease stress concentration and consequently reduce gross fracture.66. Authorities in operative technics have advocated the avoidance of thin margins of the filling that may result from overlap of the material, and overcarving or bevelling of the cavo-surface angle to prevent marginal breakdown of the brittle materials.18,79,80,83,85. They also emphasized the importance of avoiding undermined enamel in order to ensure sound marginal integrity under masticatory forces.

A recent clinical study of amalgam alloy restorations revealed the effect of the oral conditions such as traumatic occlusion in causing gross fracture.84.

In vitro systematic studies on solubility of dental cements date back to the time of Volker; however, there is some evidences that they were first carried out at an earlier time. Volker(1916) tested the solubility of powdered silicate cement in distilled water and in aqueous solutions of lactic acids in an effort to simulate factors involved in the oral environment.
Tests in distilled water do not duplicate the oral conditions. However, such tests may be of significance when different brands of one type of cement are to be evaluated. Later acetic acid, citric acid, and ammonium hydroxide were used. Different pH values, storage time, and the addition of fresh solutions at intervals employed to compensate for the difference in composition of the materials and rate of dissolution. These investigations showed that dilute organic acids are more destructive than distilled water. Citric acid seemed to be the most active agent used in dissolution. Lower pH values resulted in more destruction. When the test solutions were changed daily, solubility generally increased. Different materials showed comparative variations in solubility.

It was shown in early investigations that the solubility of silicate cements in distilled water appear to be greater than that of the zinc phosphate cement. However, in recent tests zinc phosphate cements as a group were more soluble than silicates in dilute organic acids. This finding, along with the effect of storage time and the rate of dissolution, were clearly explained in the statement by Norman, et al. in one of their series of studies on solubility, "... when specimens were placed in fresh solutions each day, there was a definite decrease in the quantity of material dissolved from silicates after the first few days, while the dissolution of zinc phosphate cement continued throughout the entire test period."
In another study, in the same series, they showed that zinc oxide-eugenol is more soluble than either zinc phosphate cement, silicate cement, or silico-phosphate cement when tested in citric acid. Zinc oxide-eugenol was not quite as soluble in acetic acid or lactic acid as either zinc phosphate or silicate cements. The silico-phosphate cement (Kryptex) showed a behavior similar to the silicate in acetic acid and lactic acid but was the least soluble in citric acid and distilled water.

In view of the deviations in the behavior of the various materials in the different solutions and the confusion that may arise when comparable data is needed, a reasonable question may arise: which of these solutions has an effect similar to the oral fluids? No reliable studies could be found in the literature to provide an answer to this question.

The clinical investigation by Wolcott, et al. was correlated with laboratory tests on solubility in distilled water. The investigators agreed that if dilute organic acids had been employed, a part of the question might have been answered.

To meet the American Dental Association specification number 8, zinc phosphate cement is allowed a maximum of 0.30 per cent weight loss from the specified exposed surface during seven days in distilled water. The silicate cement is allowed a maximum of 1.4 per cent weight loss during 24 hours in distilled water. No specifications exist for the solubility of zinc oxide eugenol or
silico-phosphate cements, however, it is reported that the former is about 0.02-0.1 per cent by weight while the latter is 0.2031-2.10 per cent by weight.

There are very few reports of clinical investigations on solubility and general disintegration of temporary filling materials in the literature. In the studies reported there were limited observations, with the greatest emphasis on silicious cements.

The early silicious cements, according to Black, had an average durability of two years. This opinion was also endorsed by Conzett and Means at the same time. Later, in 1940 a questionnaire revealed that this average life or durability was raised to 4½ years possibly due to improvements in the product and standardized manipulation. This general agreement on the durability placed the silicate in the class of a temporary filling material. Yet there are some silicate cement fillings that have lasted for as long as 25 years.

Clinical observations of silicate cements over 20 years by Henschel and similar observations on silico-phosphate cements over 18 months by Ross revealed that the restorations which were subjected most to mechanical wear of mastication and washing action of saliva, disintegrated the least. Henschel explained the disintegration of the restorations, that were not subjected to mastication, to be due to stagnation and carbohydrate degradation with acid formation resulting in an attack on the restoration. Ross had the opinion that moisture contamination from the
gingival tissue, at the time of insertion, in certain instances, dilutes the cement. These assumptions came in agreement with that of Paffenberger\textsuperscript{14,89} who also pointed out that the flora of the mouth in addition to the nutrients available which, may vary from one person to another, are probably responsible for the chemical attack on the restoration. The end products of oral disintegration such as organic acids, ammonia, and sulphides selectively attack the different cements.

The first clinical research done on the disintegration of temporary filling materials, on a standardized basis was published by Wolcott, Shiller, and Kraske\textsuperscript{16} in 1962. Four temporary filling materials were used, including zinc oxide-fatty acid, zinc phosphate cement, zinc phosphate cement with alloy, and silico phosphate cement. These materials represented a broad range of temporary restoratives having diverse physical properties. The fillings were placed in 189 Class I and II cavities almost equally distributed in four quadrants of 17 patients. The materials were weighed, mixing was standardized, and operator variables were minimized. The work was done by two dentists. General disintegration was evaluated after six months by measuring the occlusal using modified Boley gauge. The physical properties were tested in the laboratory and were compared with the clinical results. They reported that the loss of filling material on the occlusal decreased as the crushing strength increased. They also showed that, as a general rule, the disintegration increased as the solubility increased. Another point of interest
was the fact that the type and location of the cavity preparation made little difference in the failure rate.

This review of literature reveals that the physical properties of the temporary filling materials have been studied \textit{in vitro}. \textit{In vivo} studies are limited and for the most part to observations over periods of time on fillings that were not placed for study purposes, and without standardization or consideration of operator variables.

In spite of the fact that the \textit{in vitro} experimental data accumulated in previous studies and the theoretical speculations arising from such data may seem to conform in some respects with the testimony of clinical observations, the true clinical significance of many physical properties are neither clear nor sufficient for the elucidation of many clinical questions. Thus it becomes evident that the need for more clinical studies in this field is unquestionable.
The purpose of this study was to observe, clinically, the clinical disintegration, gross fracture, dental broken, and clinical fracture in Class II and Class III Restorations. The first materials, all having similar chemical nature, properties, were the under-reach (Verne-Bowen cement), the under-shine (Chilton), under-prepare coy (Vernan), and under-shine's earth (Levere).

The aims of this study were:

1. To determine the relation between the bonding base of the clinical disintegration and clinical fracture in terms of chemical deterioration, gross fracture, dental broken, and clinical fracture.

2. To determine the clinical investigation provide additional information on the chemical significance of the clinical disintegration, gross fracture, and clinical fracture in terms of chemical deterioration, gross fracture, and clinical fracture.

3. To determine if the clinical investigations provide additional information on the clinical significance of the clinical disintegration, gross fracture, and clinical fracture in terms of chemical deterioration, gross fracture, and clinical fracture.
The purpose of this study was to observe, clinically, the general disintegration, gross fracture, marginal breakdown, and surface texture in Class I and Class II restorations, of four temporary filling materials. The four materials, all having widely varying physical properties, were zinc oxide-eugenol (Temrex Anodyne cement), zinc oxide-resin (Caulk's), zinc phosphate cement (Tenacin), and silica-phosphate cement (Kryptex).

The main objectives were:

1. to search for any correlation between the in vitro data of the strength characteristics and solubility of these materials and their behavior in terms of general disintegration, gross fracture, marginal breakdown, and surface texture.
2. to evaluate clinically the materials on the basis of their resistance to general disintegration, gross fracture, and marginal breakdown.

It was intended that this clinical investigation provide additional information on the clinical significance of the present in vitro evaluation tests, and provide a better understanding of the clinical behavior of materials of known physical properties, thus providing a yardstick for improvement in the qualities of such materials.
EXPERIMENTAL PROCEDURES
PART I

Cavity Preparation

The following standards were developed in cavity preparation to assure equal opportunity of success for all the materials used. Class I cavities were prepared following Black's general principles. In each cavity preparation, there was extension of the primary grooves and development of cavity walls which were parallel and perpendicular to the pulpal floor. The pulpal floor was established in sound dentine 0.5 mm. pulpal to the dentinoenamel junction at the deepest portion of the occlusal surface. Care was taken to eliminate unsupported enamel at the cavity margins and to develop a cavo surface angle of approximately 90 degrees. The outline form of the preparation included all main occlusal pits in all the molars except in the maxillary second primary molar and the maxillary first permanent molars. The outline form never crossed the oblique ridge. Only the mesial pit of the maxillary molars was included in the preparation. The distal pit, when carious, was filled with the same material as the mesial pit but was not scored in the results because of its minute size.

Class II cavities did not differ appreciably from the accepted conventional design for amalgam alloys. All maxillary and mandibular first primary molars selected for the study had distal-occlusal cavities; the mesial pits were included in the occlusal outline. All maxillary and mandibular second primary molars
presented mesial-occlusal cavities. The distal pits in the lower molars were included in the outline form. The axial walls of the proximal box of the deciduous tooth cavity preparation were parallel to the outside contour of the tooth and converged slightly towards the occlusal. The axial-pulpal line angle was gently rounded. No retention grooves were included in the preparation. The buccal and lingual proximal surfaces were flared to carry the preparation into a self-cleansing area and to such a degree that the margins could be easily seen and evaluated.

Testing Procedures in Dentoform Teeth

Eighteen cavities were prepared in dentoform teeth representing maxillary and mandibular first and second primary molars and the first permanent molar. The cavities were first prepared as Class I cavities and checked for the consistency in the preparation of the corresponding molars. Later, the same cavities were extended to Class II cavities and checked again by the instructing staff. All the prepared dentoform teeth were kept to be filled in the procedures for establishing a workable powder-liquid ratio and in standardization procedures of carving the margins.

Establishing the Powder-Liquid Ratio

The powder-liquid ratio was established for each of the following materials:

A. Zinc oxide-eugenol (Temrex Anodyne Cement)
B. Zinc oxide-rosin eugenol (Caulk's)
C. Zinc phosphate cement (Tenacin)
D. Silico-phosphate cement (Kryptex)
From each material two grams of powder were weighed, using the analytical balance, and packaged, (the contents of the packages were used in trials to establish the powder - liquid ratio of each material). Contents of each package were transferred onto a Caulk, thermometer containing dry glass slab cooled to 65-75° F. Four drops of the corresponding liquid were used as a starting amount. Mixing was started when the temperature was 65° F. Spatulation was done in an effort to incorporate, in the liquid, the maximum amount of powder possible into a workable consistency allowing enough time for placement in the cavity and quick carving. The drops of liquid were increased when the amount of the mix was not enough to fill two large cavities and decreased when the amount was in excess of that needed. Powder was increased whenever it was possible to add more to the mix. The technique of mixing was according to the instructions found in the standard operative textbooks for the respective type of material. After a number of trials with each material, the unused powder from the successful mix was again weighed, using the analytical balance, and subtracted from the original. As a result of the tests, it was found that the most desirable powder-liquid ratio was as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Powder Gr.</th>
<th>Liquid Drops</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Zinc oxide-eugenol (Temrex)</td>
<td>0.80</td>
<td>6</td>
</tr>
<tr>
<td>B. Zinc oxide-rosin eugenol (Caulk's)</td>
<td>0.65</td>
<td>3</td>
</tr>
<tr>
<td>C. Zinc phosphate cement (Tenacin)</td>
<td>0.85</td>
<td>4</td>
</tr>
<tr>
<td>D. Silico-phosphate cement (Kryptex)</td>
<td>0.55</td>
<td>3</td>
</tr>
</tbody>
</table>
Technique of Mixing

The technique of mixing was standardized for the four materials. The mixing techniques for zinc oxide-eugenol and zinc oxide-rosin were similar. On a clean dry glass slab cooled to 65°F., powder was placed and divided into halves, halves into quarters and finally quarters into eights. The specified number of drops of the corresponding liquid was dispensed from its dropper, the first portion drawn to the liquid and spatulated with pressure and a rotary motion until all the powder was wetted. The same procedure was followed for the other portions, spatulating each portion for about ten seconds. The mix was completed within one minute.

Zinc phosphate cement powder was placed on a clean dry glass slab cooled to 65°F and divided into halves, then each half into thirds. Four drops of liquid, using the same dropper each time, were dispensed. The first one-sixth of powder was drawn into the liquid. Spatulation was continued in light rotary motion for approximately 10 seconds. In like manner, the remaining portions were spatulated. Frequent scraping up of the mass and spreading it out again under pressure was done during mixing. Mixing was completed within one minute.

Silico-phosphate cement powder was placed on a clean dry Caulk's glass slab cooled to 65°F and divided into 3 portions. The third portion was divided into two parts. Three drops of the corresponding liquid were dispensed. The first two-thirds of the
powder were drawn together into the liquid and pressed lightly until all of the powder was wetted then spatulated in a rotary motion. In a like manner the other two portions were incorporated one at a time. The mix was completed within one minute.

Standardizing the Carving on Dentoform and Extracted Teeth

When four dentoform teeth were restored with each filling material and carved, in an effort to standardize the carving techniques, it was found that by using a stainless steel plastic instrument it was possible to carve the zinc oxide eugenol containing materials with only slight chipping at margins. It was almost impossible to complete the carving of zinc phosphate cement and silico-phosphate cement with a plastic instrument. A number 6 round bur was used with better results. In cases of the zinc phosphate and silico phosphate cements the test seemed impractical since in an effort to reproduce good margins the dentoform material yielded to the bur before it affected the filling material itself, thus these trial tests were conducted on extracted teeth.

Sound extracted primary molars were not available. Since only reproduction of well defined margins and consistent surface texture with each of the four materials was the purpose of the trial tests all types of extracted molars were used.

Carving and finishing using hand instruments first, then the round bur was successful. Five teeth were filled with each material, carved and examined with the aid of the binocular microscope. The consistency was found to be satisfactory.
Selection of Cases

The children who participated in this study were selected from a group of children being treated in the Department of Pedodontics of Indiana University School of Dentistry. The age of the subjects ranged from 4 to 12 years. Maxillary and mandibular first and second primary molars and first permanent molars with occlusal or incipient proximal carious lesions were selected for the experimental fillings. Each patient had full-mouth radiographs including bite-wing films. Extensively decayed teeth or teeth that required other than standard outline form of the preparation were excluded. All teeth had apparently healthy pulp tissue and had not presented symptoms of painful pulpitis. A routine medical and dental history was taken in every case.

All teeth selected were in functional occlusion. The deciduous teeth selected would be retained at least six months before exfoliation.

Clinical Procedures

The clinical portion of the study started after the ability of the operator to consistently reproduce cavity preparations was checked by clinical instructors in the Department of Pedodontics.

A local anesthetic was given prior to the operative procedures. The teeth to be operated were isolated with medium weight, dark rubber dam to facilitate the cutting of an ideal cavity preparation and to eliminate the ingress of moisture during the placement and hardening of the temporary filling material.  

91-96.
Cavity preparations were made with an air turbine handpiece and a number 331 friction grip bur. Line angles were placed in the cavity with a number 35 carbide bur revolving at a conventional speed. Walls were finished with a number 558 bur and hand instruments. Since only teeth with incipient lesions were selected for the study, no cavities required a base of another material. No varnish of any type was used prior to placing the filling. Brass T-bands which were contoured and wedged were used for all Class II cavities. No difficulty was encountered in the band adhering to the filling so no lubricant needed with any of the materials.

Standardized procedures for determining powder-liquid ratios, spatulation and glass slab temperature were adhered to in the preparation of all filling materials. A stainless steel plastic instrument was used to place the material in the cavity. A standardized carving procedure, using a Wall's carver and a large round bur, running at conventional speed was carried out to clear all the margins of overhanging filling material. Extreme care was taken at this step to prevent chipping of the filling.

It was decided to complete the carving of the silico-phosphate cement at the initial visit despite the danger of disturbing the gel formation. In the case of silico-phosphate cement, vaseline coating was used immediately after finishing.

After the removal of the rubber dam, occlusion was checked with the aid of articulating paper and adjusted if necessary. It is generally agreed that patients should not chew on newly restored
teeth for a period of time but this factor was difficult to control with patients in this age range. Hence, no attempt was made to restrict masticatory forces on the fillings during the first twenty-four hours.

There was equal distribution of the filling materials in the four quadrants with some effort to place all four different materials in the mouth of each patient so each material would undergo similar clinical experience. After the placement of each filling or fillings, the patient was reappointed at intervals of one week, one month, three months, and six months for observation.

Observation Visits

At the four observation visits the following procedures were carried out. There was visual inspection of the filling with the aid of a mirror and a sharp explorer. Each filling was checked for dissolution of material, fracture, or marginal breakdown. A perforated sheet metal tray was cut and trimmed to the desired size and molded as a tray for a rubber base impression. A bees wax rim was placed around the periphery of the tray to prevent injury to the soft tissue. After drying the field, a rubber base impression was taken, using the injection technique, with the light bodied material supported by the heavy body mix in the tray. The rubber base impression was poured in yellow stone and labeled. The label included the serial number of the patient, the time of observation, the teeth filled, the cavity type and the type of filling material. Models of each patient were stored in a labeled box for later evaluation. If a filling was
disintegrated during the observation period, it was replaced with silver amalgam. For purposes of comparison fractured restorations were replaced with another material belonging to the same category (considering the zinc oxide-eugenol (Temrex), and zinc oxide-resin eugenol, as one category; zinc phosphate cement and silico-phosphate cements as another category).

Notations were made on the patient's chart indicating lack of observation, delay in the time of observation, date of fracture of the restorations and type of replacement.

The total number of restorations placed in 37 patients was 137, distributed as follows:

<table>
<thead>
<tr>
<th>Material A</th>
<th>Zinc oxide-eugenol (Temrex)</th>
<th>Class I</th>
<th>15</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Class II</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Material B</td>
<td>Zinc oxide-resin eugenol</td>
<td>Class I</td>
<td>17</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class II</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Material C</td>
<td>Zinc phosphate cement</td>
<td>Class I</td>
<td>17</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>(Tenacin)</td>
<td>Class II</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Material D</td>
<td>Silico-phosphate cement</td>
<td>Class I</td>
<td>18</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>(Kryptex)</td>
<td>Class II</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

_Evaluation of the Surface Texture_

An evaluation of the surface texture of each rubber base impression was done before pouring in stone. The impression was rinsed, dried by a stream of air and viewed under the binocular microscope. Observations on the surface texture of each material were noted by the operator. His findings were confirmed by staff members in the Department of Pedodontics and the Department of Dental Materials of Indiana University School of Dentistry.
Evaluation of the General Disintegration and Strength Characteristics

Evaluations were made on the stone casts by three clinicians, including the operator, all from the Department of Pedodontics of Indiana University School of Dentistry. Evaluation scores were marked by the evaluators on a card for each patient. The card was specially designed for the evaluation in this study. The general disintegration was graded as follows:

0 - No visual surface or margin change detected
1 - Slight visual change but with a loss of surface material less than 0.5 mm
2 - Definite visual change but with a loss not greater than half the depth of the cavity
3 - More than \( \frac{3}{2} \) the depth of the restoration was lost as result of solubility or surface disintegration

Other scoring methods were developed to record certain conditions such as:

X - Filling had been replaced due to loss of the temporary restoration (X equals 3 in the numerical scoring)
M - An observation missed due to failure to keep appointment or other reason
F - Fractured restoration; e.g., FW - fracture was first noticed at one week observation; FM - fracture was first noticed at one month observation; gross fracture was scored 2
mF - Only margin is fractured or chipped, e.g., mFW or mFM
L - Clear line of demarcation separating the restoration from the tooth substance.

Restorations were considered failure if they showed more than 0.5 mm loss, i.e., grades 2 and 3

The mean grading of the three evaluators was tabulated. The percentage of failure of a material within a given period was the percentage of occurrence of 2 and 3 among the total number of
of restorations observed during this period. In case of missing observations, between two unchanged observations, the missing one was scored the same.

Percentages of gross fractures and chipped margins were calculated for comparison.

PART II

Buccal Pits

At the completion of the clinical aspect of the study, it was found that the two types of zinc oxide-eugenol demonstrated different rates of disintegration. To clarify the reason for the higher disintegration rate of one type over the other type it was decided to place the two materials in cavities under the same conditions of the oral environment and eliminate forces of mastication.

Five pairs of buccal pit cavities were prepared in lower first permanent molars and second deciduous molars in different patients. Again all aspects of the technique including cavity size were standardized. The fillings were in the same oral environment, being in one mouth, on one side of the jaw and occupying the buccal pits of two adjacent molars. The diameter of each buccal pit cavity was just large enough to accommodate a #558 fissure bur and the depth of the cavity was 0.5 mm. beneath the dentinoenamel junction.

Following the previously established standards of manipulation, each buccal pit was filled in order that each pair would
contain both of the zinc oxide-eugenol type materials so the two materials would have equal distribution. The surface of the fillings were finished flush with the buccal surface of the tooth (Figure 1).

Observations of the restorations were made on models prepared from rubber base impressions. The amount of depth created by the disintegration was the element of evaluation.

PART III

Physical Property Tests

Physical property tests were conducted in the laboratory in order to determine the properties of the different materials when manipulated in the manner employed in this clinical study. This would afford a direct comparison between specific properties and clinical behavior. Hence the powder-liquid ratios and mixing procedures, utilized in preparation of these specimens, exactly paralleled those described previously for each material. The properties tested were those felt to be pertinent to the clinical behavior of materials. They were compressive strength, solubility and abrasion resistance.

Compressive Strength Tests

Compressive strength of all materials was tested, in the manner described in the American Dental Association Specification Number 8 for dental phosphate cement. Molds six millimeters in diameter and twelve millimeters high were used to form the specimens. Three minutes from the start of the mix the specimens were placed in a
humidor at $37^\circ$ C. Thirty minutes later the specimens were separated from the molds and immersed in distilled water for seven days. At the end of seven days compressive strength was determined on a Richle testing machine using a cross-head speed of 0.01 inches per minute. A minimum of five specimens of each material were tested.

### Solubility and Disintegration Tests

(a) Solubility tests on all materials were conducted in accordance with American Dental Association Specification Number 8 for dental zinc phosphate cement. Five-tenths milliliter of mixed cement was squeezed between two glass plates to form 20 millimeter discs. Three minutes from the start of the mix the discs were placed in 100 per cent humidity at $37^\circ$ C. One hour later the discs were removed and two discs of the same material were suspended in tared weighing bottle containing 50 milliliters of distilled water. The bottle was stored for seven days at $37^\circ$ C. At the end of this time the discs were removed and the water evaporated. The amount of residue was determined gravimetrically and the per cent solubility calculated. A minimum of two such tests were performed for each material.

(b) A second series of solubility tests was also conducted employing a different procedure. Norman, Swartz and Phillips utilized a test in which the specimens were placed in fresh solution each day. They felt this test to be more satisfactory for comparing one type of cement with another and also to be somewhat more indicative of the clinical behavior of the material. For these
reasons the solubility of the materials in distilled water and in 0.001 M acetic acid solution pH 4 was measured by this procedure.

A glass plate having an etched circle 10.4 millimeters in diameter was used to form the specimens. Before the cement hardened a stainless steel wire was inserted into the specimen. The specimens were then stored in a humidor at 37° C for 50 minutes. The free end of the wire was then attached to a watch glass. The specimen was suspended in 25 milliliters of the test solution which was contained in a tared #2 Coors crucible. The crucibles were stored at 37° C for 24 hours after which the specimens were transferred to new crucibles containing fresh solutions. The crucibles were evaporated on a steam bath and the residue for each 24 hours was determined gravimetrically over a period of seven days. The mean exposed surface area of the specimens was found to be 229 square millimeters. Solubility was calculated on the basis of milligrams per square centimeters of exposed surface area. A minimum of four specimens of each material was tested in each of the two media.

Abrasion Resistance

The relative resistance of the materials to abrasion by a tooth brush was investigated. This particular method has been used previously by Swartz, et al., to investigate wearing qualities of cement type materials. Cylindrical specimens of the type used in the compressive strength tests
were prepared and stored in distilled water for seven days. The specimens were then weighed and mounted in the pan of a mechanical tooth brushing machine. They were brushed for 30 minutes in a slurry of calcium carbonate abrasive using three row nylon tooth brushes having a bristle diameter of 0.013 inches. The specimens were reweighed and the per cent weight loss calculated. A minimum of four specimens of each material was tested.
RESULTS
MANIPULATION AND CARVING

Generally the proportions used in the mixing of the cements in this study resulted in a thick consistency. However, there were no difficulties in handling, insertion or carving of the zinc oxide-eugenol (Temrex), zinc phosphate cement (Tenacin), or silico-phosphate cement (Kryptex).

Zinc oxide-rosin eugenol presented two phases before complete setting. After completion of mixing it had a thick consistency which soon flowed into thinner gummy consistency after insertion. During this phase it was almost impossible to use either a plastic instrument or round bur. The operator had to wait for two to two and one half minutes before carving. Any carving during the flowing phase caused the material to stick to the instruments used.

The stickiness in zinc oxide-rosin eugenol also presented difficulties in cleaning the instruments.

SURFACE TEXTURE

Over four hundred reproductions of the surface texture of the four different materials, reproduced by rubber base impressions have shown marked consistency within each group of material over different periods of observation.

To the naked eye and under the binocular microscope, zinc oxide-eugenol (Temrex) has always shown the smoothest and glossiest surface of all the materials used (Figures 2 and 3). Zinc oxide-rosin eugenol showed the roughest and most pitted surface with a dull porous appearance (Figure 4). In some instances particles of
the surface layer of zinc oxide-rosin eugenol were held by the rubber base material giving a whitish appearing surface layer to the impression.

Zinc phosphate cement (Tenacin) as shown in Figures 5a and 6 was second to zinc oxide-eugenol (Temrex) in smoothness but did not show the same shining glossy appearance as did both zinc oxide-eugenol (Temrex) and the silico-phosphate cement (Kryptex). Silico-phosphate cement (Kryptex) showed a pitted surface (Figure 5b), but exhibited glossy appearance that ranked second to zinc-oxide-eugenol (Temrex).

GENERAL DISINTEGRATION, MARGINAL CHIPPING AND CROSS FRATURES

One Week Observation

a. Zinc oxide-eugenol (Temrex): Results are shown and summarized in Tables I and II. Among the 34 restorations observed 15 were Class I and 19 were Class II restorations. Of the 15 Class I restorations observed, seven did not show any evidence of disintegration, whereas seven restorations demonstrated very slight disintegration within a range of surface loss not exceeding one half millimeter. One restoration exhibited a definite visual change with a loss not greater than half the depth of the cavity. Of the 19 Class II restorations observed, 12 did not show any evidence of disintegration. Five restorations demonstrated very slight disintegration within a range of surface loss not exceeding one half millimeter. One restoration exhibited a definite visual change but with a loss not greater than half the depth of the cavity. One
restoration was completely disintegrated. Among these there was one gross fracture and one case exhibited marginal chipping.

b. Zinc oxide-rosin eugenol (Caulk's): Results are shown and summarized in Tables I and III. Among the 31 restorations observed, 17 were Class I and 14 were Class II restorations. Of the 17 Class I restorations only one did not show any evidence of disintegration. Two restorations exhibited very slight disintegration within a range of surface loss not exceeding one half millimeter. Four restorations demonstrated definite visual change but with a loss not greater than half the depth of the cavity. Ten restorations were completely disintegrated. Of the 14 Class II restorations observed, two did not show any evidence of disintegration. Three restorations exhibited very slight disintegration within a range of surface loss not exceeding half millimeter. Seven restorations showed definite visual change but with a loss not exceeding half the depth of the cavity. Two restorations were completely disintegrated. No gross fractures were detectable as the filling material sloped proximally showing an evident loss without clear cut fracture. However three restorations exhibited marginal chipping.

c. Zinc phosphate cement (Tenacin): Results are shown and summarized in Tables I and IV. Among the 38 restorations observed, 17 were Class I and 21 were Class II restorations. Of the seventeen Class I restorations observed, nine did not show any evidence of disintegration. Eight restorations demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter.
Of the 21 Class II restorations, 15 did not show any evidence of disintegration. Six restorations demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter.

d. Silico-phosphate cement (Kryptex): Results are shown and summarized in Tables I and V. Among the 34 restorations observed, 18 were Class I and 16 were Class II restorations. Of the 18 Class I restorations observed, 12 did not show any evidence of disintegration, whereas six demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Of the 16 Class II restorations observed, seven did not show any evidence of disintegration, whereas seven demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Two fractured restorations were observed.

One Month Observation

a. Zinc oxide-eugenol (Tomrex): Results are shown and summarized in Tables I and II. Among the 33 restorations observed, 15 were Class I and 18 Class II restorations. Of the 15 Class I restorations five did not show any evidence of disintegration. Seven demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Three restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. Of the 18 Class II restorations observed, four did not show any evidence of disintegration. Ten restorations demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Three restorations
exhibited a definite visual change with a loss not greater than half the depth of the cavity. Only one restoration was completely lost. One fractured restoration was observed and three exhibited marginal chipping.

b. Zinc oxide-rosin eugenol (Caulk's): Results are shown and summarized in Tables I and III. Among the 31 restorations observed, 17 were Class I and 14 were Class II restorations. Of the 17 Class I restorations, two demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Two restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. Thirteen restorations were completely disintegrated. Of the 14 Class II restorations, only one demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Four restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. Nine were completely disintegrated.

c. Zinc phosphate cement (Tenacin): Results are shown and summarized in Tables I and IV. Among the 38 restorations observed, 17 were Class I and 21 were Class II restorations. Of the 17 Class I restorations, seven did not show any evidence of disintegration. Nine demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Only one restoration exhibited a definite visual change with a loss not greater than half the depth of the cavity. Of the 21 Class II restorations, 12 did not show any evidence of disintegration. Eight demonstrated very slight disintegration.
within a range of surface loss not exceeding half millimeter. Only one restoration exhibited a definite visual change with a loss not greater than half the depth of the cavity.

d. Silico-phosphate cement (Kryptex): Results are shown and summarized in Tables I and V. Among the 34 restorations observed, 18 were Class I and 16 were Class II restorations. Of the 18 Class I restorations seven did not show any evidence of disintegration. Eleven demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Of the 16 Class II restorations two did not show any evidence of disintegration. Eleven demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Fractures were assigned a value of "2" in scoring. Three were observed in this group of restorations and two of these occurred during the first week. No change in the fracture was noticed and the proximal part of the fracture was still retained. Two restorations presented chipped margins.

Three Months Observation

a. Zinc oxide-eugenol (Temrex): Results are shown and summarized in Tables I and II. Among the 33 restorations observed, 15 were Class I and 18 were Class II restorations. Of the 15 Class I restorations, four did not show any evidence of disintegration. Four demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Four restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. Three
restorations were almost lost. Of the 18 Class II restorations two did not show any evidence of disintegration. Eight demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Seven restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. One restoration was completely disintegrated. Two restorations showed marginal chipping.

b. Zinc oxide-rosin eugenol (Caulk): Results are shown and summarized in Tables I and III. Two among the 17 Class I restorations and one among the 14 Class II restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. All the remainder of the restorations were lost or replaced as a result of total disintegration.

c. Zinc phosphate cement (Tenacin): Results are shown and summarized in Tables I and IV. Among the 38 restorations observed, 17 were Class I and 21 were Class II restorations. Of the 17 Class I restorations two did not show any evidence of disintegration. Twelve demonstrated very slight disintegration within a range of surface loss not exceeding half millimeter. Two restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. One restoration exhibited loss greater than half the depth of the cavity. Of the 21 Class II restorations five did not show any evidence of disintegration. Thirteen demonstrated very slight disintegration within a range of surface loss not exceeding one half
millimeter. Two restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. One restoration was completely disintegrated. One restoration exhibited marginal chipping.

d. Silico-phosphate cement (Kryptex): Results are shown and summarized in Tables I and V. Among the 34 restorations observed, 18 restorations were Class I and 16 were Class II. Of the 18 Class I restorations observed, six did not show any evidence of disintegration. Ten demonstrated very slight disintegration within a range of surface loss not exceeding one half millimeter. Two restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. Among the 16 Class II observed restorations, 11 demonstrated very slight disintegration within a range of surface loss not greater than one half millimeter. Five restorations exhibited a definite visual change with a loss not greater than half the depth of the cavity. These five restorations were two old gross fractures and three new fractures.

MARGINAL INTEGRITY

By the end of the third month there were 31.60 per cent chipped margins among all Class II zinc oxide-eugenol (Temrex) restorations. Zinc oxide-rosin eugenol (Caulk) did not show a clean cut fractured margins. The margins were sloped and disintegrated. Zinc phosphate cement (Tenacin) Class II restorations experienced 4.78 per cent chipped margins. Silico-phosphate cement (Kryptex) Class II
restorations exhibited 12.53 per cent chipped margins. During the
three months observations a fine line of demarcation separating the
restoration from the tooth substance was observed in 7.9 per cent
of Tenacin restorations and 20.60 per cent of Kryptex restorations.

GENERAL OBSERVATIONS ON SOME CASES AVAILABLE AFTER SIX MONTHS

General Disintegration

a. Zinc oxide-eugenol (Temrex) - Among the nine Class I restora-
tions observed, one restoration showed very slight disintegration
within a range of surface loss not exceeding one half millimeter.
Four restorations exhibited a definite visual change with a loss not
greater than half the depth of the cavity. Four restorations were
completely disintegrated. Among the six Class II restorations
observed, two restorations demonstrated very slight disintegration
within a range of surface loss not exceeding one half millimeter.
Two restorations exhibited a definite visual change with a loss not
greater than half the depth of the cavity. Two restorations were
completely disintegrated.

b. Zinc oxide-rosin eugenol - No restoration was left for observa-
tion. All restorations disintegrated and were replaced.

c. Zinc-phosphate cement (Tenacin) - Among the 12 Class I restora-
tions observed, nine demonstrated very slight disintegration within a
range of surface loss not exceeding one half millimeter. Two restora-
tions exhibited a definite visual change with a loss not greater than
half the depth of the cavity. One restoration was completely disinte-
grated. Among the nine Class II restorations, two did not show any
evidence of disintegration. Six restorations demonstrated very slight disintegration within a range of surface loss not exceeding one half millimeter. One restoration exhibited a definite visual change with a loss of material not greater than half the depth of the cavity.

d. Silico-phosphate cement (Kryptex) - Among the 14 Class I restorations observed six did not show any evidence of disintegration. Eight restorations demonstrated very slight disintegration within a range of surface loss not exceeding one half millimeter. Among the five Class II restorations observed three demonstrated very slight disintegration within a range of surface loss not exceeding one half millimeter. The other two restorations were fractured.

General Observations

The surface texture of all the zinc oxide-eugenol (Temrex) restorations had the same characteristic appearance shown during the three months observations. No gross fractures were observed but sloping of the proximal part was always exhibited. Sharpness of the carving faded into smooth curves.

The surface texture of all Class I and Class II zinc-phosphate (Tenacin) restorations appeared to be smoother with time (Figures 7a and 8). Abrasion and disintegration was maximum at the centre of the occlusal part of the restoration. The sharpness of the carving faded into smooth curves.

The surface texture of all Class I and Class II silico-phosphate (Kryptex) restorations did not change after the first three months
(Figures 7b and 9). There was no evidence of abrasion. The sharpness of the carving did not change its appearance. In the fractured Class II restorations the proximal portion was retained without dislodgement.

RESTORATIONS REPLACED BY OTHER STUDY FILLING MATERIALS

Five of the zinc oxide-rosin eugenol (Caulk) restorations that disintegrated within one week were replaced in zinc oxide-eugenol (Temrex). The Temrex restorations showed no evidences of disintegration during the first month. Four fractured Class II silica-phosphate restorations were replaced by zinc phosphate (Tenacin). When three of them were observed for three months, no fracture occurred. The fourth (Tenacin) restoration was observed for only two months without any fracture experienced.

BUCCAL PIT RESTORATIONS

All the five pairs of buccal pit restorations showed the same results. In every pair, the buccal pit cavity that was restored in zinc oxide-eugenol (Temrex) did not exhibit evidence of disintegration after the first month but exhibited very slight disintegration around the margins by the third month. The buccal pit cavity that was restored in zinc oxide-rosin (Caulk) was disintegrated during the first week (Figures 10-11). These disintegrated buccal pit restorations were replaced by zinc oxide-eugenol (Temrex) and did not show evidence of disintegration during the first month but exhibited very slight disintegration around the margins after one month.
LABORATORY TEST OF COMPRESSION STRENGTH

The results of the compressive strength tests conducted in the laboratory are shown and summarized in Table VI. The value for zinc oxide-eugenol (Temrex) was 2,900 pounds per square inch. The value for zinc oxide-rosin eugenol was 2,200 pounds per square inch. The value for zinc-phosphate cement (Tenacin) was 18,800 pounds per square inch. The value for silico-phosphate cement (Kryptex) was 20,900 pounds per square inch.

LABORATORY TEST FOR SOLUBILITY

The results of solubility tests, conducted in accordance with American Dental Association Specification Number 8, are summarized in Table VII. Zinc oxide-eugenol (Temrex) showed a 0.837 per cent weight loss. Zinc oxide-rosin eugenol (Caulk) showed a 0.037 per cent weight loss. Zinc-phosphate cement (Tenacin) showed a 0.018 per cent weight loss. Silico-phosphate cement (Kryptex) showed a 0.565 per cent weight loss.

When tests were used which employed fresh solutions of water every day for 7 days, zinc oxide-eugenol (Temrex) showed loss of 0.87 mg. per sq. cm. of surface area during the first 24 hours and 5.52 mg. per sq. cm. for seven days. Zinc oxide-rosin eugenol showed loss of only 0.04 mg. per sq. cm. of surface area during the first 24 hours and 1.47 in seven days. Zinc phosphate cement (Tenacin) showed loss of 0.17 mg. per sq. cm. of surface area during the first 24 hours and 1.29 mg. per sq. cm. of surface area in seven days. Silico-phosphate cement (Kryptex) showed loss of 1.21 mg. per sq. cm.
of surface area during the first 24 hours and 2.72 mg. per sq. cm. of surface area in seven days.

On using 1/1000 M acetic acid of pH 4 as a media, zinc oxide-eugenol (Temrex) lost 3.04 mg. per sq. cm. of surface area and 18.5 mg. per sq. cm. of surface area over seven days. Zinc oxide eugenol-rosin showed loss of 0.83 mg. per sq. cm. of surface area on the first 24 hours and 4.57 mg. per sq. cm. over seven days. Zinc phosphate cement (Tenacin) showed loss of 1.91 mg. per sq. cm. of surface area during the first 24 hours and 13.3 mg. per sq. cm. of surface area in seven days. Silico-phosphate cement (Kryptex) showed loss of 1.83 mg. per sq. cm. of surface area in the first 24 hours and 7.39 mg. per sq. cm. of surface area in seven days.

LABORATORY TEST FOR ABRASION RESISTANCE

As shown in Table VIII zinc oxide eugenol (Temrex) showed 24.53 per cent weight loss when slurry of calcium carbonate abrasive was employed. In the same tests zinc oxide rosin-eugenol showed 11.48 per cent weight loss; zinc-phosphate cement (Tenacin) showed 0.23 per cent weight loss; silico-phosphate cement (Kryptex) showed 0.36 per cent weight loss.
TABLES AND ILLUSTRATIONS
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CLASS</th>
<th>1 WEEK</th>
<th>1 MONTH</th>
<th>3 MONTHS</th>
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<td>I</td>
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<td>20.</td>
<td>46.7</td>
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<td>II</td>
<td>10.6</td>
<td>22.3</td>
<td>44.4</td>
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<td>82.</td>
<td>88.</td>
<td>100.</td>
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<tr>
<td></td>
<td>II</td>
<td>64.3</td>
<td>92.9</td>
<td>100.</td>
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<td>C. TENACIN</td>
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<td>D. KRYPTEX</td>
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<td>II</td>
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<td>18.7</td>
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Table II

Amount and Distribution of General Disintegration
In Class I and Class II Restorations
(Zinc oxide-eugenol "Temrex")

<table>
<thead>
<tr>
<th>No. of Restorations</th>
<th>Class</th>
<th>Grade of Scoring*</th>
<th>1 Wk.</th>
<th>1 Mo.</th>
<th>3 Mo.</th>
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<td>Total</td>
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</table>

* The general disintegration was graded as follows:
0 - No visual surface or margin change detected
1 - Slight visual change but with a loss of surface material less than $\frac{1}{2}$ mm
2 - Definite visual change but with a loss not greater than half the depth of the cavity
3 - More than $\frac{1}{2}$ the depth of the restoration was lost as result of solubility or surface disintegration
Table III

Amount and Distribution of General Disintegration
In Class I and Class II Restorations
(Zinc oxide-rosin eugenol "Caulk")

<table>
<thead>
<tr>
<th>No. of Restorations</th>
<th>Class</th>
<th>Grade of Scoring*</th>
<th>No. of Restorations</th>
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</thead>
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<td></td>
<td>1 Wk.</td>
<td>1 Mo.</td>
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<td>Observed</td>
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<tr>
<td>Total</td>
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<td>7</td>
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<td>3</td>
<td>2</td>
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* The general disintegration was graded as follows:
0 - No visual surface or margin change detected
1 - Slight visual change but with a loss of surface material less than \( \frac{1}{2} \) mm
2 - Definite visual change but with a loss not greater than half the depth of the cavity
3 - More than \( \frac{1}{2} \) the depth of the restoration was lost as result of solubility or surface disintegration
Table IV

Amount and Distribution of General Disintegration
In Class I and Class II Restorations
(Zinc Phosphate Cement "Tenacin")

<table>
<thead>
<tr>
<th>No. of Restorations</th>
<th>Class</th>
<th>Grade of Scoring*</th>
<th>No. of Restorations</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 Wk.</td>
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<td>17</td>
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* The general disintegration was graded as follows:
0 - No visual surface or margin change detected
1 - Slight visual change but with a loss of surface material less than \( \frac{1}{2} \) mm
2 - Definite visual change but with a loss not greater than half the depth of the cavity
3 - More than \( \frac{1}{2} \) the depth of the restoration was lost as a result of solubility or surface disintegration.
Table V

Amount and Distribution of General Disintegration
In Class I and Class II Restorations
(Silico phosphate cement "Kryptex")

<table>
<thead>
<tr>
<th>No. of Restorations</th>
<th>Class</th>
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<th>No. of Restorations</th>
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</tr>
<tr>
<td>Total</td>
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<td>34</td>
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</table>

* The general disintegration was graded as follows:
0 - No visual surface or margin change detected
1 - Slight visual change but with a loss of surface material less than $\frac{1}{2}$ mm
2 - Definite visual change but with a loss not greater than half the depth of the cavity
3 - More than $\frac{1}{3}$ the depth of the restoration was lost as result of solubility or surface disintegration
### Table VI

<table>
<thead>
<tr>
<th>Material</th>
<th>Compressive Strength (1 week) lbs/in²</th>
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<tr>
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<tr>
<td>B Zinc oxide-rosin eugenol</td>
<td>2,200</td>
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<tr>
<td>C Tenacin</td>
<td>18,800</td>
</tr>
<tr>
<td>D Kryptex</td>
<td>20,900</td>
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<tr>
<td>Material</td>
<td>A.D.A. Test (Per Cent)</td>
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<tr>
<td>Temrex</td>
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<tr>
<td>Zinc oxide-rosin eugenol</td>
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<tr>
<td>Tenacin</td>
<td>0.018</td>
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<tr>
<td>Kryptex</td>
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Table VIII

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<tr>
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<td></td>
<td>Percentage wt. loss</td>
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<td>B Zinc oxide-resin eugenol</td>
<td>11.48</td>
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<tr>
<td>C Tenacin</td>
<td>0.23</td>
</tr>
<tr>
<td>D Kryptex</td>
<td>0.36</td>
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</table>
PERCENTAGE OF FAILURES OF CLASS I
AND CLASS II TEMREX RESTORATIONS

Table IX
PERCENTAGE OF FAILURES OF CLASS I AND CLASS II ZINC OXIDE-ROSIN EUGENOL RESTORATIONS

![Graph showing percentage of failures over time for Class I and Class II restorations.]

Table X
PERCENTAGE OF FAILURES OF CLASS I AND CLASS II TENACIN RESTORATIONS

Table XI
PERCENTAGE OF FAILURES OF CLASS I AND CLASS II KRYPTEX RESTORATIONS

<table>
<thead>
<tr>
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<th>Class I</th>
<th>Class II</th>
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<tbody>
<tr>
<td>1 Wk.</td>
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<tr>
<td>1 Mo.</td>
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</tr>
<tr>
<td>3 Mo.</td>
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<td></td>
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</table>

Table XII
PERCENTAGE OF FAILURES IN CLASS I AND CLASS II RESTORATIONS IN 3 MONTHS

Table XIII
TABLE XIV

Dotted line - Class I
Solid line - Class II

A - Zinc oxide-eugenol (Temrex)
B - Zinc oxide-resin eugenol (Caulk)
C - Zinc phosphate cement (Tenacin)
D - Silico-phosphate cement (Kryptex)
PERCENTAGE OF FAILURES IN CLASS I AND
CLASS II RESTORATIONS IN 3 MONTHS

Table XIV
Figure 1. a. Shows buccal pit cavity in mandibular first permanent molar filled with zinc oxide-resin eugenol "at the time of insertion."

b. Shows buccal pit cavity in mandibular second primary molar filled in zinc oxide-eugenol (Temrex) "at the time of insertion."
Figure 2. Demonstrates the typical smooth glossy surface texture of zinc oxide-eugenol (Temrex) as shown in the rubber base impression "three month observation".

Figure 3. Two Class II zinc oxide-eugenol (Temrex) restorations in maxillary first and second primary molars. The surface texture has smooth glossy appearance (one month observation).
Figure 4. Demonstrates the typical rough pitted surface texture of the zinc oxide-rosin eugenol (Caulk) as shown in the rubber base impression (one month observation).
Figure 5. Rubber base impression of two Class II restorations in maxillary first and second primary molars.

a. The typical surface texture of zinc phosphate cement (Tenacin) is smoother than that of silico-phosphate cement (Kryptex) (three month observation).

b. Shows the typical rough pitted surface of silico-phosphate (Kryptex) restoration.
Figure 6. Shows the typical appearance of two Class II zinc phosphate cement (Tenacin) restorations in mandibular first and second primary molars (three month observation).
Figure 7.  

a. Shows Class II zinc phosphate cement (Tenacin) in mandibular first primary molar after six months.

b. Shows Class II silico-phosphate cement (Kryptex) in mandibular second primary molar after six months.
Figure 8. Shows sound proximal marginal integrity of zinc phosphate cement (Tenacin) after six months in maxillary second primary molar, clearly visible after shedding of first primary molar.

Figure 9. Class I (a) and Class II (b). Silico-phosphate (Kryptex) restorations in maxillary first permanent molar and first primary molar after six months.
Figure 10. The same case shown in Figure 1 after one week.

a. The buccal pit cavity in mandibular first permanent molar is filled with zinc oxide-rosin eugenol (Caulk) and shows some evidences of disintegration.

b. Buccal pit cavity in second primary molar filled with zinc oxide-eugenol (Temrex). The margin shows no change after one week.

Figure 11. Rubber base impression of buccal pit restorations after one week. It shows in a evidences of disintegration of zinc oxide-rosin eugenol (Caulk). In b no evidences of disintegration of zinc oxide-eugenol (Temrex).
Figure 12. Rubber base impression of buccal pit restorations after one month. The same case shown in Figure 11. It shows in a evidences of advanced disintegration of zinc oxide-resin eugenol (Caulk); in b, no evidences of disintegration of zinc oxide-eugenol (Temrex).

Figure 13. Rubber base impression of buccal pit restorations after three months. The same case shown in Figures 11 and 12. It shows in a evidences of advanced disintegration of zinc oxide-resin eugenol (Caulk); in b, evidences of slight disintegration of zinc oxide eugenol (Temrex) are visible.
DISCUSSION
It can be stated that through clinically standardized studies for evaluation of filling materials we are able to provide reliable data for comparison. In the present study the consistency in the clinical behavior of each material was satisfactory to substantiate this statement (Tables IX to XIV). However, human error should be always considered.

The overall picture of the behavior of the different materials was clearly established by the end of three months observation. Zinc-phosphate cement (Tenacin) was the material that disintegrated the least. Class I and Class II Tenacin restorations demonstrated a uniform rate of disintegration and showed little deviation in their behavior.

Silico-phosphate cement (Kryptex) ranked second to zinc phosphate cement (Tenacin) in the resistance to general disintegration. Unlike the other materials the percentage of failures of Class I and Class II silico-phosphate restorations showed a marked deviation. Class I silico-phosphate restorations disintegrated the least of all the materials used in the study. However, the high percentage of gross fractures in Class II silico-phosphate restorations obviously raised the failure scoring and caused silico-phosphate to rank second to zinc phosphate in the percentage of general disintegration. The high number of fractures of silico-phosphate can be attributed possibly to the procedures dictated by the standardized requirements in carving. It is a well-known fact that silicate or silico-phosphate cements should be molded into the final desired shape at the time of
insertion to eliminate all carving or finishing procedures since any mechanical interference during the initial setting process disturbs the gel formation. This fact was considered at the time of the planning of the study. However, it was decided to standardize the procedures with full awareness that the gel formation might be disturbed. The aim was to eliminate any effect of traumatic occlusion or premature contact. The result of such disturbance probably weakened both the matrix and the surface. This fact was supported by our findings in the clinical evaluation of the surface texture in this study. Both weak matrix and rough surface affected the strength characteristics. The weakness of the material was more evident in Class II restorations as they are subjected to the same stresses induced in Class I restorations and in addition to tensile stresses.

The occurrence of marginal fracture in silico-phosphate restorations was almost three times that which occurred in zinc phosphate and can possibly be explained in the same way. Another property that may explain the higher percentage of fractures in silico-phosphate is that the material might be more resistant to abrasion. During masticatory forces it was possible that other materials yielded due to less abrasion resistance and freed the bite from possible premature contacts and thus escaped fatigue and fracture.

The fact that when zinc phosphate cement (Tenacin) was used to replace fractured Class II silico-phosphate (Kryptex) the new restorations did not show signs of fractures during the three month
observation period. This seems to relegate the possibilities of individual local factors, in such fractures, into a secondary plane of consideration.

Zinc oxide-eugenol (Temrex) ranked third in resistance to general disintegration. The general disintegration of Class I and Class II restorations followed the same general pattern.

The material that showed the least resistance to general disintegration was the zinc oxide-rosin eugenol (Caulk). Its fast disintegration could be attributed to both its weakness and solubility. However, it was obvious that solubility plays the greatest role in disintegration of the restoration. This was evident in restorations that were not subjected to any significant forces namely those placed in buccal pits.

This study suggests that there may be a relationship between smoothness of surface texture and its resistance to general disintegration. The material with the roughest surface demonstrated the least resistance to disintegration. The surface of zinc phosphate (Tenacin) restoration were smoother than those of silico-phosphate (Kryptex) and capable of resisting disintegration more than silico-phosphate in spite of the well-known fact that silico-phosphate cement is stronger and more insoluble in the oral fluids.

The two brands of zinc oxide-eugenol used in this study showed no significant difference in solubility or strength in the laboratory tests. However, the one that had the better surface texture, namely the zinc oxide-eugenol (Temrex), lasted longer and exhibited better resistance to general disintegration.
Comparing the laboratory results in this study with the clinical findings it was evident that no correlation did exist between the laboratory solubility tests and the general disintegration of the materials in the mouth.

It was noted that the clinical behavior of these materials did show a marked relationship with the results obtained by Norman et al. using citric acid (pH 4) in laboratory studies on the same materials. However, this coincidence should be interpreted with great conservation since the consistency of the mix used in the two studies are different.

Compressive strength tests did show some relationship to the general disintegration. Zinc phosphate cement (Tenacin) and silico-phosphate cement (Kryptex) were markedly stronger than zinc oxide eugenol (Temrex) and zinc oxide-rosin eugenol (Caulk). There was no significant difference in the laboratory values for the compressive strength between zinc oxide eugenol (Temrex) and zinc oxide-rosin eugenol (Caulk). However, there was an obvious clinical difference in their rate of disintegration. Zinc oxide eugenol (Temrex) showed a marked superiority to zinc oxide-rosin eugenol (Caulk) in this respect. This might be attributed to the relative ability of zinc oxide-eugenol (Temrex) cement to resist solubility in the oral fluids as was shown when this material was placed in adjacent buccal cavities. It also had a superior surface texture.

Wolcott, Shiller and Kraske in a similar study used zinc oxide-fatty acid, zinc phosphate cement, zinc phosphate cement with
alloy, and silico-phosphate cement. In spite the fact that they used materials, proportions, and evaluation index that were different from those used in this study, the relationship between compressive strength and general disintegration observed in both studies were in agreement. However, they found that as the solubility in distilled water increased, the general disintegration increased with the exception of silico-phosphate cement which showed greater solubility but lower disintegration.

Abrasion resistance tests showed the superiority of zinc phosphate (Tenacin) and silico-phosphate (Kryptex) over the zinc oxide-eugenol (Temrex) and the zinc oxide-rosin eugenol (Caulk), but failed to give any correlation between the comparative behavior of zinc oxide-eugenol (Temrex) and zinc oxide-rosin eugenol (Caulk) in the mouth.
SUMMARY AND CONCLUSIONS
The purpose of this study was to evaluate clinically by critical observation, the general disintegration, gross fracture, marginal breakdown and surface texture of four temporary filling materials placed in Class I and Class II cavities. The materials used in the study were zinc oxide-eugenol (Temrex), zinc oxide-rosin eugenol (Caulk), zinc phosphate cement (Tenacin) and silico-phosphate cement (Kryptex). The four materials were selected because they had widely varying physical properties thus allowing a comparison of these properties and the clinical behavior of the various materials.

In the preliminary portion of this study it was first necessary to develop and standardize all manipulative and clinical procedures. Optimal powder-liquid ratios for each of the four materials were established after a series of trials and then standardized. Mixing of the materials was carried out using a Caulk (thermometer containing) dry glass slab. Mixing was started when the temperature was 65°F. In standardizing and perfecting cavity preparation, Class I and Class II cavities were prepared in both dentoform and extracted teeth. Cavities did not differ appreciably from the accepted conventional design for amalgam alloy. Care was taken to eliminate unsupported enamel at the cavity margins and to develop cavo-surface margins of 90 degrees. Carving and finishing of the margins was standardized on extracted teeth and checked under the binocular microscope.

Physical property tests were conducted in the laboratory in order to determine the properties of the different materials utilizing the standardized powder-liquid ratios and mixing procedures.
This would afford a direct comparison between specific properties and clinical behavior. The properties tested were those recognized as being pertinent to the clinical behavior of materials. They were compressive strength, solubility, and abrasion resistance. The compressive strength was tested in the manner described in the American Dental Association Specification Number 8 for dental zinc phosphate cement.\textsuperscript{70} Solubility tests on all materials were conducted in accordance with the American Dental Association Specification Number 8 for dental zinc phosphate cement.\textsuperscript{70} A second series of solubility tests were also conducted employing the procedure evolved by Norman et al.\textsuperscript{66} Distilled water and acetic acid were used as media. Specimens were placed in fresh solutions daily.

Once the preliminary portion of this study was completed, the clinical part was started but only after the ability of the operator to consistently reproduce ideal cavity preparations was established. The teeth selected for the clinical study were the maxillary and mandibular first and second primary molars and the first permanent molars. Thirty-seven children were selected for the study. The age of subjects ranged from 4 to 12 years. Each patient had full-mouth radiograph including bite wing films. Teeth that required restorations other than the standard type were excluded. A local anesthesia was given prior to the operative procedures. The teeth to be operated upon were isolated with a rubber dam. A total of 137 standardized cavities were prepared in an effort to equalize the distribution of the materials between
the four quadrants. None of the cavities required a base, and also cavity varnish was not used. Brass "T" bands which were contoured and wedged were used in the placement of the filling materials in all Class II cavities. All the standardized procedures in manipulation and mixing were adhered to throughout the clinical portion. Carving was carried out with the aid of a Wall's carver and a large round bur. After removal of the rubber dam the occlusion was checked with articulating paper and re-adjusted. No attempt was made to restrict masticatory forces on the filling during the first 24 hours. Fractured silico-phosphate cement restorations were replaced by zinc phosphate cement during the course of the study. A rubber base impression of each restoration was taken at the one week, one month, and three months observation visits. Impressions were examined for the surface texture with the aid of a binocular microscope and evaluated. Impressions were then poured in stone, labelled and kept as permanent records for evaluation.

Before the termination of the clinical aspect of the study, it was found that the two types of zinc oxide-eugenol demonstrated different rates of disintegration. To clarify the reason for this difference, it was decided to place the two materials in five pairs of buccal pit cavities where the forces of mastication are negligible. Each pair was prepared in adjacent molars, filled with the two different zinc oxide materials and finished flush with the surface. All of the standardized procedures were followed both in manipulation and in method of observation.
Evaluations regarding the general disintegration, gross fracture and marginal breakdown were made on the stone casts by three evaluators. A grading system of four scores was developed based on the amount of loss of the material. The mean grading of the three evaluators was obtained. The grading was critical to the extent that a loss of surface material exceeding one half millimeter was considered as a failure or a disintegrated restoration. Gross fractures were also recorded as failures.

Results have shown that zinc phosphate cement (Tenacin) was the material that disintegrated the least. Class I and Class II (Tenacin) restorations demonstrated essentially the same rate of disintegration. Silico-phosphate cement (Kryptex) ranked second to zinc phosphate cement (Tenacin) in the resistance to general disintegration. Class I (Kryptex) restorations disintegrated the least. However, the high percentage of gross fractures in Class II (Kryptex) restorations obviously raised the score of failure. The high number of fractures of silico-phosphate can be attributed possibly to the procedures dictated by the standardized requirements in carving. Disturbing the gel formation by carving and finishing during the initial setting process probably weakened the structure of the matrix. This possibility was substantiated by the pitted surface texture in Kryptex restorations. Zinc oxide-eugenol (Temrex) ranked third in resistance to general disintegration. Class I and Class II restorations followed the same pattern of disintegration. Zinc oxide-rosin eugenol (Caulk's) showed the
least resistance to disintegration. A smooth surface texture apparently adds to the resistance to general disintegration of the material. There is no correlation between the present laboratory solubility tests and the general disintegration of these materials in the mouth.

Compressive strength shows some relationship to the general disintegration. Abrasion resistance tests showed the superiority of zinc phosphate cement (Tenacin) and silico-phosphate cement (Kryptex) over the zinc oxide-eugenol (Temrex) and the zinc oxide-rosin eugenol (Caulk).

The physical properties of temporary filling materials to be considered in future investigations are: solubility, compressive strength, tensile strength, brittleness, surface texture, and abrasion resistance.


CURRICULUM VITAE
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The purpose of this study was to evaluate clinically, the general disintegration, gross fracture, marginal breakdown, and surface defects in Class I and Class II restorations of four groups: (1) Dilettante, (2) AffinACT, (3) AffinACT with no grouting, and (4) AffinACT with a proximal-grouting technique. The results indicated that the restorative procedures for each of the four restorative materials were satisfactory. Compressive strength, flexibility and expansion random samples were tested in the laboratory on the three standardized models used in the clinical tests. A total of 207 standardized projects were processed in a number of permanent blank or 17 controls on models with the four models in addition to random the distribution between the four groups. Subjective impressions were taken in presentable form to the evaluation to the study. The results of the various methods confirmed the observers' reports. The AffinACT group (smooth) exhibited the least resistance to disintegration and the greatest surface disintegration with the AffinACT-grouted (smooth) performed considerably more than the smooth surface. The smooth group showed the greatest resistance to disintegration. AffinACT-grouted exhibited the least breaking in the study. The AffinACT-grouted restorations had almost equal failure in Class II cavitations due to breakdown. The AffinACT-grouted group surface than the AffinACT-grouted group. There is no correlation between marginal adaptation and clinical disintegration. Compressive strength seems to be only in the general hardness of the materials.

ABSTRACT
The purpose of this study was to evaluate clinically, the general disintegration, gross fracture, marginal breakdown, and surface texture in Class I and Class II restorations of four temporary filling materials having widely varying physical properties. They were zinc oxide-eugenol (Temrex), zinc oxide-rosin eugenol (Caulk's), zinc phosphate cement (Tenacin), and silico-phosphate cement (Kryptex). Powder-liquid ratios and all manipulative procedures for each of the four materials were standardized. Compressive strength, solubility and abrasion resistance tests were carried out in the laboratory on the same standardized mixes used in the clinical part. A total of 137 standardized cavities were prepared in deciduous and permanent teeth of 37 children and restored with the four materials in an effort to equalize the distribution between the four quadrants. Rubber base impressions were taken as permanent records for evaluation at the one week, one month and three months' observation visits. Zinc oxide-rosin eugenol (Caulk) exhibited the least resistance to disintegration and the roughest surface while the zinc oxide eugenol (Temrex) exhibited considerably more resistance and the smoothest surface. Zinc phosphate showed the greatest resistance to disintegration. Silico-phosphate cement exhibited the same behavior in Class I restorations but showed higher failure in Class II restorations due to fractures. Zinc phosphate exhibited smoother surface than the silico-phosphate cement. There was no correlation between in-vitro solubility and clinical disintegration. Compressive strength seemed to be related to the general durability of the materials.