

ENDODONTICS

The American Association of Endodontists

Captain Warren J. Hedman, Editor

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THE EFFECT OF TEMPERATURE CHANGE ON THE SEALING
PROPERTIES OF TEMPORARY FILLING MATERIALS

Part I

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ONE of the prime considerations in the selection of a temporary filling material is the material's ability to seal the margins of the cavity within which it is placed. Temporary filling materials are used in many phases of dentistry. During restorative dental procedures, temporary filling materials are used to protect the prepared tooth surface until the final restoration is placed. During endodontic procedures, temporary filling materials are used to seal the access opening in the crown between treatments so as to prevent fluid exchange between the root canal and the mouth.

The authors of current endodontic textbooks all agree on the importance of sealing the access opening between treatments, but they do not agree on the material to be used.

Grossman,¹ in discussing the selection of a temporary filling material, states that zinc oxide-eugenol cements are probably the best and that gutta-percha preparations, intermediate, and zinc phosphate cements are the worst. He recommends the use of zinc phosphate cement placed over gutta-percha to seal posterior teeth. For anterior teeth, he recommends zinc oxide-eugenol cement over gutta-percha.

Presented at the annual meeting of the American Association of Endodontists, Chicago, Illinois, Feb. 6, 1960.

This research report is the first phase of a broad study to determine the relative efficiency of sealing agents utilized in dentistry.

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Sommer, Ostrander, and Crowley² state that the pulp-chamber opening should be sealed by applying a softened layer of gutta-percha over the dressing, with a space of 1.5 mm. allowed for the final cement seal. The operator is cautioned that "gutta-percha is not a leakproof seal. Therefore, if any should adhere to the side of the pulp chamber it would afford avenues of leakage and result in contaminated cultures." The pulp chamber opening is then dried with alcohol, and the orifice is sealed with a creamy mix of "permanent cement."

Stewart³ mentions that a double seal is generally employed to prevent medication from escaping from the tooth; the inner seal generally consists of gutta-percha, and an outer seal of "some cement substance is then placed."

Coolidge and Kesel⁴ merely state: "The tooth is sealed up with cement until a subsequent appointment."

It is obvious from the foregoing that a controlled study was indicated to determine which material would most effectively seal the coronal access opening between endodontic treatments so as to prevent fluid exchange between the root canal and the mouth.

PREVIOUS STUDIES

Room Temperature.—In 1939, Grossman⁵ investigated the sealing properties of temporary filling materials. As a testing procedure, he used glass capillary tubes, the inner surface of which had been roughened with a coarse carborundum stone. Each tube was filled at one end with the test filling material to a depth of 2 or 3 mm. The portion of the tube above the test filling material was packed with a cotton wick. Tubes so prepared were suspended over an aqueous solution of dye, the filled end was submerged, and the unfilled open end extended above the level of the dye. Discoloration of the cotton wick by the dye solution indicated leakage of the test filling material. Grossman found the sealing properties of the zinc phosphate cements the worst, the gutta-percha fillings intermediate, and the zinc oxide-eugenol cements the best.

He states: "Zinc oxide-eugenol cements were found to be leakproof, without exception, in all cases."

Fischer⁶ made a careful study of the sealing properties of zinc phosphate cement and other, permanent, filling materials. He found that under the conditions of testing used in his study, every filling material tested showed some degree of fluid penetration at the margin.

Massler and Ostrovsky,⁷ and Weiss⁸ tested the relative sealing properties of a number of commonly used filling materials. The results of these two studies confirmed the reports of previous investigators, that is, that the commonly used filling materials exhibit marginal leakage in a relatively short period of time and that, at room temperature, zinc oxide-eugenol cement and amalgam are the most effective sealing agents.

Temperature Change.—In 1952, Nelson, Wolcott, and Paffenbarger⁹ demonstrated the effect of temperature change on the marginal seal of various, filling materials. They determined that a temperature change of 43° C. was produced

under an acrylic restoration when test subjects drank beverages adjusted to the upper and lower limits of thermal tolerance of the mouth (60°C . and 4°C ., respectively). Taking into consideration this temperature change and the difference in the coefficients of thermal expansion of the resin filling and tooth structure, they computed that a crevice 10 microns in diameter could develop at the junction of the filling and the tooth surface during the cooling cycle. Although this crevice is below the limit of visual acuity, which is 50 microns, it is five to twenty times as large as the size of bacteria commonly found in the mouth (for example, *lactobacillus*, 2 microns; *streptococcus*, 0.5 microns).

In 1955 Seltzer¹⁰ tested the penetration of color-producing microorganisms through the margins of acrylic and amalgam restorations, both at constant body temperature and after various temperature changes. In no instance did the organisms penetrate the margins of the restorations maintained at constant body temperature. Penetration of microorganisms did take place, however, in teeth that had undergone temperature change.

In 1958 Hirsch and Weinreb¹¹ investigated the cavity-sealing properties of silicate cements, acrylic filling materials, and amalgam under conditions simulating those found in the mouth. They reported that although acrylic restorations exhibit a very satisfactory initial cavity seal, after repeated temperature changes a solution of a dye was able to penetrate between the tooth and the acrylic filling material. This penetration was attributed to the difference in thermal expansion between the tooth and the acrylic restoration. The marginal adaptation of silicate cements was unsatisfactory before and after repeated temperature change. Of the materials tested, only amalgam maintained its good marginal seal after repeated temperature change.

It was apparent, after a review of the literature, that the sealing properties of temporary filling materials had not been evaluated under conditions similar to those encountered in the mouth. The following experiments were therefore performed, our objective being to test the sealing properties of temporary filling materials by means of test procedures that produced as closely as possible conditions similar to those found in the mouth.

TEST PROCEDURE

Tooth Preparation.—One hundred seventeen recently extracted noncarious, nonrestored, sound anterior teeth were used in this study. During the time between extraction and the laboratory procedures, an interval which was kept minimal, the teeth were stored in normal saline solution to prevent desiccation.

Approximately 2 mm. of the root end of each tooth was removed with a carborundum disc. A Class 1 type of cavity was prepared in the center of the cut root end and filled with amalgam. This was done to eliminate the possibility of dye penetration through the root apex area (Fig. 1).

On the lingual surface, halfway between the incisal edge and the cingulum, a funnel-shaped access cavity was prepared, exposing the pulp chamber. This cavity was of a size and shape that would permit convenient endodontic manipulation. The material in the pulp chamber was removed with a No. 6

round bur. No attempt was made to remove material in the root canal, since it was felt that any such material would be an added barrier to seepage from the root apex area.

Cotton fibers were packed into the clean, dry pulp chamber to a level approximately 2 mm. below the lingual surface of the funnel-shaped access cavity. The filling material to be tested was placed over the cotton fibers until the access cavity was filled. All materials used were burnished tightly against the margins of the cavity to ensure as perfect a marginal adaptation as possible.

MATERIALS

Nine filling materials were included in this study—eight commonly used temporary filling materials and amalgam, which was included as a control. Tested were gutta-percha (both temporary stopping and base plate), two brands of zinc phosphate temporary cement, two brands of zinc phosphate permanent cement, zinc oxide-eugenol cement, Cavit (a zinc oxide, polyvinyl preparation), and amalgam.

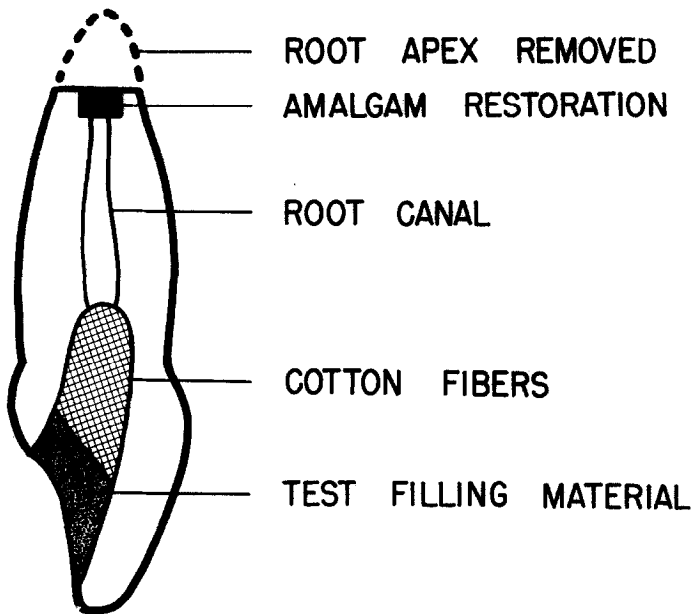


Fig. 1.—Diagrammatic cross section of test tooth.

The cavity-sealing properties of all test materials were evaluated both at room temperature and after being subjected to repeated temperature change.

Manipulation of Materials.—Gutta-percha materials were warmed gently and placed within the access cavity while soft. As it cooled, the gutta-percha was burnished against the cavity walls with a ball burnisher. The zinc phosphate temporary cements and the zinc phosphate permanent cements were mixed on a glass slab in the proportions recommended by each manufacturer until the consistency was that of heavy cream. The cement was then placed within the access cavity, and as the cement hardened it was burnished against

the cavity margins. The zinc oxide-eugenol cement was mixed to a puttylike consistency immediately before use. The excess eugenol was expressed by squeezing the mass between the folds of an amalgam squeeze-cloth. The zinc oxide-eugenol mixture was then placed within the cavity. The excess was removed by wiping the lingual surface of the tooth with a cotton pellet dampened with water. The material was at the same time burnished against the cavity margins with the dampened cotton pellet. The Cavit was squeezed from its tube and placed within the access cavity. It was manipulated in a manner similar to that used with the zinc oxide-eugenol cement. The amalgam restorations were placed by accepted operative techniques.

After the test filling was placed within the access cavity, the tooth was returned to the normal saline solution. The prepared and filled teeth were stored in saline solution at room temperature for twenty-four hours before testing, to permit the restorations to "mature."

ROOM TEMPERATURE STUDY

Twenty-seven teeth were included in this phase of the study. After storage in normal saline solution at room temperature for twenty-four hours, three teeth filled with each of the nine test filling materials were placed in a 2 per cent aqueous solution of aniline blue dye. The teeth remained in the dye solution at room temperature for seventy-two hours. They were then removed from the solution, washed, and scrubbed with a brush to remove all traces of dye from the surface. The teeth were sectioned longitudinally to expose the cotton fibers in the pulp chamber under the test filling material. A blue discoloration of the cotton fibers indicated an imperfectly sealed access cavity. If the color of the cotton fibers remained unchanged, it indicated that a leak-proof seal had been maintained.

TEMPERATURE-CHANGE STUDY

Ninety teeth were included in this phase of the study. After storage in normal saline solution at room temperature for twenty-four hours, ten teeth filled with each of the nine test filling materials were placed in water at 60° C. for one minute and then transferred to a 2 per cent aqueous solution of aniline blue dye at 4° C. for one minute. This was then repeated nine times, making a total of ten temperature cycles. The teeth were removed from the solution, washed, scrubbed with a brush to remove all traces of the dye from the surface, and sectioned longitudinally as above.

RESULTS

Room Temperature Study.—After immersion in the dye solution at room temperature for seventy-two hours, all teeth filled with the following materials showed definite leakage of dye into the pulp chamber: temporary stopping gutta-percha, base plate gutta-percha, both brands of zinc phosphate temporary cement, and both brands of zinc phosphate permanent cement. Dye penetration was along the junction of the filling material and tooth structure.

None of the teeth filled with zinc oxide-eugenol cement, Cavit, or amalgam showed leakage of dye into the pulp chamber.

Temperature Change.—In teeth subjected to ten cycles of temperature change from 60° C. to 4° C., the following results were obtained: All teeth filled with the following materials evidenced definite leakage of dye into the pulp chamber: temporary stopping gutta-percha, base plate gutta-percha, both brands of zinc phosphate temporary cement, and both brands of zinc phosphate permanent cement. Five out of ten teeth filled with zinc oxide-eugenol cement showed leakage. Cavit did not allow dye penetration in any of the ten teeth filled with this material. Amalgam was equally effective in its ability to maintain a leakproof seal (Fig. 2).

FILLING MATERIAL		ROOM TEMPERATURE— 72 HRS.		TEMPERATURE CHANGE 60° C.—4° C. (10 CYCLES)	
		NO. OF TEETH	LEAKAGE	NO. OF TEETH	LEAKAGE
Gutta-percha temporary stopping	(Caulk)	3	3	10	10
Gutta-percha base plate	(Caulk)	3	3	10	10
Zinc phosphate temporary cement	(Moyer)	3	3	10	10
Zinc phosphate temporary cement	“Pro-tem” (Caulk)	3	3	10	10
Zinc phosphate permanent cement	(Flecks)	3	3	10	10
Zinc phosphate permanent cement	(Ames)	3	3	10	10
Zinc oxide-eugenol	(U. S. P.)	3	0	10	5
Cavit	(Premier)	3	0	10	0
Amalgam	(S. S. White)	3	0	10	0

Fig. 2.—Results of room temperature and temperature-change study.

DISCUSSION

The conditions under which this study was conducted may appear more exacting than necessary, since the materials were to be evaluated under conditions reproducing as closely as possible conditions of clinical usage. Nevertheless, we decided to use a dilute aqueous solution of dye rather than a saliva-dye suspension, since the oral environment is often aqueous in nature. This is especially true during the ingestion of beverages (which are often at the extremes of the mouth's thermal tolerance) and during oral hygiene procedures (which often involve compounds, one of whose ingredients may be a surface-tension-reducing agent). The use of such preparations would markedly alter the normally viscous nature of fluids in contact with tooth surfaces.

Cavities prepared in recently extracted teeth were used, rather than cavities prepared in laboratory apparatus. It was felt that this would more nearly parallel conditions of clinical usage.

Teeth filled with the test materials were immersed in the dye solution during the cooling phase. Souder and Paffenbarger¹² and Nelson and co-workers⁹ showed that the space at the junction of the tooth wall and the filling material is widest during the cooling cycle.

Three teeth filled with each of the test filling materials were included in the study under conditions of room temperature, since this phase of the investigation was conducted to explore work reported by previous investigators.⁵⁻⁸

The results obtained in the temperature-change phase of the study were not unexpected, for the most part. It was not surprising to find that materials which permitted dye penetration at room temperature also sealed cavities poorly when subjected to ten cycles of temperature change. It was surprising, however, to find that the zinc oxide-eugenol cement, which up to the present had been considered the most effective cavity-sealing agent (on the basis of previous studies conducted at room temperature), did not seal cavities as well as might be expected. Zinc oxide-eugenol cement sealed only five of the ten test cavities in which it was used when teeth so filled were subjected to ten cycles of temperature change. The only temporary filling material which effectively sealed all experimental cavities, under conditions of this study, was Cavit. Amalgam, a permanent filling material, was equally effective.

SUMMARY

The cavity-sealing properties of nine filling materials (eight temporary filling materials and amalgam) were tested at room temperature and also after ten cycles of temperature change from 60° C. to 4° C. The ability of a 2 per cent aqueous solution of aniline blue dye to penetrate the margins of cavities filled with each of the test filling materials was used as a means of comparing their cavity-sealing properties. The inability of the test filling material to maintain a leakproof seal of the cavity margins was evidenced by a blue discoloration of cotton fibers placed beneath the test filling.

Under the conditions of testing at room temperature, the following materials showed consistent leakage: temporary stopping gutta-percha, base plate gutta-percha, two brands of zinc phosphate temporary cement, and two brands of zinc phosphate permanent cement. The materials that showed no leakage at room temperature were zinc oxide-eugenol cement, Cavit, and amalgam.

Of the teeth similarly filled with each of the nine test filling materials and subjected to ten cycles of temperature change, those which showed leakage to the dye solution at room temperature also showed leakage when subjected to temperature changes. Although zinc oxide-eugenol cement did not show leakage at room temperature, it did show leakage in five out of ten teeth subjected to temperature changes.

Of the temporary filling materials tested, only Cavit maintained a leak-proof cavity seal both at room temperature and after repeated temperature changes.

REFERENCES

1. Grossman, L. I.: *Root Canal Therapy*, ed. 5, Philadelphia, 1960, Lea & Febiger.
2. Sommer, E. D., Ostrander, F. D., and Crowley, M. C.: *Clinical Endodontics*, Philadelphia and London, 1956, W. B. Saunders Company.
3. Stewart, G. G.: *D. Clin. North America*, pp. 823-834, November, 1957.
4. Coolidge, E. D., and Kesel, R. G.: *Endodontology*, Philadelphia, 1956, Lea & Febiger.

5. Grossman, L. I.: Study of Temporary Fillings as Hermetic Sealing Agents, *J. D. Res.* **18**: 67-71, 1939.
6. Fischer, M.: Experimental Investigations on the Tightness of Fit of Filling Materials Commonly Used in Dentistry, *Schweiz. Monatschr. Zahn.* **59**: 595, 1949.
7. Massler, M., and Ostrovsky, A.: Sealing Qualities of Various Filling Materials, *J. Dent. Children* **21**: 228-234, 1954.
8. Weiss, M. B.: Improved Zinc Oxide-Eugenol Cement, *Illinois Dent. J.* **24**: 261-271, 1958.
9. Nelson, R. J., Wolcott, R. B., and Paffenbarger, G. C.: Fluid Exchange at the Margins of Dental Restorations, *J. Am. Dent. A.* **44**: 288-295, 1952.
10. Seltzer, S. S.: Penetration of Microorganisms Between the Tooth and Direct Resin Fillings, *J. Am. Dent. A.* **51**: 560-566, 1955.
11. Hirsch, L., and Weinreb, M. M.: Marginal Fit of Direct Acrylic Restorations, *J. Am. Dent. A.* **56**: 13-21, 1958.
12. Souder, W., and Paffenbarger, G. C.: Physical Properties of Dental Materials, Circular of the National Bureau of Standards, C 433, Washington, 1942, U. S. Government Printing Office.

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