Journal of the Dental Association of South Africa **33**, 339 - 344

The leakage of materials used as endodontic dressing seals*

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Keywords: Dental materials; endodontics; leakage

SUMMARY

One hundred extracted human canine teeth were cleaned, lingual access cavities were cut, the root canals were cleaned, paper points were placed in the root canals and temporary filling materials were placed in the access cavities. The teeth were sealed short of the restoration margins and immersed in a dye solution for 144 hours. Subsequently the crowns were examined microscopically for dye penetration and the paper points were examined for staining. All materials tested leaked.

OPSOMMING

Eenhonderd verwyderde oogtande is skoongemaak en daarna is toegang tot die wortelkanale d.m.v. linguale toegangskawiteite verkry. Papierpunte is in die wortelkanale geplaas en die toegangsopeninge met tydelike herstellingsmateriale verseël. Die tande is tot naby die herstellingsrande verseël en vir 144 uur in 'n kleurstofoplossing gedompel. Die tandkrone is daarna mikroskopies ondersoek vir penetrasie van kleurstof en die papierpunte is vir verkleuring ondersoek. Al die materiale wat getoets is het gelek.

INTRODUCTION

The leakage of endodontic dressing seals is important for two reasons. Bacteria and irritant substances may leak into the pulp cavity, and beyond, from the mouth. Equally, toxic drugs such as arsenical preparations may escape from the pulp cavity.

Much has been written about the leakage of dental restorations and a variety of methods have been used to study the phenomenon. Seven techniques which have been applied are mentioned by Going (1972), namely, radioactive isotope penetration, dye penetration, bacterial penetration, air pressure, marginal percolation, scanning electron microscopy and neutron activation analysis, and it is suggested that future investigations might employ electron microprobe analysis and ion beam milling.

The bulk of published observations on leakage relate to materials which it is hoped will be durable. Nevertheless, the leakage of temporary materials used as endodontic dressing seals has received the attention of a number of observers. Grossman (1939) tested the leakage of 10 materials by a dye penetration method, using glass tubes to contain the materials. The period of exposure to the dyes was not stated, nor were the details of bacterial penetration tests reported. The conclusion reached was that zinc oxide/eugenol(ZOE) cements do not leak. Parris and Kapsimalis (1960) used a dye penetration method to test the leakage of 9 materials. Room temperature and thermal cycled tests were used and the period of exposure to the dye was 72 hours. Cavit and ZOE were most effective in preventing leakage. Messing (1961) used dye penetration to study the leakage of a polystyrene-fortified ZOE cement, another ZOE cement and a zinc phosphate cement. Neither of the ZOE materials leaked, but the period of exposure to dye was only 24 hours. Swartz and Phillips (1962) employed radioactive isotope penetration to compare the leakage of ZOE and gutta-percha. ZOE did not leak but gutta-percha did with a 24 hour exposure to isotope solution. Longer exposure resulted in leakage of ZOE. Parris *et al* (1964) examined the leakage of 12 temporary filling materials by dye penetration, following an immersion period of 72 hours. Four of the materials did not leak, but when the materials had been subjected to thermal cycling only CAVIT and KWIKSEAL permitted no leakage. The

* Based on papers read at meetings of the South African Division of the International Association for Dental Research, Durban 1976 and Stellenbosch 1977.

sealing efficacy of the materials was also investigated by a bacterial penetration method, and it was found that 4 of the temporary filling materials did not leak, including CAVIT and KWIKSEAL. Marosky, Patterson and Swartz (1977), in another radioactive isotope penetration study, examined 6 temporary sealing materials, using exposure periods of 3 days and 10 days, with and without thermal cycling. All the materials leaked under all conditions.

MATERIALS AND METHODS

The materials selected for testing were 5 zinc polycarboxylate cements, 3 ZOE preparations and one zinc oxide/polyvinyl material. The materials are identified in Table I. DURELON is supplied with the liquid in a graduated syringe, POLY-F is a fluoridated cement, OXICAP is capsulated, BONDAL comes as bottled powder and liquid and BONDALCAP-C is presented in a syringe-capsule. NOBETEC has fibres incorporated in the zinc oxide powder and Canada balsam and balsam of Peru in the liquid, EUGENOL CEMENT is an accelerated ZOE preparation and PROPAC is a two-paste system packed in collapsible tubes. CAVIT is stated to contain zinc oxide, calcium sulphate, zinc sulphate, glycol acetate, polyvinyl acetate, polyvinyl chloride – acetate, and triethanolamine (Widerman, Eames and Serene, 1971; and Marosky, *et al*, 1977). It is presented as a single paste in a collapsible tube and may be had in white or red. NOBETEC may also be had with red colouring in the liquid. The materials used in this study were without red colouring.

One hundred extracted non-carious adult, human, canine teeth were stored under refrigeration until required and then cleaned with hand scalers and pumice. Access cavities were cut in the lingual surfaces of the teeth using a diamond point in an air turbine handpiece to gain access and extended and undercut with a large round steel bur at slow speed, and the root canals were cleaned and enlarged with sodium hypochlorite solution and hand files to file size 60. The teeth were dried with compressed air and a size 30 paper point was inserted in the root canal of each tooth.

Each test material (except material 9) was mixed in accordance with the manufacturer's instructions and placed in the access cavities of 10 of the prepared teeth. Materials 1, 2 and 4 were mixed to a luting consistency, for better wetting. Material 9 requires no mixing. Materials 1, 2, 3 and 4 were difficult to insert deeply into the access cavities, due to the presence of air trapped by the cements. These materials also showed a tendency to pull away from cavity margins during the removal of excess cement. Because of the aforementioned difficulty experienced in inserting the zinc polycarboxylate cements deeply into the access cavities, material 5 was included in this study. One of the authors (S.K.) routinely uses JIFFY [1] tubes to insert material 1 in access cavities in clinical endodontic practice. Hence 10 teeth were tested with material 1, using JIFFY tubes for cement application. The cement inserted with JIFFY tubes and material 5 were both trimmed in the same manner as the other zinc polycarboxylate specimens. Little difficulty was experienced with the insertion of materials 6, 7, 8 and 9, which were tamped down in the access cavities with cotton wool saturated with water. Small amounts of excess material were removed with excavators from the lingual enamel of all 100 teeth when the cements had set. The roots of the teeth were examined closely and in all cases where the apical foramina were large enough to permit application of a seal the foramina were sealed with SEVRITON [2] direct filling resin. The surfaces of the teeth were then painted with two coats of celluloid (nail) varnish, the cement surfaces and cavity margins being left uncovered. The teeth were then immersed in a solution of BLAK-RAY [3] red fluorescent water dye (strength – one tablet in 25 *ml* deionized water) for 144 hours at 37 °C. This dye was used by Holliger (1967) and is readily detected by ultraviolet fluorescence. The bottles containing the specimens were numbered for identification of the materials used after examinations were completed.

Subsequently the varnish was removed from the crowns of the teeth with excavators and the crowns were separated from the roots using a diamond disc 910/54, size ISO 220 [4]. The paper points were removed from the root canals and examined and graded according to the amount of staining. The grading was done by the following criteria:

00 No fluorescence in ultraviolet.
0 No staining in white light.
1 Slight staining in white light.
2 Moderate staining in white light.
3 Heavy staining in white light.

When a paper point was graded 0, it was examined microscopically by ultraviolet radiation. In such cases the paper point was examined alongside an unused paper point. This control was considered necessary because some paper points, under certain circumstances, exhibit autofluorescence in ultraviolet radiation (Fig. 1). The crowns were embedded in a clear resin and then sectioned longitudinally in a labio-lingual plane, using a diamond wheel on an ISOMET 11-1180 [5] low speed saw. The sections were mounted in a glycerine medium, the cover slips being sealed at the edges with model cement ("sticky wax"). The sections were examined microscopically by ultraviolet light. All microscopic examinations were made using a UNIVAR [6] microscope. The amount of leakage seen microscopically was graded by the following criteria:

1. No leakage;
2. Leakage not beyond the amelo-dentinal junction;
3. Leakage into the pulp chamber.

1. Lee Smith Co., Chicago, U.S.A.
2. Amalgamated Dental, London, England.
3. U.V. Products Inc., San Gabriel, U.S.A.
4. Hager & Meisinger Gmbh. Düsseldorf, West Germany.
5. Buehler, Evanston, U.S.A.
6. C. Reichert A G, Vienna, Austria.

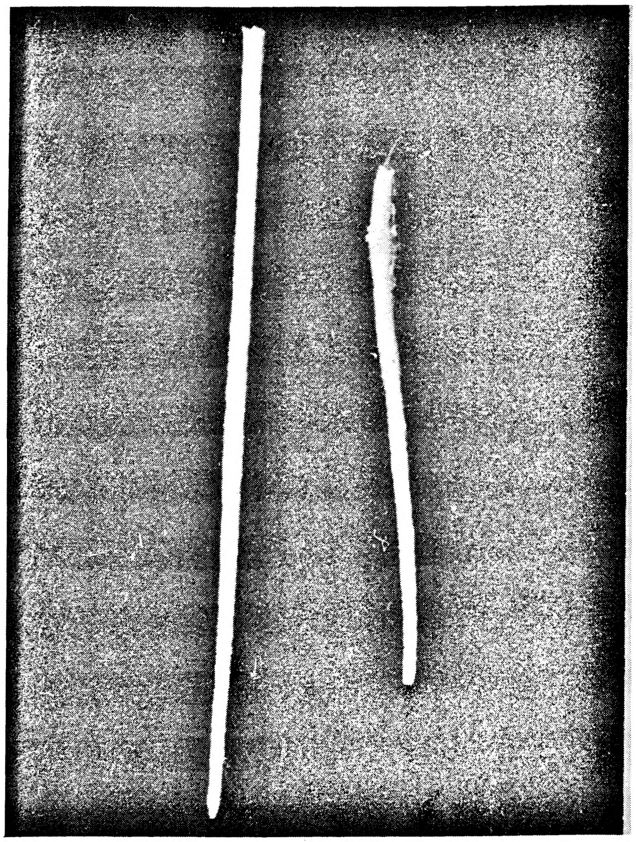

Fig. 1. Control point (left) and stained point (NOBETEC) (right) photographed in white light. Although the apical end of the stained point appeared unstained in white light it fluoresced vividly in ultraviolet.

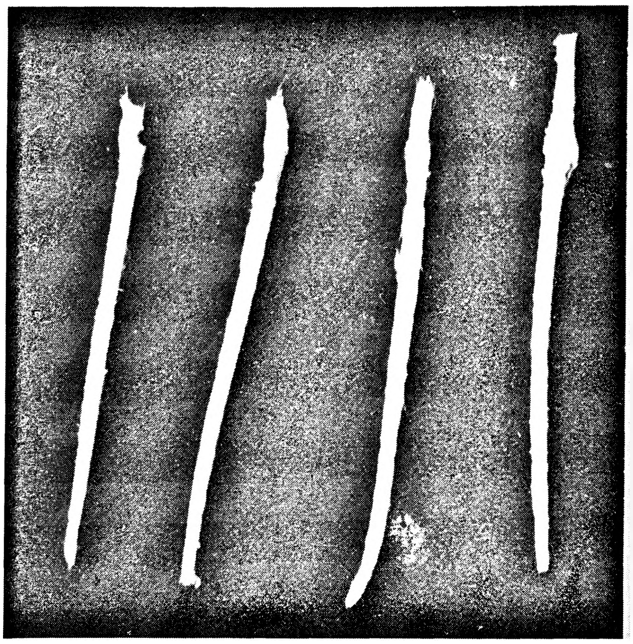

Fig. 2. Lightly stained points (CAVIT).

RESULTS

The amount of staining of the paper points is shown in Table II. The amount of leakage seen in the sections is shown in Table III. It will be seen that all the materials permitted some leakage, whether judged by the appearance of the paper points, or by the microscopic appearance. The most leakage occurred with ZOE materials, whilst the zinc polycarboxylate cements and CAVIT permitted little heavy staining of paper points.

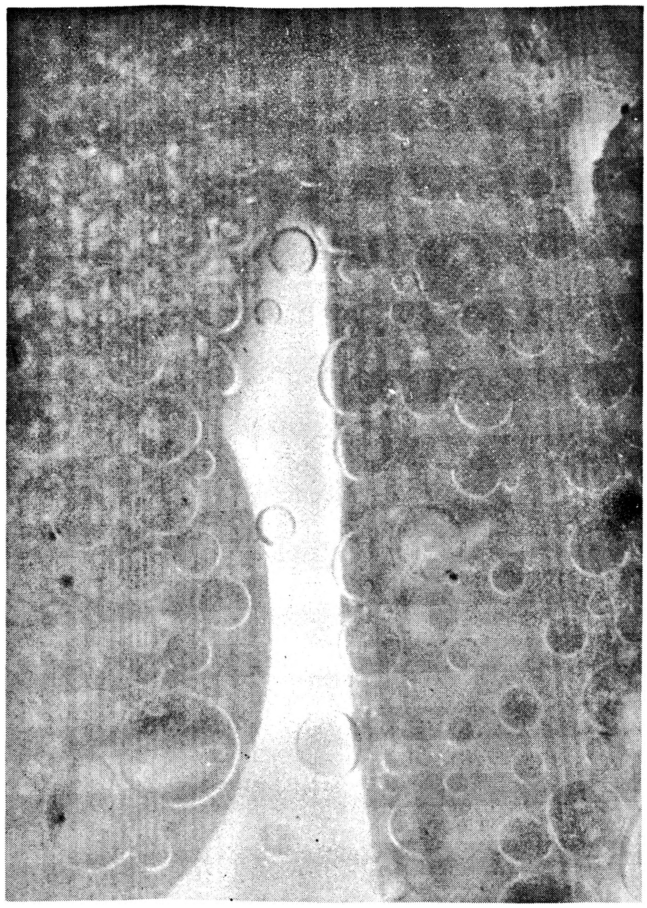

Fig. 3. Air bubbles in mountant (CAVIT). (Space due to entrapped air).

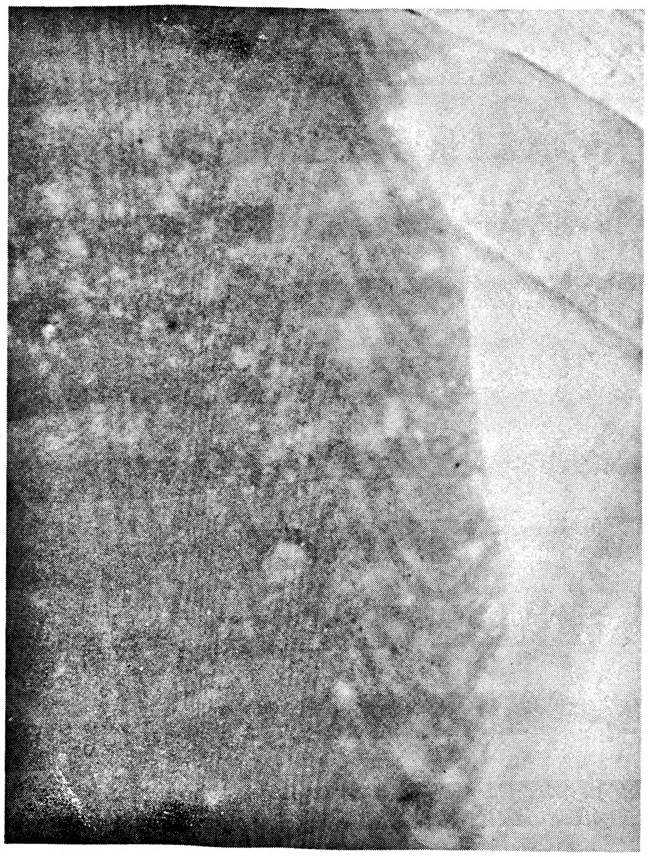

Fig. 4. Porosity in CAVIT. (Top right - enamel; bottom right - dentine).

DISCUSSION

Grossman (1939), Parris and Kapsimalis (1960), and Messing (1961), all found that ZOE cements did not leak, or leaked less than other materials tested. The studies by Swartz and Phillips (1962) and by Marosky *et al* (1977) showed that leakage of radio-isotope increases with the period of exposure. The dye penetration studies previously reported have involved periods of exposure considerably less than the 144 hours used in the present investigation.

Material 9 (CAVIT), has previously been reported effective in preventing leakage (Parris and Kapsimalis, 1960). In the present study, leakage was observed in all the sections of teeth filled with CAVIT although only one paper point showed heavy staining. The slightly stained points (Fig. 2) were not merely very lightly stained, but the stain did not extend very far towards the apical ends of the points. It appears that the leakage associated with CAVIT is due to the porous nature of the material. In examining sections of teeth filled with CAVIT it was apparent that air displaced from the pores in the material had formed bubbles in the glycerine mounting medium (Fig. 3). Remounting of the saturated sections eliminated the bubbles, and the porous nature of the material could be clearly seen (Fig. 4). The porosity of CAVIT is associated with very high water sorption and dye penetration, as reported by Widerman *et al* (1971).

Taken as a group the zinc polycarboxylate materials were less successful in leakage prevention than had been expected. Smith (1971) attributed the adhesion between zinc polycarboxylate cements and enamel to their ability to chelate with metal (calcium) ions and later (Smith and Cartz, 1973) suggested that sulphate in polyacrylic acid may also contribute to that adhesion. The adhesion of zinc polycarboxylate cement to both enamel and dentine was demonstrated by Phillips, Swartz and Rhodes (1970), the tensile bond to dentine being weaker than that to enamel. The attachment to dentine appears to be at least partly mechanical, due to the tubular structure of dentine (Valcke, 1973). Despite the ability to attach to enamel and dentine, only materials 4 and 5 prevented leakage into the pulp chamber in a few cases. Material 4 did not permit severe leakage, although it was difficult to insert it in the access cavities. In one specimen of material 4 the layer of cement was only 0,4 mm thick (Fig. 5). Forcible injection of zinc polycarboxylate cements (material 1 with JIFFY tubes and material 5) did not eliminate leakage, although the cements flowed into the root canals (Figs. 6 and 7). A ZOE material (material 8) also flowed into root canals (Fig. 8). This is undesirable in clinical practice since it renders recovery of points unnecessarily difficult.

In the preparation of the teeth used in this study no special care was taken in finishing the enamel margins of the access cavities. It has been observed that marginal leakage of a filling material may be associated with poor preparation of cavity margins (Valcke, 1971). Possibly some reduction in the leakage of the endodontic dressing seals studied would result from careful finishing of the enamel margins.

In considering the possible clinical significance of the results of this study it is necessary to bear in mind the difference in size between microbes and molecules. Dye penetration does not necessarily imply the likelihood of bacterial penetration. On the other hand, the probability of leakage of materials placed in pulp cavities or access cavities seems fairly high, especially with small molecules such as As_2O_3. This underlines the wisdom of, firstly, avoiding the use of such substances as far as possible and, secondly, leaving them in the tooth for the shortest possible period.

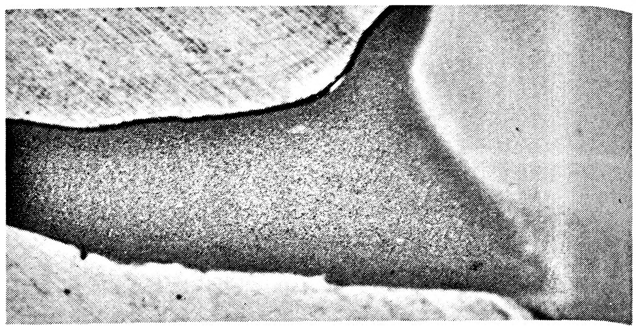

Fig. 5. BONDAL, 0,4 mm thick at left. (Top – embedding resin in air space; bottom right – enamel; top right – dentine; bottom centre – cement surface).

Fig. 6. Leakage (BONDALCAP). Fluorescence at edges of cement – some porosity. (Top – surface).

ACKNOWLEDGEMENTS

The authors wish to thank Dr. J.C. Austin and Mrs. H. Wilton-Cox for technical assistance; Mrs. M.L. Jansens for photographic work; Miss J.A. Lovatt for typing; and the manufacturers and distributors who provided the materials examined.

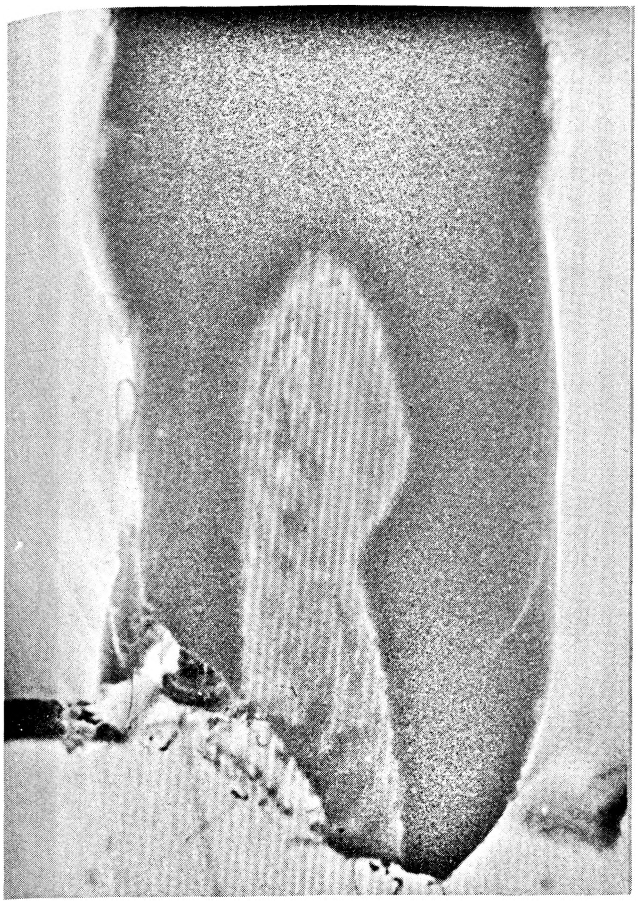

Fig. 7. DURELON (placed with JIFFY tube) in root canal. Leakage (streak of fluorescence at right). Space left by removal of paper point – "whiskers" of paper retained.

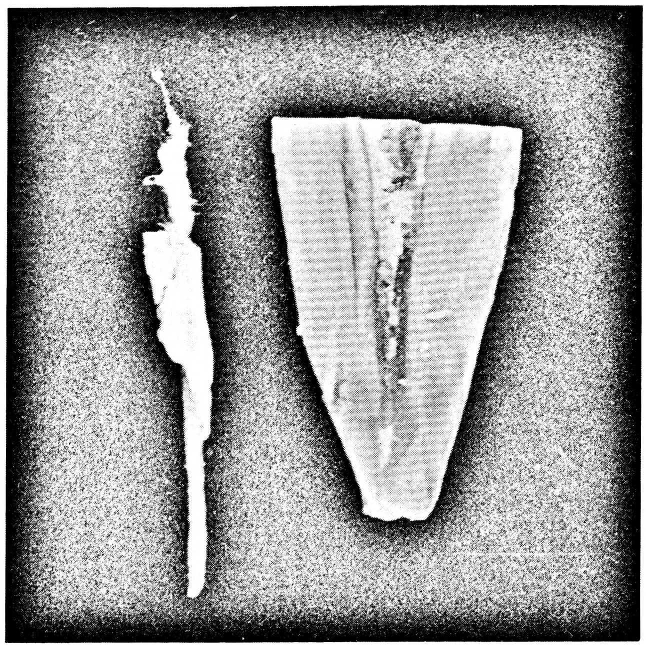

Fig. 8. PROPAC in root canal; heavily stained paper point with adherent cement at left.

Table I.

No.	Material Name.	Type.	Manufacturer	Batch
1	DURELON	Polycarboxylate	ESPE Gmbh, Seefeld/Oberbay, W. Germany.	PAO 98B
2	POLY-F	Polycarboxylate	Amalgamated Dental, London, England.	SF7 SF (powder) SH3 TA(liquid)
3	OXICAP	Polycarboxylate	VIVADENT, Schaan, Liechtenstein.	100670
4	BONDAL	Polycarboxylate	VIVADENT, Schaan, Liechtenstein.	0611071
5	BONDALCAP-C	Polycarboxylate	VIVADENT, Schaan, Liechtenstein.	251171
6	NOBETEC	ZOE	Bofors, Nobel-Pharma, Sweden.	Z1403(powder) U1450(liquid)
7	EUGENOL CEMENT	ZOE	G-C Dental Industrial Corporation, Tokyo, Japan	JS 30(powder) NZ 13(liquid)
8	PROPAC	ZOE	G-C Dental Industrial Corporation, Tokyo, Japan	KX 17
9	CAVIT	Zn0/polyvinyl	ESPE Gmbh, Seefeld/Oberbay, W. Germany.	75091

Table II.

Material	Number of paper points showing amount of staining				
No	00	0	1	2	3
1	0	0	0	8	2
1 + tube	0	0	3	1	6
2	0	0	1	9	0
3	0	0	1	9	0
4	3	1	3	3	0
5	2	0	2	2	4
6	0	0	2	1	7
7	0	0	0	0	10
8	0	0	0	2	8
9	0	0	8	1	1

Table III.

Material	Number of sections showing amount of leakage		
No.	1	2	3
1	0	0	10
1 + tube	0	0	10
2	0	0	10
3	0	0	10
4	2	1	7
5	0	2	8
6	0	0	10
7	0	0	10
8	0	0	10
9	0	0	10

REFERENCES

Going, R.E. (1972) Microleakage around dental restorations: a summarizing review. *The Journal of the American Dental Association,* **84,** 1349 - 1357.

Grossman, L.I. (1939) A study of temporary fillings as hermetic sealing agents. *Journal of Dental Research,* **18,** 67 - 71.

Holliger, H.H. (1967) Penetration of restoration margins. *Dental Radiography and Photography,* **40,** 9 – 14.

Marosky, J.E. Patterson, S.S. & Swartz, M.L. (1977) Marginal leakage of temporary sealing materials used between endodontic appointments and assessed by calcium 45 – an in vitro study. *Journal of Endodontics,* **3,** 110 - 113.

Messing, J.J. (1961) A polystyrene-fortified zinc oxide/eugenol cement. *British Dental Journal,* **110,** 95 - 100.

Parris, L. & Kapsimalis, P. (1960) The effect of temperature change on the sealing properties of temporary filling materials. *Oral Surgery, Oral Medicine and Oral Pathology,* **13,** 982 - 989.

Parris, L., Kapsimalis, P. Cobe, H.H. & Evans, R. (1964) The effect of temperature change on the sealing properties of temporary filling materials. Part II. *Oral Surgery, Oral Medicine and Oral Pathology,* **17,** 771 - 778.

Phillips, R.W., Swartz, M.L. & Rhodes, B. (1970) An evaluation of a carboxylate adhesive cement. *The Journal of the American Dental Association,* **81,** 1353 - 1359.

Smith, D.C. (1971) A review of the zinc polycarboxylate cements. *The Journal of the Canadian Dental Association,* **37,** 22 - 29.

Smith, D.C. & Cartz, L. (1973) Crystalline interface formed by polyacrylic acid and tooth enamel. *Journal of Dental Research,* **52,** 1155.

Swartz, M.L. & Phillips, R.W. (1962) Influence of manipulative variables on the marginal adaptation of certain restorative materials. *Journal of Prosthetic Dentistry,* **12,** 172 - 181.

Valcke, C.F. (1971) Observations on a composite resin filling material. *The Journal of the Dental Association of South Africa,* **26,** 120 - 133.

Valcke, C.F. (1973) Adhesion of certain restorative materials to dentin. *Journal of Dental Research,* **52,** 614.

Widerman, F.H., Eames, W.B. & Serene, T.P. (1971) The physical and biologic properties of Cavit. *The Journal of the American Dental Association,* **82,** 378 - 382.