

OBSERVATIONS ON A COMPOSITE RESIN FILLING MATERIAL*

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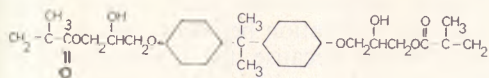
IN the latter half of 1969 a new composite resin filling material was offered for trial. It was decided to subject the material to a clinical trial, a histological examination of pulpal responses, and tests of marginal leakage and absorption.

THE MATERIAL

The material—ADAPTIC**—is of the thermosetting aromatic resin type. Composite resin dental restorative materials consist of two phases: a filler and a resin, or mixture of resins.

The fillers used in composite resins are inorganic, although sometimes treated with organic materials.¹ In the case of ADAPTIC the filler is finely-divided, treated α -quartz and this constitutes some 72-75 per cent of the material.

Unlike some composite resins ADAPTIC contains no methyl-methacrylate. The resinous phase consists of Bowen's resin, with 9.0 per cent bismethacrylate of bisphenol A and 15 per cent triethyleneglycol bismethacrylate. Hardening is effected by a catalyst—benzoyl peroxide—and an aromatic tertiary amine accelerator. Bowen's resin is the basis of several restorative materials and has the following graphic formula:



Information available² at the time of commencing these trials suggested that the physical properties of ADAPTIC might render it more durable than other

tooth-coloured plastic restorative materials. The following figures were reported:

Compressive strength	32,000 - 34,950 p.s.i.
Hardness (Rockwell)	100 - 103
Linear thermal expansion	22 p.p.m. /C°
Linear polymerisation shrinkage	0.5%

Favourable values were also reported for water sorption and solubility, flexural properties (strength and modulus), abrasion resistance and stain resistance.

PRESENTATION, MANIPULATION AND SHELF LIFE

The material is supplied in two jars, one containing a "universal paste", the other containing a "catalyst paste". Included with these pastes is a supply of double-ended wooden mixing sticks and a mixing pad. A set of four "tinted universal pastes" for shade modification is also offered. The manufacturers recommend that the material should not be exposed to temperatures in excess of 75°F. (24°C.). In the trials to be described the material was stored in a domestic-type refrigerator and allowed to stand at room temperature for at least an hour before use. The material appears to be most easily manipulated at a room temperature of about 22°C. The working characteristics of material treated in this manner have appeared unchanged in clinical use after sixteen months.

Since the quartz filler in the material settles during storage the material in each jar must be well stirred before use to ensure a homogeneous mix. Mixing entails placing equal amounts of the "universal paste" (modified, if desired, by the incorporation of "tinted universal pastes") and "catalyst paste" on the mixing pad and mixing the two masses thoroughly with one of the wooden sticks. The proportions are not critical and visual esti-

*Based on a paper presented at the meeting of the South African Division of the International Association for Dental Research, Cape Town, September 19th, 1970.

**Johnson & Johnson, New Brunswick, N.J., U.S.A.

mation of proportions seems to be adequate.

In manipulating the material cross-contamination of the contents of the two jars must be avoided, since such cross-contamination will lead to hardening of the material contaminated. If the person stirring or mixing the material is distracted cross-contamination can easily occur. It has been found helpful to mark one end of the mixing stick with a red pen and use that end for the red-labelled "catalyst paste"

Mixing takes not more than thirty seconds, leaving about ninety seconds for placement in the cavity. Since the quartz filler will abrade steel instruments used in placing the material in the cavity, with resultant discolouration of the restoration, it is essential to reduce manipulation with steel instruments to a maximum.

CLINICAL TRIAL

In selecting cases for clinical trial the choice of teeth to be restored was restricted to those where cosmetic considerations were involved. The makers of the material describe it as an "anterior/posterior dental restorative". The view was taken, however, that posterior teeth can be restored very well with familiar materials (for example amalgam, cast gold) and that the most important application of a tooth-coloured material is in the restoration of anterior teeth. Recently Messing³ has observed, in discussing composite restorative materials, that "we now have at our disposal a new group of aesthetic materials which would appear to be superior to silicate and acrylic in many respects, notably in abrasion resistance, tensile strength and colour stability." The most durable aesthetic restorative material hitherto available is probably the porcelain inlay, but it has inherent disadvantages in the very demanding laboratory technique involved and in the presence of luting cement which cannot be protected by a bevelled cavity margin on which to burnish the inlay.⁴ Hence a tooth-coloured restorative material demands special consideration with regard to Class III, IV and V restorations.

Fifty teeth were restored with the material. The restorations were distributed as in Table I.

TABLE I. Distribution of restorations.

Class of restoration	I*	III	IV	V	Total
Number of restorations	7	II	7	25	50

*Developmental defects in facial surfaces of incisors, canines and premolars.

Two of these restorations (both Class V) failed initially because moisture seeping from the gingival crevice prevented accurate adaptation of the material to the cervical walls of the cavities. In both cases placement of rubber dam facilitated the successful insertion of a fresh mix of the material. Although moisture will not prevent the setting of the material, accurate working demands a clean, dry cavity. These conditions are best assured by the use of rubber dam.

In cases where a four-walled cavity is restored the material will usually pick up the colour of the surrounding calcified tissues well enough to give a cosmetically acceptable result. Some difficulty was encountered initially in colour-matching two types of restorations. These were:

- Cases in which the teeth were grossly discoloured; and
- Cases in which substantial parts of both the labial and lingual surfaces of the teeth had been lost.

The "tinted universal pastes" referred to above are available in four shades: white, grey, yellow and brown. In cases of gross discolouration of the teeth (type a) the grey, yellow and brown shades permit acceptable colour matching. In type b cases, where both the labial and lingual walls of the cavity have been lost, the restoration becomes conspicuous, presumably because the translucency of the material permits incident light to pass through the restoration without being reflected back to the viewer, thus giving an appearance of undue darkness. The addition of white tinted paste obviates this defect.

Trimming of this material by the tools customarily employed for finishing traditional plastic restorations presents difficulties, since it is so hard that conventional steel finishing burs are rapidly destroyed and almost completely ineffective.

In fact, the surface of a restoration cut with a steel bur is rapidly darkened by the particles of steel lost by the bur and, similarly, drawing the point of a steel probe across such a surface under pressure will leave a dark line of steel particles.

It was found that restorations could be satisfactorily trimmed with tungsten carbide burs (as used for cavity preparation), abrasive paper discs and white abrasive stones. Recently two very effective rotary trimming instruments have been tried:

- i. Friction-grip tungsten carbide finishing burs (Fig. 1), which are commercially available* and
- ii. Friction-grip fine-grain diamond finishing points (Fig. 2), which are in a developmental stage.**

These friction-grip instruments were used in turbine handpieces (Siemens*** and Kavo "All-Air"****) and in a Micro-Mega Mod. 120E handpiece****, covering a speed range from about 12,000 to 400,000 r.p.m. They have also been used in a prototype friction-grip head for the Micro-Mega 40 NC SP contra-angle handpiece (Tête FG ϕ 1,6).*****

This handpiece, for the belt-driven wrist-joints, covers the speed range from 500 to 12,000 r.p.m.

* "JET" T.C. finishing burs, Beavers Dental Products, Ltd., Morrisburg, Ontario, Canada.

** Prototype diamond finishing points, Amalgamated Dental International, London, England.

*** Siemens A.G., Bensheim, West Germany.

**** Kaltenbach & Voigt, Biberach/Riss, West Germany.

*****Prodonta S.A., Geneva, Switzerland.

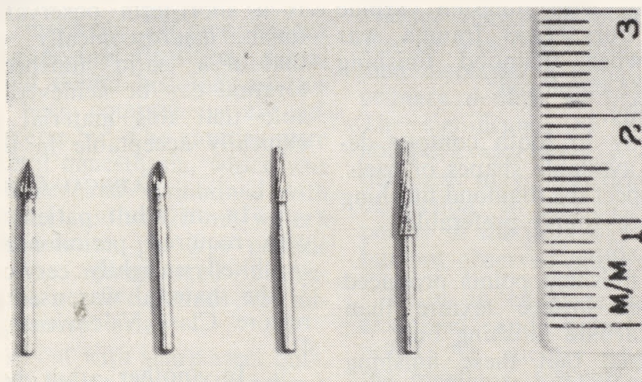


FIG. 1. Friction-grip tungsten carbide finishing burs. Left to right—7106, 7404, 7713, 7206.

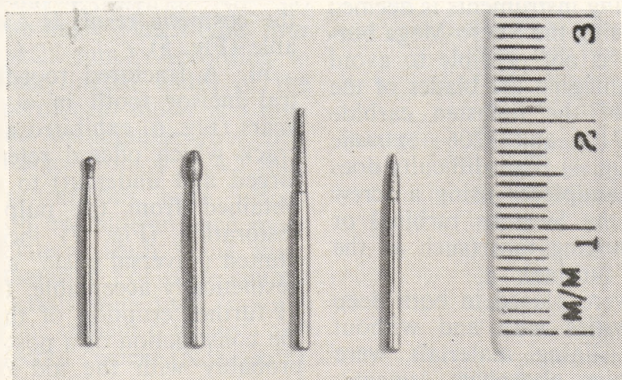


FIG. 2. Friction-grip fine-grain diamond finishing points.

Results obtained with these tools were observed in the light of several criteria and these results may be summarised as follows:

- a. Effectiveness (speed of removal of material).

This was good with both types of tool. Excess material was removed more easily than with any other trimming instruments employed in this trial.

- b. Injury to enamel.

This was least noticeable with tungsten carbide finishing burs. At high speeds damage to enamel was difficult to avoid with either type of tool. Least damage was observed when the tools were used in the Micro-Mega Tête FG ϕ 1,6.

- c. Injury to gingival tissue.

Injury to gingival tissue is difficult to avoid in trimming sub-gingival restorations with tungsten carbide finishing burs. Less trauma was evident when diamond finishing points were employed.

- d. Adaptability.

Adaptability to tooth contour depends on available shapes of tools. In this respect the diamond finishing points were found preferable.

- e. Surface texture.

Diamond finishing points produced a smoother surface texture than tungsten carbide finishing burs.

It is considered that these finishing tools should not be used with turbine handpieces, as the speed attained makes their action difficult to control.

One other point in connection with these new trimming instruments is deemed noteworthy. In using the Micro-Mega bur-changing tool it is not possible to avoid the danger of damaging the blades of the bur with two of the tungsten carbide finishing burs (7106 and 7206—extreme left and right—Fig. 1). This difficulty does not arise with handpieces using a screw chuck (such as the Siemens turbine) or a plastic bur-changing tool (such as the Kavo "All Air" turbine).

Restorations were placed in both deep and shallow cavities with and without linings. Various lining materials were used, including zinc phosphate cements, polycarboxylate cements, fortified zinc oxide/eugenol cements and EBA cements.

No incompatibility with lining materials has been noted clinically. In no case have post-operative pulpal symptoms yet developed. Comparisons of electrical tests of pulp vitality (with a Siemens "Sirotest" pulp tester)* pre- and post-operatively have revealed no alteration in pulpal sensitivity. This suggestion that the material is innocuous to the pulp, at least in the short term, is supported by a small series of histological tests in vervet monkeys. These conclusions concerning linings agree with the findings of Ribbons.⁵

It has not been found possible to achieve a high polish on the surfaces of ADAPTIC restorations. However, a number of these restorations which extend into the gingival crevice area have been kept under observation and no clinical signs of gingival irritation have been observed. It should be emphasised that this is a short-term observation. A surface finish macroscopically comparable to that of a "satin" finished gold foil restoration can be achieved, so it is probable that this material will be found clinically acceptable in this regard.

CLINICAL CASES

- i. In an adult patient aged 46 years who required periodontal therapy and exhibited unsightly cervical caries (Fig. 3) the material was used successfully to restore Class V cavities in 42111 (Fig. 4).

- ii. In another adult patient aged 53 years a root-filled mandibular canine presented labial and linguo-distal-incisal cavities. Having regard to the mosaic of restorations and discolourations present the cosmetic result is considered acceptable (Fig. 5).

- iii. A fractured root-filled upper central incisor tooth in a patient aged 10 years (Fig. 6) exhibited an inciso-cervical crack which offered retention (when enlarged and undercut) to supplement that obtained from the pulp chamber. The restoration (Fig. 7) incorporates white "tinted universal paste" and is considered aesthetically acceptable. It may serve until further eruption of the tooth permits the construction of a post-retained crown, probably with the aid of gingival surgery.

*Siemens A.G., Bensheim, West Germany.

iv. A patient aged 11 years presented with a vital, fractured maxillary central incisor (Fig. 8). Marked imbrication prevented demonstration of a deep Class III cavity except in an abnormally angled radiograph (Fig. 9). The Class III cavity and a palatal slot provided retention for a successful proximo-incisal restoration (Fig. 10).

v. Another child aged 11 years presented a carious pit on the labial surface of a left maxillary canine, with three carious fissures radiating therefrom (Fig. 11). These defects were excised (Fig. 12) and satisfactorily restored with ADAPTIC (Fig. 13).

PULPAL RESPONSES (Histological)

Materials and method

Buccal Class V fillings were placed in all four first permanent molars of each of six vervet monkeys (*Cercopithecus Aethiops*). The normal dentition, dental morphology and dental histology of this primate have been comprehensively described by Ockerse.^{6,7,8} The cavities were cut under general anaesthesia, which was induced with ether and maintained with sodium cyclonal (1 gm. to 20 ml. water). 1 ml. of this solution per five pounds body weight was administered intravenously and 2 ml. per five pounds was administered intramuscularly.

Cavities were cut with sharp steel burs, using a slow handpiece (about 600 r.p.m.). An attempt was made to cut the cavities to a uniform depth. The depth chosen was that of the cutting head of a No. 5 inverted cone bur (American No. 38) miniature contra-angle latch-type bur (approximately 1.25 mm.). According to Ockerse⁶ the bucco-lingual width of the maxillary first permanent molar is 5 mm. and that of the mandibular first permanent molar ranges from 4 to 4.5 mm.

ADAPTIC restorations were placed in the cavities on one side in each monkey, the contralateral teeth being filled with a control material. For these control fillings two materials were used: a cap-sulated carboxylate cement (Oxicap*) and a zinc oxide/eugenol cement (Nobetec**).

These materials were selected for their reputed non-irritant characteristics.^{9,10}

Two monkeys were sacrificed after twelve days, two after thirty-three days and two after sixty-one days. Thus a total of twelve pulps related to ADAPTIC fillings and six pulps related to each control material became available for histological examination. The teeth which had been filled were removed from the animals as soon as possible after sacrifice and the roots severed to permit easy access of fixative. The teeth were fixed in Bouin's fluid, subsequently decalcified, and serial sections were cut. The sections were stained with haematoxylin and eosin.

Cavity-related sections were examined and the remaining thickness of primary dentine between the pulpal walls of the cavities and the pulps was noted. The average remaining thickness of primary dentine was 0.813 mm. Only one specimen displayed a remaining thickness of primary dentine of less than 0.30 mm. The significance of these figures must not be exaggerated, since the remaining thickness may be distorted by the plane of section. In one case a pin-point exposure of the pulp was clinically evident, but not observed microscopically.

Pulps in cavity-related sections were examined and pulpal reactions were noted. An attempt was made to grade the reactions, following the general line of classification employed by Stanley *et al.*¹¹ The pulpal reactions for which sections were examined were:

Firstly: Cellular displacement into dentinal tubules. This reaction was not observed in the sections examined and has been omitted from Table II.

Secondly: Inflammatory response — judged on the criteria of cellular infiltration and engorgement of blood vessels. These observations are enumerated in Table II on the following basis:

1. No inflammatory cells or engorged blood vessels.
2. Few chronic inflammatory cells or slight engorgement of blood vessels.

* Vivadent, Schaan, Liechtenstein.

**Bofors Nobel-Pharma, Sweden.



FIG. 3.



FIG. 4.

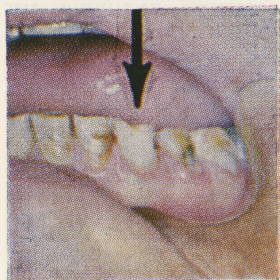


FIG. 5.

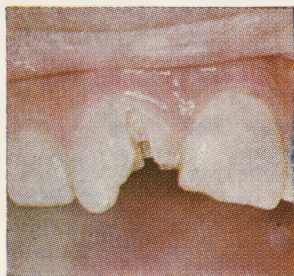


FIG. 6.

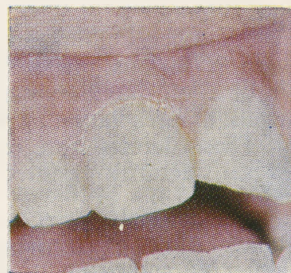


FIG. 7.

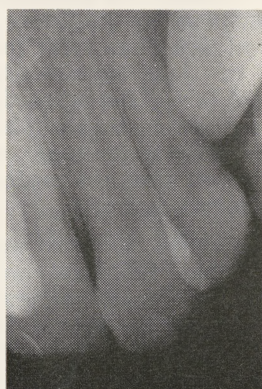


FIG. 8.

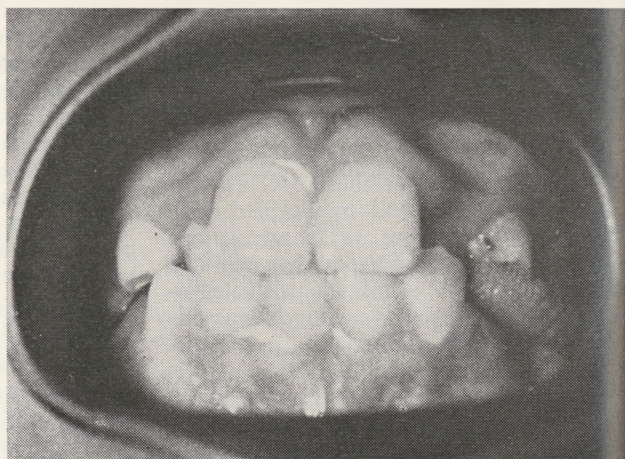


FIG. 10.



FIG. 9.

FIG. 3. Cervical caries 421 | 1.

FIG. 4. Restorations 421 | 1.

FIG. 5. Restoration | 3.

FIG. 6. Fractured 1 | prepared for restoration.

FIG. 7. Fractured 1 | restored.

FIG. 8. Fractured | 1. (Normal radiograph.)

FIG. 9. Fractured | 1. (Abnormally angled radiograph.)

FIG. 10. Restored | 1.

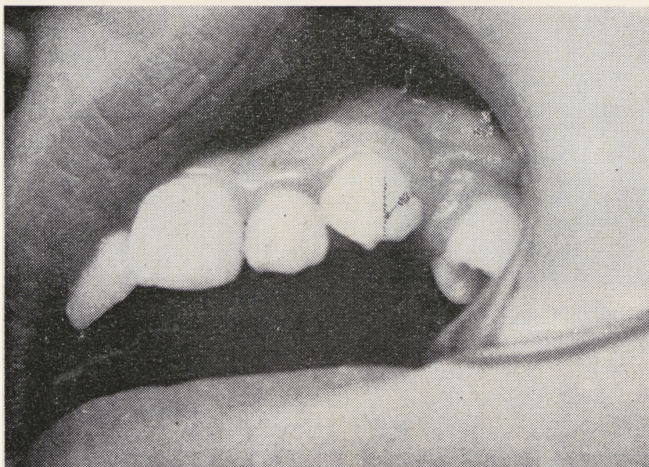


FIG. 11. Labial defects | 3.

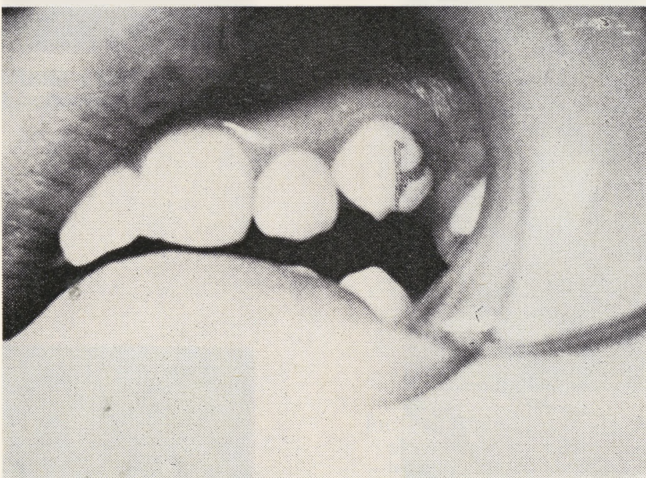


FIG. 12. Prepared cavity | 3.

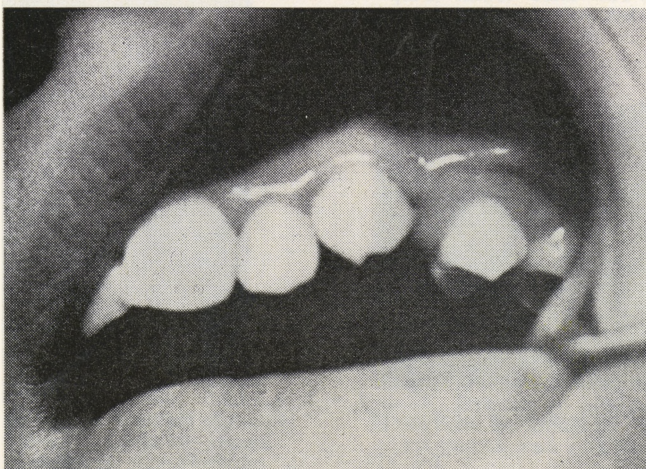


FIG. 13. Restored | 3.

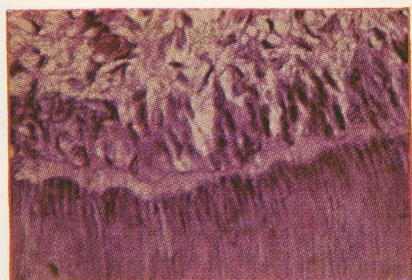


FIG. 14. Oxicap filled tooth. Slight destruction of odontoblasts. 12 days.

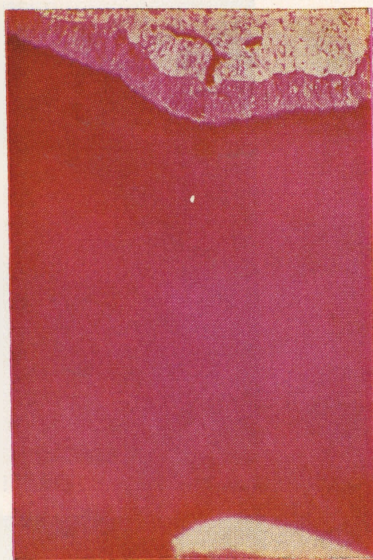


FIG. 15. ADAPTIC filled tooth. (Pulp—top: cavity—bottom). 12 days.

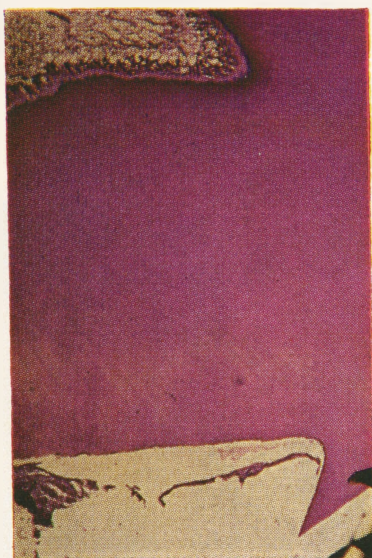


FIG. 16. ADAPTIC filled tooth. (Pulp—top: cavity—bottom). 33 days.

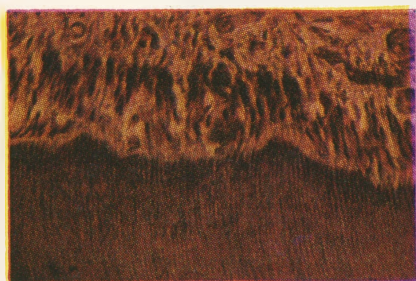


FIG. 18. Greater magnification of Fig. 17. Periphery of pulp.



FIG. 17. Nobetec filled tooth. (Pulp—top: cavity—bottom). Some destruction of odontoblasts. 61 days.

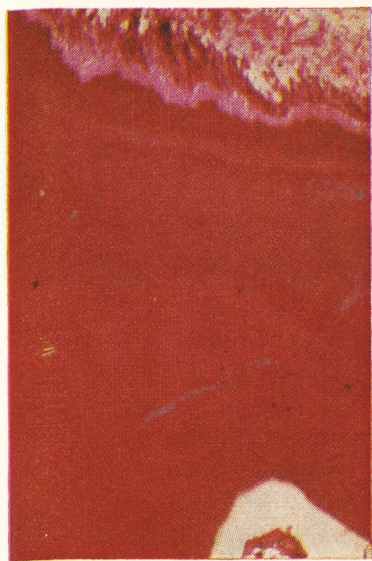


FIG. 19. ADAPTIC filled tooth. (Pulp—top: cavity—bottom). 61 days.



FIG. 20. Greater magnification of Fig. 19. Slight thickening of pre-dentine.



FIG. 22. Dye-treated silicate filling. Deep absorption in filling (top). Penetration to pulp cavity (bottom).



FIG. 21. ADAPTIC filled tooth. (Pulp—top: cavity—bottom). Marked destruction of odontoblasts. Irregular reparative dentine. 61 days.

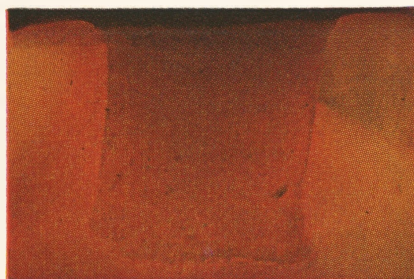


FIG. 23. Dye-treated silicate filling. Deep absorption in filling and penetration beyond pulpal wall of cavity.

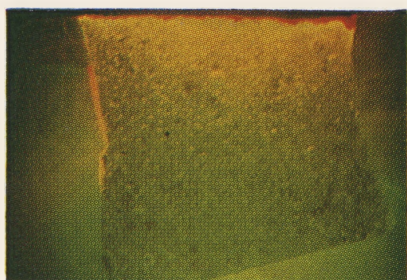


FIG. 24. Dye-treated ADAPTIC filling.
Limited penetration at good margins.

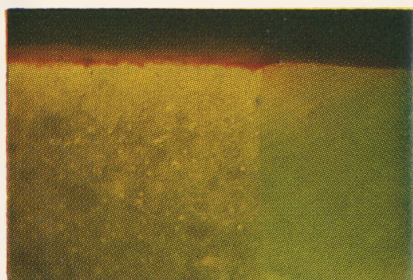


FIG. 25. Dye-treated ADAPTIC filling.
Insignificant penetration at good cavity margin.

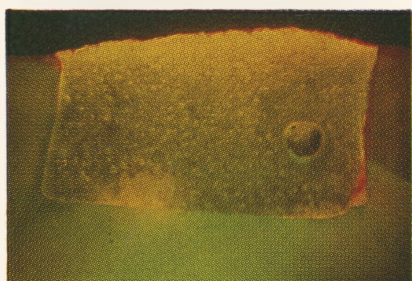


FIG. 26. Dye-treated ADAPTIC filling.
Penetration at poorly-adapted margin
(right) .

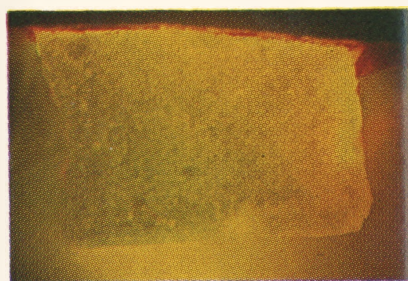


FIG. 27. Dye-treated ADAPTIC filling.
Penetration at poor margin (right).

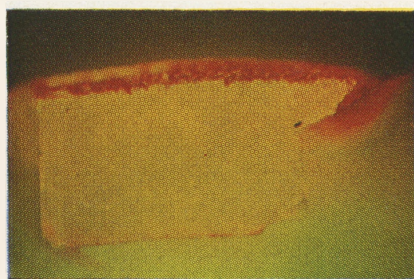


FIG. 28. Dye-treated ADAPTIC filling.
Penetration at bad margin (right).

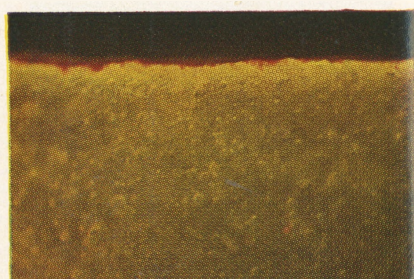


FIG. 29. Dye-treated ADAPTIC filling.
Insignificant surface staining in section
at right-angles to surface.

3. Many chronic inflammatory cells or marked engorgement of blood vessels.
4. Acute inflammatory cells and engorgement of blood vessels.

Thirdly: Production of reparative dentine. These observations are enumerated in Table II on the following basis:

1. No reaction.
2. Thickening of pre-dentine.
3. Deposit of secondary tubular dentine.
4. Deposit of irregular reparative dentine.

Fourthly: Destruction of odontoblasts. These observations are enumerated in Table II on the following basis:

1. Few odontoblasts destroyed.
2. Many odontoblasts destroyed.

Results

The observations described are summarised in Table II and illustrated in Figs. 14 - 21. In the twelve-day group no severe inflammatory reactions were seen, although some odontoblasts were disturbed in one of the Oxicap filled teeth (Fig. 14). A slightly greater destruction of odontoblasts was seen in one of the four ADAPTIC filled teeth. Other

ADAPTIC filled teeth showed little or no inflammatory reaction (Fig. 15). In the thirty-three day group no pulpal abnormalities were seen in the Oxicap filled teeth, although one Nobetec filled tooth showed some chronic inflammatory cells and the other displayed reparative dentine formation, apparently related to an accidental exposure of the pulp. In the ADAPTIC filled teeth one showed a marked inflammatory response (Fig. 16). In the sixty-one day group one Nobetec filled tooth showed some destruction of odontoblasts (Figs. 17 & 18). One ADAPTIC filled tooth showed fairly numerous chronic inflammatory cells and all four showed some formation of reparative dentine (Figs. 19 & 20), while one showed marked destruction of odontoblasts (Fig. 21). The conclusions to be drawn from this small series of histological examinations are:

1. The reactions to the composite resin material are not notably more severe than the reactions to bland lining/temporary filling materials.
2. The severity of the pulpal reaction to the composite materials does not show a clear increase with time.

MARGINAL LEAKAGE AND ABSORPTION

Two methods were used to examine marginal leakage and absorption of ADAPTIC fillings:

1. Dye penetration.
2. Autoradiography.

In each case the results were compared with those obtained in silicate fillings.

TABLE II. Pulpal responses.

Material	Number of teeth	Days to sacrifice	Inflammatory response				Reparative dentine				Odontoblasts destroyed	
			1	2	3	4	1	2	3	4	1	2
Nobetec	2	12	0	2	0	0	2	0	0	0	0	0
Oxicap	2	12	1	1	0	0	1	1	0	0	1	0
ADAPTIC	4	12	3	1	0	0	3	1	0	0	0	1
Nobetec	2	33	1	1	0	0	1	0	1*	0	0	0
Oxicap	2	33	2	0	0	0	2	0	0	0	0	0
ADAPTIC	4	33	2	1	1	0	2	1	1	0	0	1
Nobetec	2	61	2	0	0	0	0	1	1	0	0	1
Oxicap	2	61	1	0	1	0	0	1	1	0	0	0
ADAPTIC	4	61	3	0	1	0	0	3	0	1	1	1

*Pulp exposed accidentally.

Materials and method

Apparently sound extracted human premolar teeth were used. The teeth were obtained from several sources and received in aqueous antiseptic solutions. Calculus was removed from the teeth, which were then immersed in water at room temperature for a short period until Class V cavities could be prepared. Cavities were prepared with steel burs and the enamel margins were finished with sharp steel chisels. The cavities were debrided with water spray and surface dried with compressed air. Cavities were filled with ADAPTIC and the restorations were trimmed as soon as the material had set. After trimming the restored teeth were stored in water at 38°C. Similarly treated teeth filled with silicate cement had the restorations trimmed 24 hours after insertion.

After four months the teeth were removed from the water, surface dried with compressed air and coated with a protective layer of nail varnish, except for the areas immediately surrounding the restorations, in an attempt to seal the apical foramina and any other potential points of entry for solutions.

Twelve teeth filled with ADAPTIC and six teeth filled with silicate cement were immersed in Blak-Ray red fluorescent water dye* (strength—one tablet in 25 ml. deionised water) for six days at 38°C. This dye was used by Holliger¹² and is readily detected by ultra-violet fluorescence. Ground sections of these teeth were prepared using a Kent Mk. 2 automatic lapping and polishing machine.**

Eighteen teeth filled with ADAPTIC and six teeth filled with silicate cement were prepared in the same way as those for the dye penetration test and used for autoradiography. These teeth were immersed for 24 hours in ⁴⁵Ca solution (aqueous Ca Cl₂ solution—0.1 mc. per ml.) at 38°C. They were hemisected and then washed in an attempt to remove all radioactive debris. Autoradiographs were then made by strapping the teeth on to glass microscope slides with pressure-

sensitive cellulose tape. Before attaching a tooth to the supporting slide a Kodak ultra-speed x-ray film,*** size 3.5 cms. x 2.2 cms. was removed from its packing and sandwiched between the ground surface of the tooth and the slide. This of course was done in a dark-room, and the specimens were then left in a light-proof box for an eighteen hour exposure before development by routine method.

The ground sections of the dye-tested teeth were examined microscopically by transmitted ultra-violet radiation and the autoradiographs were examined with an x-ray viewer. The penetration of both dye and radioisotope arising from marginal leakage was assessed as:

1. No penetration.
2. Penetration *not beyond* the amelodentinal junction.
3. Penetration *not beyond* the pulpal wall of the cavity.
4. Penetration *beyond* the pulpal wall of the cavity.

The absorption of the dye and radioisotope by the filling material was observed and classified as:

1. Surface staining.
2. Absorption in the superficial part of the filling.
3. Absorption throughout the filling.

Results

The observations described are summarised in Tables III and IV and illustrated in Figs. 22 - 33. In the teeth subjected to dye penetration tests all teeth

TABLE III. Dye tests.

Material	Leakage penetration				Absorption		
	1	2	3	4	1	2	3
ADAPTIC	4	0	7	1	12	0	0
Silicate	0	0	0	6	0	0	6

TABLE IV. Autoradiographs.

Material	Leakage penetration				Absorption		
	1	2	3	4	1	2	3
ADAPTIC	0	1	12	5	18	0	0
Silicate	0	0	0	6	0	0	6

* U.V. Products, Inc., California, U.S.A.

**Engis Ltd., Maidstone, England.

***Eastman Kodak Co., Rochester, N.Y.,



FIG. 30.

FIG. 30. Autoradiograph: silicate filling (right). Penetration of radioisotope to pulp chamber: deep absorption.



FIG. 31.

FIG. 31. Autoradiograph: silicate filling (left). Penetration of radioisotope to pulp chamber: deep absorption.



FIG. 32.

FIG. 32. Autoradiograph: ADAPTIC filling (right). Linear penetration of radioisotope along amelo-dental junction: no absorption.



FIG. 33.

FIG. 33. Autoradiograph: ADAPTIC filling (left). Linear penetration of radioisotope along defect: no absorption.

filled with silicate cement showed penetration beyond the floor of the cavity and absorption of the dye throughout the filling (Figs. 22 & 23). Teeth filled with ADAPTIC showed a lesser degree of penetration. Where penetration was deep it was associated with poorly prepared cavity margins (Figs. 24, 25, 26, 27 & 28). Absorption was limited to surface staining, which was most clearly demonstrable in sections ground in a plane approximately at right-angles to the surface of the filling (Fig. 29). In the teeth subjected to autoradiographic tests of leakage the silicate controls all showed absorption of radioactive calcium throughout the filling and leakage beyond the pulpal wall of the cavity (Figs. 30 & 31). In the ADAPTIC filled teeth the penetration was much less, although in some cases defects in the teeth permitted linear penetration along the defect; absorption, except at the surface of the restoration, was not noted (Figs. 32 & 33).

CONCLUSIONS

This composite resin restorative material is relatively simple to manipulate in clinical practice and is capable of giving acceptable cosmetic results. It is not notably more injurious to the pulp than materials recognised as being innocuous. Leakage and absorption are negligible in comparison with silicate cements.

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REFERENCES

1. BOWEN, R. I. Dental filling material comprising vinyl silane treated fused silica and a binder consisting of the reaction products of bisphenol and glycidyl acrylate. U.S. patent No. 3,066,112, Nov. 27, 1962.
2. LEE, H. L., SWARTZ, M. L. and SMITH, F. F. Physical properties of four thermosetting dental restorative resins. *J. dent. Res.*, 48: 526, 1969.
3. MESSING, J. J. The present place of composite restorative material. *Apex*, 4: 29, 1970.
4. VALCKE, C. F. Anterior cervical porcelain inlays. *J. dent. Ass. S. Afr.*, 17: 380, 1962.
5. RIBBONS, J. W. Handling properties of a new composite filling material. *Brit. dent. J.*, 129: 509, 1970.
6. OCKERSE, T. The anatomy of the teeth of the vervet monkey. *J. dent. Ass. S. Afr.*, 14: 209, 1959.

7. OCKERSE, T. The eruption sequence and eruption times of the teeth of the vervet monkey. *J. dent. Ass. S. Afr.*, 14:422, 1959.
 8. OCKERSE, T. The histology of the teeth of the vervet monkey. *J. dent. Ass. S. Afr.*, 18:35, 1963.
 9. PLANT, C. G. The effect of polycarboxylate cement on the dental pulp. *Brit. dent. J.*, 129:424, 1970.
 10. MANLEY, E. B. A preliminary investigation into the reaction of the pulp to various filling materials. *Brit. dent. J.*, 60:321, 1936.
 11. STANLEY, H. R. SWERDLOW, H. STANWICH, L. and SUAREZ, C. A comparison of the biological effects of filling materials with recommendations for pulp protection. *J. Amer. Acad. Gold Foil Oper.*, XII: 56, 1969.
 12. HOLLIGER, H. H. Penetration of restoration margins. *Dent. Radiogr. Photogr.*, 40:9, 1967.
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