Pulpal responses to two luting cements

C F Valcke, P E Cleaton-Jones; J C Austin, M Forbes and C Sam

MRC University of the Witwatersrand, Dental Research Institute, Johannesburg

Keywords: cements.

SUMMARY

Labial cavities in vervet monkeys were filled with two luting cements and 2 control materials (negative and positive). Specimens were recovered and examined histologically. There was little difference between the pulpal reactions to the 4 materials. The reactions to the two test materials (luting cements) are, in 28 and 56 day specimens, not more severe than the reactions to the negative control material.

OPSOMMING

Labiale kaviteite in die tande van blou-ape is met 2 sementeringsemente en met 'n negatiewe en 'n positiewe kontrole materiaal herstel. Die toestande is herwin en histologies ondersoek. Die pulpareaksies teenoor die 4 materiale het min verskil. Die reaksies teenoor die twee sementeringsegmente was in die 28- en 56-dag toetsgroepe nie erger as die reaksie wat deur die negatiewe kontrole materiaal uitgelok is nie.

INTRODUCTION

At an accelerating pace new cements are being offered to the dental profession for the luting of fixed restorations. A number of investigations of the pulpal effects of such cements have been published (Plant, 1970; Valcke, 1971; Smith, 1971; Barnes and Turner, 1971; Jendresen and Trowbridge, 1972; Plant and Jones, 1976; Tobias, Browne and Plant, 1978; Valcke *et al*, 1980b). The object of this investigation was to ascertain the pulpal responses, in non-human primates, 2 luting materials — Reocap-Temp and ChemBond.

MATERIALS AND METHODS

Reocap-Temp is a syringe-capsulated calcium hydroxide cementing medium which is mixed in a vibrating machine and is recommended for the cementation of temporary restorations, but not for trial cementation of final restorations.

ChemBond is a glass-ionomer material, offered as a permanent luting cement in powder/liquid form, with a varnish.

The control materials were Super-Syntex silicate cement as an irritant positive control and zinc oxide/eugenol (ZOE) cement, without modifiers, as a non-irritant negative control. The materials are listed in Table 1.

The experimental animals were 24 young, adult vervet monkeys (*Cercopithecus aethiops*). After immobilization with intramuscular ketamine hydrochloride* the monkeys were examined. Those with gross dental or periodontal lesions were rejected. Selected subjects were anaesthetized with intravenous pentobarbitone sodium**.

In each aneasthetized animal a labial cavity was cut in each of the 8 (maxillary and mandibular) incisor teeth. The cavities were cut with new, plain cut, inverted cone, tungsten carbide friction grip burs, size ISO 010 (U.S. 35) in a W&H Fine-Air 391 handpiece***, operated with water spray. No special finishing procedure was employed on the enamel margins of the cavities. The cavities were flushed with an air-water spray and dried with compressed air, but cavities to be filled with Reocap-Temp were left moist in accordance with the manufacturer's instructions. In each animal 2 of the 8 cavities were filled with each of the test and control materials. The ZOE fillings were coated with lime water in order to accelerate setting. The cavities to be filled with each material were allocated at random by drawing lots, as were the time intervals of 2, 28 or 56 days for specimen retrievals. The materials were inserted with anti-adhesive coated Oxicap**** instruments in order to facilitate handling.

Specimens were retrieved after the animals were anaesthetized with intravenous pentobarbitone sodium and their tooth pulps were fixed *in situ* by perfusion with phosphate buffered formol saline (Retief and Austin, 1973). Blocks of tissue containing the incisor teeth were recovered and decalcified in formic acid at room temperature. No fillings had been lost prior to recovery of the material. Fillings present after decalcification were carefully removed with a needle. The teeth were then separated and embedded in Paraplast***** under vacuum. Serial labio-lingual sections were cut at 7 μm

*Ketalar, Parke davis, Cape Town, South Africa.
**Sagatal V, Maybaker, Port Elizabeth, South Africa.
***Dentalwerk, Buermoos, Austria.
****Vivadent, Schaan, Liechtenstein.
*****Sherwood Medical Industries, St. Louis, U.S.A.

intervals and stained with haematoxylin and eosin. Sixteen unsatisfactory specimens were rejected and thus 176 specimens were available for independent examination by 2 examiners using a Univar****** optimal micrl scope. At this stage the sections were not identifiable either in regard to post-operative time interval or filling material used. The assessments were made using criteria proposed by Stanley (1968). The features observed were the remaining dentine thickness, expressed as the shortest distance between the cavity floor and the pulpal periphery, and the shortest remaining dentinal tubule length; displacement of odontoblast nuclei; superficial and deep inflammatory cell infiltrations; and the thickness and width of reparative dentine.

RESULTS

The mean pulpal responses to the test and control materials are shown in Table II. Two day specimens showed limited displacement of ondontoblast nuclei and minimal inflammatory responses, which were least in ZOE specimens and greatest in Super Syntrex specimens. In 28 and 56 day specimens, no displaced odontoblast nuclei or inflammatory reactions were observed, but many specimens displayed the formation of reparative dentine (Figs. 1 - 6).

Table I: Identification of Materials.

Type	Brand	Manufacturer	Batch
ZOE Cement			
Zinc Oxide GR Max. As 0,0001%	Merck Analytical	Merck, Darmstadt, West Germany	8166559
Eugenol	B.D.H. Lab reagents 164,21	B.D.H. Chemicals Ltd, Poole, England	650579
Silicate cement	De Trey Super Syntrex	Amalgamated Dental Co London, England	Liquid PA 18 Powder TIE (Sh.30)
Calcium Hydroxide temporary cement	Reocap-Temp	Vivadent, Schaan, Liechtenstein	270989 1290
Glass Ionomer permanent cement	ChemBond	Amalgamated Dental Co London, England	YC8 YB17 YE Liquid YC8 YD Powder YB17, YC Varnish YB7 YC

Table II: Mean pupal response to test and control materials.

Post-operative time interval	Material	No. of. teeth	Shortest dentinal tuoule length	Remaining dentine thickness	Mean odontoblast displacement	Mean superficial inflammatory response	Mean deep inflammatory response	Reparative dentine thickness	Reparative dentine width
			x̄ ± SD mm	x̄ ± SD mm	0 — 3°	0 — 3°	0 — 3°	x̄ ± SD mm	x̄ ± SD mm
	ZOE	14	1,37 ± 0,63	0,58 ± 0,21	0,5	0,1	0,0	0,0	0,0
	Super Syntrex	14	1,25 ± 0,34	0,65 ± 0,18	0,8	0,8	0,3	0,0	0,0
2 days	Reocap-Temp	14	1,14 ± 0,65	0,58 ± 0,28	0,7	0,5	0,1	0,0	0,0
	Chembond	13	0,96 ± 0,43	0,45 ± 0,15	0,8	0,7	0,0	0,0	0,0
	ZOE	19	1,11 ± 0,54	0,61 ± 0,19	0,0	0,0	0,0	0,15 ± 0,26	0,99 ± 1,00
	Super Syntrex	15	1,01 ± 0,59	0,49 ± 0,26	0,0	0,0	0,0	0,09 ± 0,14	1,27 ± 1,04
28 days	Reocap-Temp	18	0,96 ± 0,53	0,53 ± 0,27	0,0	0,0	0,0	0,11 ± 0,14	1,18 ± 0,90
	ChemBond	11	1,13 ± 0,37	0,54 ± 0,21	0,0	0,0	0,0	0,05 ± 0,05	1,02 ± 0,90
	ZOE	13	0,88 ± 0,40	0,45 ± 0,21	0,0	0,0	0,0	0,17 ± 0,05	1,44 ± 0,86
	Super Syntrex	15	1,09 ± 0,65	0,50 ± 0,16	0,0	0,0	0,0	0,17 ± 0,10	1,46 ± 1,11
56 days	Reocap-Temp	15	0,85 ± 0,42	0,48 ± 0,25	0,0	0,0	0,0	0,16 ± 0,09	1,66 ± 1,23
	Chembond	15	1,11 ± 0,27	0,51 ± 0,13	0,0	0,0	0,0	0,14 ± 0,08	1,09 ± 0,90

******C Reichert A.G., Vienna, Austria.

Fig. 1: ZOE: 2 days: Odontoblast displacement Grade 1. X415.

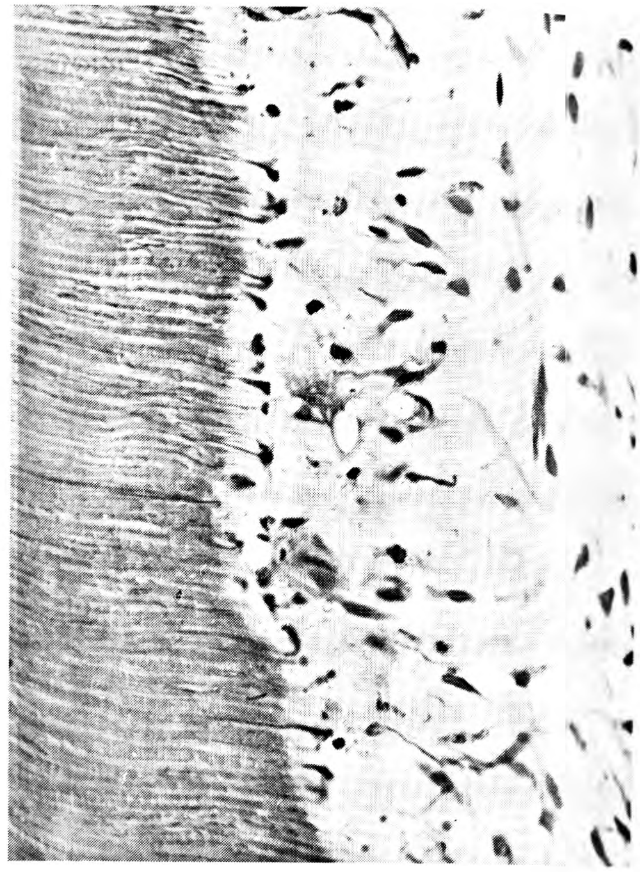

Fig. 3: Reocap-Temp: Odontoblast displacement Grade 1. Superficial inflammation, grade 1. X415.

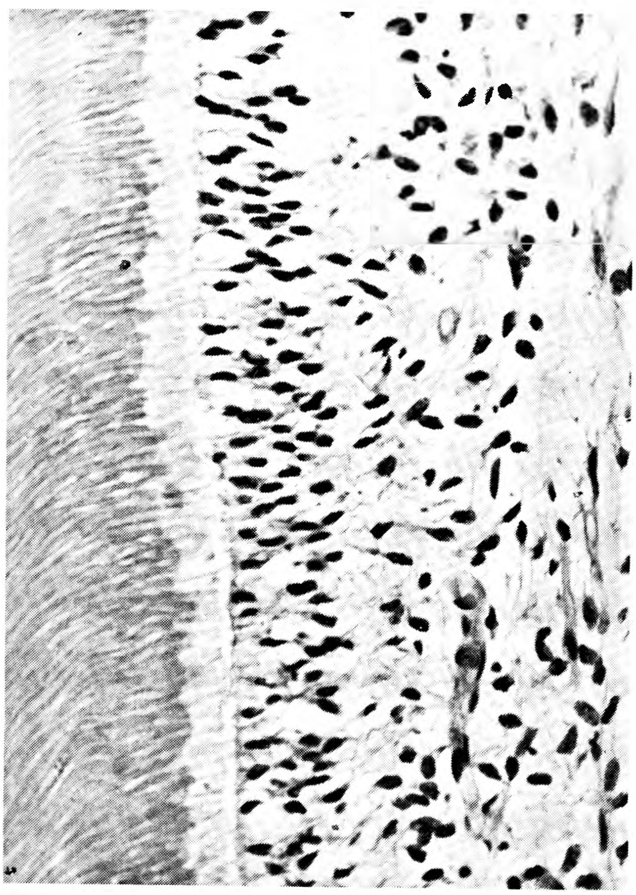

Fig. 2: Reocap-Temp: 2 days: no reaction. X415.

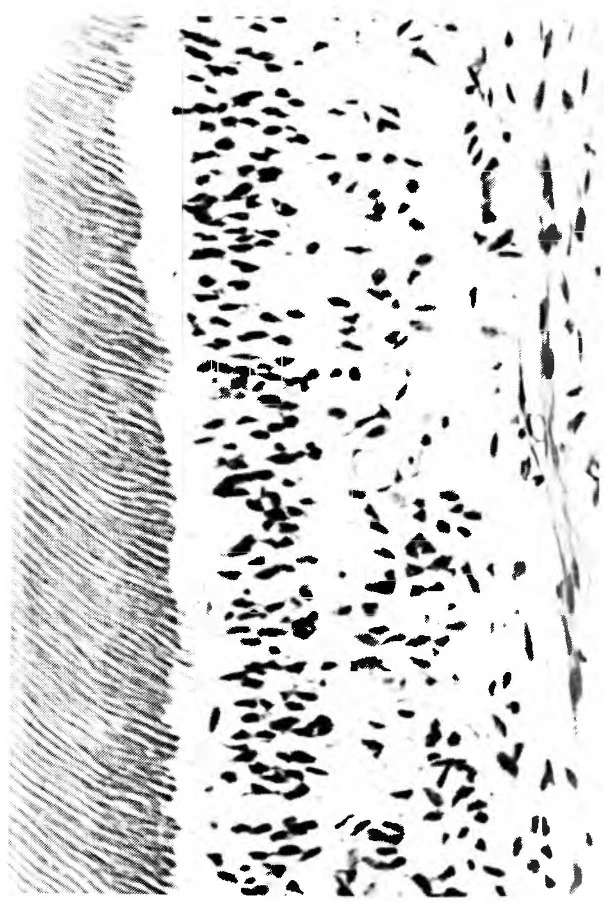

Fig. 4: ChemBond: 2 days: no reaction. X414.

Fig. 5: ChemBond; 2 days: Odontoblast displacement, grade 2. Superficial inflammation, grade 2. X415.

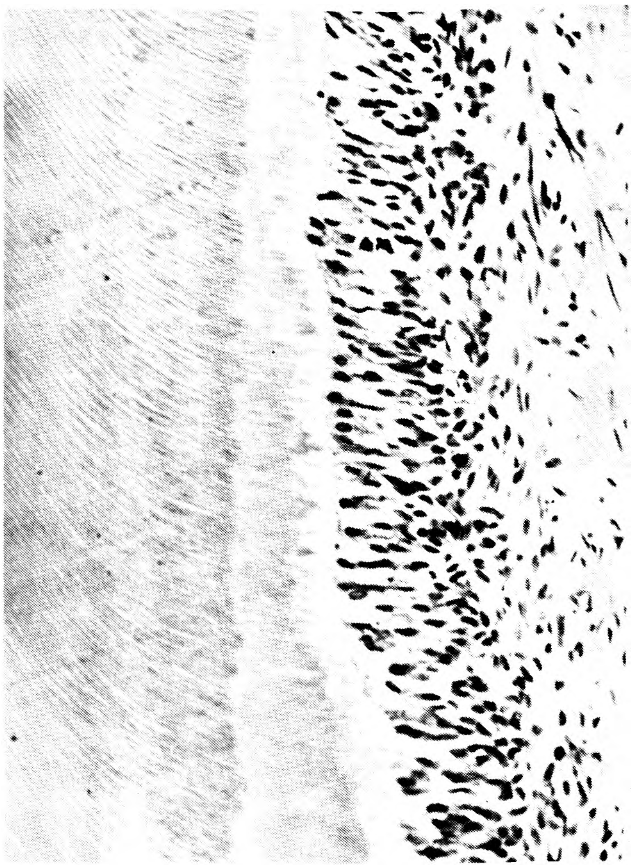

Fig. 6: Reocap-temp: 56 days: Reparative dentine. X275.

Table III shows the number and percentage of teeth in each experimental group displaying the abnormalities observed. A one-way analysis of variance was undertaken to test the statistical significance of differences in mean pulpal responses between the materials. A χ-square test was used to ascertain whether significant differences existed between the 4 materials in regard to the number of specimens showing pulpal responses. There were no statistically significant differences in the pulpal responses of the 4 materials used in this study.

DISCUSSION

The methodology employed in this study was based on that proposed by the Council on Dental Materials and Devices of the American dental Association (1972). The suitability of the vervet monkey as a model for pulpal studies has been demonstrated (Retief and Austin, 1973).

Reocap, a capsulated calcium hydroxide cement, used as a lining material, has been available for some years, and has proved effective in reducing the inflammatory response to a direct filling resin (Valcke *et al,* 1980a). Reocap-Temp is a further development. Calcium hydroxide cements have been discussed by Wilson *et al* (1981).

ChemBond is a glass-ionomer luting and lining material, the consistency appropriate to the intended use being selected by variation of the powder/liquid ratio, according to the manufacturer's instructions. The particle size of the powder is much smaller than that of the manufacturer's glass-ionomer filling material (Aspa). The liquid is a co-polymer of polyacrylic acid and little is known of the pulpal responses to such materials as itaconic avid, but the liquids employed in glass-ionomer cements are basically similar to those of the polycarboxylate cements, which have been found to be relatively non-irritant to the dental pulp (Plant, 1970; Barnes and Turner, 1971; Valcke, 1971; Jendresen and Trowbridge, 1972; Tobias *et al,* 1978). The similarity of glass-ionomer and polycarboxylate cements in their biocompatibility has been noted by Bogopolsky (1981).

In selecting control materials certain difficulties were encountered. In some previous studies (Valcke, 1971; Valcke *et al,* 1980a; Valcke *et al,* 1980b), Nobetex******, a commercial, accelerated, reinforced ZOE material was used as a non-irritant negative control. It was found to be more irritant than expected, a finding compatible with that of Brännström and Nyborg (1976). Cavitec********, another commercial ZOE material, w found to be insufficiently durable if used, unprotected, as a control material in monkeys (Valcke *et al,* 1980b). It was decided to revert to the use of unmodified ZOE, as employed by Manley (1936).

*******Bofors, Nobel-Pharma, Bofors, Sweden.
********Kerr Mfg. Co. Michigan, U.S.A.
*********Vivadent, Schaan, Liechtenstein.

Table III: Numbers of teeth (%) showing the presence of 1° or more of odontoblast nuclei displacement, surperficial and deep inflammation and the formation of reparative dentine.

Post-operative time interval	Material	No. of teeth	Odontoblast displacement		Superficial inflammation		Deep Inflammation		Reparative Dentine	
			n	%	n	%	n	%	n	%
	ZOE	14	7	50,0	1	7,1	0	0	0	0
	Super Syntrex	14	6	42,9	5	35,7	2	14,3	0	0
2 days	Reocap-Temp	14	7	50,0	5	35,7	1	7,1	0	0
	ChemBond	13	6	46,2	5	38,5	0	0	0	0
	ZOE	19	0	0		0	0	0	16	84,2
	Super Syntrex	15	0	0	0	0	0	0	12	80,0
28 days	Reocap-Temp	18	0	0	1	5,6	0	0	14	77,8
	Chembond	11	0	0	0	0	0	0	7	63,6
	ZOE	13	0	0	0	0	0	0	13	100,00
	Super Syntrex	15	0	0	0	0	0	0	13	86,7
56 days	Reocap-Temp	15	0	0	0	0	0	0	12	80,0
	Chem-Bond	15	0	0	0	0	0	0	12	80,0

The selection of an irritant positive control material has also presented difficulties. Silicate cement has long been regarded as a very irritant, even lethal, material in relation to the dental pulp (Manley, 1936), but one material, Silicap********* has proved a relatively mild irritant (Plant and Jones, 1976; Valcke *et al*, 1980a; Tobias, Plant and Browne, 1981). Super Syntex appears to be more irritant than Silicap (Tobias *et al,* 1981) and was selected as the positive control.

The test materials, Reocap-Temp and ChemBond are not, under the experimental conditions described, more irritant than the negative control material in 28 and 56 day specimens.

The most striking feature of this investigation was the very small difference between the responses to the 4 materials used. In previous studies conducted at this MRC Dental Research Institute, similar procedures have been employed. It is well recognised that the cutting instruments used in cavity preparation cause pulpal damage and that the cavity toilet procedures are also damaging (Cotton, 1971).

Studies of the pulpal effects of materials are not well standardised as regards cutting and cavity toilet methods. In the present study a new model handpiece, Fine Air 391, was used. It is possible that this instrument causes less pulpal damage than other instruments previously used and hence modifies the pulpal response to test materials. There is, perhaps, a need for an investigation of the influence of different handpieces, with differing arrangements of their coolant systems, on the pulpal rections to cavity preparation.

ACKNOWLEDGEMENTS

The authors wish to express their thanks to the Director and Staff of the National Institute for Virology for making the experimental animals and operating facilities available for this study; to the suppliers of the materials used; and to Mrs J Long for typing the manuscript.

REFERENCES

Barnes, D.S. & Turner, E.P. (1971) Initial response of human pulp to zinc carboxylate cement. *The Journal of the Canadian Dental Association,* **37,** 265-266.

Bogopolsky, S. (1981) Les ciments verre ionomère. *Revenue d'Odonto-Stomatologie, X,* 53-58.

Brånström, M. & Nyborg, H. (1976) Pulp reaction to a temporary zinc oxide/eugenol cement. *The Journal of Prosthetic Dentistry,* **35,** 185-191.

Cotton, W.R. (1971) Pulpal responses to cavity drying. *Journal of Dentistry of Children, XXXVIII,* 85-92.

Council on Dental Materials and Devices of the American Dental Association (1972), Recommended standard practices for biological evaluation of dental materials. *Journal of the American Dental Association,* **84,** 382-387.

Jendresen, M.D. & Trowbridge, H.O. (1972) Biologic and physical properties of a zinc polycarboxylate cement. *The Journal of Prosthetic Dentistry,* **28,** 264-271.

Manley, E.B. (1936) A preliminary investigation into the reaction of the pulp to various filling materials. *British Dental Journal,* **60,** 321-331.

Plant, C.G. (1970) Th: effect of polycarboxylate cement on the dental pulp. *British Dental Journal,* **129,** 424-426.

Plant, C.G. & Jones, D.W. (1976) The damaging effects of restorative materials. *British Dental Journal,* **140,** 373-377; 406-412.

Retief, D.H. & Austin, J.C. (1973) The vervet monkey (*Cercopithecus aethiops*) as an experimental model for pulpal studies. *Jounral of the Dental Association of South Africa,* **28,** 98-103.

Smith, D.C. (1971) A review of the inc polycarboxylate cements. *The Journal of the Canadi 'ental Assocation,* **37,** 1-8.

Stanley, H.R. (1968) Design of a human pulp study. I and II. *Oral Surgery, Oral Medicine and Oral Pathology,* **25,** 633-647; 756-764.

Tobias, R.S., Browne, R.M. & Plant, C.G. (1978) Pulpal response to a glass ionomer cement. *British Dental Journal,* **144,** 345-350.

Tobias, R.S., Plant, C.G. & Browne, R.M. (1981) A comparative pulpal study of the irritant effects of silicate cements. *British Dental Journal,* **150,** 119-124.

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., Cleaton-Jones, P.E., Austin, J.C., Pain. E. & Vieira, E. (1980a) The pulpal response to a direct filling resin without an inorganic filler — Isopast. *Journal of Oral Rehabilitation,* **7,** 1-10.

Valcke, C.F., Cleaton-Jones, P.E., Austin, J.C., Pain. E. & Vieira, E. (1980b) The pulpal response to an experimental luting resin. *Journal of the Dental Association of South Africa.* **35**, 751-756.

Wilson, A.D., Prosser, H.J., Paddon, J.M. & Gilhooley, R.A. (1981) Calcium hydroxide dimer (cal-mer) cements. *(British Dental Journal,* **150,** 351-353.