From: The Norwegian Institute of Dental Research
(Director: Dr. philos. B. NYGAARD ÖSTBY.)

PULP REACTIONS TO RESIN CEMENTS

by
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With the introduction of the resin cements an entirely new material for cementing purposes has been offered to the profession. According to a report issued by A.D.A.'s Council on Dental Research[1] "the resin cements appear to be essentially acrylic resins and are somewhat similar to the direct filling resins. The liquids appear to be largely methyl methacrylate monomer".

The same report emphasizes that, since there is considerable evidence that direct filling resins irritate the pulp, sometimes fatally,[2,3], a bio-assay is needed before a proper evaluation of the usefulness of the resin cements can be made. The Council concludes that it considers these materials to be in a developmental stage and should be used accordingly, viz. as experimental materials.

As a part of an investigation on tissue changes incident to external influences some of the new resin cements were tested. A report on the results will be given here as a contribution to the evaluation of these materials.

MATERIAL AND METHOD

Caulk's Grip Cement, Smith's and Justi's Resin Cements were inserted in experimentally prepared cavities in premolars of individuals 10—14 years of age. The cavity was placed in the

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gingival third of the buccal surface, which was clinically intact in all cases but one. The cavities were prepared with diamond stones and steel burs under a steady stream of lukewarm water. Prior to the insertion of the cement the cavity was sprayed with lukewarm water and dried with cotton and a mild stream of temperated air. Experimentally these methods proved to cause the least reaction in the pulp.

In most cases a small amount of the cement was placed on the exposed dentin in the cavity, whereupon the latter was immediately filled with amalgam in the usual way. This procedure was supposed to result in the forming of a thin film of cement covering the dentin, similar to that formed when an inlay or a crown is fastened. For comparison some cavities were filled entirely with resin cement.

The experimental series comprises 29 teeth and the observation time varied from 2 to 133 days. As some of the brands (Smith's and Justi's) are claimed to possess bactericidal properties, samples from the bottom of the cavities in which these cements had been used, were cultured in various media. After extraction the teeth were decalcified in 5 % nitric acid, embedded in paraffin and cut in serial sections of 5 micron thickness. The sections were stained either with hematoxylin-eosin, iron-hematoxylin (Hansen), Azan or Masson. In each case the sections were first inspected in order to select the one passing through the deepest part of the cavity. The measurement of the distance between cavity bottom and pulp was made along the dentinal tubules.

In examining the pulp changes, however, a "third dimension" evaluation was obtained by registering the findings in all serial sections. This procedure, apparently not employed in previous works on pulp reactions, will presumably give more exact information about the injury.

The main emphasis is laid on cellular reactions, although the changes in the odontoblast layer and in the ground substance of the pulp are considered as well. The accumulation of polymorphonuclear leukocytes, lymphocytes and plasma cells, as well as the proliferation of pre-existing cells are doubtless the main criterion of the noxious influence of implants.

RESULTS AND COMMENTS

In Tables I and II a survey of the experiments and the findings is presented*, and the photomicrographs show sections from some of the teeth filled with resin cements (Figs. 1, 2, 4, 6, 9 and 10) and from control teeth filled with zinc phosphate cement (Fig. 5), cement and amalgam (Fig. 7 top) and with amalgam alone (Fig. 3 and Fig. 7, bottom), as well as with zinc phosphate cement and Texton (Fig. 8).

All the teeth in which resin cement had been inserted showed pathologic changes of various degree in the pulp tissue. In one case observed for two days, the examination revealed a partial necrosis (Fig. 1), in the others aspiration of odontoblasts, accumulations of polymorphonuclear leukocytes, lymphocytes and plasma cells were observed in the area subjacent to the cavity. The neutrophilic leukocytes were most frequent in the short time experiments, and assembled along the pulpo-dentinal membrane in the partially destroyed odontoblast layer (Fig. 2). However, they were also found in cases with an observation time up to 44 days, denoting the presence of an irritant (Fig. 6)[4].

With increasing observation time a destruction of the ground substance and the fibrils in an area of the pulp tissue was observed. This area was of varying extent, fluid filled and infiltrated with masses of inflammatory cells (Figs. 4, 6, 9 and 10). These phenomena, together with proliferation of the fixed cells, indicate the establishment of a chronic inflammation, from which no resolution is to be expected[4].

A study of Table I reveals a correlation between the depth of the cavity and the severity of the reactions. Only the cases S.G.'s +4 and S.G.'s 4+ show an inverse correlation, and the explanation may be that the experimental area in case S.G.'s +4 had been carious prior to cavity preparation (Fig. 6).

Subjacent to the cavities filled with cements there was a more

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* In the tables the following abbreviations are employed: leuk. for polymorphonuclear leukocytes, pl. for plasma cells, ly. for lymphocytes and pr. for proliferating cells.

The degree of the cellular infiltration is indicated by varying numbers of +: + occasional, ++ small concentration, +++ larger accumulation, can be followed through several sections, ++++ still larger accumulation, can be followed through all sections. R. A. stands for reticular athrophy.

Table 1

Resin-Cements

Case	Tooth	Days of obs.	Bact. growth	Cavity – pulp in mm	Filling material	Inflam. cells		Fig. No.
						leuk.	pl., ly., pr.	
B. N.	4+	2	neg.	1.1	Smith's & am.	+++	+++	1
S. E.	4+	2	neg.	1.9	Caulk's & am.		+ (+)	
T. H.	4+	2	pos.	1.5	Caulk's & am.	+	+	
T. H.	4—	2	neg.	1.9	Caulk's & am.	+++	++	
A. I.	4+	5	pos.	1—2.5	Smith's & am.		++	
A. I.	4—	5	pos.	2.5	Smith's & am.		+++	
S. F.	+5	5	pos.	2.0	Smith's & am.	+++	+++	2
T. H.	+4	7	pos.	0.9	Caulk's	++	++	
T. H.	—4	7	pos.	1.6	Caulk's & am.		+	
B. C.	4+	7		1.4	Justi's & am.	+	++	
J. H.	4+	7		2.1	Justi's & am.	+++	+++	
S. A.	4+	9		1.8	Justi's & am.	++	++	
R. K.	4+	12	pos.	1.6	Smith's & am.	++	+++	
H. W.	+4	26	neg.	1.9	Caulk's & am.		++	
U. H.	+4	28	neg.	1.5	Caulk's & am.	+	++	
S. F.	5+	29	pos.	0.4	Smith's & am.	+++	+++	
S. J.	+4	33	pos.	1.0	Caulk's & am.	+	+++	4
T. O.	+4	35		2.4	Justi's		+++	
T. O.	—4	35		2.6	Justi's & am.		++	
S. A,	+4	37		2.0	Justi's & am.		R. A.	
B. H.	4+	42	pos.	0.9	Smith's		+++	
S. G.	+4	44		1.3	Justi's & am.	+	++++	6
S. G.	4+	44		0.7	Justi's & am.		++	
R. T.	+4	46	pos.	2.4	Smith's & am.		++	
E. A.	4—	47		1.0	Smith's & am.		++	
E. J.	+4	126	pos.	2.4	Justi's & am.		++	
E. J.	4+	126	pos.	1.6	Justi's		++++	9
B. B.	4—	133	pos.	1.6	Smith's & am.		+++	10

severe reaction than in cases where amalgam had been packed onto the cement. This may be ascribed both to the fact that the former contained more of the irritating substance and to the circumstance that the resin cements constitute a poor sealing on account of their physical properties[1].

The table shows that the bactericidal ability which Smith's and Justi's cements are proved to possess in vitro, deteriorates

Table 2

Control-Cases

Case	Tooth	Days of obs.	Cavity – pulp in mm	Filling material	Inflam. cells		Fig. No.
					leuk.	pl., ly., pr.	
A.L.H.	+5	5	1.8	Amalgam			3
U. H.	4—	26	1.6	De Trey's Cement...			5
R. K.	4—	63	2.1	Amalgam		+	7 bottom
R. K.	—4	63	2.3	De Trey's Cement & amalgam.....		+	7 top
R. K.	+4	63	2.4	De Trey's Cement & Texton	++	++++	8

in a short time in the tooth. It is possible, of course, that the growth in some cases was due to contamination. However, every effort was made to avoid contamination and the technique was the same in all cases. It should be mentioned, too, that the samples consisted of powder removed from the bottom of the cavity by means of a round bur. Consequently the samples were mixtures of dentin and resin cement, and one would have expected an inhibition of growth in the case of contamination, if the resin cement had been bactericidal.

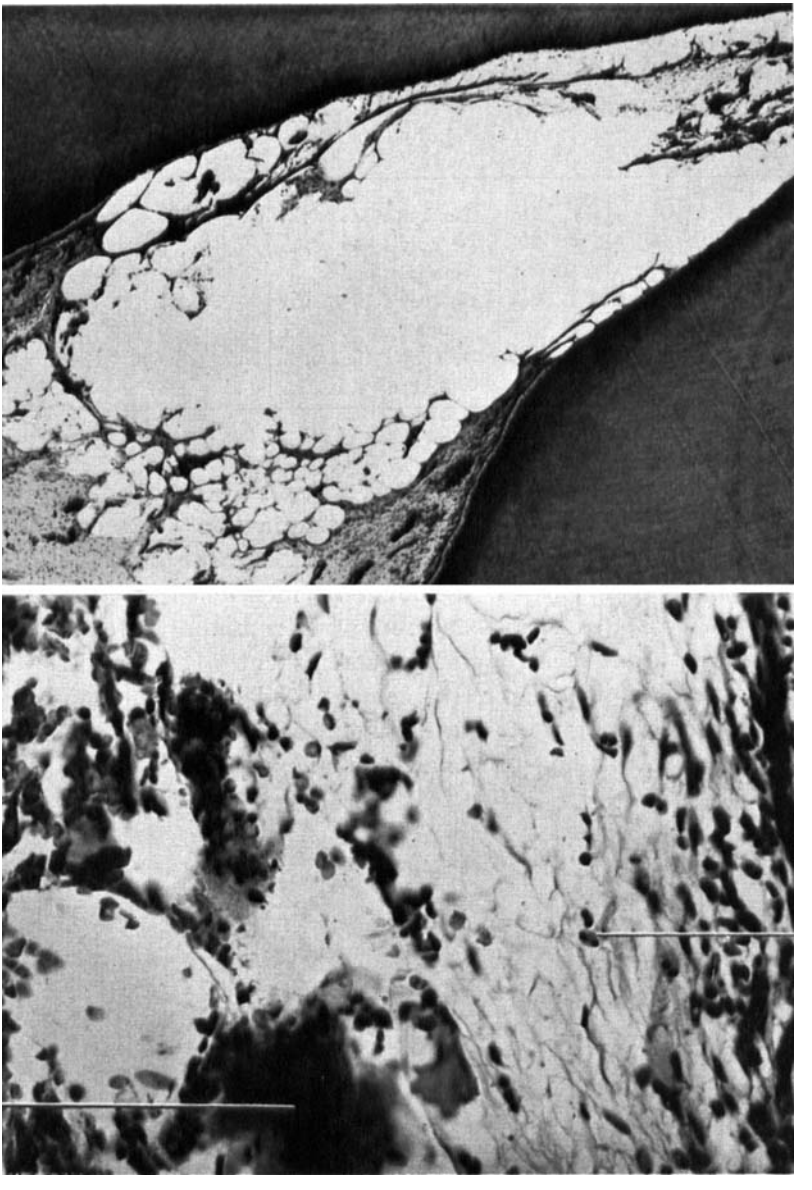

Fig. 1. Section from B.N.'s 4+. Smith's Resin Cement and amalgam. Observation time two days. Distance of cavity floor from pulp 1.1 mm.

Top: Necrotic pulp horn subjacent to cavity.

Bottom: Necrotic tissue bordering the destroyed part. Polymorphonuclear leukocytes and aggregated erythrocytes, fluid accumulation in the tissue.

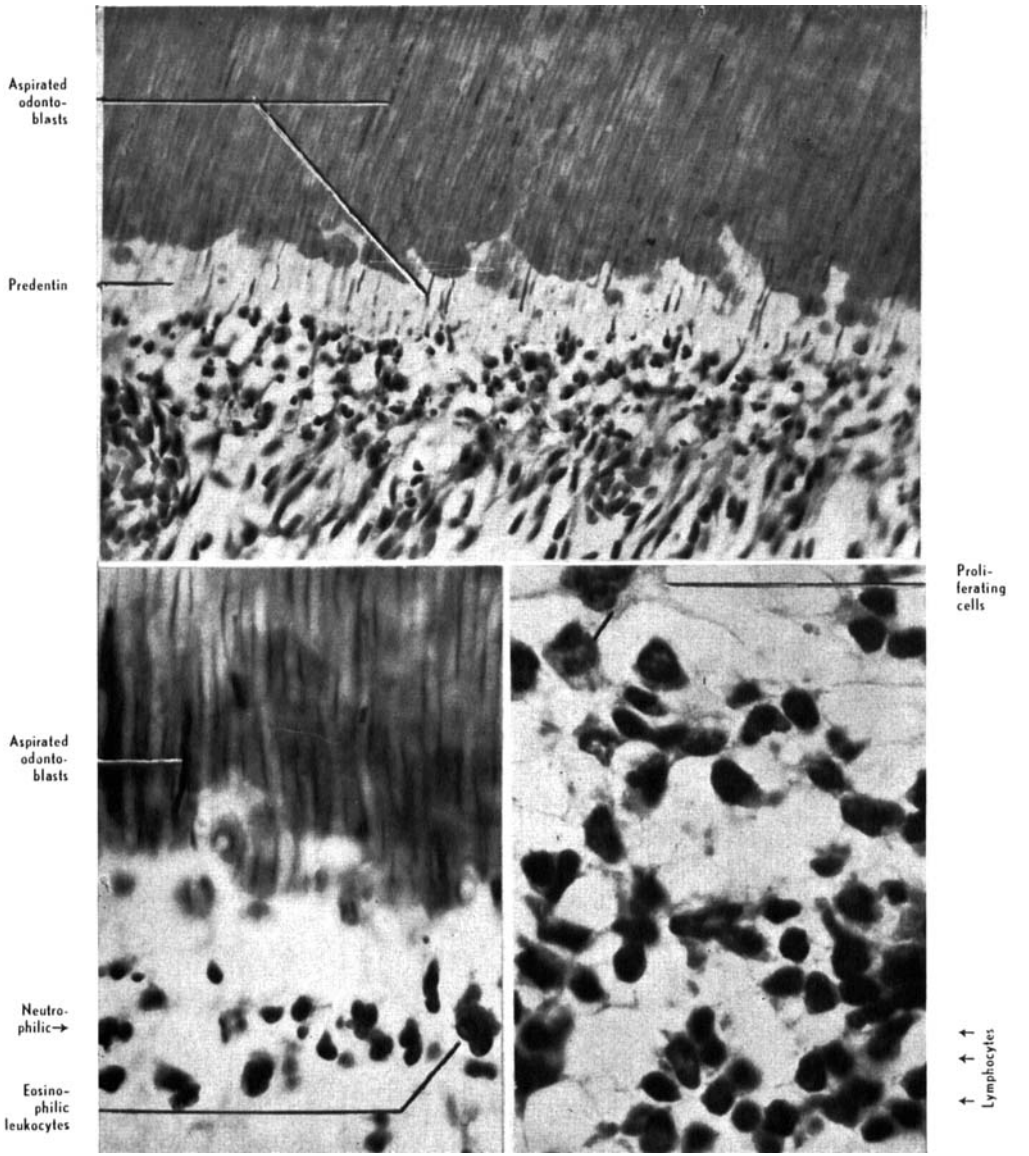

Fig. 2. Section from S.F.'s +5. Smith's Resin Cement and amalgam. Observation time five days. Distance of cavity floor from pulp 2 mm.

Top: "Aspirated odontoblasts" in the dentinal tubules, polymorphonuclear leukocytes along predentin zone, dilated capillaries filled with erythrocytes in the odontoblast layer.

Bottom left: Detail of section shown in top picture. Odontoblasts in some tubules, neutrophilic and eosinophilic leukocytes.

Bottom right: Detail from a more central part of the pulp. Fluid filled spaces in ground substance, lymphocytes and proliferating cells.

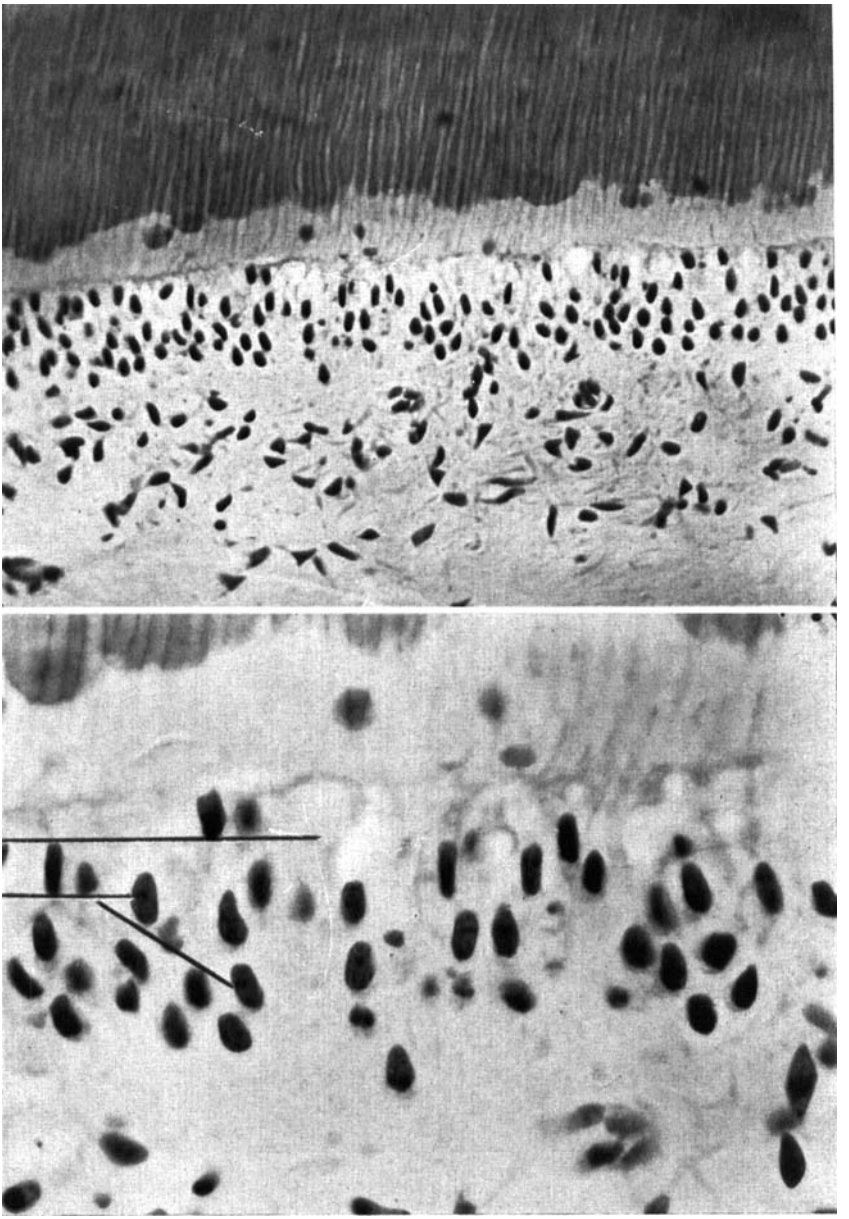

Fig. 3. Control case. Cavity filled with amalgam only. Observation time five days. Distance of cavity floor from pulp 1.8 mm.

Top: Detail of dentin and pulp subjacent to cavity. Normal conditions.

Bottom: High magnification from same area. Vacuoles between the odontoblasts and nucleoli in the odontoblast nuclei. (Similar observations frequently made in intact pulps).

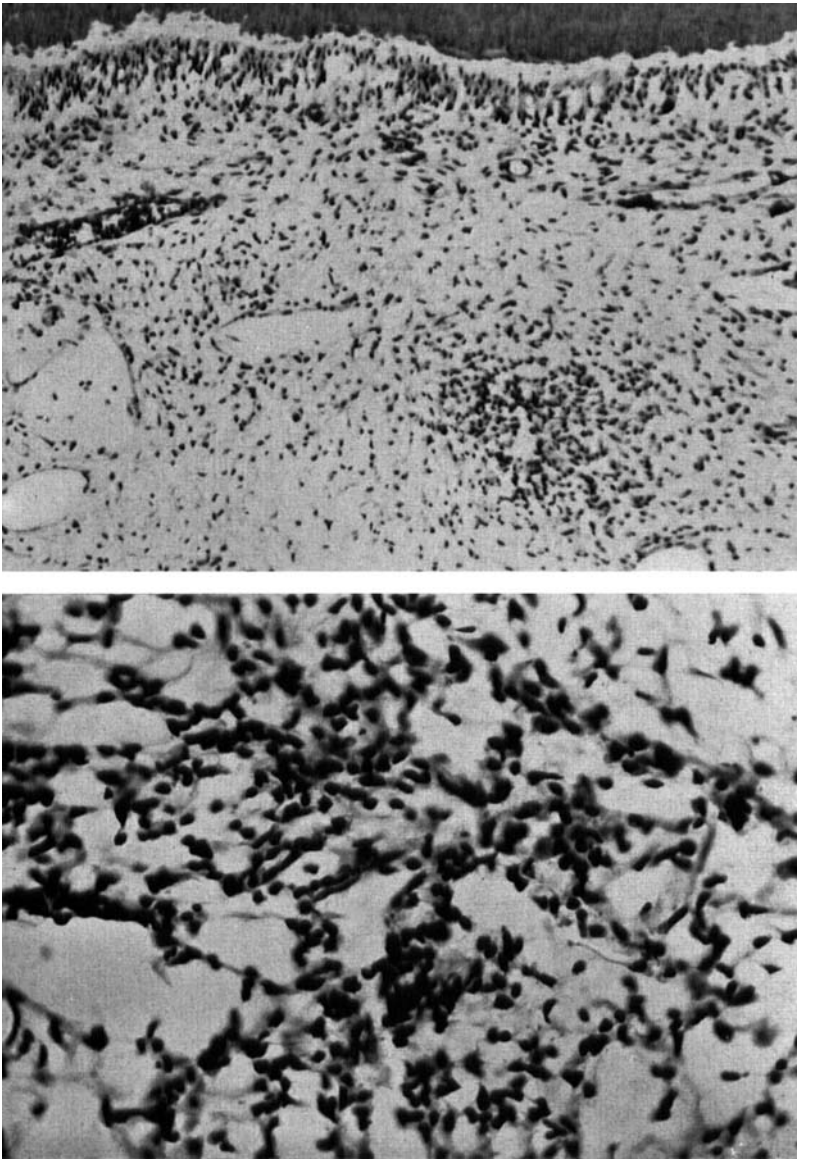

Fig. 4. Section from S.J.'s +4. Caulk's Grip Cement and amalgam. Observation time 33 days. Distance of cavity floor from pulp 1 mm.

Top: Inflammation area in pulp tissue.

Bottom: High magnification of same area. Spaces in the ground substance filled with fluid and inflammatory cells.

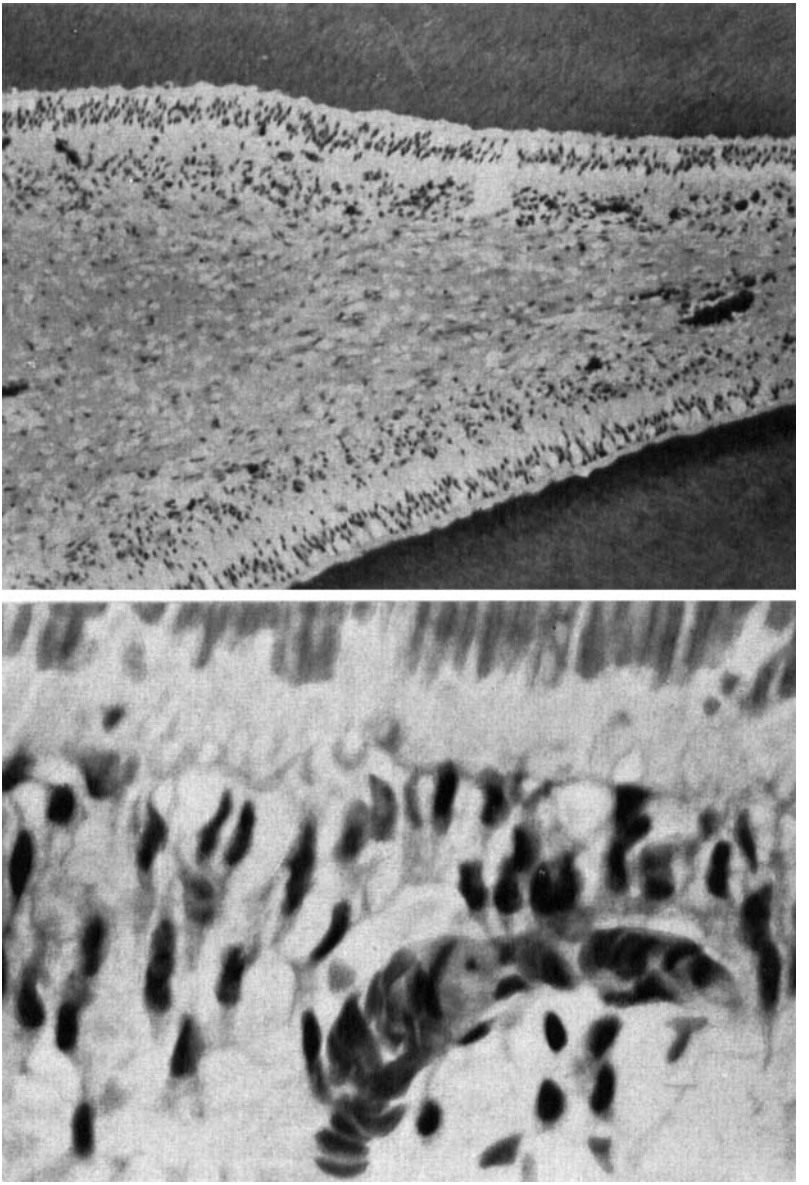

Fig. 5. Control case. The entire cavity filled with soft mix of DeTrey's Cement Improved. Observation time 26 days. Distance of cavity floor from pulp 1.6 mm.

Top: Detail of area subjacent to cavity.

Bottom: High magnification. Normal conditions, perhaps with the exception of a capillary filled with erythrocytes between the odontoblasts.

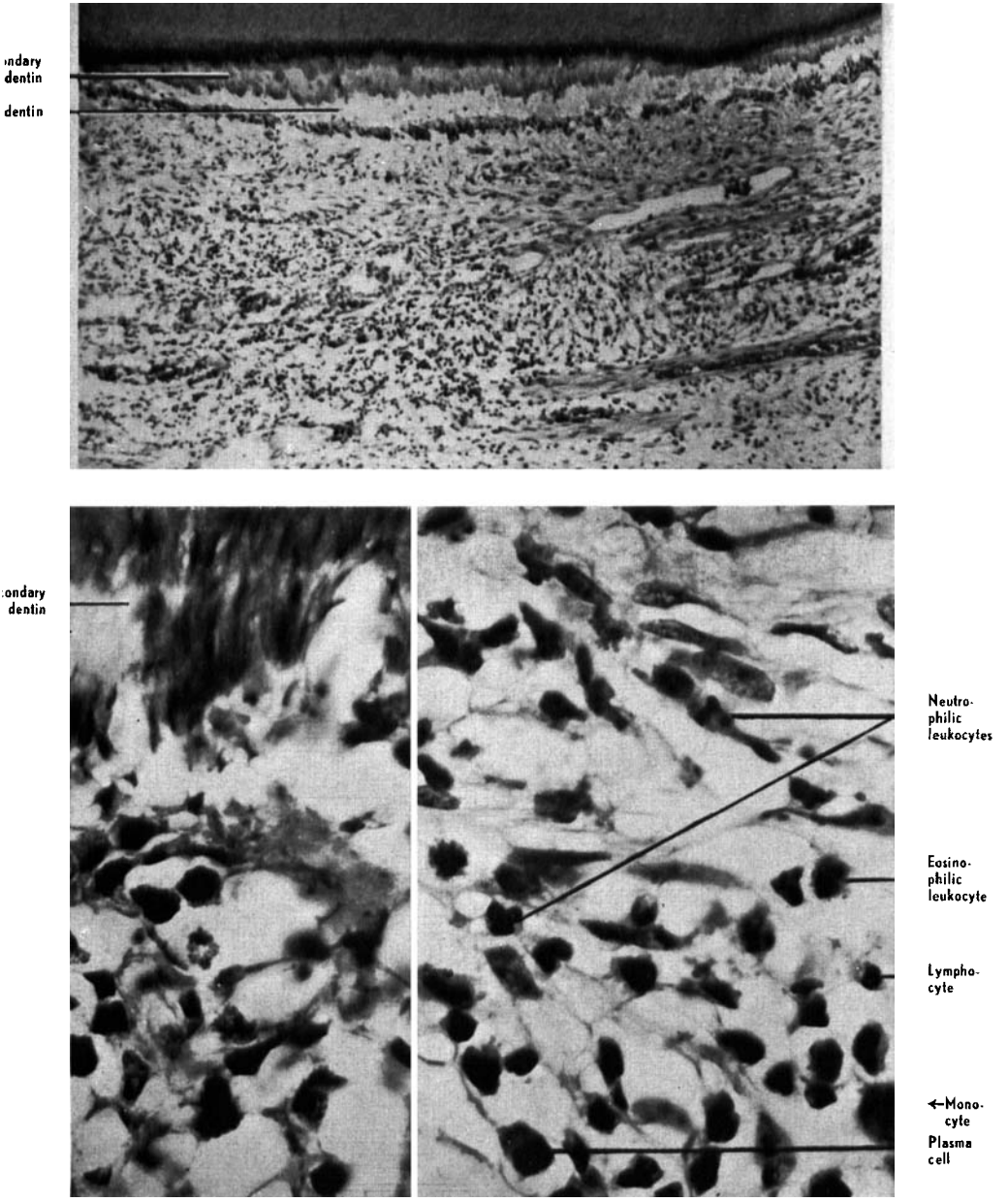

Fig. 6. Section from S.G.'s +4. Dentin caries. Justi's Cement and amalgam. Observation time 44 days. Distance of cavity floor from pulp 1.3 mm.

Top: Zone of secondary dentin subjacent to cavity. Reduced odontoblast layer along a rather wide predentin zone. Extensive area of damaged pulp tissue with masses of inflammatory cells.

Bottom left: Detail of the secondary dentin and adjacent pulp tissue. Irregularity of dentin formation and abnormal cell forms.

Bottom right: Several cell types in damaged area of pulp: a monocyte, lymphocytes, plasma cells, occasionally neutrophilic leukocytes and proliferating fixed cells. (Reactive dentin formation caused by caries has obviously not protected the pulp).

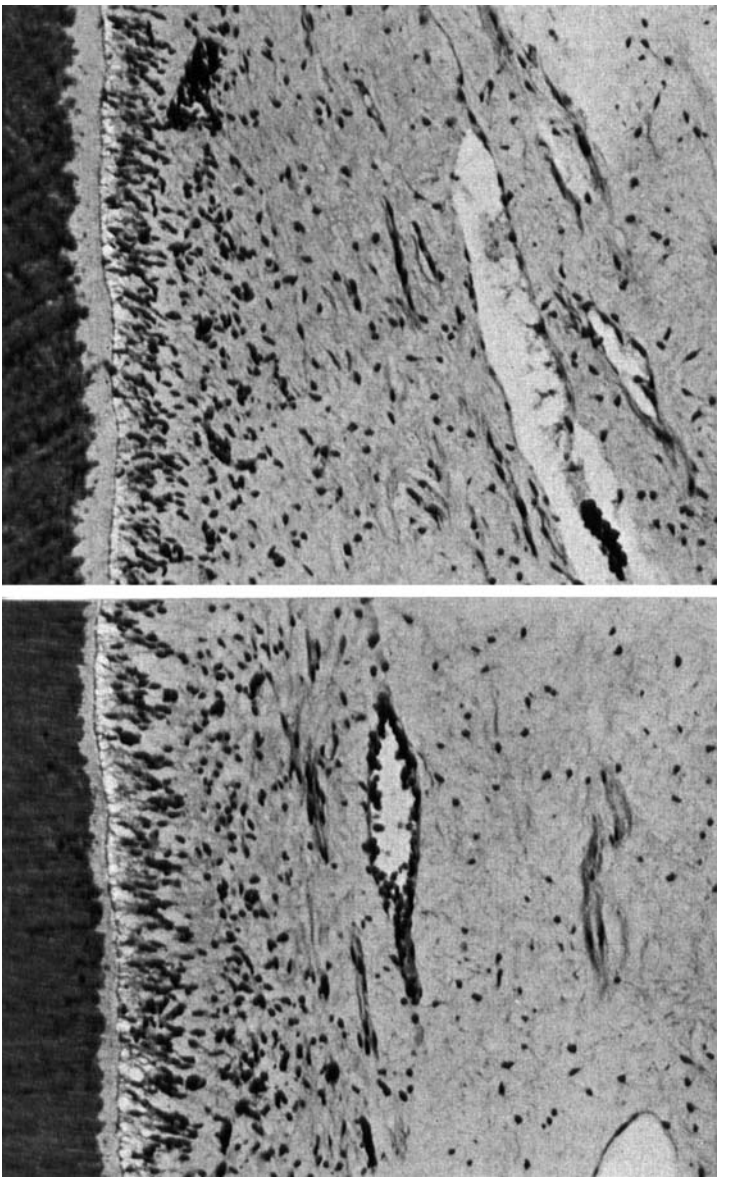

Fig. 7. Sections from two control teeth in the same individual.
Top: DeTrey's Cement Improved and amalgam. Observation time 63 days. Distance of cavity floor from pulp 2.3 mm. No changes in the pulp.
Bottom: Amalgam. Observation time 63 days. Distance of cavity floor from pulp 2.1 mm. Normal conditions in the pulp.

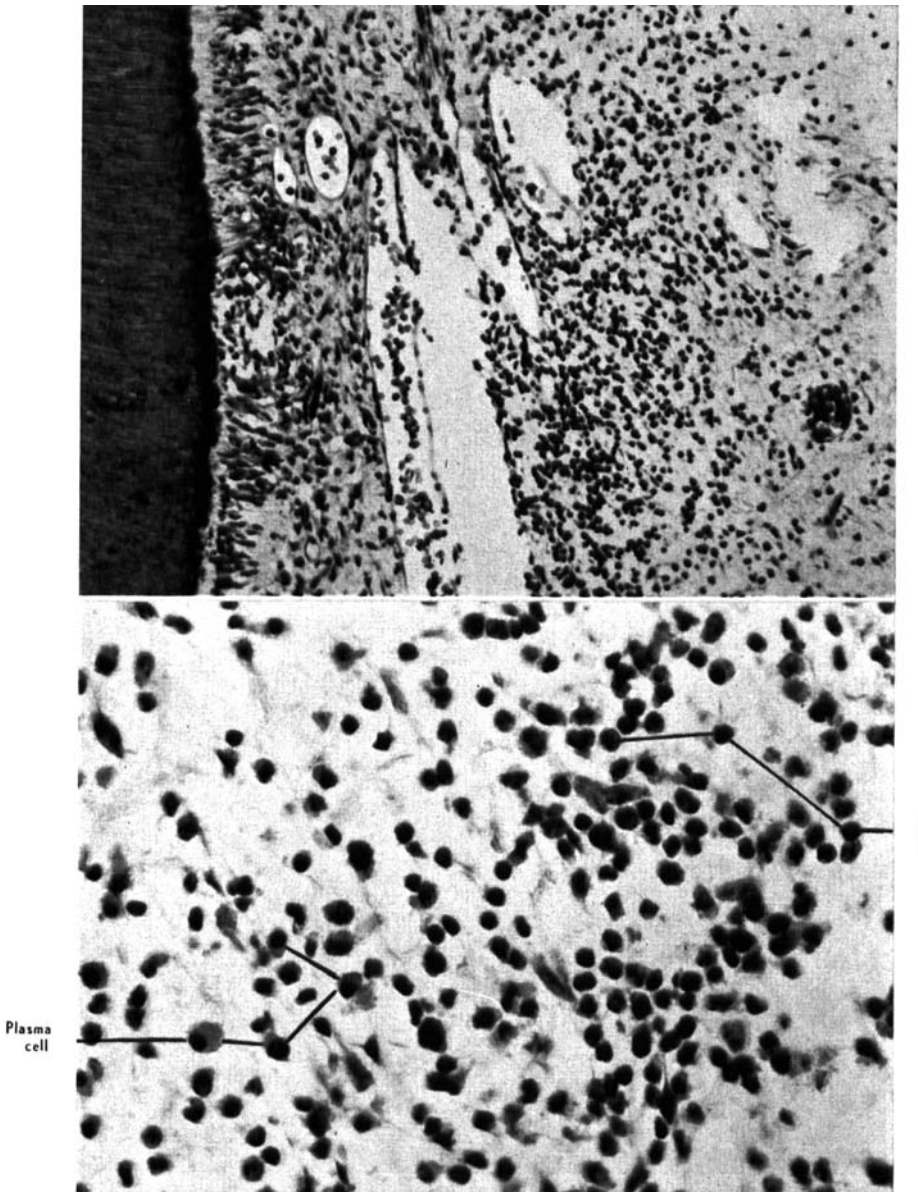

Fig. 8. Section of another tooth from the same individual as shown in Fig. 7. DeTrey's Cement Improved and Texton. Observation time 63 days. Distance of cavity floor from pulp 2.4 mm.

Top: Pulp injury subjacent to cavity. Odontoblasts partially destroyed. Dilated vessels and masses of inflammatory cells in the pulp tissue.

Bottom: Detail of damaged area. Conspicuous abundance of plasma cells and many lymphocytes in the fluid filled tissue.

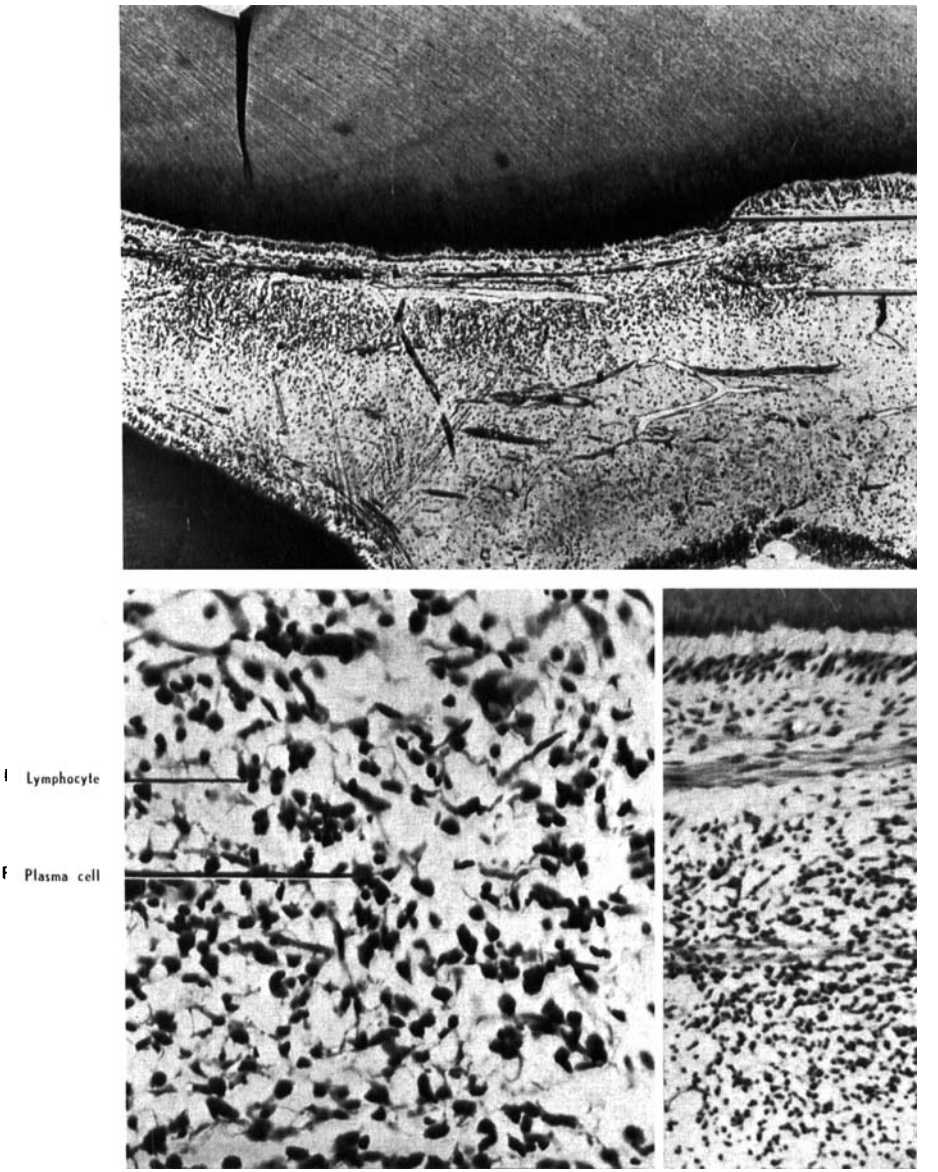

Fig. 9. Section from E.J.'s 4+. Justi's Resin Cement. The entire cavity filled. Observation time 126 days. Distance of cavity floor from pulp 1.6 mm.

Top: Section of pulp horn subjacent to cavity. Irregular dentin formation below cavity. In corresponding pulp tissue round cell infiltration.

Bottom right: Section of same part of pulp showing concentration of round cells.

Bottom left: Section of inflamed tissue. Fluid accumulation, lymphocytes and plasma cells.

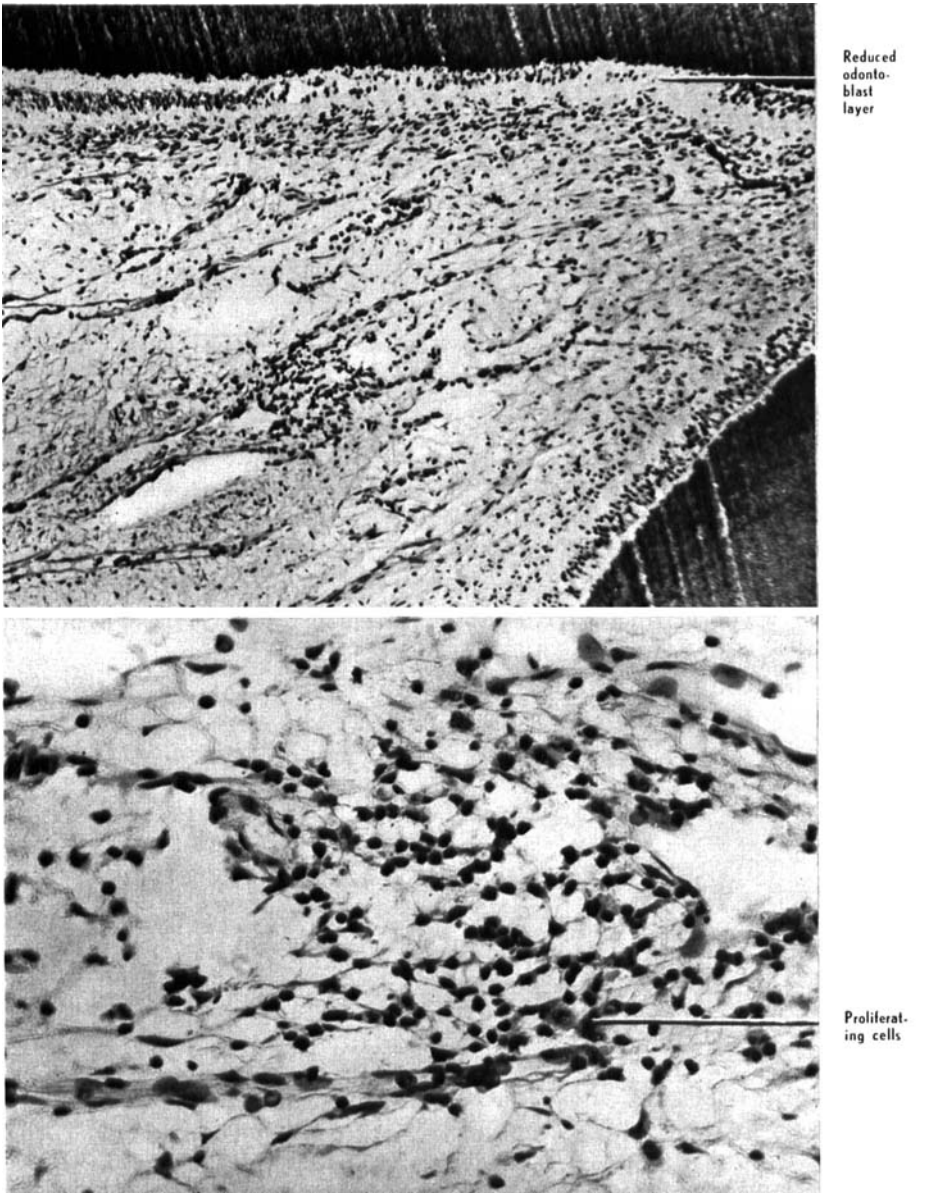

Fig. 10. Section from B.B.'s 4--. Smith's Resin Cement and amalgam. Observation time 133 days. Distance of cavity floor from pulp 1.6 mm.

Top: Inflamed pulp tissue subjacent to cavity. Reduced odontoblast layer, fluid accumulation and round cell infiltration.

Bottom: High magnification. Spaces in the ground substance filled with fluid, lymphocytes and proliferating cells.

SUMMARY AND CONCLUSIONS

Three kinds of resin cements, Caulk's Grip cement, Smith's Resin Cement and Justi's Resin Cement, were tested experimentally in 29 teeth of children in order to determine whether or not these materials are harmful to the pulp.

Two brands, Smith's and Justi's, were also tested as to their claimed bactericidal properties.

The time of observation varied from 2 to 133 days. The findings led to the following conclusions:

1. All three cements tested caused pathologic changes in the pulp tissue.

2. The nature of these changes suggests that they are irreversible.

3. Considering the limited area of dentin exposed to the influence of the cement in these experiments, a far more extensive and severe reaction in the pulp tissue may be expected when inlays and crowns are fastened with these resin cements.

4. The claim that resin cements have a bactericidal action in vivo is not sustained by this investigation.

5. The irritating effect of resin cements on the pulp seems to be somewhat similar to that of direct filling resins.

RÉSUMÉ ET CONCLUSIONS

EFFET DES CIMENTS RÉSINEUX SUR LA PULPE

Trois espèces de ciments résineux, Caulk's Grip Cement, Smith's Resin Cement et Justi's Resin Cement, ont été expérimentalement éprouvés sur 29 dents d'enfant pour déterminer si ces materiaux étaient nuisibles à la pulpe.

Deux d'entre eux, ceux de Smith et de Justi, ont aussi été éprouvés quant à leurs prétendues propriétés bactéricides.

Le temps d'observation a varié entre 2 et 133 jours. Les résultats observés ont amené aux conclusions suivantes:

1. Les trois ciments éprouvés ont causé des changements pathologiques dans le tissu pulpaire.

2. La nature de ces changements suggèrent qu'ils sont irréversibles.

3. Etant donnée l'étendue limitée de dentine exposée à l'influence du ciment dans ces expériences, on doit s'attendre à une réaction beaucoup plus vaste et sévère dans le tissu pulpaire, quand des inlays et des couronnes sont scellés avec ces ciments résineux.

4. L'assertion que les ciments résineux ont un effet bactéricide in vivo n'est pas confirmée par cette investigation.

5. L'effet irritant des ciments résineux sur la pulpe paraît ressembler quelque peu à celui des obturations en acryle.

ZUSAMMENFASSUNG UND SCHLUSSFOLGERUNGEN

PULPAREAKTIONEN AUF RESIN ZEMENTE

Drei Resin Zemente, Caulk's Grip Cement, Smith's Resin Cement und Justi's Resin Cement, wurden experimentell in 29 Kinderprämolaren geprüft, um zu entscheiden, ob diese Materialien etwa einige schädigende Wirkung auf die Pulpa ausüben.

Zwei von den Zementen, Smith's und Justi's, welche eine baktericide Wirkung besitzen sollen, wurden auch auf diese Eigenschaft untersucht.

Die Versuchszeit dauerte von 2 bis 133 Tagen. Die erhobenen Befunde liessen den folgenden Schlussfolgerungen zu:

1. Alle drei Zemente verursachten pathologische Veränderungen im Pulpagewebe.

2. Der Charakter der Veränderungen deutete auf eine irreversible Schädigung.

3. Wenn man in Betracht zieht, dass der Teil des Dentins, der der Einwirkung dieser Zemente in diesen Experimenten ausgesetzt wurde, äusserst begrenzt war, darf man eine viel ausgedehntere und ernsthaftere Reaktion seitens der Pulpa erwarten, wenn Inlays und Kronen mit diesen Zementen zementiert werden.

4. Die Behauptung, dass die Resin Zemente eine bakterietötende Wirkung im Zahn haben, wurde durch diese Untersuchungen nicht bestätigt.

5. Die Resin Zemente scheinen ähnliche schädigende Wirkung zu besitzen wie die der selbstpolymerisierenden Kunstharze, die als Füllungsmaterialien verwendet werden.

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