LINING MATERIAL WITH SPECIAL REFERENCE TO DROPSIN

A comparative study by C.G. Plant, B.D.S, F.D.S and M. J. Tyas, B.D.S

The pH of Dropsin and three other cavity lining materials was measured. The histological effects on the pulp of Dropsin and two of these materials is described and compared. There was no direct correlation between the pH of the materials during setting and the changes they caused in the pulp. Water absorption by a setting lining material as a possible cause of pulpal damage.

A survey was undertaken of 1,000 dental practitioners throughout the United Kingdom. This showed that Dropsin was widely used, being the fifth most popular lining material. 16.3 % of 686 dentists, who replied to the survey, stated that they used Dropsin as a cavity liner. Despite this wide use there are no reports in the literature about the material or its effect on the dental pulp.

Dropsin cavity lining material is marketed by Harald Nordin SA (Chailly/Switzerland). The manufacturer state that the material has a neutral pH 1_ minutes after mixing and is, therefore, harmless to the dental tissues.

The purpose of this work was twofold: first, to investigate the pH of Dropsin whilst it was setting; secondly, to observe any effects it might have on the pulp and to investigate any correlation of these effects with the pH.

Composition

The manufacturer would not divulge the exact composition of Dropsin but they indicated that the constituents were:

Liquid — Phosphoric acid-25 %
Aluminium hxdroxide-8%
Distilled water-67%

Powder — Zinc oxide
Calcium hydroxide
Magnesium oxide
Aluminium hydroxide

(I)pH of Dropsin during Setting

The object of the first part of this work was to establish the pH of Dropsin immediately after mixing and to record the changes in the pH during the ensuing 24 hours. For purposes of comparison the pH changes of three other lining materials were also recorded over the same period of time. The other lining materials used were S.S. White cavity lining, S.S. whit zinc phosphate cement and zinc oxide/eugenol (B.P.)

Materials and Method

The pH of Dropsin and the three materials listed above were measured by using a glass electrode with a calomel reference electrode inserted into the setting material on a glass stab. A Dynacap (Pye) pH meter was the instrument used in these measurements, with both electrodes and material enclosed in a humidity oven at 37°C.

Moisture or fluid from two sources may affect a lining material whilst it is in the mouth. The first is the moisture in the air in the oral cavity and this can be simulated in vitro by using a humidity oven. The second source of moisture, that from vital dentine, cannot be simulated in vitro. Neither was it possible, with the equipment available, to measure the pH of lining material in vivo on vital dentine. As the passage of fluid from non-vital dentine to lining material is artificial, it was decided to provide the maximum amount of moisture by surrounding the setting material with air with as high a relative humidity as possible.

This was achieved by placing the setting material in a humidity oven at 37+-1°C with distilled water thus providing a relative humidity of 87+-5 %. The pH was measured over a period of 24 hours, each material being tested three times. Before each test the electrodes were cleaned, washed and buffered using standard buffer solutions; at the end of each test the validity of the pH measurements were checked with a standard buffer solution.

A standardized powder/liquid ratio and mixing time was used for each material to determine the standard powder/liquid ratio and mixing time several trial mixes were made. Due attention was paid to the manufacturers general instructions regarding the consistency of each material. The powder/liquid ratio of the mix giving the consistency most suitable for the standard. These ratios and mixing times, as given below were used throughout all the investigation.

Results

Figure 1 shows the pH during setting of the four materials tested in 87 % relative humidity at 37°C. The first pH measurement for each material was made at the first full minute after mixing. Because the mixing time for each material was different this made the time from the start of the mix to the first pH measurement vary according to the material used.

Fig. 1. Variation of pH with time for lining materials.

Dropsin: at 1 minute after the start of mixing, the pH of Dropsin was 2.2. A pH of 4 was reached after 9 minutes and after 24 hours the pH was 6.8.

SS White cavity lining: 2 minutes after the start of mixing the pH was 4.5. it then rose sharply to pH 6.4 at 5 minutes then fell to the region of pH 5. At 30 minutes the pH began to rise and reached pH 6.8 at 24 hours.

Zinc phosphate cement: a pH of 1.7 was recorded at 2 minutes. The pH rose gradually but did not reach pH4 for 1 hour. Thereafter the pH rose steadily to rach 6.4 at 24 hours.

Zinc oxide/eugenol: the pH fell from 5.8 at 5 minutes to 5.1 at 7 minutes and maintained this level until 1 hour. From this time the pH rose gradually to reach 6.6 at 24 hours.

These results apply to one batch of material in each case; different batches were not evaluated.

Discussion

The pH values of the four materials were very similar after 24 hours, and were in the range of 6 to 7. in the first 10 minutes, however, two distinct pairs of material were seen.

Powder/Liquid Ratio and Mixing time for materials used

Material	Manufacturer	P/L ratio	Mixing time
Dropsin	Nordin SA, Switzerland	2/1	0.5
S.S. White cavity lining	SS White (GB)	3/1	1.5
Zinc phosphate cement	"	1.5/1	1.5
Zinc oxide/eugenol	"	5/1	4

(1)SS White cavity lining and zinc oxide/eugenol, having almost identical pH in the 5 and 6 region..
(2)Dropsin and zinc phosphate which have a much more acid reaction of between pH 1.6 and 4.4.
If the hydrogen ion concentration is a major factor in causing pulpal damage it would be reasonable to assume from the above results that:
(1)SS White cavity lining and zinc oxide/eugenol would cause similar charges in the pulp and that these would be relatively mild.
(2)Dropsin and zinc phosphate, because of their early acidity, would cause more severe changes. The changes due to Dropsin, however, should be less severe, particularly if the pulp only undergoes marked change when the hydrogen ion concentration remains high for more than a few minutes.

(II) Effect of Dropsin in the Pulp
The main aim of this section was to establish the histological response of the pulp to Dropsin when this material is used as a cavity lining. A further aim was to attempt to correlate this histological response with the pH of Dropsin.
For purposes of comparison and to act as controls, SS White cavity lining and zinc oxide/eugenol were also used to obtain a histological response. As with Dropsin these results were compared with results of the pH determinations.

Materials and Method
Fifty-five sound teeth, which were to be extracted for orthodontic purposes, were used in this experiment. Occlusal or buccal cavities were cut in 51 of these teeth using tungsten-carbide burs, round No 5 and flat fissure no 558. A ball-bearing Kavo handpiece was used, running at a speed of 30.000 rpm throughout cavity preparation, which was achieved by intermittent cutting (5 to 10 seconds cutting periods) using a light pressure. The aim was to cut well into dentine with the floor of the cavity placed as near to the pulp as possible without explosing. Cotton-wool pledges were used to dry the cavity as use of a air syringe has been shown to cause pulpal changes (Bränström 1960).
When the cavities were completed they were treated by one of the methods shown below. After extraction the apical third of the root was removed by means of a hand saw and the tooth placed into 10 % neutral buffered formalin.
The teeth were decalcified and serial sections prepared through the cavity site where the minimum thickness of dentine between cavity floor and pulp remained. Sections were stained with haematoxylin and eosin.
The sections were examined for the features listed in the tables; reduction in odontoblasts, vacuolisation in the odontoblast layer, aspiration of odontoblasts, hyperaemia, vacuoles I the pulp and inflammatory cells in the odontoblast layer.
An arbitrary scale for degrees of change was used, 0=no change, 1=mild, 2=moderate, 3=severe. All slides carried one number only, so that there was no indication of the material used in the cavity. The examinations were carried out by one person so that the arbitrary scale of change was applied consistently.

Grouping of Teeth
(1) *Dropsin lining-29 teeth.*
A creamy mix of Dropsin was used to build up a lining of normal thickness. Care was taken to cover all exposed dentine on the cavity floor. The lining was allowed to set fully until it was hard to a probe and was then covered with amalgam or zinc oxide/eugenol.
The teeth were extracted fro 3 to 175 days after the procedure.
(2)*Controls-26 teeth.*
(a)Cavities in 18 of the control teeth were completely filled with either SS White cavity lining material or zinc oxide/eugenol dressing.
SS White cavity lining was placed in 8 cavities and zinc oxide/eugenol dressing in 10.
The teeth were extracted from 3 to 77 days after cavity preparation.
(b)Four control teeth were extracted immediately after cavity preparation in order to study any histological changes caused by this procedure.
(c)Four sound teeth were also collected during this series to form unoperated controls.

Results
Results of histological examination showed that no extensive damage was suffered by the pulp with any of the material used in this survey.
Only one tooth showed evidence of inflammation-this being with the control material SS White cavity lining, where a mild degree of inflammation of the odontoblast layer was seen.
Very small isolated areas of inflammatory cells were seen in the body of the pulp in three sections. These were well away from the zone of tubules cut during cavity preparation and their presence is thought to be unrelated to this procedure. Similar focal collections of inflammatory cells have been reported by Shovelton and Marsland(1960) beneath cavities prepared with an air turbine handpiece.

Table II shows that Dropsin caused a small degree of change in the pulp, mainly in the form of a mild reduction I odontoblasts. The control materials, SS White cavity lining and zinc oxide/eugenol if considered as a single group (Table III), caused a more marked change than Dropsin. In 7 of the 18 teeth a moderate or severe reduction in odontoblasts took place whereas with Dropsin only 4 out of 29 teeth suffered similar effects.

In tables IV and V, the controls are subdivided into a group of zinc oxide/eugenol. From this it can be seen that SS White cavity lining was the material mainly responsible for the changes shown in the control group as a whole. 6 out of 8 teeth filled with SS White cavity lining showed moderate to severe reduction in odontoblasts. The results for zinc oxide/eugenol (Table V) confirm its bland nature as reported by Gurley and Van Huxsen (1940) and others.

The results obtained from control cavities which were unfilled (Table VI) showed a mild to moderate degree of vacuolisation in the odontoblasts in 3 out of 4 teeth used. This vacuolisation is also seen in the experimental cavities although for some reason it is less in cavities lined with Dropsin, occurring in only 3 cases out of 29.

Table II. Effect of Dropsin on the pulp (number of teeth showing changes)

Total teeth in group	29	Reduction in odontoblast	Vacuolisation of odontoblast	Aspiration of odontoblast	Hyperoemia	Vacuoles in pulp	Inflammatory cells in odontoblast layer
Number showing normal appearance	8						
Degree of change	0	11	26	25	27	28	29
	1	14	1	3	1	1	0
	2	3	1	1	1	0	0
	3	1	1	0	0	0	0

Table III. Effect of control materials S.S. White Cavity Lining and Zinc Oxide/Eugenol on the pulp

Total teeth in group	18	Reduction in odontoblast	Vacuolisation of odontoblast	Aspiration of odontoblast	Hyperoemia	Vacuoles in pulp	Inflammatory cells in odontoblast layer
Number showing normal appearance	7						
Degree of change	0	11	13	16	15	18	17
	1	0	3	1	3	0	1
	2	3	2	1	0	0	0
	3	4	0	0	0	0	0

Table IV, Effects of S.S. White Cavity Lining on the pulp (number of teeth showing changes)

Total teeth in group	8	Reduction in odontoblast	Vacuolisation of odontoblast	Aspiration of odontoblast	Hyperoemia	Vacuoles in pulp	Inflammatory cells in odontoblast layer
Number showing normal appearance	1						
Degree of change	0	2	5	6	6	8	7
	1	0	1	1	2	0	1
	2	3	2	1	0	0	0
	3	3	0	0	0	0	0

Table V, Effects of Zinc Oxide/Eugenol on the pulp (number of teeth showing changes)

Total teeth in group	10	Reduction in odontoblast	Vacuolisation of odontoblast	Aspiration of odontoblast	Hyperoemia	Vacuoles in pulp	Inflammatory cells in odontoblast layer
Number showing normal appearance	6						
Degree of change	0	9	8	10	9	10	10
	1	0	2	0	1	0	1
	2	0	0	0	0	0	0
	3	1	0	0	0	0	0

Table VI, Effects of Cavity Preparation on the pulp (number of teeth showing changes)

Total teeth in group	4	Reduction in odontoblast	Vacuolisation of odontoblast	Aspiration of odontoblast	Hyperoemia	Vacuoles in pulp	Inflammatory cells in odontoblast layer
Number showing normal appearance	1						
Degree of change	0	3	1	4	4	4	4
	1	1	1	0	0	0	0
	2	0	2	0	0	0	0
	3	0	0	0	0	0	0

Discussion

There is considerable difficulty in measuring the pH of setting materials and for most of the time the lining materials were in the set state when measurement was required. It is generally considered that measurements of pH should be made in solution, but the electrodes used in this experiment are also recommended for semi-solids. An alternative means of measuring the pH of cavity lining is the indirect method in which the set material is crushed and dissolved in distilled water and the pH of the resulting solution determined. Hearvey et al. (1944) utilised this method of pH determination but pointed out its limitation. Whilst that method gives a true pH of the resulting solution it does not bear a direct relationship to the set material at any particular time. For this reason it was decided to use glass electrodes inserted into the setting lining material. The final pH readings of the semi-solid should be reliable because of the high water content, assuming that the electrodes are not disturbed from their original contact with the material. A similar method of measuring the pH of a semi-solid has been described by Norman et al. (1966) in which antimony electrodes were used. The author were unable to obtain reproducible results by using antimony electrodes and these were abandoned. Norman et al. (1966) found the pH of setting zinc phosphate cement to the higher than indicated by the present results.

A further criticism of all ph measurements of cements and lining materials is the cement-tooth interface is the critical area and the pH of this may be different from the pH of the internal mass of the cement. It is possible that fluid from the dentinal tubules could react with the cement or lining material at this interface and thereby buffer extremes of pH.

The measurement of pH at the lining-dentine interface on a vital tooth is not however, possible with any equipment available at present. The method of measuring pH used in this work seems the nearest approach to this ideal. The measurement is a direct one on material with a high water content and the results were reproducible from day to day. This approach is in agreement with that used by Kent and Wilson (1969).

The histological results given above do not have a close correlation with the pH measurements described in the first part of this paper. SS White cavity lining causes more damage to the pulp than zinc oxide/eugenol although the pH of these materials is very similar.

It should be remembered however, that the zinc oxide/eugenol and SS White cavity lining materials are not aqueous systems and, therefore, the recorded values may not have the same significance as those of zinc phosphate cement and Dropsin. Dropsin has a similar pH to zinc phosphate cement in the early stages of setting but the response of the pulp to these two materials is quite different. Dropsin causes a mild reaction, mainly in the form of reduction of odontoblasts, whereas it has been reported that zinc phosphate causes severe pulpal changes (Brännström and Nyborg, 1960; Manley, 1943). Conversely, SS White cavity lining, which has a higher pH than Dropsin, has a more marked effect on the pulp. These results indicate that hydrogen ion concentration is not directly related to pulpal damage and that factors other than hydrogen ion concentration per se must be sought to explain the pulp reactions that have been observed. It may be that a material in contact with dentine may have to maintain a low pH for a certain minimum time before pulpal changes are produced. However, Nixon (1959) has shown that a marked reaction occurs in the pulp of human teeth when they are subject to a zinc phosphate filling for as little as 40 minutes. It is possible that a critical pH may exist between the pH of zinc phosphate cement and that of Dropsin and that a material with a pH above this level will not damage the pulp. Evidence against this, however, is the more marked pulpal reaction caused by SS White cavity lining when compared with Dropsin.

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EFFECT OF DIFFERENT CAVITY LINING MATERIALS ON THE POLYMERISATION OF COMPOSITES

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Summary

The aim of this study was to investigate in vitro the effect of different cavity lining materials on the polymerisation of a chemically curing composite (Brilliant) and a light-curing composite (Brilliant Lux). Super EBA zinc oxide-eugenol cement was used as a negative control for the cavity lining materials. The degree of polymerisation (conversion rate) was determined using the Knoop microhardness test.

It was found that the majority of the cavity liners tested (Ketac-Bond, Vitrebond, Dropsin, Dycal, Alkaliner) inhibited the depth of polymerisation in the adjacent composite layers to the same degree as Super EBA. Alkaliner exhibited a similar result with Herculite and Dual-Cement, the other composite materials tested. The light-curing glass ionomer cement (Vitrebond) had the least effect on polymerisation. The light-curing composites used in this test were more affected than the chemically curing material.

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Introduction

The increased controversy about amalgam and other metal filling materials in recent years has caused uncertainty among patients (Lussi 1987, Lussi et al. 1989). This uncertainty, combined with higher aesthetic expectations, has increased the demand for tooth-coloured posterior fillings.

The many systems currently on the market (porcelain inlays/ overlays, composite inlays/ overlays, veneers) all involve cementation using composite materials. Adhesion of composite to enamel, dentine or porcelain has been and still is the subject of many studies. To what extent the degree of polymerisation of light-curing composites and light-curing glass ionomer cements depends on the light source, its output and maintenance as well as the length of exposure has also often been the subject of investigation (NEWMAN et al. 1983, MATSUMOTO et al. 1986, HOTZ et al. 1989, BURKE et al. 1990). It was found that polymerisation is inadequate, at least at the base of the filling, if the exposure time is too short, if the increments polymerised are too thick or if the unit is not functioning properly. This leads to a reduction in the final hardness on the inside of a filling, which can have clinical consequences, as the filling may fracture when loaded and the marginal fit may be impaired. Temporary restorations with a zinc oxide-eugenol content can also cause significant softening of the light-curing composites fitted later (HOTZ et al. 1992). Various cavity lining materials can also impair polymerisation of chemically curing composites. Cavity liners with a zinc oxide-eugenol content, calcium salicylate cements and chemically curing glass ionomer cements had a marked effect (CIVJAN et al. 1973, GRAJOWER et al. 1974, MARSHALL et al. 1982, LINGARD et al. 1981). Results with the zinc phosphate cement were slightly contradictory, as in most cases polymerisation inhibition was only minimal (CIVJAN et al. 1973, GRAJOWER et al. 1974).

There have only been a few studies on the effect of cavity lining materials on the polymerisation of light-curing composites. BERRONG et al. (1989), for example, found that the composite material was impaired by glass ionomer cement.

The aim of this study was to investigate in vitro the effect of different cavity lining materials on the polymerisation of chemically curing and light-curing composite materials. The degree of polymerisation (conversion rate) was determined using the Knoop microhardness test.

Materials and methods

The effect of five cavity liners (Ketac-Bond, Vitrebond, Dropsin, Dycal and Alkaliner) on the polymerisation of two composites (Brilliant Lux, Brilliant) was tested. Only Alkaliner was tested as a cavity liner for other composites (Herculite, Dual-Cement). A zinc oxide-eugenol cement (Super EBA) was used as a negative control (Tab. 1).

Fabricating the specimens

Standard holes ("cavities") with a diameter of 4 mm and a depth of 1.9 mm ± 0.1 mm were drilled in Plexiglas (Fig. 1). Plexiglas was used as preliminary tests indicated a comparable depth of polymerisation in the composite inserted in Plexiglas and in cavities of extracted teeth. It was also found in a previous test that the depth of polymerisation of composites in "cavities" in brass plates and Plexiglas plates was similar. With all the materials the margin was softer than the core of the filling regardless of the cavity wall material (HOTZ et al. 1992). Any possibility of the Plexiglas interface affecting the microhardness of the composite through the cavity liner could be ruled out, as the cavity liners used did not have a significant effect on the depth of polymerisation of the composites tested (LUSSI & HOTZ, unpublished).

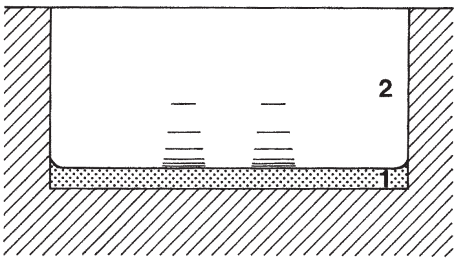


Fig. 1 Test set-up. Plexiglas "cavity" (diameter 4 mm, depth 1.9 mm) with cavity liner (1) and composite (2). Knoop microhardness measured at 25 µm, 50 µm, 100 µm, 500 µm and 1000 µm from the cavity liner.

The cavity liners were inserted into the "cavities" according to the manufacturer's instructions. Twice the recommended exposure time was used with light-curing cavity lining materials to attain maximum polymerisation. Self-curing cavity liners were cured in air saturated with steam. After the cavity liner was cured in accordance with the clinical criteria, the composites (Tab. 1) were inserted into the "cavities" and polymerised. A coverglass was pres-

sed onto the filling to ensure uniform compression. The exposure time using a Translux CL lamp (Kulzer, Germany) was 120 sec., with the coverglass being removed after 20 sec. Previous tests had indicated that an exposure time of 60 sec. was adequate to polymerise a layer of composite 2 mm thick (HOTZ et al. 1989). The lamp was tested at regular intervals with a radiometer (Demetron, Danbury, CT, USA) and never fell below the displayed output of 40 mW/cm2. Ten specimens were fabricated for each composite and cavity liner. The specimens were post-cured in a hot-air cabinet (T = 37∞C) for a minimum of 7 days before being tested.

Determining the degree of polymerisation

The specimens were each embedded in small glass tablets in cold-curing synthetic resin (Epofix, Struers, Denmark). After the resin had fully hardened, the specimens were sliced open vertically through the centre of the filling using a diamond disc with glycerine coolant. Then they were embedded in Paladur (Kulzer, Germany) with the ground surface facing up in plane-parallel steel rings and prepolished with moist silicon sandpaper grit size 500 (30 µm), 1000 (18.3 µm) and 4000 (5 µm) on a Knuth rotor (Struers, Denmark) and polished to a high-lustre with 3 µm polishing spray (Struers) on a cloth-covered polishing disc. Polymerisation of the composite specimens was recorded using the Knoop hardness test on a Leitz Miniload-2 unit (Leitz, Switzerland), (DE LANGE et al. 1980, FERRACANE 1985, HASEGAWA et al. 1991, KAYS et al. 1991, PIRES et al. 1993). The diamond was pressed onto the surface with a force of 100 ponds for 30 sec. during each measurement. The Knoop microhardness was measured twice at 25 µm, 50 µm, 100 µm, 200 µm, 500 µm and 1000 µm from each cavity liner (Fig. 1). The mean was determined at each distance for subsequent calculations.

Statistical analysis

The degree of polymerisation was determined using the standard procedure for recording demineralisation and remineralisation phenomena (FEATHERSTONE et al. 1990). As no significant differences in hardness could be determined at 500 µm to 1000 µm from the cavity liner, it was assumed that the final hardness of each composite had been attained at this depth. Hardness measurements taken further away from the cavity liner, i.e. nearer the light source, did not indicate any difference in curing hardness. The degree of polymerisation in each segment (Fig. 2) was determined by comparing the calculated surface with the possible surface. As the final hardness of the composites tested was not the same, the surface of the last segment was standardised to 100% to allow comparison. As the measurements were not distributed normally, non-parametric techniques were applied. Differences in polymerisation were checked for significance using the Wilcoxon test. The significance level was set at $p \leq 0.01$.

Tab. 1 Cavity liners and composites used

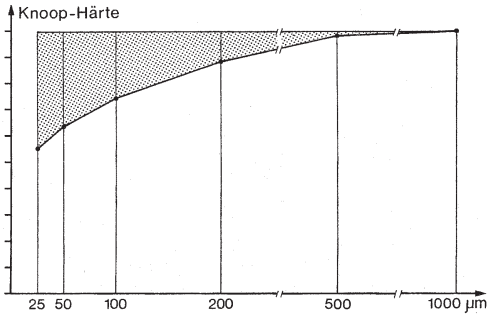
	Manufacturer	Type	Curing
Ketac-Bond®	Espe, Seefeld, D	Glass ionomer	self-curing
Vitrebond®	3M, St Paul, MN, USA	Glass ionomer	light-curing
Dropsin®	Nordin, Chailly, CH	Zn-phosphate	self-curing
Super EBA®	Staident, Staines, GB	ZnO-eugenol	self-curing
Alkaliner®	Espe, Seefeld, D	Ca(OH)2	self-curing
Dycal®	De Trey Dentsply, Constance, D	Ca(OH)2	self-curing
Brilliant Lux®	Coltène, Altstätten, CH	Composite	light-curing
Brilliant®	Coltène, Altstätten, CH	Composite	self-curing
Herculite®	Kerr, Basle, CH	Composite	light-curing
Dual-Cement®	Vivadent, Schaan, FL	Composite	light-curing/self-curing

Results

The final hardness (distance from the cavity liner 1000 µm) of the five composites tested varied between 43.6 Knoop hardness (Dual-Cement) and 88.4 Knoop hardness (Brilliant). The hardness of Brilliant Lux was statistically significantly lower than the final hardness up to 200 µm from the cavity liner (Tab. II). Curing of Brilliant paste/paste system was on average better. The hardness was only significantly lower than the final hardness up to 50 µm from the interface of the composite and cavity liner. Super EBA and Alkaliner were exceptions, as curing of the composite was significantly impaired up to 100 µm. The effect of Alkaliner cavity liner on the hardness was also tested with Herculite and Dual-Cement composites as a comparison. The light-curing and self-curing Dual-Cement exhibited a significantly lower hardness up to 50 µm from the cavity liner; inhibition of polymerisation was greater with Herculite light-curing composite. Calculation of the surface percentage enabled the total reduction in hardness caused by a specific cavity liner to be calculated (Fig. 3). It indicated a significant effect on different composites to a depth of 500 µm for the majority of cavity liners. Dycal, Ketac-Bond and Vitrebond, which only inhibited Brilliant to a depth of 200 µm, were exceptions.

Knoop hardness

Fig. 2 Determining the degree of polymerisation. The shaded surface indicates areas of reduced polymerisation.



Discussion

The conversion rate of composites can be reliably recorded using microhardness tests (FERRACANE 1985, DE WALD & FERRACANE 1987). It is advisable to determine the hardness after storage for 7 days at 37∞C, as polymerisation has been completed as far as possible by that time (LEUNG et al. 1983). Dental practitioners are well aware that cavity liners with a zinc oxide-eugenol content can impair the polymerisation of composites when there is direct contact. It emerged from this study, however, that all other

Tab. II Knoop microhardness of different composites with different cavity liners depending on the distance from the interface (x±SEM)

Composite	Cavity liner	Knoop microhardness at a distance from the cavity liner of					
		25 µm	50 µm	100 µm	200 µm	500 µm	1000 µm
Brilliant Lux	Ketac-Bond	34,2±2,0	46,2±1,5	60,1±1,8	66,5±1,6*	67,9±2,0	70,2±2,1
	Vitrebond	53,5±2,0	59,8±1,9	63,0±1,2	65,0±1,8*	67,3±1,6	69,8±2,3
	Dropsin	39,9±2,7	50,8±2,5	63,9±1,2	66,9±1,1*	68,1±1,3	70,0±1,2
	Super EBA	33,9±3,1	30,1±2,1	50,3±1,7	63,1±0,9*	64,5±0,9	64,9±0,8
	Alkaliner	29,5±1,8	43,3±1,8	57,6±1,5	61,9±1,9*	63,7±1,4	64,6±1,8
	Dycal	20,9±1,9	29,1±2,5	44,6±4,3	57,9±4,0*	61,8±3,5	64,6±2,4
Brilliant	Ketac-Bond	55,1±4,5	73,8±3,1*	84,9±1,8	87,8±1,2	91,4±1,0	88,0±1,7
	Vitrebond	62,6±3,9	79,7±2,2*	86,7±1,8	91,6±1,4	91,8±1,5	92,6±1,2
	Dropsin	49,8±2,2	65,3±1,5*	77,4±1,4	79,9±1,0	80,8±0,7	82,4±1,2
	Super EBA	40,7±4,4	60,1±2,5	81,1±1,3*	94,6±2,3	98,7±1,8	98,7±1,8
	Alkaliner	43,5±2,8	62,4±2,1	79,1±1,6*	84,3±0,9	87,5±1,1	87,7±1,2
	Dycal	43,2±1,7	60,6±2,0*	76,8±1,5	80,1±1,4	80,8±1,0	81,1±1,1
Herculite	Alkaliner	27,6±1,4	38,5±2,1	56,7±2,0	66,6±0,9*	70,9±1,3	73,9±1,7
Dual-Cement	Alkaliner	23,2±1,1	32,9±0,8*	40,9±1,3	43,4±1,2	44,7±1,2	43,6±1,1

The hardness figures marked with an asterisk and the figures to the left are statistically significantly different from the final hardness (1000 µm).

materials tested, i.e. calcium salicylate cements, glass ionomer cement, light-curing glass ionomer cement and also zinc phosphate cement, impaired polymerisation with chemically curing composites and also, more markedly, with light-curing composites. The differences were relatively small and the light-curing glass ionomer cement was the best. The causes of this polymerisation inhibition are not known. Possible causes could be chemical influences, e.g. liquid content of the cavity liner, availability of free radicals, pH and presence of polymerisation inhibitors, about which little is known. The effect of the temperature should also be taken into consideration. Exposure of the composite specimens with the Translux CL also increased the temperature of the material (HANSEN & ASMUSSEN 1993). This can have a positive effect on the conversion rate. It is possible, however, that the interface may be cooled by the material underneath and this could affect polymerisation. LUNDEN & KOCH (1992) found improved polymerisation with in vivo cured fillings compared with in vitro placed fillings. They also attributed this observation to the increased temperature in the oral cavity. On the other hand our measurements, for which the specimens were preheated to 37∞C and the composite material was inserted at 37∞C, did not indicate that the temperature had any effect.

It is impossible to say how critical polymerisation inhibition at the interface of the cavity liner is clinically. Some physical properties of the composite materials appeared to change little due to this effect (POWELL & HUGET 1993). An in vitro experiment indicated, however, that the marginal integrity of cemented composite inlays could be impaired by different cavity lining materials, with the modulus of elasticity of the cavity liner playing an important role (KREICI et al. 1998, STAEHLE et al. 1992). It can be assumed from this study that not only the modulus of elasticity of the cavity liner but also the softening of composite at the interface is important in this respect. There is no reason to advise against the application of the tested cavity lining materials based on these results. In areas adjacent to the pulp, pulp protection should still be used with the entire spectrum of activity of, e.g. calcium salicylate cements. Though the materials tested are similar in relation to the level of significance, the results indicate that light-curing glass ionomer cement has advantages.

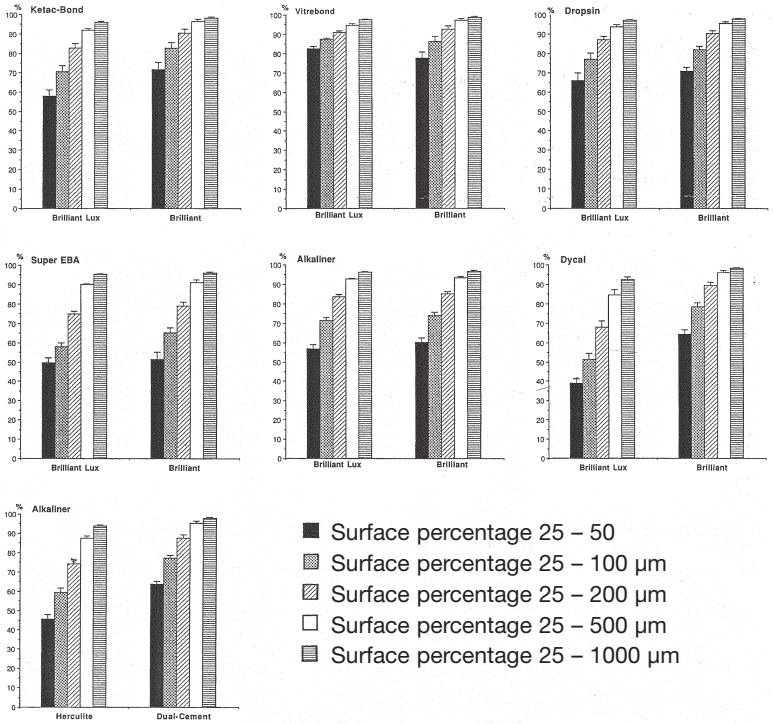


Fig. 3 Polymerisation inhibition of different composites (x±SEM) by cavity liners depending on the distance from the interface (in surface percentages between 500 – 1000 µm to 100% standardised surfaces). The columns marked with an asterisk and the columns to the left are statistically significantly different from the surface percentages of 25 – 1000 µm.