

# Curing depth of visible light-activated composites

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Three composites, two microfilled (Heliosit® and Silux®) and one macrofilled (Prisma-Fil®), were exposed to visible light from three different light units. The depth of the cure was estimated by measuring the length of the test specimen after removing the uncured material. The macrofilled composite cured to a greater depth than the microfilled materials. The curing depth of Heliosit was lower, of Silux about the same, and of Prisma-Fil higher than the values of curing depth given by the manufacturers. The shade of the pastes influenced the curing depth of the macrofilled more than that of the microfilled composites. Doubling the exposure time increased the curing depth by about 1/3. Exposure through tooth substance reduced the curing depth by at least 1/3. The curing effectivity of Prisma-Lite® was slightly greater than that of Heliomat® and the 3M® unit. □ *Composite resins; dental fillings; dental materials*

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Although light-activated composites offer several advantages compared with chemically polymerized resins, they have been little used in Scandinavia. The appearance of several different visible light systems on the market in addition to earlier ultraviolet light equipment seems now to increase the interest for the method. Compared with the UV light, the visible light results in deeper curing (4, 6, 8) and is more effective through enamel (2, 4, 5, 7, 8), and the intensity of the light source does not diminish with time (2). Although much has thus been reported about light-activated composites, new brands and even new types of material and activating equipment are continuously appearing on the market. The aim of this study was therefore to test the effect of factors such as the type of light source, exposure time, shade of composite, and interfering tooth substance on the curing depth of some recently marketed light-activated composites.

## Materials and methods

The test composite brands and the light equipment used are listed in Table 1. The

wavelengths of the apparatuses have been given by their manufacturers, and the approximate illuminating power values were obtained with a Lunasix® camera light meter (scale 12–22, corresponding to 350–350,000 lx). Test samples were made by filling a white, non-transparent polyethylene mold, 6 mm deep and 4 mm in diameter, with the composite. A mylar strip was pressed on the top of the mold to remove excess material. During curing the tip of the light source was held against the strip, covering completely the top of the filling. In one series a 0.8-mm-thick enamel–dentin slab was placed on the strip and the light source tip was held against this slab. The slab had been prepared from an extracted human molar so that an even layer of enamel remained to cover one side of the ground section. The size of the square-shaped slab was 8 × 8 mm. Immediately after being cured, the specimen was removed from the mold, and the incompletely cured bottom part was carved away by hand with a sharp instrument until no material could be scraped off. The length of the remaining specimen was measured with a micrometer (1/1000), and the obtained value was considered the depth of the cure.

To test the reproducibility of the method,

Table 1. The materials tested and visible light units used

Brand name of composite	Batch no.	Type	Name of light unit	Code	Wavelength	Electric power (W)	Illuminating power (lx)	Manufacturer
Heliosit® (22)	080382	Microfilled	Heliomat®	H	400-505	150	28,000	Vivadent
Heliosit® (30)	021081							
Silux®	040682	Microfilled	3M LC®	3M	420-480	75	48,000	3M Co.
Prisma-Fil®	031182	Macrofilled (barium glass)	Prisma-Lite®	P	~470	150	30,000	Caulk Co.

10 specimens of Silux® (gray shade) were cured with Prisma-Lite® for 20 sec. To test the suitability of the plastic mold, 10 other specimens of Silux were made in a split tooth mold (human lower canine) measuring  $2 \times 2.5 \times 5$  mm (Fig. 1).

## Results

The mean curing depth of the 10 Silux control specimens was 2.71 mm and the range, 2.58 to 2.85 mm. For the specimens made in the tooth mold the mean value was 3.05 mm and the range, 2.78 to 3.25 mm.

Fig. 2 shows the curing depth of one shade of the composites activated with the different light units for 10 and 20 sec. Prisma-Fil® hardened to a depth twice that of the two microfilled materials. Increasing the exposure time influenced the curing depth of Heliosit® only slightly but increased the depth of the two other materials by at least one third. The curing effect of Prisma-Lite was slightly greater than that of the other units.

The influence of the shade of the material (Fig. 3) was minimal in connection with Silux, but the increased darkness of Prisma-Fil reduced the curing depth. The values obtained for Silux were similar to those presented in the manufacturer's leaflet (Table 2) but were lower for Heliosit and higher for Prisma-Fil.

Exposure through a layer of tooth substance (Figs. 4 and 5) reduced the curing depth by approximately 1 mm.

## Discussion

The curing depth values of specimens made in the plastic mold were slightly lower than those of samples from the tooth mold, in contrast to earlier results (1). Usually the curing depth is estimated by measuring the hardness of the top and bottom of composite specimens (manufacturer's leaflets; 1, 7). The method is more complicated than the one used in this study, which was similar to the one reported by Ruyter & Øysaet (6). The control test showed a satisfactory reproducibility, and the values corresponded

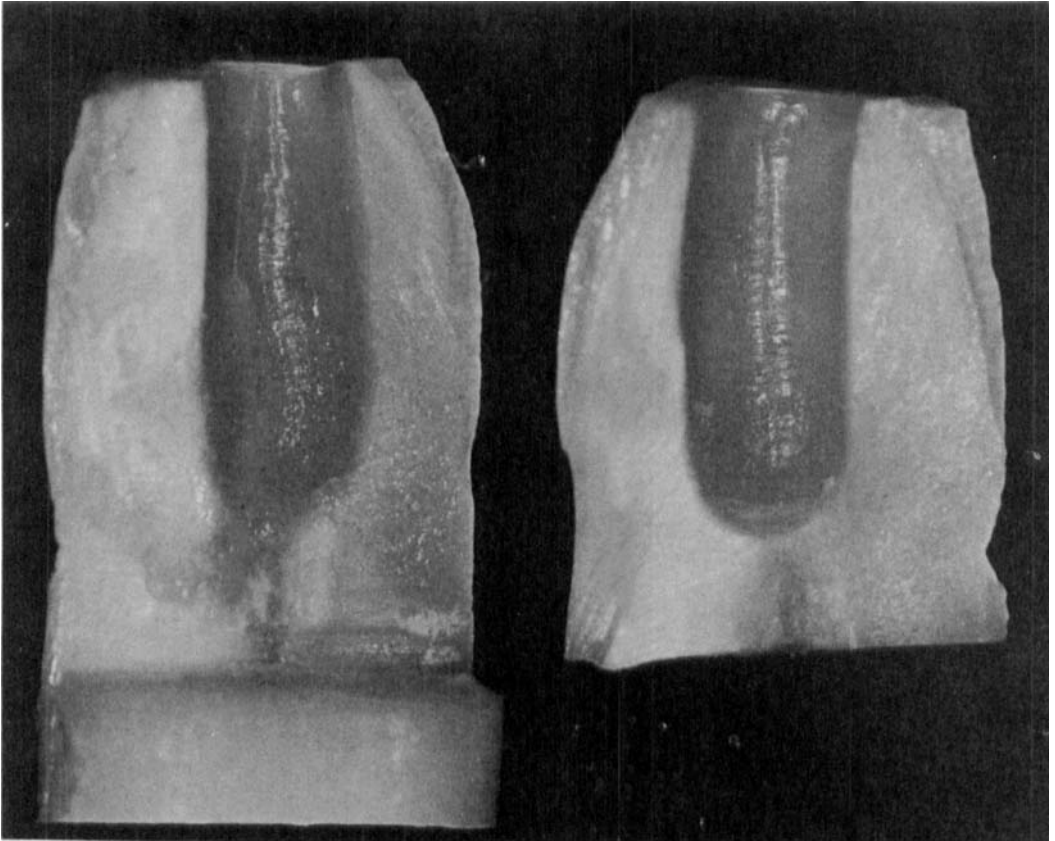


Fig. 1. Split mold made of a human lower canine.

well with the values given by the manufacturer of Silux. The reason for obtaining lower values for Heliosit and higher for Prisma-Fil than the values reported may partly be due to the different composition of the materials. Heliosit contains 60% (by weight) soft organic resin material, whereas Silux contains 50% and Prisma-Fil only 24%. Consequently, it was easier to remove incompletely cured material from the Heliosit than from the Prisma-Fil specimens.

The extent of an acceptable curing depth has not been established, but 2–3 mm has been suggested as a minimum value (6). The mean labiolingual dimension of a central incisor in the upper jaw exceeds 7 mm (3). Consequently, a normal cavity could be at least 4 mm deep, with a 1-mm-thick labial

layer of tooth substance (Fig. 6). To cure a filling in such a cavity with one palatal exposure would require a minimum depth of cure of 4 mm. Alternatively, two exposures may be done, but then the shading effect of the labial tooth substance has to be considered. The decreasing effect of 1 mm of tooth substance on curing depth was reported to be 1 mm for Prisma-Fil in the manufacturer's leaflet, which is slightly lower than the values obtained with Prisma-Fil and Silux in this study. Assuming that 1 mm of tooth substance reduces the curing depth by 1.5 mm, activating a filling, like the one described, from two sides requires a curing depth of almost 3 mm from each side. There seem therefore to be no reasons to allow a minimum curing depth of less than 3 mm.

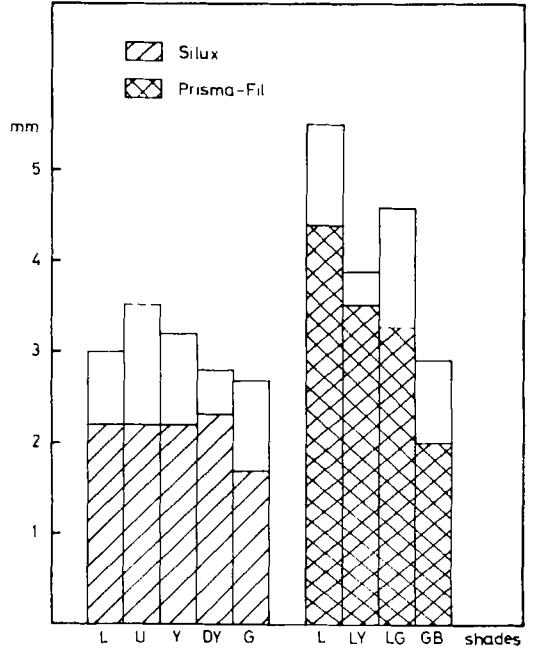
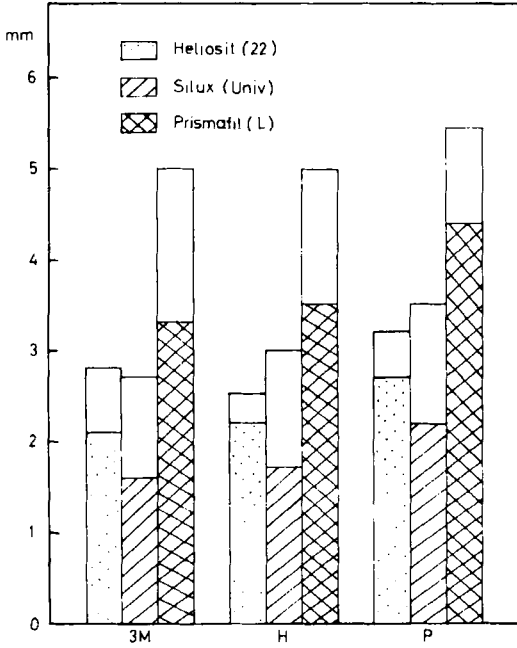


Fig. 2. Curing depths of composites, using different light sources for 10 sec (marked bars) and 20 sec (open bars).

Fig. 3. Curing depths of the different shades of Silux® and Prisma-Fil®, using Prisma-Lite® for 10 sec (marked bars) and 20 sec (open bars).

When the recommended exposure times were used, Prisma-Fil clearly exceeded this value, and Silux reached it, whereas Heliosit remained below.

Although the high values obtained with Prisma-Fil may have been slightly influenced by the method error mentioned above, the results confirm earlier findings (6) that

it is safer to use macrofilled than microfilled materials in connection with light activation.

The stronger activating effect of Prisma-Lite compared with the two other light sources seems not to be directly correlated to such easily measurable data as electric and illuminating power. Judging from the wavelength data given by the manufacturers,

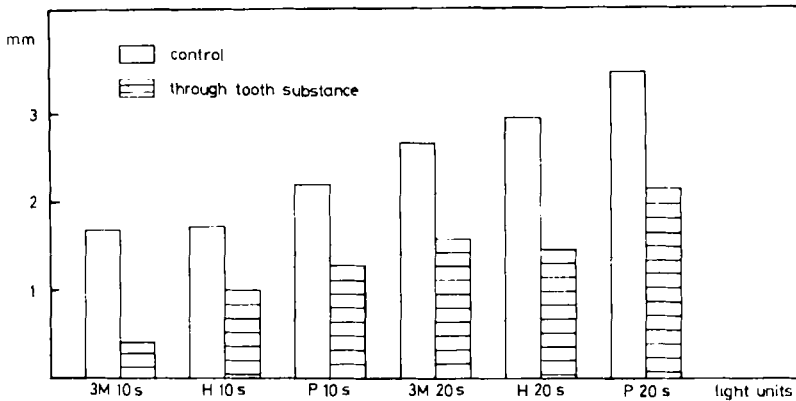


Fig. 4. Curing depth of Silux® (universal shade) when the exposure was done through an enamel-dentin slab with the different light sources for 10 sec and 20 sec.

Table 2. Curing depth of the tested materials as reported by their manufacturers and as obtained in the study

Brand name	Shade	Light unit	Exposure times (sec)	Curing depth (mm)		Difference	
				Reported values	Obtained values		
Helosit®	22	Heliomat®	20	4.5	2.5	-2.0	
			40	5.5	3.5	-2.0	
	20		3.5	1.9	-1.6		
	40		4.0	2.3	-1.7		
Silux®	U & G	3M® unit	20	3.0	2.7	-0.3	
			Prisma-Fil®	L	Prisma-Lite®	10	3.5
20	4.0					5.5	+1.5
LG & LY	GB		10	2.5	3.4	+0.9	
		20	3.5	4.2	+1.2		
		10	1.5	2.0	+0.5		
		20	2.0	2.9	+0.9		

the spectrum of Prisma-Lite was the narrowest one, thus probably resulting in the most concentrated and effective lightbeam. The difference was, however, small and hardly important clinically. The Prisma-Lite unit is definitely much heavier and more clumsy than Heliomat® and the 3M® apparatus, which certainly is an aspect of significance for the practising dentist.

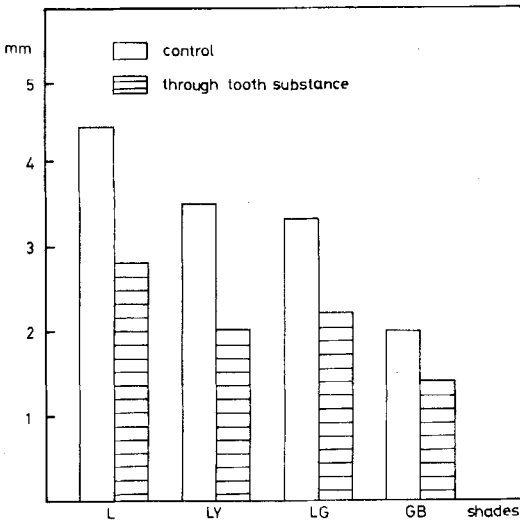


Fig. 5. Curing depths of different shades of Prisma-Fil® when the exposure was done through an enamel-dentin slab with Prisma-Lite® for 10 sec.

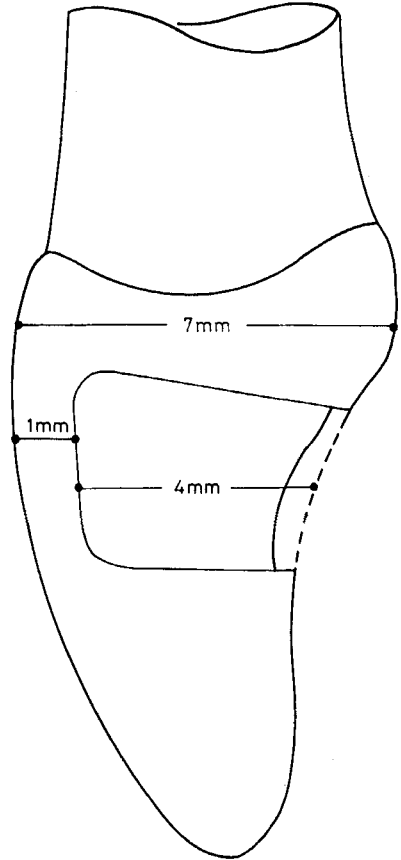


Fig. 6. Schematic drawing of an upper central incisor with a class-III cavity.

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