

# Three-year study of cervical erosions restored with resin and dentin-bonding agent

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Cervical erosions without undercuts and traditional cavity preparation were restored with a light-activated microfilled resin in combination with two different dentin-bonding agents, Gluma and the chemically activated version of Scotchbond. In the Gluma group the final polishing was postponed for at least 1 day; in the Scotchbond group polishing was performed 5 to 15 min after polymerization. The results of the two clinical tests are therefore not comparable. Under these experimental conditions the cumulative 3-year survival rate for the fillings in the two groups were 96% (Gluma) and 66% (Scotchbond). It is concluded that cervical erosions should be restored without undercuts or traditional cavity preparation on the condition that the enamel is acid-etched, polishing of the gingival area is postponed, and an effective dentin-bonding agent is used. □ *Dental materials; in vivo study; marginal adaptation*

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The concept of dentin-bonding agents is rather new in dentistry. Many *in vitro* studies have been published within the last few years, but clinical investigations are scarce (1-5). Even though laboratory studies may predict the clinical behavior of dental restorative materials and dentin-bonding agents, good *in vitro* results are not per se a guarantee of success *in vivo*. Clinical trials are therefore necessary because they provide the ultimate tests.

The purpose of this clinical study was to evaluate the 3-year cumulative survival rate of a light-activated microfilled resin, used in combination with two different dentin-bonding agents, to restore cervical erosions without traditional cavity preparation or undercuts.

## Materials and methods

Over an 18-month period 105 cervical erosions were restored with a light-activated microfilled resin (Silux<sup>®</sup>, 3M, USA) and a dentin-bonding agent: either Gluma<sup>®</sup> (Bayer, FRG) or the chemically activated

version of Scotchbond Dental Adhesive<sup>®</sup> (3M); the latter should not be mistaken for the newly marketed Scotchbond 2 Dental Adhesive<sup>®</sup>. During the first 6 months of the study, 30 cervical erosions were restored with Silux/Scotchbond, and during the following 12 months, 75 erosions were restored with Silux/Gluma. All restorations were inserted by the author with the following procedures.

### *Cavity preparation*

The superficial, saliva-contaminated dentin in the erosion was removed with a slowly rotating, fine-grained diamond. An 0.5-mm-wide cavosurface bevel was prepared in the enamel at a 45° angle to the external enamel surface. Apart from this, no further preparations were used; that is, the cavities were not undercut. No rubberdam was applied.

### *Gluma*

This dentin-bonding agent is a mixture of glutaraldehyde and HEMA, and it is supposed to bond to the amino and amido groups of the collagen (6). The freshly cut

dentin in the erosion was rubbed for 10 sec with a cotton pellet soaked in Gluma Cleanser, which is an 0.5 M ethylenediaminetetraacetic acid (EDTA) solution adjusted to pH 7.4 with NaOH (6). The cavity was then rinsed and dried, both for 10 sec. In cases of deep erosions, the bottom of the cavity was covered with a thin layer of a calcium hydroxide cement (Dycal<sup>®</sup>, Caulk, USA). The enamel part of the cavity, previously beveled, was etched for 60 sec, rinsed with water for 30 sec, and dried for 10 sec. After this, Gluma was applied with a small brush, and after 10 sec the primed dentin was dried with compressed air until the cavity and the etched enamel looked completely dry. The primed dentin and the acid-etched enamel were covered with a low-viscous resin (Silux Enamel Bond<sup>®</sup>, 3M), and as much as possible of this resin was blown out of the cavity until the dentin had a slightly oily surface. The restorative resin was taken directly from the material syringe with a hand instrument and then applied to the cavity. The restorative resin and the low-viscous resin, covering the dentin-bonding agent and the acid-etched enamel, were polymerized simultaneously for 40 sec with a visible light-curing unit (3M/LC Lamp, 3M, Denmark). No cervical matrix was used.

### *Scotchbond*

Scotchbond is a phosphate-based bonding agent that presumably bonds to the inorganic part of the dentin (7). According to the manufacturer, the smear layer should not be removed before application of the dentin-bonding agent. However, in previous *in vitro* studies I have found a slight but statistically significant improvement in marginal adaptation when the smear layer was partly removed by an 0.05% EDTA solution with a pH of approximately 3 (8). Therefore, 15 of the 30 Scotchbond fillings were placed after use of the weak EDTA solution to clean the dentin. The other 15 Scotchbond fillings were inserted without previous cavity cleaning except copious water spray. The use of water spray and EDTA was randomized. The bottom of deep erosions was covered the enamel was etched and the bonding agent

applied. A gentle stream of air was used to spread the adhesive and to evaporate the solvent. The restorative resin was then applied and polymerized as described above under 'Gluma'.

### *Polishing*

After irradiation the fillings were left undisturbed for 5 to 15 min. The restorations were then finished with fine-grained diamonds and with coarse and medium Sof-Lex discs (3M) at low speed for gross reduction, followed by the fine and extra-fine Sof-Lex discs for final polishing. The fine-grained diamonds and the coarse and medium Sof-Lex discs were used dry, whereas the final polishing was performed wet. Both the enamel and the gingival area of the 30 Scotchbond restorations were finished at the placement visit, whereas polishing of the gingival area of the 75 Gluma fillings was postponed for at least 1 day; only gross surplus was removed by means of a fine-grained diamond at very low speed. The reason for handling Scotchbond and Gluma fillings in different ways will be discussed later.

### *Evaluation*

The registration included marginal gap and marginal discoloration. The fillings were evaluated by two examiners calibrated before and during the study. The enamel part of the cavity and the gingival part were assessed separately, using the criteria shown in Table 1. These criteria are based on the USPHS guidelines (9), but slightly changed as proposed by Smales (10). The grading '3' corresponds to category 'Charlie' in the USPHS system. The restorations were evaluated at base line and after 3 years (a final registration will later be made after 5 years). Only restorations with initial gradings of 0 were accepted in this study.

### *Statistics*

The patients were recalled approximately every 6 months, making it possible to register

Table 1. Criteria for assessing marginal discoloration and marginal gap

Assessment	Grading	Discoloration	Gap
Perfect	0	None	None
Acceptable	1 = minor faults	Slight	Explorer catches
	2 = major faults	Obvious	Explorer sticks
Unacceptable	3 = replace	Gross	Dentin exposed

whether any restoration had been lost since last recall. Trial time was arranged into intervals of 6 months, and for each interval the effective number of exposed restorations was calculated. The cumulative survival rate of Gluma fillings and of Scotchbond fillings was analyzed with life tables and log rank tests (11).

### Results

Scotchbond fillings whose cavity had been cleaned with the weak EDTA solution had a slightly better survival rate than that of restorations for which the cavity cleaning was restricted to water spray: 73% of the failures were found in the latter group, but the difference was not statistically significant ( $P > 0.1$ ). The data were therefore pooled.

The analysis showed a statistically significant difference ( $P < 0.001$ ) between the survival rate of Gluma fillings and that of Scotchbond fillings (Fig. 1). The 3-year cumulative survival rate for Gluma restorations was 96% and for Scotchbond 66%, with 95% confidence intervals of 91–100% and 49–83%, respectively. Three of the 75 Gluma restorations and 10 of the 30 Scotchbond fillings were lost. As to the latter, six fillings fell out and another four had to be replaced because of secondary caries in the gingival area. Three of the 4 restorations with secondary caries and 5 of the lost restorations were among those 15 fillings placed at the beginning of the study. One would have expected an equal frequency among the first- and the last-placed fillings. However, the difference between observed and expected failures was not statistically significant ( $P > 0.1$ ). During the study four Gluma

and one Scotchbond restoration were either lost to follow-up or withdrawn.

After 3 years the marginal area of 68 Gluma and 19 Scotchbond restorations could be assessed (Table 2). In the acid-etched enamel part of the cavity, 95% of both the Gluma and the Scotchbond fillings had a perfect marginal adaptation. In the gingival part 6% of the Gluma and 11% of the Scotchbond restorations had a slight marginal discoloration along a minor part of the periphery, but no obvious discoloration was seen for either adhesive (Table 2). Marginal gaps in the gingival area were found for 12% of the Gluma fillings and 16% of the

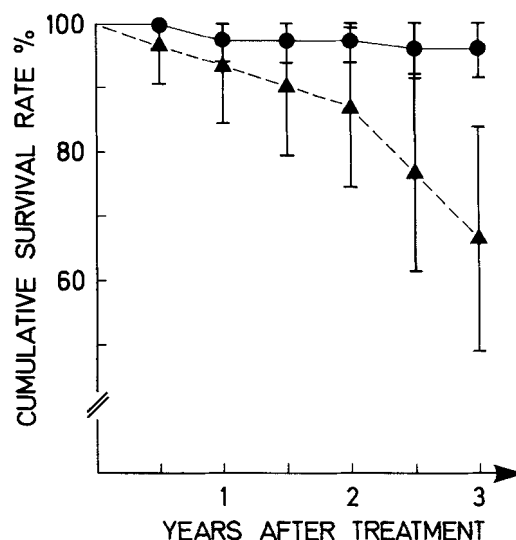


Fig. 1. Cumulative survival rate for resin restorations in non-undercut cervical erosions restored with Silux/Gluma (upper line) and with Silux/chemically activated Scotchbond (lower line). The survival rates are not comparable because of different polishing procedures.

Table 2. Three-year assessment of marginal discoloration (MD) and marginal gap (MG) in the enamel part and in the gingival area of the resin-restored cervical erosions. For gradings, see Table 1

Dentin-bonding agent	MD				MG			
	0	1	2	3	0	1	2	3
Enamel								
Gluma	66	3	—	—	65	4	—	—
Scotchbond	18	1	—	—	18	1	—	—
Gingiva								
Gluma	65	4	—	—	61	8	—	—
Scotchbond	17	2	—	—	16	2	—	1

Scotchbond fillings; one of the latter restorations had to be replaced after 3 years and 2 months because of secondary caries, leaving but 18 Scotchbond fillings for the future 5-year registration.

The inter-examiner agreement on the marginal discoloration was very high (96%); only 3 of the 87 restorations had to be re-assessed. Evaluation of marginal gaps proved to be more difficult: the initial co-scoring was 87%, but consensus was reached on all restorations. The main problem was to distinguish between a small surplus and a narrow gap.

## Discussion

The statistical analysis showed that the 3-year cumulative survival rate of Gluma restorations was significantly higher than that of Scotchbond fillings. One reason may be that the bond strength mediated by Gluma is markedly higher than that mediated by the first marketed version of Scotchbond (12, 13). But the statistical analysis should be cautiously interpreted. The 30 Scotchbond restorations in this study were the first cervical erosions restored by me *in vivo*, using a dentin-bonding agent. Even though one may have placed several hundred fillings *in vitro* (8, 14, 15), there still are essential differences between laboratory and clinical conditions. Also, the use of Scotchbond and Gluma was not randomized; that is, the 30

Scotchbond restorations were placed at the beginning of the study, whereas all 75 Gluma fillings were placed in the last part. The fact that most of the failures with Scotchbond were among those 15 erosions restored first suggests that clinical experience is an important variable.

Furthermore, it should be borne in mind that the gingival area of all 30 Scotchbond fillings was finished within 5 to 15 min after polymerization, whereas the final polishing of the 75 Gluma fillings was postponed for at least 1 day. Early polishing and removal of the filling surplus may disrupt the bond between dentin and resin. Moreover, laboratory studies have shown that no commercial dentin-bonding agent is strong enough to prevent totally the formation of a contraction gap (12, 14–16). Therefore, the gingival area should not be polished before the hygroscopic expansion of the resin has closed the contraction gap (14, 16). If the polishing is done too soon, grinding debris will be pressed into the marginal gap and hinder the expanding resin from closing the gap.

The reason for changing the polishing procedure during the study was that two laboratory investigations (14, 15) had shown that even strong dentin-bonding agents could not prevent the formation of a contraction gap between resin and dentin cavity wall: with the Silux/Gluma combination final polishing of the gingival area must be postponed for 1 day, and if one uses the chemically activated version of Scotchbond, polishing of this part of the restoration must be postponed for 7 days (15); postponement for 10 min, as advocated by some manufacturers, or even 1 h is not sufficient (16). In the present study polishing of the gingival area of the 30 Scotchbond restorations was done within 5 to 15 min after polymerization. The premature finishing of the gingival area of the Scotchbond fillings in combination with the low bond strength of this dentin-bonding agent (12, 13) may actually be the major cause of the high frequency of failures with Silux/Scotchbond. Given the different polishing procedure and the non-randomized placement, a comparison between the results obtained with Gluma and those obtained with the chemically activated Scotchbond

would not be correct. There are, however, a few clinical studies of Scotchbond which should be discussed and compared with the results of the present investigation.

Tyas & Beech (1) tested the chemically activated version of Scotchbond in cervical erosions with the same procedures as used in this study—that is, no undercuts, etching of the enamel for 60 sec, air drying of the cavity, application of Scotchbond, followed by a gentle air stream to evaporate the solvent. Instead of Silux, Tyas & Beech (1) used another light-activated, microfilled resin (Concept®, Southern Dental Industries, Australia) or a chemically activated microfilled resin (Isopast®, Vivadent, Liechtenstein). But they too did not postpone the final polishing. As in the present study, they used fine-grained diamonds and Sof-Lex discs at low speed for trimming and polishing. Tyas & Beech (1) found an 88% cumulative survival rate for Scotchbond restorations in cervical erosions after both 1 and 2 years. This is in very good agreement with the results of the present study, in which the 1-year survival rate was 93% and the 2-year result was 87% (Fig. 1).

Tyas et al. have recently published another paper with a clinical evaluation of Scotchbond (2). In that study 6 practitioners restored 175 cervical erosions with Silux and the chemically activated Scotchbond. Minimal trimming only of the restorations was done, and this was delayed until at least 10 min after polymerization. Final trimming and polishing, if required, took place at a subsequent visit. The average 1-year cumulative survival rate was only 75%, but the adjacent enamel was not acid-etched. However, one of the practitioners had a 100% survival rate. Tyas et al. (2) point out that no trimming of the restoration was carried out by that practitioner at the placement visit. As already discussed, this is presumably a very important variable.

Vanherle et al. have also tested the survival rate of Silux plus Scotchbond for restoring cervical erosions (4). These authors studied the survival rate both with and without acid-etching of the enamel, and they too polished the restorations at the placement visit. Vanherle et al. (4) found a 6-month

survival rate of 85% in non-etched cavities, as opposed to 98% in cavities with etched enamel. The latter result (98% with etched enamel) is also in very good agreement with the 6-month survival rate of 97% for Scotchbond restorations in the present study (Fig. 1).

I have previously advocated the use of an 0.05% EDTA solution as cavity cleanser for Scotchbond (8). In the present study fewer failures were found when the cavity was cleaned with the weak EDTA solution than when cavity cleaning was done with water spray. But even though 73% of the failures were found among the water-sprayed erosions, the difference between the two cavity cleaning procedures was not statistically significant ( $P > 0.1$ ). A final conclusion on cavity cleaning procedures can therefore not be reached.

As to Gluma, Hörsted et al. (3) have published a clinical study with survival rates over an 18-month period. They tested Gluma in cervical erosions, with and without acid-etching of the enamel, and found a 100% survival rate (18 months) if the enamel had been etched. In the present study the 18-month cumulative survival rate was 97.3% (Fig. 1). Hörsted et al. (3) found that the 18-month survival rate was but 75% if the enamel was not acid-etched.

None of the cervical erosions were undercut. The only cavity preparation was removal of the superficial, saliva-contaminated dentin in the erosion with a slowly rotating diamond. This could be done nearly painlessly, and giving an anesthetic was necessary in only 4% of the cases. This gentle operation should carry great weight, not only because of the nearly painless procedure, but especially because very small amounts of sound tooth tissues were removed.

The marginal adaptation in the acid-etched part of the erosions was very good; only few and minor faults were found (Table 2). In the gingival area the number of faults was somewhat higher, but only one Scotchbond filling had an unacceptable marginal gap with secondary caries. One should, however, bear in mind that a further four Scotchbond restorations had been replaced earlier because of secondary caries. The possible

reasons for the high frequency of lost Scotchbond fillings and secondary caries have already been discussed.

In conclusion, it can be said that i) cervical erosions with acid-etched enamel, restored with Silux as restorative material and Gluma as dentin-bonding agent, have a very high 3-year survival rate; ii) the cavity need not be undercut; and iii) polishing of the gingival area should, with this combination of restorative resin and dentin-bonding agent, be postponed for at least 1 day.

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