Effect of polyacrylic acid treatment of dentin on adhesion of glass ionomer cement

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This investigation measured the effect of polyacrylic acid treatment of dentin on adhesion of glass ionomer cement. The dentin was ground on paper no. 220 or no. 500 and treated with a polyacrylic acid solution of 10% or 25% for either 10 or 30 sec. The differences observed in the scanning electron microscope between the differently treated dentin surfaces were not reflected in the bond strength results. Only variations in surface texture due to different coarseness of grinding influenced the adhesion. For specimens ground on paper no. 220, pretreatment with polyacrylic acid enhanced adhesion of glass ionomer cement. Polyacrylic acid had no effect on bonding between glass ionomer cement and dentin ground on paper no. 500. □ *Dental materials; in vitro study; surface treatment*

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One of the most important properties of glass ionomer cements is their ability to adhere chemically to tooth substance (1–4). Undercutting is rendered superfluous, and sound dentin thereby spared (5–7). However, effective adhesion is only attainable when adhesive and substrate are brought into intimate interfacial contact. Thus, among other factors, chemical adhesion depends on the roughness of the tooth surface.

Several procedures have been suggested for cleaning and smoothing dentin surfaces before bonding, to improve adhesion (8–11). Powis et al. (1) argued that polyacrylic acid might be a suitable conditioner for pretreatment of enamel and dentin and found that a 25% solution enhanced the bond strength considerably. On the basis of the latter study, McLean & Wilson (12) recommended polyacrylic acid as the conditioner of choice.

Only a few works have been conducted to either invalidate or confirm the observed effect of polyacrylic acid. Furthermore, in most studies only one concentration of polyacrylic acid and one time of application were investigated. Conceivably, the optimum effect of polyacrylic acid conditioning is obtained when the smear layer is only just removed and the treatment discontinued before demineralization of the underlying dentin. Thus, the concentration of the polyacrylic acid solution, the duration of the conditioning, and the thickness of the smear layer may all influence the effect of pretreatment with polyacrylic acid.

The purpose of the present study was to investigate the effect of the polyacrylic acid concentration and the duration of conditioning on the adhesion of a glass ionomer cement to dentin and on the appearance of dentin surfaces.

Materials and methods

The glass ionomer cement used in this study was Ketac-Fil (ESPE, Seefeld, FRG). A 25% solution of polyacrylic acid was purchased (Struers, Copenhagen, Denmark). Part of the solution was diluted to a 10% aqueous solution of polyacrylic acid.

Bond strength determination

Sixty extracted human teeth that had been kept in 1% chloramine solution since extraction were embedded in epoxy resin (Epofix;

Table 1. Bond strengths (MPa) between glass ionomer cement and dentin; mean value and standard deviation

Polyacrylic acid solution	Bond strength (MPa)	
Concentration/duration	Paper no. 220	Paper no. 500
Untreated	3.1 ± 1.42	4.0 ± 0.98
10%/10 sec	4.6 ± 0.37	3.7 ± 1.91
10%/30 sec	5.0 ± 1.74	3.8 ± 1.08
25%/10 sec	4.3 ± 0.61	3.7 ± 0.75
25%/30 sec	4.6 ± 0.60	4.0 ± 1.71

Struers) and left for 24 h to polymerize. Half of the teeth were then ground on wet carborundum paper no. 220 and the other half on paper no. 500 to produce flat dentin surfaces. The dentin surfaces were produced on different parts of the teeth, and no standardized method was used to place the surfaces at an identical depth. The teeth of either surface roughness were then randomly divided into five groups. One group served as control, while teeth of the other four groups were subjected to conditioning with a polyacrylic acid solution of either 10% or 25% for either 10 or 30 sec. The solution selected for treatment was applied to the dentin surface by means of a brush for the specified time. The surface was rinsed with deionized water for 30 sec and dried with air, taking care not to dessicate the dentin. Specimens of all series were mounted in an assembly, enabling a cylinder of glass ionomer cement to be bonded to the surface. A Ketac-Fil capsule was then activated and mixed in accordance with the manufacturer's instructions with a Duomat 2 (Degussa, Frankfurt, FRG) for 10 sec. The cement was squeezed into the hole in the mold (height, 2.5 mm; diameter, 3.5 mm), immediately covered with varnish (ESPE Varnish; ESPE), and gently dried with air for 15 sec. After 10 min at ambient temperature, the bond test specimens were removed from the assembly, the circumference of the glass ionomer cement cylinder was varnished, and the specimens transferred to a waterbath at 37°C. After storage for 24 h, shear bond strengths were determined with a Universal Testing Machine (Instron Ltd., U.K.) at a crosshead speed of 1.0 mm/min, as previously described (13).

Scanning electron microscopy (SEM)

Fifteen dentin specimens of each surface roughness were assigned to one of five groups. The surface of the specimens was then prepared in accordance with one of the five procedures described above, vacuum-coated with gold, and examined under a SEM operating at an accelerating voltage of 30 kV. The fracture surfaces were also examined by SEM.

Results

Bond strength determination

Mean values and standard deviations of the shear bond strengths are listed in Table 1. The statistical treatment involved analyses of variance and Student's t tests.

In the two control groups the strength of the bond between glass ionomer cement and untreated dentin ground on paper no. 220 was similar to that of the bond to dentin ground on paper no. 500 ($p > 0.05$). For each of the two grinding procedures the four mean values of bond strength obtained with dentin treated with polyacrylic acid were compared and found not to differ significantly ($p > 0.05$). Accordingly, for each of the two grinding procedures, a new mean value and standard deviation was calculated, pooling all results obtained with dentin treated with polyacrylic acid. Comparison of these mean values (4.6 ± 0.95 with paper no. 220 and 3.8 ± 1.36 with paper no. 500) showed that higher bond strength of glass ionomer cement was obtained to conditioned dentin ground on paper no. 220 than on paper no. 500 ($p < 0.01$). Moreover, when

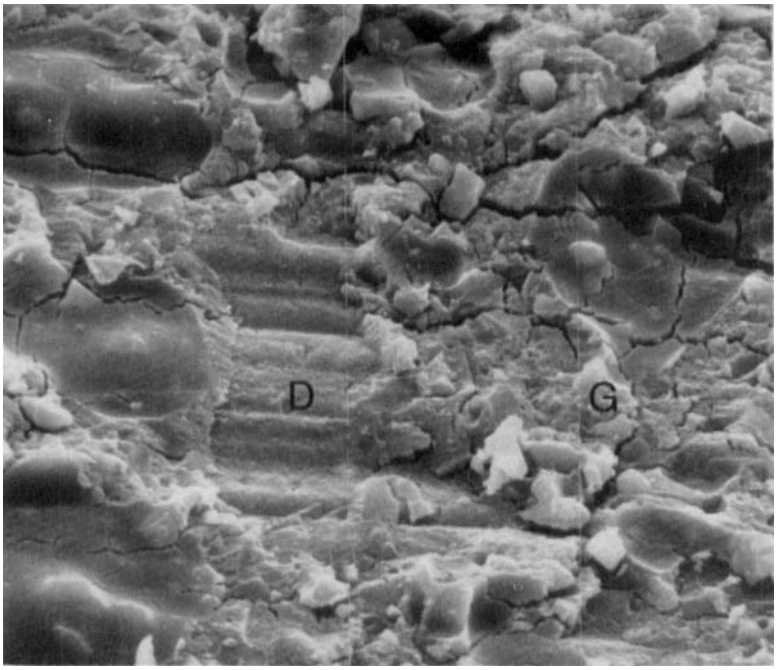

Fig. 1. Scanning electron micrograph of fracture surface between dentin and glass ionomer cement. D = dentin; G = glass ionomer cement. (Original magnification, ×640.)

the dentin had been ground on paper no. 220, treatment with polyacrylic acid resulted in an increase in bond strength ($p < 0.01$). With dentin ground on no. 500 no difference in bond strength was found.

As can be seen in Fig. 1, the failure of the bond between glass ionomer cement and dentin was both adhesive and cohesive. The largest fracture areas consisted of glass ionomer cement resulting from cohesive failure within the cement. In other small parts of the surface, dentin was exposed as a result of adhesive failure between dentin and cement.

SEM

Figs. 2a-e show representative examples of the dentin surfaces examined. Treatment with a 10% polyacrylic acid solution for 10 sec (Fig. 2b) resulted in removal of the smear layer formed by grinding (Fig. 2a), revealing the dentinal tubules. Prolongation of the conditioning to 30 sec caused a partial opening of the tubules (Fig. 2c). Widening of the tubules resulted from use of the more concentrated solution of polyacrylic acid. After treatment with 25% polyacrylic acid solution for 30 sec the dentinal tubules were opened totally and cleared to a considerable depth (Fig. 2d). Comparison of surfaces ground on paper no. 220 with those ground on paper no. 500 showed that after the same conditioning the tubules of the dentin surfaces ground on the finer paper were more exposed (Figs. 2c and 2e), indicating a thinner smear layer.

Discussion

This study both confirms and disagrees with the claimed effect of conditioning with polyacrylic acid. Thus, an increase in bonding between conditioned dentin and glass ionomer cement was found only when the dentin had been ground on carborundum paper no. 220. This suggests that with a smear layer of a certain thickness, the conditioning has a positive effect on bond strength. The statistically significant increase in bond strength from 3.1 MPa to 4.6 MPa may seem clinically irrelevant. A bond strength of 4.6 MPa

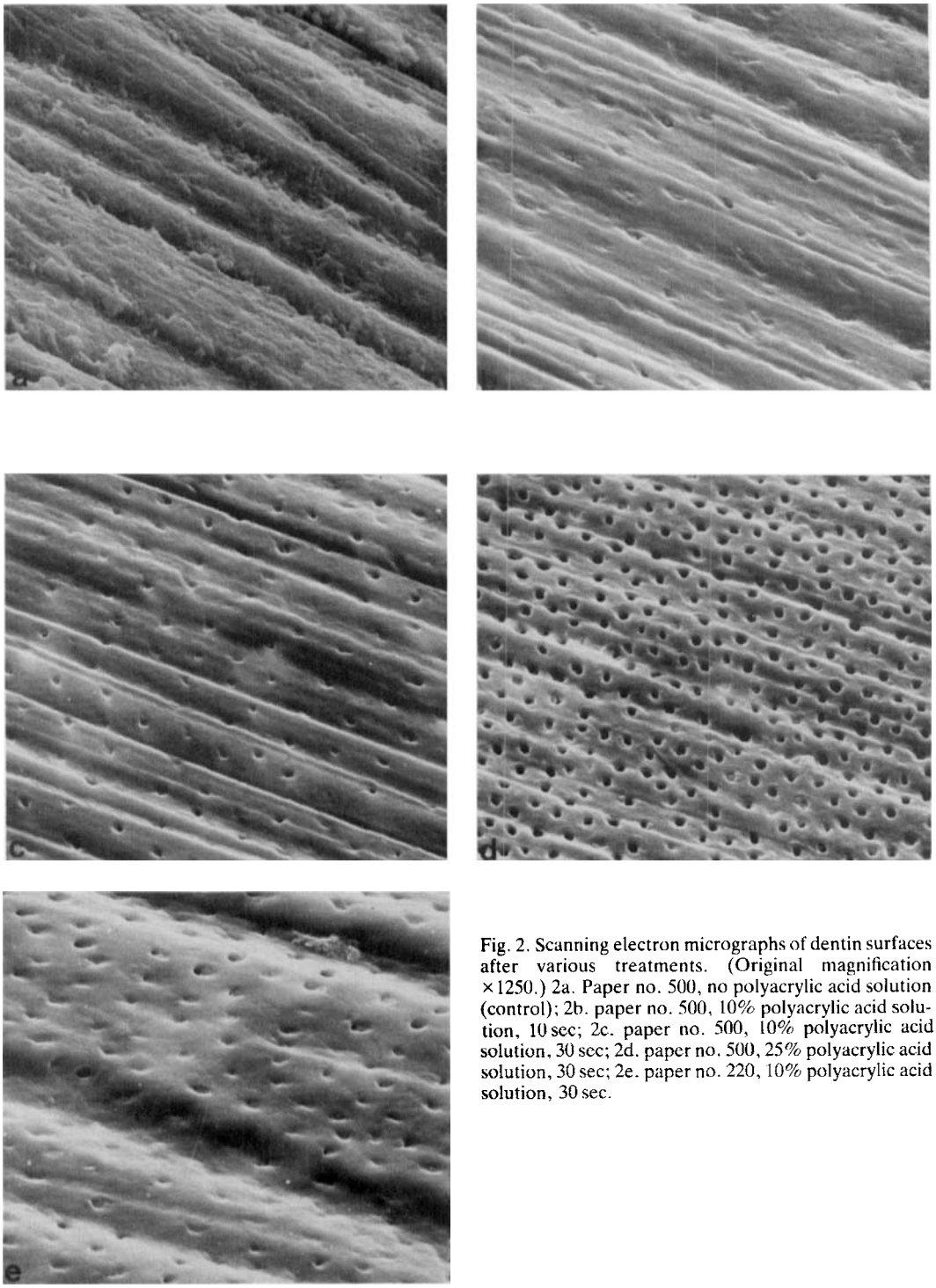

Fig. 2. Scanning electron micrographs of dentin surfaces after various treatments. (Original magnification ×1250.) 2a. Paper no. 500, no polyacrylic acid solution (control); 2b. paper no. 500, 10% polyacrylic acid solution, 10 sec; 2c. paper no. 500, 10% polyacrylic acid solution, 30 sec; 2d. paper no. 500, 25% polyacrylic acid solution, 30 sec; 2e. paper no. 220, 10% polyacrylic acid solution, 30 sec.

could, however, turn out to be just what is needed to ensure the durability of a glass ionomer cement restoration.

No effect was found for dentin ground on paper no. 500, which may indicate that conditioning could have a deleterious effect on the strength of the bond between glass ionomer cement and more smoothly cut dentin with a thinner smear layer. Clinically, using burs and diamonds, it is more likely, however, that thicker smear layers than the ones produced by grinding on carborundum paper nos. 220 and 500 will be produced. Taking this and the present findings into account, use of polyacrylic acid pretreatment seems relevant.

The lack of a significant difference in bond strength between the two control groups was unexpected, as the bond strength has earlier been found to depend on the roughness of the tooth surface (1). A possible explanation is the rather high standard deviations (1.42 MPa and 0.98 MPa, respectively) in relation to a smaller difference in bond strength between the two groups (0.9 MPa).

The differences observed in SEM between dentin surfaces treated with different polyacrylic acid solutions for different periods of time (Fig. 2) did not give rise to differences in the strength of the bond to glass ionomer cement. One reason for this lack of differences in adhesion might be that the failures were mostly cohesive (Fig. 1). Apparently, the demineralizing action of the polyacrylic acid solutions did not influence the bond strengths, even after a 30-sec treatment period. On the other hand, the results of the investigation give no reason for extending the conditioning beyond 10 sec or for the preference of a 25% polyacrylic acid solution over a 10% solution.

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