Bonding of adhesive resin to acid-etched enamel *in vitro*

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The bonding of a resinous sealant material to acid-etched sound human enamel was studied by means of a scanning electron microscope. Both the resinous bonding surfaces and the respective enamel surfaces of the specimens were exposed for inspection by dissolving one half of each specimen in hydrochloric acid so that only the resin matrix remained. Acid etching caused selective dissolution of the surface enamel so that, compared with the rod cores, more interprismatic substance was dissolved. The bonding surfaces of the resin material showed exact replication of the corresponding etched enamel. Tags of sealant, approximately 10 microns in length, were found on the acid-etched specimens.

Key-words: dental caries; prevention

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Various authors (*Buonocore*, 1973; *Buonocore & Davila*, 1973; *Going et al.*, 1974; *Leinfelder et al.*, 1974; *Meurman & Helminen*, 1974; *Meurman et al.*, 1975) have shown that acid-etch-bonded dental resins are effective in preventing occlusal caries as pit and fissure sealants and in bonding composite restoratives directly to the tooth. Clinicians have been especially interested in the effect of acid etching on the tooth and the retentive nature of the resin-enamel interphase. An in vitro technique was used in the present study to obtain actual morphological information on acid-conditioned enamel and on the corresponding resin surface.

MATERIAL AND METHODS

Twenty enamel blocks (of approx. 2mm × 3 mm × 5 mm) were prepared from the labial surfaces of freshly extracted, noncarious human premolar teeth. These specimen blocks were cleaned with pumice slurry, washed with distilled water and stored in a saline solution. The intact enamel surfaces of 16 specimens were etched with 30 % phosphoric acid for 60 seconds, washed with distilled water and dried with compressed, oil-free air. Half the acid-etched enamel surface was then coated with nail varnish. A commercial resin fissure sealant/restorative material[1]) was applied to the other half of each specimen according to the manufacturer's instructions. After the resin had set, the specimens were sectioned perpendicular to the surface along the margin of the resin coating with a water-cooled

[1]) Concise Enamel Bond®, Dental Products 3M, St. Paul, Minnesota, U.S.A.

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steel saw[2]). The varnished halves were then immersed in acetone to remove all the varnish. One non-coated etched enamel surface per specimen was thus obtained for the study. The resin-coated specimen halves were demineralized by use of a 10 % hydrochloric acid bath for 24 hours. The bonding surface of the resin was thus revealed for examination. All specimens were then studied with a scanning electron microscope[3]); an accelerating voltage of 20 kV was used throughout. Special attention was paid to the bonding surface of the resin, which was compared to the respective acid-etched non-coated enamel surface of the other half of the specimen. Photomicrographs were taken at magnifications ranging from 300 × to 10,000 ×.

In addition to the 16 specimens prepared as above, two enamel blocks were coated with the resin material without prior etching. The author thought it would be interesting to compare the enamel-resin interphase of a non-etched system with the other specimens. The two remaining enamel blocks were used as intact reference specimens.

RESULTS

The acid-etched specimens showed long tags of sealant on the bonding surface of the resin material, as seen in Fig. 1. The tag configuration represented resin penetration into the microspaces of enamel created by acid etching. The outermost edges and tips of the tags revealed by the demineralization of enamel appeared rounded, and their average length was calculated to be approx. 10 microns. The bonding surface of the resin material was found to correspond to that of the etched enamel. In all specimens studied the enamel showed a selective dissolution pattern with more material loss in the rod peripheries than in the rod-core regions (Fig. 2).

The bonding surface of the resin cast on to intact enamel showed no tag formation (Fig. 3). However, enamel perikymata and rod-head and rod periphery structures were exactly replicated. This suggests that the resin material studied has a highly adaptive nature.

DISCUSSION

The selective dissolution of surface enamel caused by acid etching has been widely studied. However, whether the major mineral loss occurs at the enamel rod core regions or at the rod peripheries is disputable (*Gwinnett et al.*, 1972; *Myers et al.*, 1974; *Silverstone*, 1974; *Simmelink et al.*, 1974). Differences in these respects could perhaps be explained if the variations in enamel mineralization and maturation processes were known and the nature of background enamel taken into consideration in every trial with adhesive resins. The present findings, however, showed that slight variations in morphological aspects of enamel dissolution did not play any major role in the enamel-resin interphase — at least, not to the extent that the sealant material could be made to flow into the etched microspaces of the surface enamel. The resin tag formation on the bonding surface of the material showed such a complicated configuration in all acid-etched specimens studied that the nature of the retentive surface became evident without further reference to changes in the enamel ultrastructure.

The rounded and »simple» appearance and short average length of the tags of the

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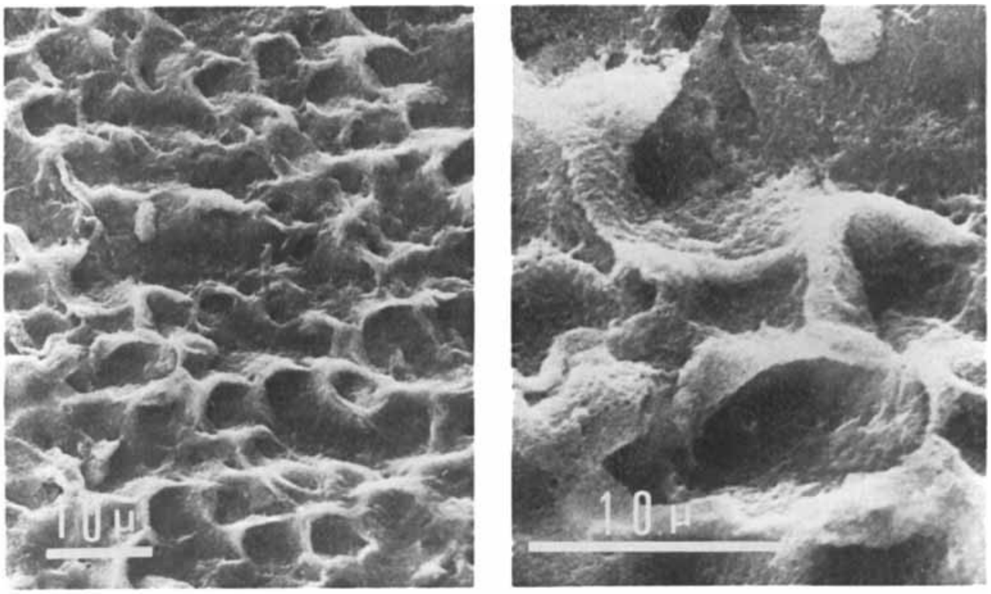
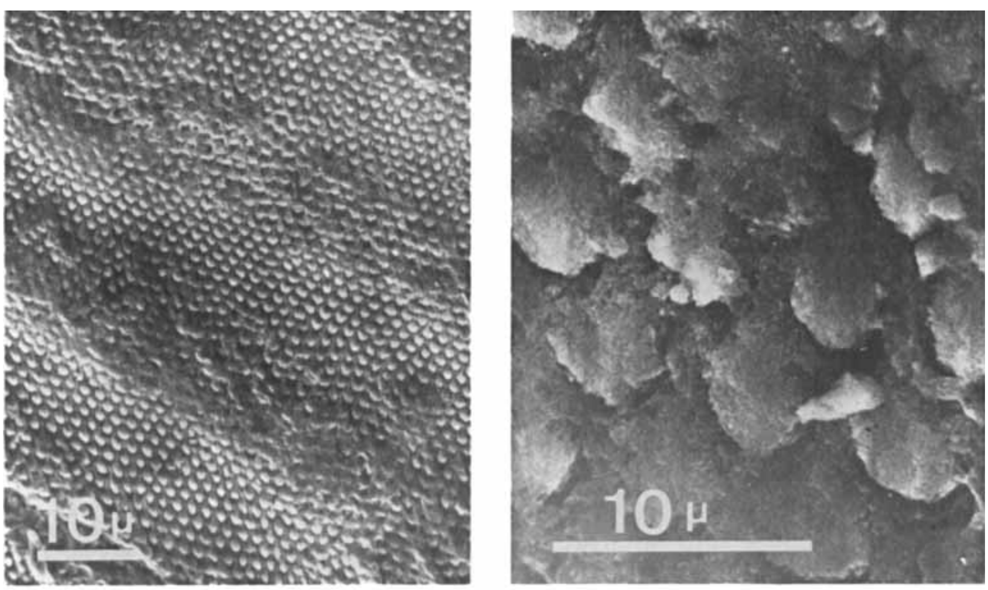
[2]) Meisinger 232-190, Hager & Meisinger GmbH, Düsseldorf, BRD.
[3]) Japan Electron Optics Laboratories SEM JSM-U3.



A B

Fig. 1. Bonding surface of a resinous fissure sealant revealed by demineralization of the corresponding enamel specimen. Numerous tags of resin can be seen which had penetrated the microspaces in etched enamel. Original magnification A. 1200 ×, B. 3500 ×.



A B

Fig. 2. Acid-etched tooth enamel, which shows a selective dissolution pattern with more mineral loss in the rod peripheries than in the prism core regions. Original magnification A. 1200 ×, B. 3500 ×.

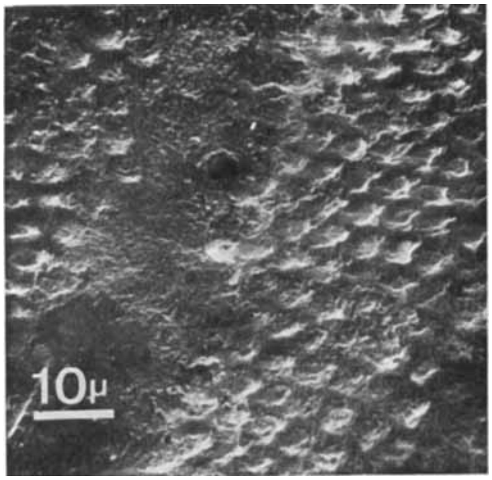


Fig. 3. Fitting surface of a resin cast on to intact tooth enamel without acid conditioning. No resinous tag formation can be seen but still the surface enamel has been exactly replicated in the resin matrix. Original magnification 1200 ×

present material as compared with previous findings by other authors (*Gwinnett & Matsui*, 1967) may be due to the fact that hardening began before the material had completely filled all the available ultraspaces. Materials hardened with ultraviolet light in situ may have better chance of and may be allowed more time for setting in and filling every ultrasocket formed by the etchant. These aspects are supported by the findings of *Dogon & Henry* (1975). But we may safely conclude that acid etching makes the enamel surface indisputable retainable for resinous sealant materials. However, we need to study further the numerous factors that may affect the bonding interphase.

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