The stability of water in the pores of acid etched human enamel

ERIK ASMUSSEN & KNUD DREYER JØRGENSEN

Department of Technology, The Royal Dental College, Copenhagen, Denmark

Asmussen, E. & Dreyer Jørgensen, K. The stability of water in the pores of acid etched human enamel. *Acta Odont. Scand.* 36, 43–44

A mechanism is proposed, explaining the fact that drying by compressed air for 5–10 sec. will remove acid and dissolved enamel from the relatively long and narrow pores of etched enamel surfaces. It is a consequence of the proposed mechanism that water in the liquid state is not stable in the pores, and accordingly, that condensation of water vapour on the etched and dried surfaces is not likely to occur. This was confirmed by studying tag formation in etched enamel surfaces under conditions where water vapour will condense on unetched tooth surfaces.

Key-words: Dental materials; restorative resins; tags

Erik Asmussen, Department of Technology, The Royal Dental College, 160, Jagtvej, DK-2100 Copenhagen Ø, Denmark

It is a well established fact that pores are formed in enamel surfaces by etching with phosphoric acid. After rinsing with water and drying, restorative resins are able to penetrate into the pores, whereby the so-called tags are produced. On the other hand, it has not been explained so far how drying by compressed air for 5–10 sec. is sufficient to remove the acid and the dissolved enamel from the relatively long and narrow pores in the enamel surface. In the following a mechanism is proposed that explains this elimination of liquid from the surface pores.

Fig. 1 shows in a schematic form a liquid-filled pore after the continuous layer of surface water has been removed from the enamel surface by compressed air. The shape of the pore is approximated to a cylinder. A pressure difference ΔP exists between the two sides of the curved liquid-air interface. In the cylindrical approximation $\Delta P = 4\gamma \cdot \cos \Theta / d$, where γ is the surface tension of the liquid, Θ is the contact angle between liquid and tooth, and d is the diameter of the pore. Assuming 1) that the surface tension of the liquid is close to that of water, i.e.

$\gamma = 72$ dyne/cm (4), 2) $\Theta = 0°$ (3) and 3) $d = 1$ µm, ΔP may be calculated to be $2.88 \cdot 10^6$ dyne/cm². Even allowing for possible variations in the shape of the pore and in the values assumed for γ, Θ and d, it appears that the pressure in the liquid may become lower than its vapour pressure. This means that the liquid is unstable and will boil. A similar process has been reported to occur during the setting of gypsum in air (meniscus explosion (2)). Thus, the elimination of liquid from the pores of etched enamel surfaces may be explained by a mechanism of ejection due to boiling at low pressure.

Received for publication, August 24, 1977

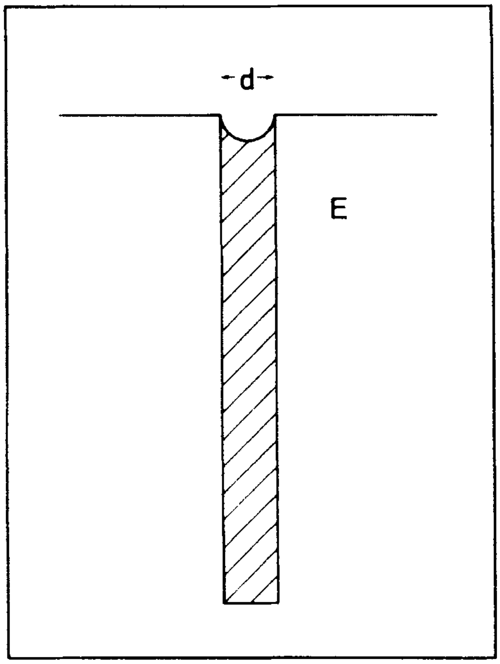

Fig. 1. Schematic presentation of a liquid-filled pore in an acid etched enamel surface, E. The diameter of the pore is d.

The drying of the etched and rinsed tooth surface will cause a decrease in temperature of the surface due to evaporation of water. In clinical situations this means that water vapour from the oral cavity will tend to condense in the surface pores, and conceivably prevent tag formation. It is, however, a consequence of the mechanism proposed above that water is not stable in the pores. The purpose of the present work was to investigate this consequence by studying tag formation in etched enamel surfaces under conditions where water vapour will condense on unetched tooth surfaces.

MATERIALS AND METHODS

Tags from Concise Enamel Bond were studied using 10 acid etched human teeth. After etching the teeth were rinsed with demineralized water and dried by compressed air for 5 sec. The experiments were carried out at a room temperature of 24 ± 1 °C. A stream of air saturated with water vapour was directed onto the etched surface five seconds before and during the application of the material. The temperature of the air stream was 28 ± 0.5 °C. When the stream of air was directed onto a smooth surface of plexiglass at 24 °C, condensed water immediately appeared. After setting of the material thin sections of the coated teeth were produced. The enamel was dissolved in hydrochloric acid and the tags were observed in an optical microscope. Details in connection with the preparation of the specimens have been described (1).

RESULTS

The microscopic examination showed for eight of the teeth tags of a length of 50 µm or more. For two teeth the longest tags were about 30 µm. No difference with respect to frequency and length could be observed between the tags in the present study and those described previously (1) where no contamination of the pores was attempted.

DISCUSSION

The microscopic examination seems to verify the deduction that in the absence of a continuous layer of surface water, water is not stable in the pores of etched enamel surfaces. It appears that a contamination of etched enamel surfaces due to condensation of water vapour is not likely to occur.

REFERENCES

1. Asmussen, E. Penetration of restorative resins into acid etched enamel. II. Acta Odont. Scand. 1977, 35, 183–191
2. Jørgensen, K.D. Science of odontological materials. Gypsum (Danish). Odontologisk Boghandels Forlag, København. 1969, 42 p
3. Newman, G.V. & Sharpe, L.H. On the wettability of tooth surfaces. J. New Jersey State Dent. Soc. 1966, 37, 289–293
4. Handbook of Chemistry and Physics, 53rd ed., The Chemical Rubber Co., Ohio. 1972–1973, F-28 p