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The Effects of the Acid Etch and Direct Bonding Technique in Orthodontics on Enamel Surface Topography

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SUMMARY

The acid etch technique and the direct bonding of orthodontic attachments have become accepted procedures in clinical orthodontics. Changes are produced in enamel surface topography by acid etching and on removal of the bonded attachments at the end of treatment. These changes were examined by scanning electron microscopy and the clinical implications of these surface changes are discussed.

OPSOMMING

In Ortodonsie word die suur-etstegniek en die direkte binding van aanhegtings aan tande as aanvaarbare kliniese prosedures beskou. Suur-etsing, sowel as die verwydering van die aanhegtings na afloop van die behandeling, veroorsaak veranderings in die oppervlaktopografie van glasuur. Hierdie veranderings is deur aftaselektronmikroskopie ondersoek en die kliniese implikasies van die waarnemings word bespreek.

INTRODUCTION

The added retention afforded by the acid etch technique has made the direct bonding of orthodontic attachments (Fig. 1) an accepted adjunct in the armamentarium of the orthodontist (Zachrisson, 1975; Retief and Sadowsky, 1975). Several resin systems have recently become commercially available for the direct bonding of plastic and metal attachments and different techniques have been developed for the placement of the brackets. These all rely on prior etching of the enamel surfaces onto which the orthodontic attachments are to be bonded.

The purpose of this investigation was to study the effects of an etching solution on human enamel surfaces and of polishing procedures on etched surfaces. In addition, clinical procedures to restore enamel surfaces after removal of bonded attachments were evaluated.

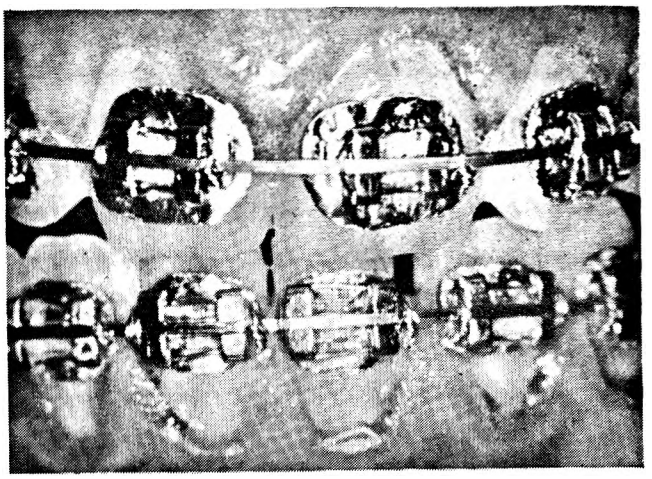


Fig. 1. **Directly bonded orthodontic attachments.**

MATERIALS AND METHODS

Freshly extracted, sound human teeth were used in this investigation. The teeth were cleaned and stored at -4°C until needed.

Some of the teeth were not etched in order to study normal enamel surfaces. The enamel surfaces of a number of teeth were etched with 50 percent phosphoric acid for two minutes. Some of the etched surfaces were polished with a rubber cup and a water slurry of pumice for varying time periods. Orthodontic attachments were bonded to some of the etched enamel surfaces under simulated clinical conditions. After allowing the resin to cure for approximately one hour, the bonded attachments were removed by hand instruments. Visible remnants of bonding material were removed with a dental scaler and the surfaces of some of these teeth polished with a rubber cup and a water slurry of pumice. A number of these polished surfaces were re-etched for two minutes with the 50 per cent phosphoric acid solution.

Specimens from each of these groups were mounted on aluminium stubs and coated with silver in a high vacuum evaporator*. They were subsequently viewed in a Cambridge S4 Stereoscan scanning electron microscope**. The machine was operated at 15 kV and

* Edwards Coating Unit, Edwards High Vacuum Ltd., Crawley, Sussex, England.

** Cambridge Scientific Instruments Ltd., Cambridge, England.



Fig. 2 **Sound human enamel. SEM X 2000.**



Fig. 3. **Human enamel etched with 50% phosphoric acid for 2 minutes. SEM X 2000.**

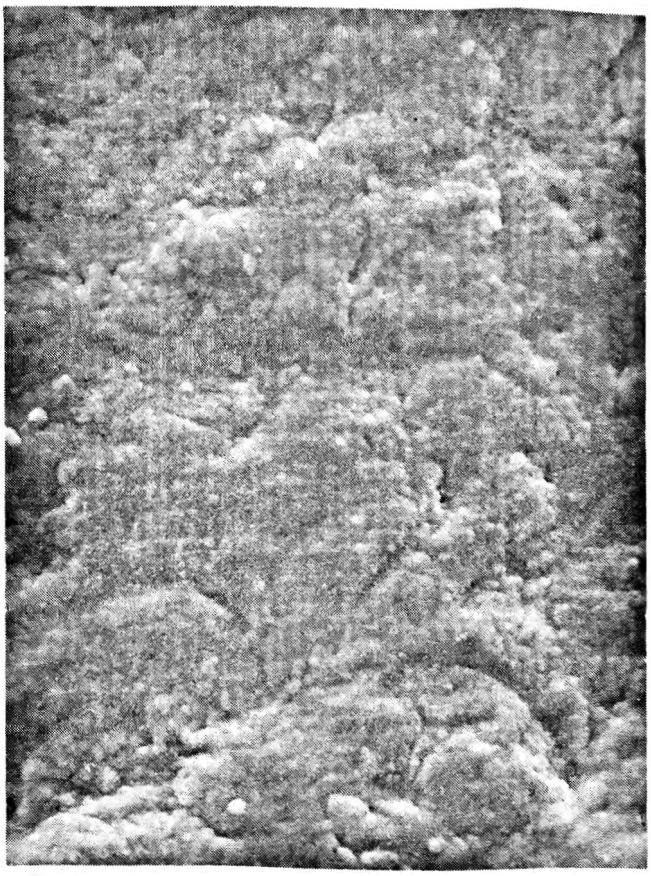


Fig. 4. **Etched enamel mechanically polished for approximately 2 seconds. SEM X 2000.**

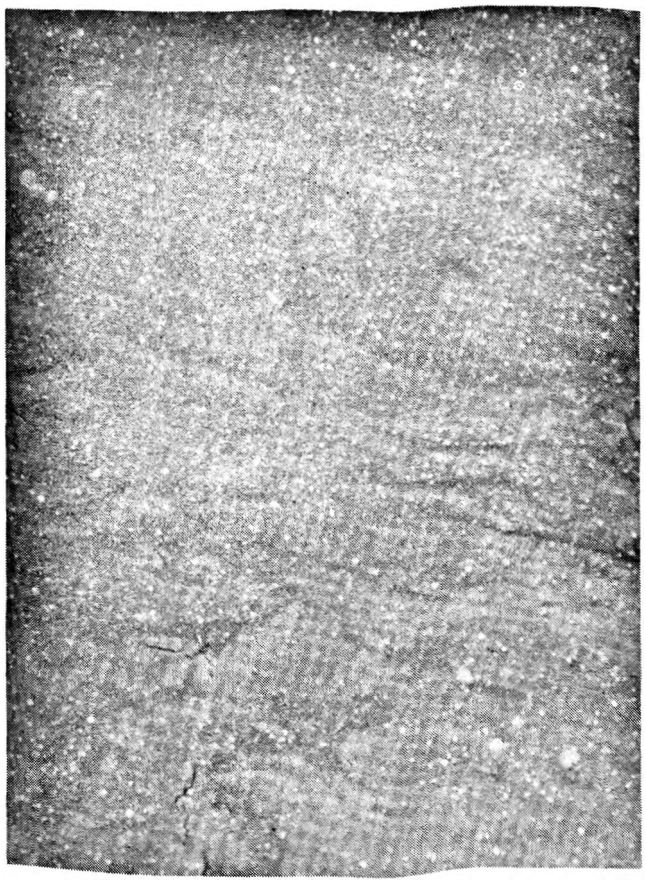


Fig. 5. **Etched enamel mechanically polished for approximately 10 seconds. SEM X 2000.**



Fig. 6. **An enamel surface from which a bonded attachment had been removed and the remaining resin removed by scaling. SEM X 2000.**

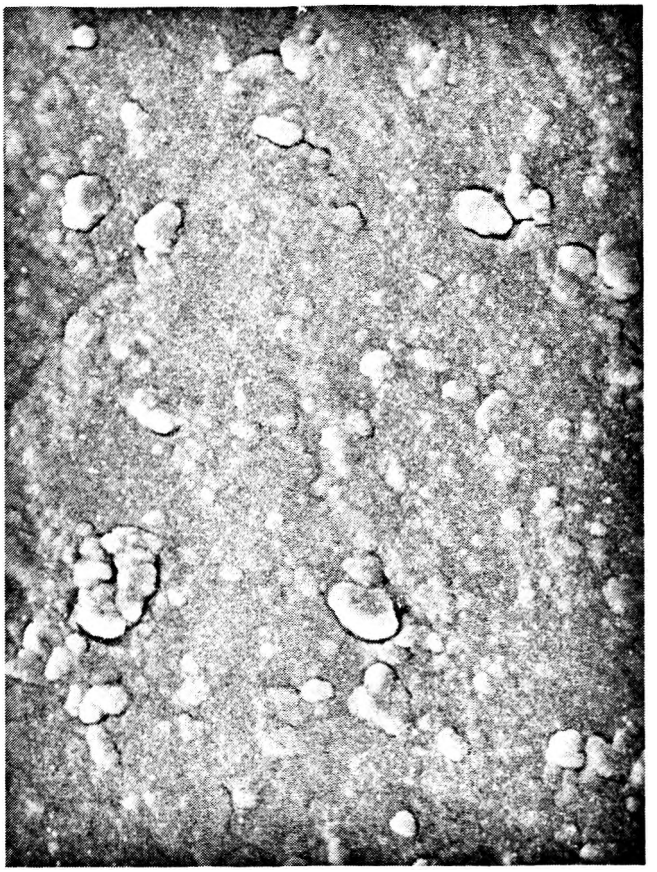


Fig. 7. **Mechanical polishing for approximately 2 seconds of the hand scaled enamel surface after bond removal. SEM X 2000.**

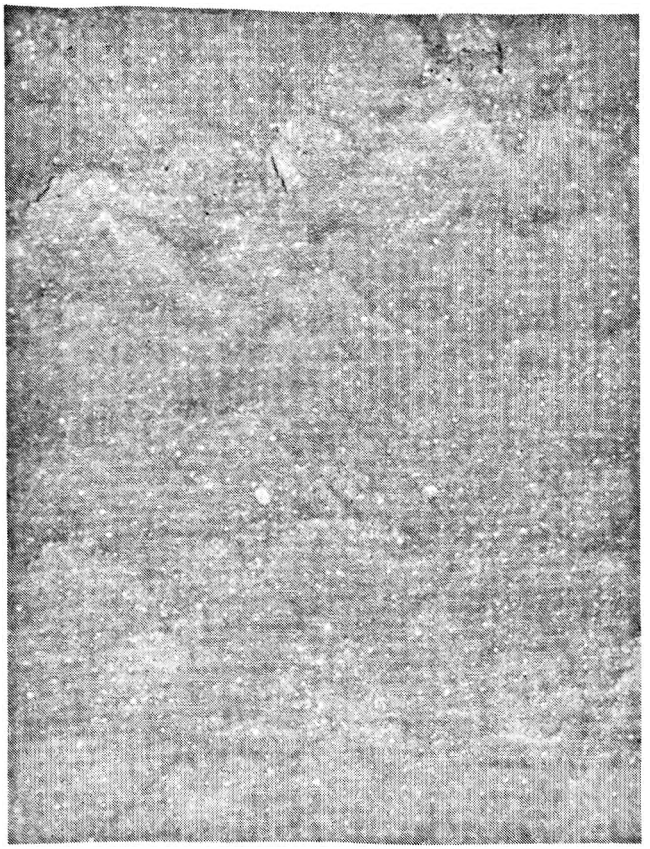


Fig. 8 **Mechanical polishing for approximately 10 seconds of the hand scaled enamel surface after bond removal. SEM X 2000.**

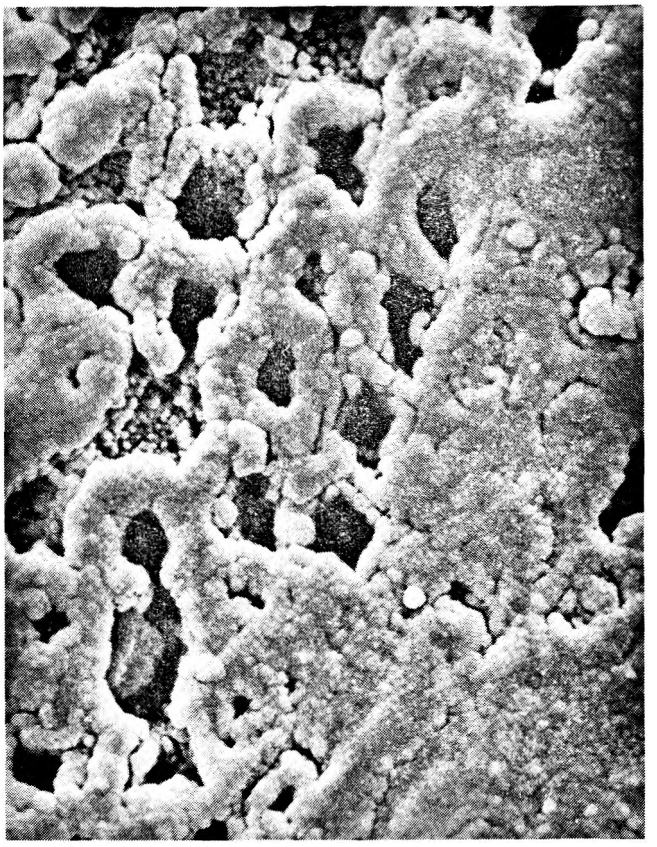


Fig. 9. **The enamel appearance after bond removal, hand scaling, mechanical polishing and subsequent phosphoric acid re-etching for 2 minutes. SEM X 2000.**

the beam-specimen angle varied to obtain the best surface projection.

RESULTS

A normal enamel surface has a relatively featureless topography (Fig. 2). An enamel surface which had been etched with 50 per cent phosphoric acid for two minutes showed the preferential etching action of the acid. The prism cores were etched to a greater extent than the prism peripheries (Fig. 3). Figures 4 and 5 are scanning electron micrographs of etched enamel surfaces that had been polished with a rubber cup and pumice for varying lengths of time. The former was polished for approximately two seconds (Fig. 4) while the latter was polished for about 10 seconds (Fig. 5). A smoother surface topography was obtained by polishing for a longer period.

The surfaces of the teeth from which the bonded attachments were removed and the visible resin remnants scraped by means of scaling instruments, showed that the normal enamel surface topography was obscured by adhering resin (Fig. 6). An appreciable amount of resin was left after polishing these surfaces with a rubber cup and pumice for two seconds (Fig. 7). Polishing for 10 seconds resulted in a smoother surface (Fig. 8).

Fig. 9 is a scanning electron micrograph of an enamel surface from which the bonded attachments were removed, the enamel surface scaled and polished and then re-etched with 50 per cent phosphoric acid for two minutes. The exposed enamel surface has been etched but the bulk of the surface was covered by resin remnants which formed a protective coating against the acid attack.

DISCUSSION

The preferential etching of the enamel surface by 50 per cent phosphoric acid produces micropores into which the curing bonding resin will flow. When cured the bonded attachments are mechanically retained to the etched surface (Gwinnett and Matsui, 1967).

Etching of the enamel surface leads to a permanent loss of superficial enamel. The depth of etch or amount of enamel lost is dependent on the acid concentration and the duration of etch (Silverstone, 1974; Retief, 1975). Etched enamel surfaces can readily be restored to their normal appearance by simple polishing procedures (Figs. 4 and 5). This confirms the observations previously reported by Newman and Facq (1971). *In vitro* studies by Lenz and Mühlemann (1963) of etched enamel surfaces suggested that the disappearance of the etching pattern could be due to abrasion or remineralization of the etched surfaces. Scanning electron microscope examinations of the *in vivo* recovery of etched enamel surfaces showed that apparent recovery of the etched surfaces had taken place (Lee *et al*, 1970; Retief, 1973). These studies did not prove that remineralization of etched enamel surfaces had occurred. Wei (1970) showed by electron microprobe x-ray spectrophotometry that etched surfaces were remineralized *in vitro*. Lee *et al* (1972) used a similar analytical technique to demonstrate that complete remineralization of etched enamel surfaces occurred *in vivo*.

When directly bonded attachments were removed at the completion of orthodontic treatment, scaling with hand instruments alone to remove the visible remnants of the bonding resin was not sufficient to produce a smooth enamel surface (Fig. 6). Further polishing with a rubber cup and pumice was required to produce an acceptable enamel surface topography (Fig. 8). The latter step is necessary to reduce plaque and debris accumulation. The time of mechanical polishing required will depend on the abrasive properties of the pumice used, the hand pressure applied and the hardness or abrasion resistance of the bonding material.

It has been shown clinically that rebonding after loss of a bonded attachment is possible (Retief and Sadowsky, 1975). This is probably due to the inflow of the bonding resin into the micropores created on a re-etched surface (Fig. 9) and chemical union between the new resin and the resin entrapped in the etched enamel surface after failure of a bond.

Concern has been expressed about the acid etch technique predisposing the enamel surface to carious attack after removal of bonded attachments. It has been shown that when the bulk of dental resins was removed from etched enamel surfaces, the materials which had penetrated the etched surfaces remained *in situ* (Gwinnett, 1971; Miura, Nakagawa and Ishizaki, 1973; Retief, 1974). Experiments carried out *in vitro* have demonstrated that the encapsulation of enamel crystallites by the resins which remained embedded within the etched enamel resulted in increased resistance to subsequent demineralization (Gwinnett and Matsui, 1967; Silverstone, 1974).

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