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Aluminablasting of human tooth enamel

M. ROMÎNU*, D. BRATU* and J. HURST‡
** Department of Prostheses Technology and Dental Materials, School of Dentistry, The University of Medicine and Pharmacy Timişoara, Spl. Tudor Vladimirescu nr. 14, 1900 Timişoara, Romania*
‡Department of Materials Technology, Faculty of Science & Engineering, The Manchester Metropolitan University, Chester Street, Manchester M1 5GD

As part of a programme aimed at enhancing the degree of bonding that can be developed between dental polymer and human tooth enamel, the enamel has been subjected to two types of pretreatment, namely, aluminablasting (a mechanical etching) and aluminablasting followed by surface etching with orthophosphoric acid. Analysis of the surfaces so prepared by scanning electron microscopy has shown that enamel patterns with different degrees of retention ability have been obtained, and that the surfaces should be capable of bonding with dental polymer.

1. Introduction

Studies of enamel surfaces/patterns which favour good adhesion with dental polymer are relatively recent. The work of Buonocore [1], who used orthophosphoric acid to etch tooth enamel, was further developed and systematized by Silverstone and Dogon [2]. Acids used included citric, pyruvic, folic, oxalic, hydrofluoric, acrylic, ethylene diamine tetra-acetic and orthophosphoric, with the latter giving the best results.

To date, four types of etching patterns have been identified and are related to the areas of enamel rods attacked by the acid. They are Type I (central), Type II (peripheral), Type III (combination of Types I and II) and Type IV (star-like or fern-like). Types I and II are acknowledged as being the most appropriate for forming good adhesive bonds with dental polymer.

Haller *et al.* [3], Becker *et al.* [4], Schilke and Geursten [5], Frentzen *et al.* [6] and Roth *et al.* [7] have all reported the use of lasers to etch tooth enamel. Their use, however, can lead to various side effects [6], for example, the melting of enamel zones, the production of microcracks and the initiation of microfractures, as well as the production of surfaces which support good adhesion to dental polymer [7].

The ability to produce acceptable enamel patterns by etching with orthophosphoric acid alone depends very much on the structure and internal properties of the enamel, and it is for this reason that the authors have investigated the effect on human tooth enamel of aluminablasting alone and aluminablasting followed by treatment with orthophosphoric acid.

2. Methods

Six groups, each of ten upper premolars extracted for orthodontic purposes, were washed in water, cleaned by brushing with water and detergent, degreased with n-butyl alcohol and finally dried. All treatments and investigations were carried out on buccal crown surfaces.

Buccal crown surface treatments were as follows:

Group 1 – blasted with alumina (50 μm), 20 s.
Group 2 – blasted with alumina (250 μm), 5 s.
Group 3 – removal of a thin enamel layer ($\sim$0.3 mm) with a fine diamond burr, blasting with alumina (50 μm), 20 s.
Group 4 – removal of a thin enamel layer ($\sim$0.3 mm) with a fine diamond burr, blasting with alumina (50 μm), 10 s.
Group 5 – blasted with alumina (50 μm), 20 s, etching with orthophosphoric acid gel, 60 s, washing, 20 s, and drying, 20 s.
Group 6 – blasted with alumina (50 μm), 10 s, etching with orthophosphoric acid gel, 60 s, washing, 20 s, and drying, 20 s.

Aluminablasting was from a distance of 5 mm, with the abrasive being directed at about a 4 mm^2 area of enamel surface. For teeth from Groups 1, 3, 4, 5 and 6, aluminablasting of relevant surface areas was undertaken with a microsandblaster (Microetcher®, Danville Engineering, USA) operating at 3×10^5 Pa pressure. Samples of teeth from Group 2 were aluminablasted using a laboratory blaster (Sablator®, Industria Technico-Medicală. Romania), operating at 5×10^5 Pa pressure. Some of the resulting surfaces were then exposed to supplementary etching with orthophosphoric acid gel (37%). Prior to blasting, samples of two of the groups (3 and 4) had the relevant areas of their surfaces abraded with a fine diamond burr.

Any washing and drying of the treated surfaces, which are indicated above, were undertaken with the air–water and air sprays of a dental unit (Dentior 5®, Intreprinderea Optică Română, Romania).

For analysis by scanning electron microscopy (SEM) (Cambridge Stereoscan 250), abraded/etched surfaces were sputter–coated with gold/palladium.

3. Results

The treated surfaces associated with Group 1 samples (Fig. 1) showed an irregular retentive relief, which in all probability was a reflection of abrasion by alumina particles impacting at different angles and energies.

The coarser grade of alumina (250 μm), as would be expected, was found to be more abrasive (Group 2 samples) and produced a more irregular microrelief than the finer grade (50 μm) of alumina; compare Fig. 2 with Figs 1, 3 and 4.

Although after treatment Group 3 samples displayed similar characteristics to Group 1 samples, the abrasive effect of the blasting process on the Group 3 samples appeared to be greater (compare Fig. 3 with Fig. 1). In our view, this was the result of the initial treatment with the fine diamond burr removing external enamel layers, as planned, and exposing lower layers of less dense material.

The abraded surfaces observed with Group 4 samples (Fig. 4) were almost identical to those displayed by Group 3 samples after treatment. Application of orthophosphoric acid gel to prior aluminablasted surfaces (Group 5 samples) afforded a more regular surface (Fig. 5), which resembled a Type II etching pattern. Presumably, the acid treatment removed

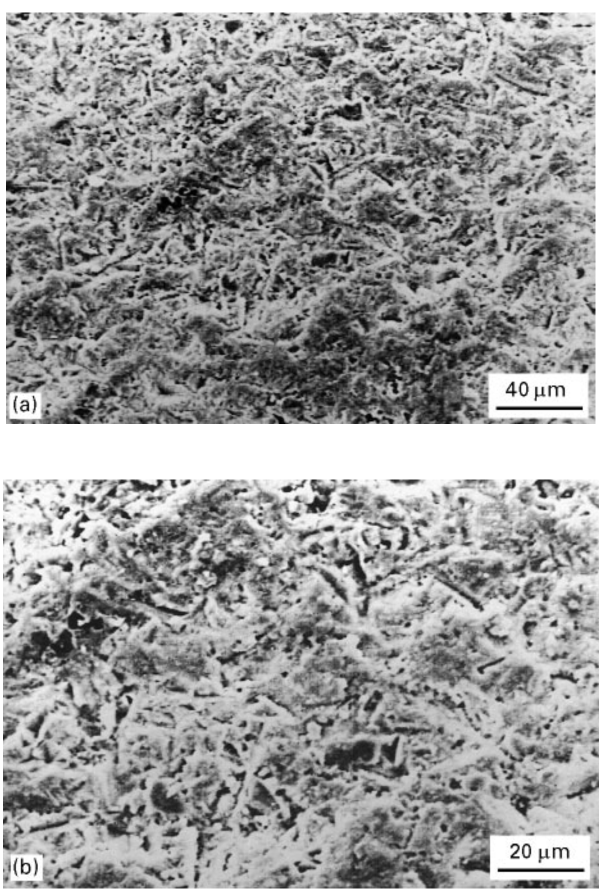

Figure 1 Aluminablasted enamel surface (Al_2O_3 50 μm, 20 s): (a) SEM × 500; (b) SEM × 1000.

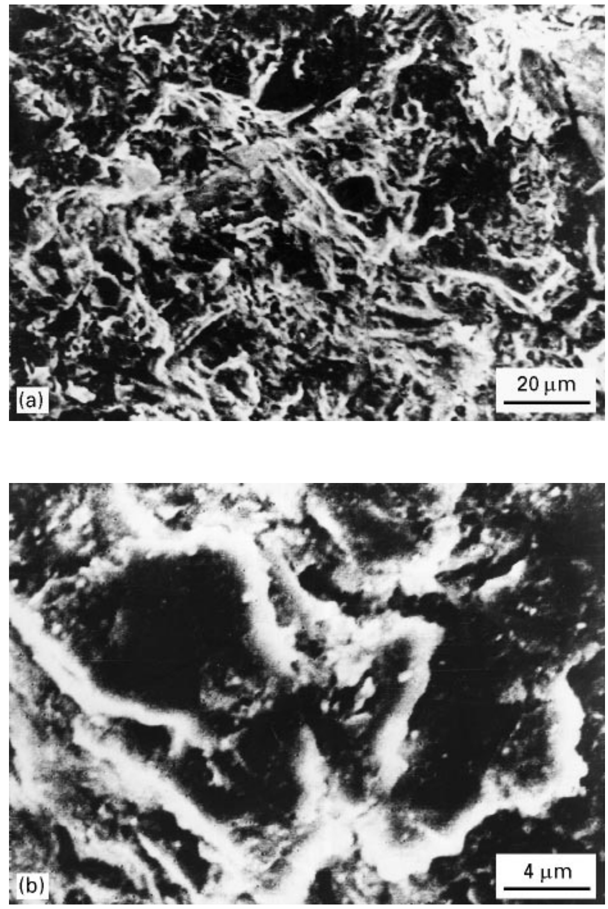

Figure 2 Aluminablasted enamel surface (Al_2O_3 250 μm, 5 s): (a) SEM × 500; (b) SEM × 2000.

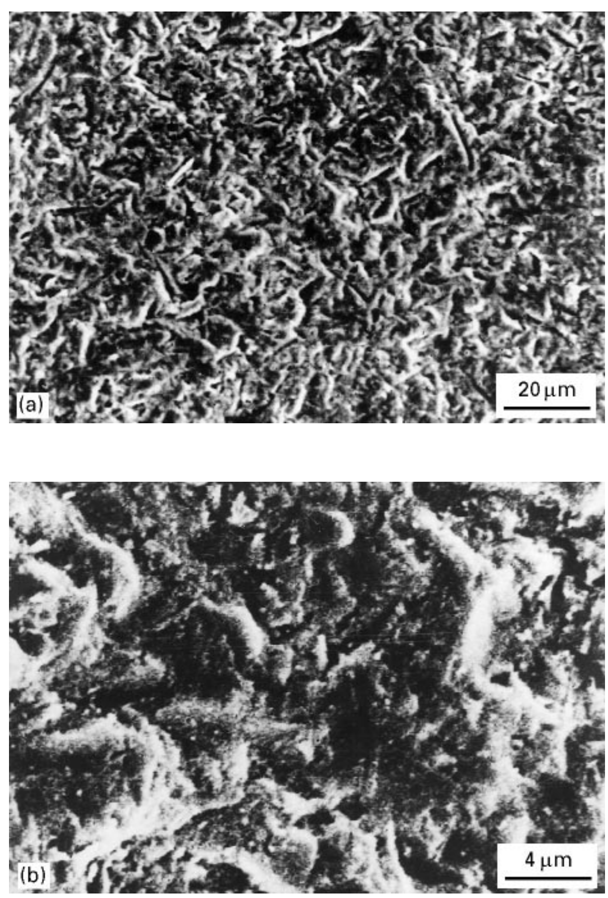

Figure 3 Aluminablasted enamel surface, after a thin enamel layer removal (Al_2O_3 50 μm, 20 s): (a) SEM × 500; (b) SEM × 2000.

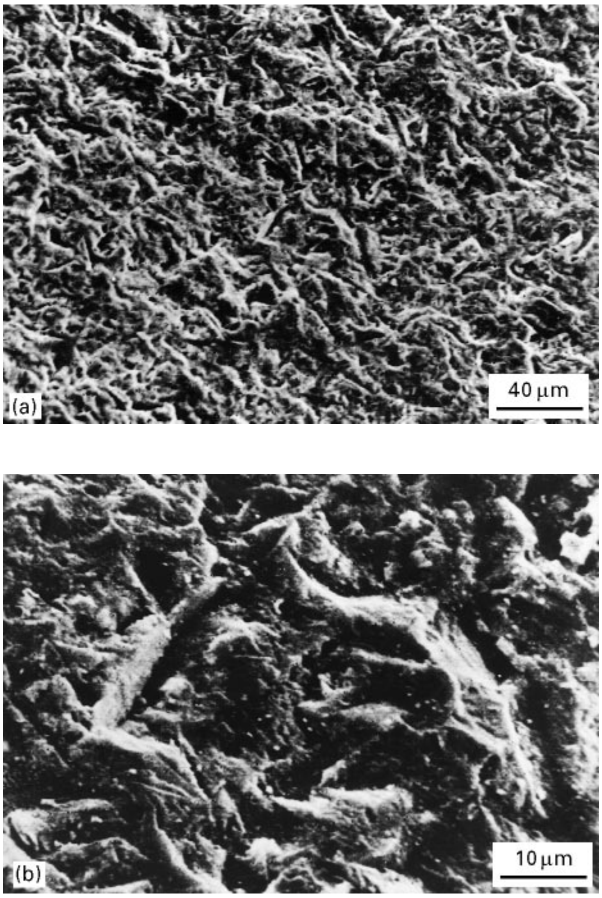

Figure 4 Aluminablasted enamel surface, after a thin enamel layer removal (Al_2O_3 50 µm, 10 s): (a) SEM × 500; (b) SEM × 2000.

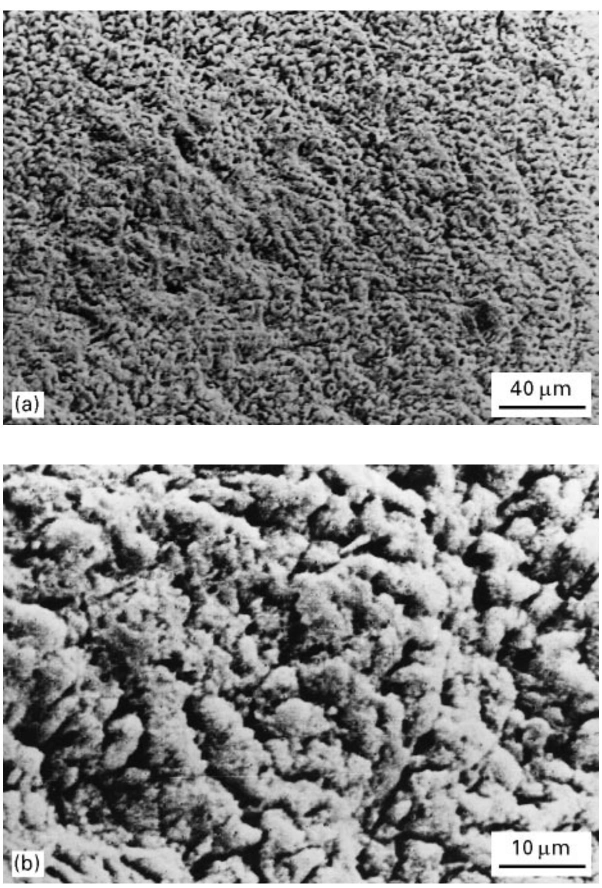

Figure 5 Aluminablasted (Al_2O_3 50 µm, 20 s) and then acid etched enamel surface (H_3PO_4 gel 37%, 60 s): (a) SEM × 500; (b) SEM × 2000.

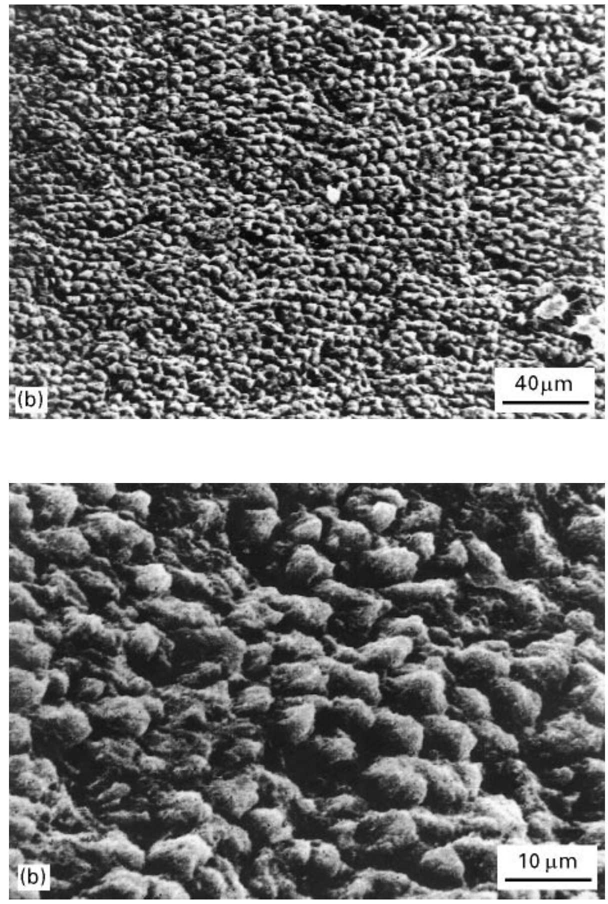

Figure 6 Aluminablasted (Al_2O_3 50 µm, 10 s) and then acid etched enamel surface (H_3PO_4 gel 37%, 60 s): (a) SEM × 500; (b) SEM × 2000.

much of the debris that was present on the surface after the initial blasting with alumina.

Group 6 samples also underwent treatment with orthophosphoric acid after their surfaces had been aluminablasted. With these samples (Fig. 6), the acid treatment produced a more regular surface than produced with Group 5 samples, presumably as a result of the shorter blasting time leaving less debris.

4. Discussion

The use of abrasive particles as a means of mechanically etching hard dental tissues is not new [8–11], but we have been unable to find in the literature any reference to aluminablasting being used to prepare human tooth enamel for a bonding operation.

Mechanical etching of enamel by aluminablasting results in a microrelief that, from our scanning electron microscopy investigations, appears very similar to that afforded by blasting with alloys. As a result we would expect that the strengths of adhesive bonds formed between the aluminablasted and alloyblasted surfaces and dental polymer to be similar.

The use of aluminablasting to prepare tooth surfaces appears to cause less damage than the use of laser, where temperatures can be so high that fusion of the enamel may occur.

It is evident that measurement of bond strengths between the aluminablasted surfaces and dental polymers is highly relevant in relation to the above comment.

Ongoing studies by the authors are aimed at optimizing conditions for aluminablasting, characterizing the mechanical properties of the enamel–dental polymer interface, and, particularly in relation to the latter point, assessing the relevance of the supplementary orthophosphoric acid treatment. Also, development of a system for protecting patients from particles of alumina is being pursued.

5. Conclusions

(i) Aluminablasting of human tooth enamel results in an irregular and retentive microrelief which closely resembles that afforded by alloyblasting.

(ii) Subsequent treatment of the mechanically etched enamel with orthophosphoric acid gel produces an enamel surface with a much more regular microrelief, where the rods within the tooth enamel are very evident.

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