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Atomic force microscopy analysis of enamel nanotopography after interproximal reduction

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Introduction: Interproximal reduction (IPR) removes enamel and leaves grooves and furrows on the tooth surface, which may increase the risk of caries. The aims of this study were to assess the nanotopography of enamel surfaces produced by the most commonly used IPR instruments and to evaluate the effect of polishing after IPR. **Methods:** Enamel slabs were cut from the interproximal surfaces of healthy premolars and then treated with diamond burs, strips, or discs, or Sof-Lex polishing discs (3M ESPE, St Paul, Minn). All samples were cleaned by sonication in distilled water. The control group had no IPR performed and was subjected only to cleaning by sonication. The enamel surfaces were assessed using atomic force microscopy. **Results:** The IPR instruments all produced surfaces rougher than the control sample; however, the samples that received polishing with Sof-Lex discs after enamel reduction were smoother than untreated enamel ($P < 0.05$ for all comparisons). The larger grit medium diamond burs and medium strips generated rougher enamel surfaces than their smaller grit counterparts: fine diamond burs and fine strips ($P < 0.001$). The difference in roughness generated by mesh and curved disks was not statistically significant ($P = 0.122$), nor was the difference caused by fine strips and mesh discs ($P = 0.811$) or by fine strips and curved discs ($P = 0.076$) (surface roughness values for medium bur, 702 ± 134 nm; medium strip, 501 ± 115 nm; mesh disc, 307 ± 107 nm; fine bur, 407 ± 95 nm; fine strip, 318 ± 50 nm; curved disc, 224 ± 65 nm). The smoothest surfaces were created by use of the entire series of Sof-Lex polishing discs after the enamel reduction (surface roughness, 37 ± 14 nm), and these surfaces were significantly smoother than the control surfaces (surface roughness, 149 ± 39 nm; $P = 0.017$). **Conclusions:** Different IPR instruments produced enamel surfaces with varied nanotopography and different degrees of roughness. Enamel surfaces treated with diamond-coated burs were the roughest, followed by diamond-coated strips and diamond coated discs. Polishing with Sof-Lex polishing discs after IPR reduced the enamel surface roughness, and this surface was even smoother than untreated enamel. (Am J Orthod Dentofacial Orthop 2017;151:750-7)

Interproximal reduction (IPR), also known as enamel reduction, interdental stripping, air rotor stripping, slenderizing, or reproximation, involves removal of enamel from the mesial or distal surfaces of the teeth. It is commonly used to create space or to correct tooth size discrepancies during orthodontic treatments with fixed and removable appliances and may be used in both the anterior or posterior regions of the mouth.[1,2] A recent study reported that most orthodontists (66%) routinely performed IPR in their practices.[3] By reducing the width of enamel at the interproximal surfaces, IPR may be effective in improving dental alignment and for enhancing postorthodontic stability, particularly in the mandibular anterior region.[4,5] In addition, IPR can reshape and improve anterior dental esthetics, for example by removing the black triangles that may become evident after alignment of crowded segments.[2,6]

IPR, however, inevitably alters the tooth enamel, changing the enamel surface morphology and contour. Numerous qualitative studies have shown that removal of this outer enamel leaves many grooves and furrows on the surfaces of the teeth.[1,7-9] Using scanning electron microscopy (SEM), grooved and roughened

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Table I. IPR instruments used in the study

IPR instrument	Model	Manufacturer	Grit	Hand piece
Burs				
Medium	Safe-tipped medium diamond	Dentsply, York, Pa	100-120 μm	High speed (400,000 rpm) with water cooling
Fine	Safe-tipped fine diamond	Dentsply, York, Pa	50 μm	High speed (400,000 rpm) with water cooling
Strips				
Medium	SS-Med interproximal strip-W	Dentsply, York, Pa	100-120 μm	N/A
Fine	SS-Fine interproximal strip-W	Dentsply, York, Pa	50 μm	N/A
Discs				
Mesh disc	Flexview mesh disc	Dentsply, York, Pa	100-120 μm	Slow speed (5000 rpm)
Curved disc	Flexview curved disc	Dentsply, York, Pa	50 μm	Slow speed (5000 rpm)
Polishing				
Sof-Lex series	Sof-Lex system kit	3M ESPE, St Paul, Minn	Variable	Slow speed (5000 rpm)
None				
Control	N/A	N/A	N/A	N/A

N/A, Not applicable.

enamel surfaces have been observed on the interproximal enamel of both deciduous and permanent teeth. These grooves and furrows form "hills and valleys," regularly or irregularly distributed, over the entire treated area.[9]

The SEM studies, however, provide only a subjective measure of surface roughness. There are only a few quantitative studies of enamel after IPR, and they have mainly measured surface roughness (R_a).[8,10] It has been found that IPR increased the surface roughness, regardless of the instruments used.[11] This roughness may increase the susceptibility of stripped enamel to bacterial adhesion and biofilm formation, which is then shielded from the mechanical clearance of salivary flow, brushing, or flossing, and thereby may promote demineralization and the buildup of plaque and calculus. Numerous studies have established that various dental materials with rough surfaces promote bacterial adhesion: eg, composite resin,[12,13] porcelain,[14] cobalt-chromium alloy,[15] and dental implants.[16] However, other studies have found that IPR did not lead to an increased caries risk.[11,17,18] Whether IPR actually increases the susceptibility of the stripped enamel to caries is still a matter of debate.[11,19,20] This may be because roughness is only 1 parameter of surface topography (detailed surface features) that influences bacterial adhesion, or it may be because the changes in the enamel surface are not significant enough to progress to a clinical event. Other topographic features of enamel surface after IPR are still poorly understood. A comprehensive investigation of surface shape and features of enamel after IPR is essential to understand the relationship between IPR and bacterial adhesion.

The aims of this study were to investigate the nano-topography of enamel surfaces produced by the most commonly used IPR instruments and to evaluate the effect on surfaces of polishing after IPR.

MATERIAL AND METHODS

Sixty-four premolars, removed from patients at the University of Otago School of Dentistry in Dunedin, New Zealand, for orthodontic purposes, were collected using the following exclusion criteria: staining, demineralization, decay, fluorosis, enamel cracks, defects, or restorations. Ethical approval for the study was obtained from the University of Otago Ethics Committee (reference number 13/105).

The extracted teeth were immediately cleaned and disinfected using 70% ethanol and stored at 4°C in sterile distilled water for less than 1 week, as described previously, before the experiments.[21] Enamel blocks measuring 3.5 mm (height) × 3.5 mm (width) × 2 mm (depth) were cut from the interproximal surfaces of the teeth. The 2-mm depth was measured from the highest point of the outer enamel toward the dentin. The blocks were cut using a straight, cylindrical, coarse diamond bur (FG 842 012; Hager & Meisinger, Neuss, Germany) with special care taken not to damage the outer enamel in any way, and then randomly allocated to 1 of 7 IPR instrument groups or the control group (n = 8 per group).

For the enamel surface preparation, the 7 IPR instruments that are most commonly used in orthodontic clinics were used in the study (Table I), including diamond burs, diamond strips, diamond discs, and Sof-Lex polishing discs (3M ESPE, St Paul, Minn). There was also a control group that was not subjected to any IPR procedures.

A total of 64 enamel slabs were used in the experiments (n = 8 per group, including the control group). All enamel stripping was carried out according to the

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