Finishing of Enamel Surfaces after Debonding of Orthodontic Attachments

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The trend in orthodontics, as in other spheres of human activity, is to simplify technical procedures so the objective can be achieved with a minimum of effort. The bonding of orthodontic attachments directly to etched enamel surfaces is an example of the clinical application of a simplified procedure. The direct bonding technique has distinct advantages over the conventional method of cementing preformed bands to teeth.[1]

Sadler[2] tested nine commercial adhesives to determine the possibility of bonding metal attachments directly to tooth surfaces. None of the adhesives evaluated were capable of bonding metal attachments directly to the teeth with a stability required for clinical orthodontics. Buonocore[3] introduced the concept of acid etching with orthophosphoric acid which involved the alteration of the tooth surface by chemical treatment to provide a modified surface to which dental resins might adhere. A cyanoacrylate resin,[4] epoxy resins[5,6,7] and acrylic resins[8,9,10] were used in conjunction with phosphoric acid etching to bond orthodontic attachments directly to tooth surfaces.

The synthesis of the bis-GMA resins by Bowen[11] and the subsequent development of the composite restorative resins based on this matrix made the direct bonding of orthodontic attachments an acceptable clinical procedure. Curing of these filled or unfilled bis-GMA resins is carried out either chemically with benzoyl peroxide-tertiary amine or by irradiation with short wave length ultraviolet light. Numerous reports on the retention rates of bonded attachments have appeared in the literature.[1,10,12-20]

With modifications of the acid etch technique and improvements of the physical and mechanical properties of the resin systems, the removal of directly bonded attachments and the finishing of the underlying enamel have become an acute clinical problem. Whereas previously a major consideration was the retention of bonded attachments, the emphasis has recently shifted to the debonding of orthodontic attachments and the removal of residual resin from tooth surfaces.[21-25]

The object of this investigation was to evaluate the efficacy of recently introduced instrumentation and techniques to dislodge bonded attachments, remove residual resin, and restore the affected enamel surfaces to an acceptable clinical condition.

Materials and Methods

Noncarious human maxillary central incisor teeth which were extracted because of severe periodontal disease were used in this investigation. The extracted teeth were stored in 70 percent ethanol prior to use. Mesh-backed stainless steel brackets were bonded to the facial surfaces of the teeth with Dynabond Adhesive System. The bonding system consisted of a bis-GMA resin with a low filler content, a low viscosity sealant, and 37 percent w/w orthophosphoric acid.

The crowns of 38 teeth were cleaned with a rubber cup and a water slurry of pumice, washed well and dried. The etching solution was applied for 60 sec-

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onds with a cotton pledget using a gentle dabbing action. The crowns of the teeth were washed well in running water and the surfaces dried with a chip syringe. The Catalyst and Universal Sealant liquids were mixed thoroughly and applied to the etched enamel surfaces with a brush. Equal portions of the Catalyst Adhesive and the Universal Adhesive were mixed well for 20 seconds on a mixing pad with a disposable plastic spatula. The mixed resin was transferred to the base of a mesh-backed bracket and the bracket seated with firm pressure on the enamel surface. The pressure was maintained until the resin had set. The slight excess of resin which had extruded around the edges of the bracket was carefully removed after five minutes with Standard Ceramisté wheels operated at approximately 10,000 rpm. The teeth with the bonded attachments were stored in distilled water at 37°C for 24 hours.

The bonded attachments were removed with a #346 direct bonding bracket remover. The edges of the brackets were engaged mesiodistally and the brackets dislodged by exerting gentle pressure. Two of these teeth and the brackets dislodged from them were prepared for viewing in the scanning electron microscope (SEM). The residual resin on the enamel surfaces of the remaining 36 teeth was removed by one of the seven procedures outlined in Table I. This was carried out under a dissecting microscope and no attempt was made to remove the resin completely. Resin removal with the burs, discs and wheels was done in a dry field with air cooling.

Procedure A

The remaining resin from four of the teeth was removed with a #349 direct bonding bracket remover. The plastic pad of the instrument was positioned against the incisal edge of a tooth and the remaining resin removed with the sharp beak of the bracket remover. The crowns of two of the teeth were then polished with a rubber cup and a water slurry of pumice at a speed of approximately 10,000 rpm for two 10 second intervals. This final polishing procedure was used as indicated in Table I.

Procedure B

The residual resin on the surfaces of four of the teeth was removed with a #1YS Starlite scaler. The crowns of two of the teeth were polished as previously described.

Procedure C

A superfine finishing diamond #1DT-SF was used to remove the remaining resin from the facial surfaces of four incisors. The diamond was operated at high speed without water cooling. Two of the teeth were polished with pumice.

Procedure D

A #FG-7406 12-bladed finishing carbide bur operated at high speed was used to remove the bonding resin from four tooth surfaces. Half the number of teeth were polished with pumice.

Procedure E

The residual resin from 4 teeth was removed with a #242 stainless steel finishing bur operated at approximately 10,000 rpm. The surfaces of two of the teeth were polished with pumice.

Procedure F

Medium (#1958M), fine (#1958F), and superfine (#19585F) Sof-lex finishing and polishing discs were used to restore the enamel surfaces of 8 teeth. The finishing protocol used is given in Table I. Only the surfaces of two of the teeth that were treated with all three discs were polished with pumice.

Procedure G

Ceramisté wheels from an enamel-adjustment kit were used to finish the surfaces of 8 teeth. The Standard, Ultra and Ultra II wheels were used as outlined in Table I. The wheels were

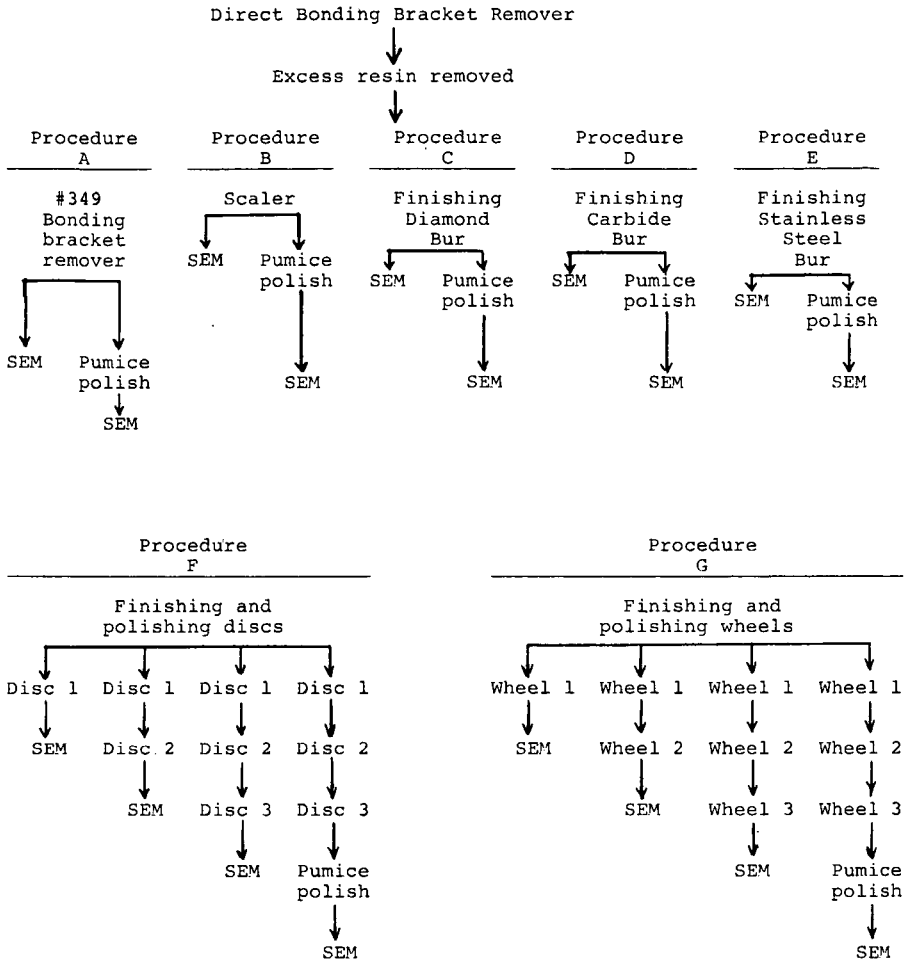

TABLE I

operated at approximately 10,000 rpm without water cooling and with light pressure.

The crowns of the teeth and specimens of the finishing and polishing discs and wheels were mounted on aluminum stubs and coated with gold palladium in a high vacuum evaporator. Orthodontic brackets and one of each of the burs used in this investigation were cemented on aluminum stubs with a silver adhesive. The specimens were viewed in a Cambridge Stereoscan Mark 2A SEM operated at 20 kV.

Results

The base of a mesh-backed orthodontic bracket is shown in Figure 1. The brackets were readily dislodged from the teeth with the bracket remover. Remnants of the resin embedded in the mesh of the bracket after removal are demonstrated (Fig. 2). Failure occurred mostly at the bracket-resin interface but occasionally areas where the failure had occurred at the resin-enamel interface were seen (Fig. 3).

The removal of the remaining resin with the #349 bracket remover resulted in severe gouging of the enamel

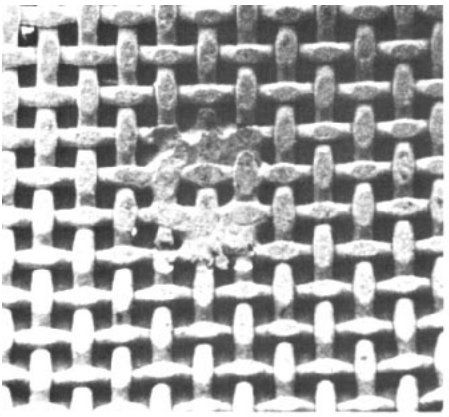

Fig. 1 Base of mesh-backed stainless steel orthodontic bracket (x 25).

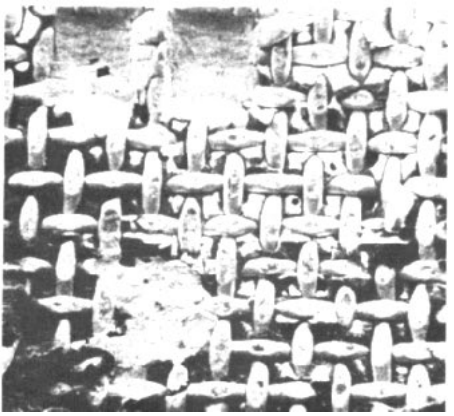

Fig. 2 Remnants of bonding resin embedded in mesh of bracket bases (x 25).

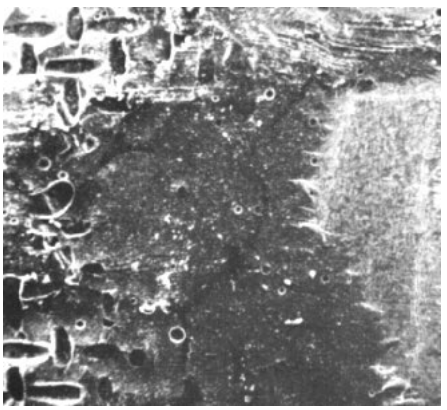

Fig. 3 Failure at the resin-bracket interface (left) and at the resin-enamel interface (right) (x 25).

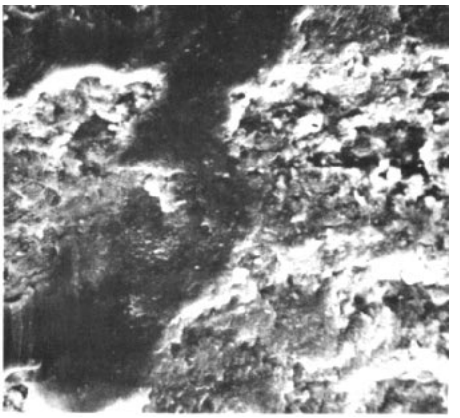

Fig. 4 Gouging of the enamel surface produced by removal of resin with a #349 bracket remover (x 700).

Fig. 5 Excess resin removed with bracket remover and enamel surface polished with rubber cup and pumice (x 700).

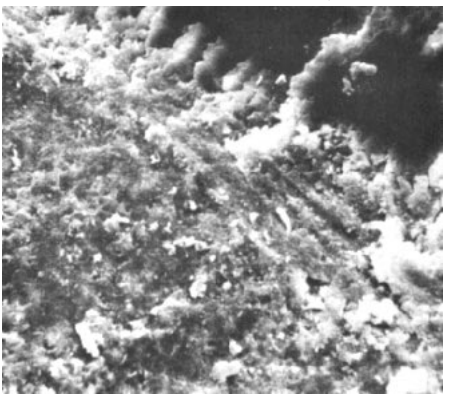

Fig. 6 Grooves produced on enamel surface by hand scalers (x 700).

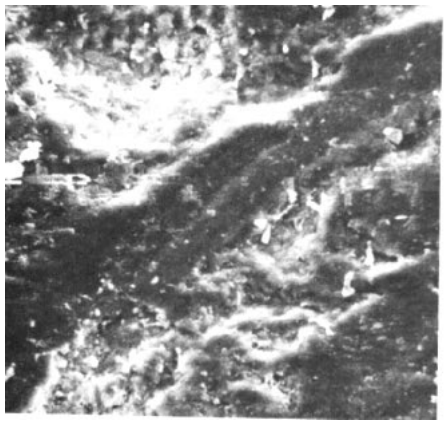

Fig. 7 Enamel surface polished with pumice after removal of remaining resin with scalers (x 700).

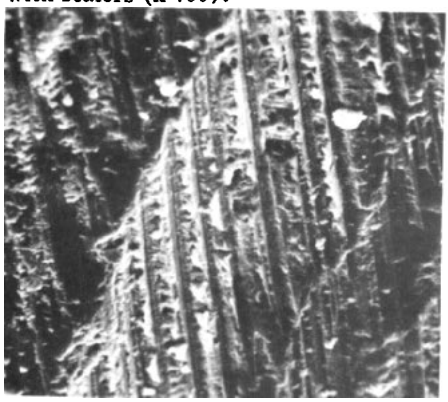

Fig. 8 Grooves and superimposed abrasion marks produced on enamel surface by diamond finishing bur (x 700).

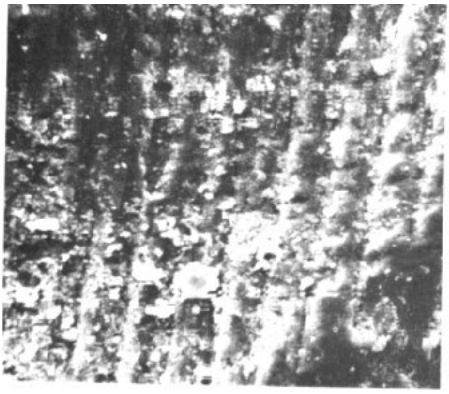

Fig. 9 Polishing did not remove serrations produced by diamond finishing bur (x 700).

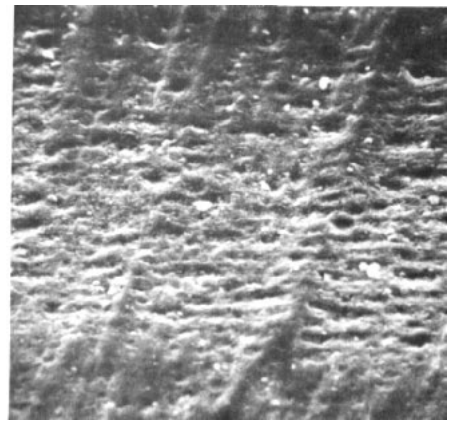

Fig. 10 Parallel grooves produced by carbide finishing bur (x 700).

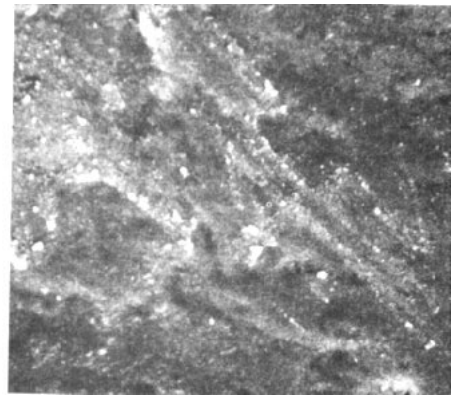

Fig. 11 Polished surface after removal of residual resin with carbide bur (x 700).

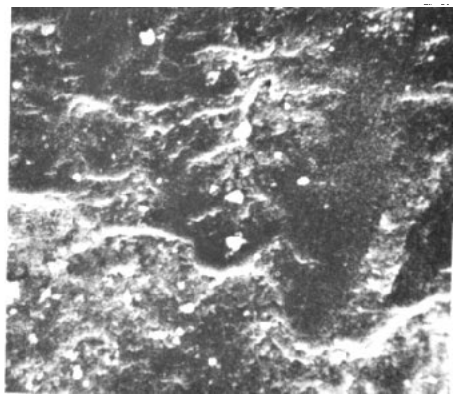

Fig. 12 Gouging of enamel surface produced by stainless steel finishing bur (x 700).

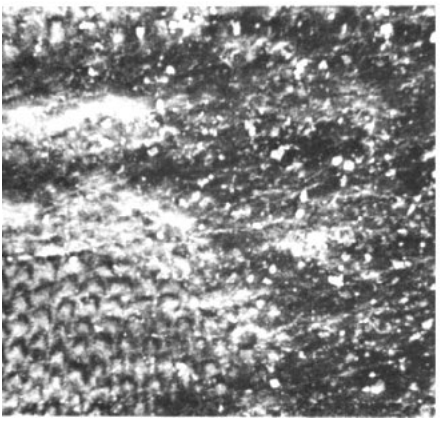

Fig. 13 Etched enamel-polished resin interface. Remaining resin removed with steel bur prior to polishing (x 700).

Fig. 14 Remaining resin removed with medium Sof-lex disc (x 700).

Fig. 15 Residual resin removed with medium followed by fine Sof-lex discs (x 700).

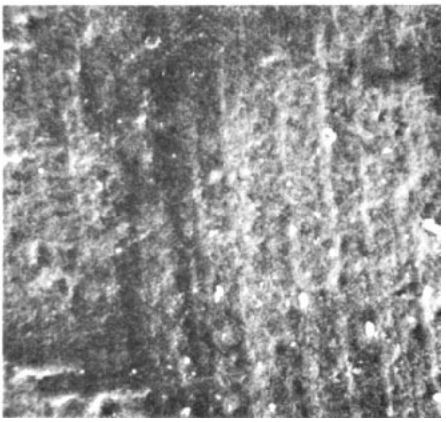

Fig. 16 Remaining resin removed with the three grades Sof-lex discs (x 700).

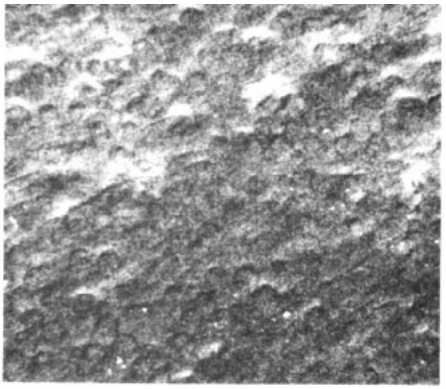

Fig. 17 Surface polished with pumice after removal of residual resin with the three grades of Sof-lex discs (x 700).

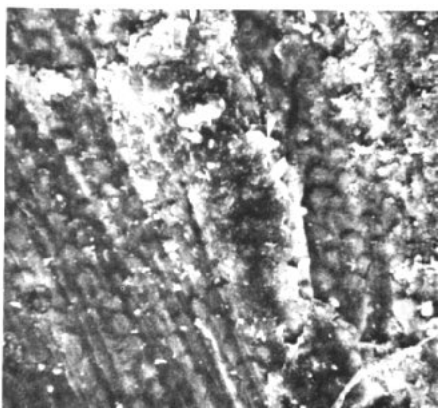

Fig. 18 Resin-enamel interface obtained with a Standard Ceramisté wheel (x 700).

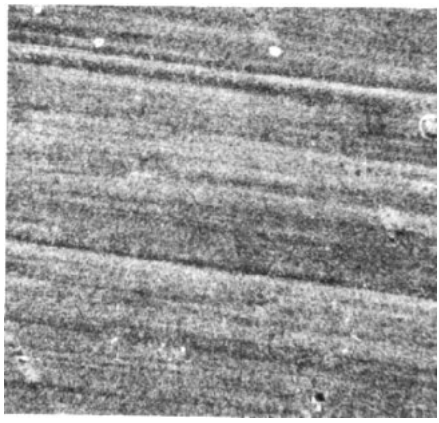

Fig. 19 Residual resin removed with Standard followed by Ultra Ceramisté wheels (x 700).

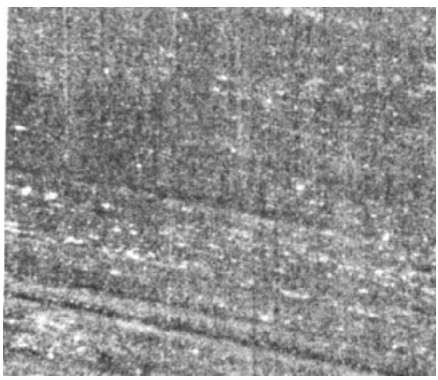

Fig. 20 Remaining resin removed with the three grades Ceramisté wheels (x 700).

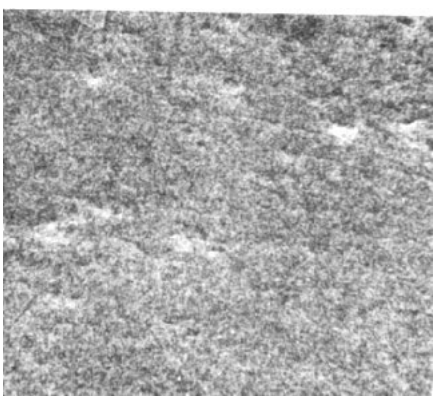

Fig. 21 Surface polished with pumice after removal of residual resin with the three grades Ceramisté wheels (x 700).

surface (Fig. 4). Polishing with the rubber cup and water slurry of pumice failed to produce an acceptable enamel surface (Fig. 5). Removal of the resin with scalers produced prominent grooves in the enamel surface (Fig. 6). Polishing also did not yield a satisfactory surface (Fig. 7).

The diamond particles embedded in the superfine finishing diamond produced grooves with superimposed abrasion marks on the resin-enamel surfaces (Fig. 8). The serrated surfaces persisted after the polishing procedure (Fig. 9).

The residual resin was readily removed with the 12-bladed carbide finishing bur. It produced parallel grooves on the resin-enamel surface (Fig. 10). Final polishing with pumice failed to restore the surface satisfactorily (Fig. 11).

The stainless steel finishing bur removed the remaining bonding resin with difficulty. These burs had to be replaced frequently because they became blunt. The stainless steel burs produced gouges on the resin-enamel surface (Fig. 12) which were not effectively removed by the polishing procedure (Fig. 13).

Surfaces produced by removing the residual resin with the medium Sof-lex aluminum oxide finishing and polishing discs (Fig. 14), medium followed by fine (Fig. 15), and medium followed by fine and superfine discs (Fig. 16) showed a progressive decrease in surface irregularities. Final polishing with pumice resulted in a satisfactory surface profile (Fig. 17).

Surfaces produced by the Standard (Fig. 18), Standard followed by Ultra (Fig. 19), and Standard followed by Ultra and Ultra II (Fig. 20) Ceramisté wheels showed a progressive decrease in abrasive marks on the resin-enamel surfaces. Final polishing with a rubber cup

and pumice produced a smooth surface profile (Fig. 21).

Discussion

The bonding system used in this investigation consists of a low viscosity sealant followed by a bis-GMA resin with low filler content. The authors support the view of Gwinnett and Gorelick[24] that the use of lightly filled resins is indicated for the bonding of orthodontic attachments. Removal of attachments bonded with a lightly filled resin should result in cohesive failure within the resin rather than at the resin-etched enamel interface. Failure at the latter interface may result in fractures occurring in the etched enamel surface.[26] A reduction in the filler content of the bonding resin should decrease the abrasive resistance of the resin and consequently make the polishing and finishing of the enamel surface easier.

Apart from the site of failure of the bonding resin, the amount of resin that will remain on the enamel surface after debonding will depend on the adaptation of the bracket base to the underlying enamel. Attachments should be carefully selected to follow the contour of the tooth. Sufficient resin to cover the bracket base should be used, the attachment seated on the tooth surface with firm pressure, and the excess resin removed after the resin has set. Thick adhesive layers are contraindicated as thick layers give weaker joints than thin.[27]

Removal of the bulk of the remaining resin prior to finishing will speed the restoration of the enamel surface. Although the debonding pliers are extremely useful to remove the bonded attachments by the application of a peel force, the use of the modified pliers for residual resin removal is not recommended. Gouges on the enamel surface were readily produced and these persisted after polishing with pumice. The hand scaling instruments are also not advocated for resin removal. Sharp scratches were inadvertently made on the enamel surface which could not be removed with the polishing procedure. Diamond finishing burs should not be used to remove the remaining resin. It was extremely difficult to control the resin removal without damaging the underlying enamel and to eliminate the abrasion grooves produced on the enamel surface. A 12-bladed carbide finishing bur is recommended for the removal of the bulk of the remaining resin provided that no attempt is made to remove the resin completely with the bur. The stainless steel finishing bur did not effectively remove the remaining resin. Resin removal was slow and the bur had to be replaced frequently because of bluntness.

The graded (medium, fine and superfine) finishing and polishing discs produced surfaces which could readily be restored satisfactorily with pumice. If an appreciable amount of resin was left, however, finishing with the Sof-lex discs was a slow procedure and resulted in the formation of facets on the resin-enamel surface. Removal of the remaining resin with the three graded Ceramisté wheels produced a smooth surface profile after polishing with pumice. This finishing procedure should only be used after the bulk of the residual resin has been removed with a carbide finishing bur. Light pressure and adequate air cooling should be employed when using the Ceramisté wheels.

It is necessary to work in a dry field when removing the remaining resin with the rotary instruments. It is difficult to clearly define the resin-enamel interface and the use of water cooling will make this well-nigh impossible. It is therefore essential that the rotary instruments should be applied with light

pressure and adequate air cooling. In this investigation no attempt was made to remove all of the remaining resin. The main objective was to produce an aesthetically and clinically acceptable surface while at the same time minimizing damage to the enamel.

Conclusions

The finishing of enamel surfaces after removal of directly bonded attachments is essential. The following procedures are suggested:

1. The bonding of mesh-backed stainless steel brackets with a lightly filled resin system.

2. Debonding of attachments with a direct bonding bracket remover.

3. Removal of the *bulk* of the remaining resin with a 12-bladed tungsten carbide bur operated at high speed with adequate air cooling.

4. Finishing of the residual resin and underlying enamel with graded polishing discs or Ceramisté wheels used with light pressure and adequate air cooling.

5. Final finishing with a rubber cup and a water slurry of pumice.

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