Periodontal Splinting With a Thin-High-Modulus Polyethylene Ribbon

Today, there has been a trend toward changing demographics of dental practices with an increase in the number of older adults seeking care. For these patients, the success of periodontal and endodontic therapy have allowed them to keep their natural teeth longer. Also, these patients want to live their lifetime with their dentition intact. One problem facing the clinician in fulfilling these patient's expectations is the increasing mobility of anterior teeth that results from loss of periodontal attachment. This is especially true of the mandibular incisors. For these circumstances, the treatment to reduce mobility by splinting periodontally involved teeth is accepted.

For many years it was thought that splinting periodontally involved teeth was necessary to control gingivitis, periodontitis, and pocket formation. It was accepted that tooth mobility contributed to attachment loss and the formation of vertical osseous defects. Increased mobility of teeth was a direct consequence of traumatic occlusion, bruxism, and clenching. There was general acceptance that even normal physiologic function, including mastication and swallowing, contributed to tooth mobility.[1]

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These concepts were investigated with clinical studies that reported that when teeth were occlusally overloaded and when other variables that contribute to periodontal disease were controlled, it was difficult to produce gingivitis, periodontitis, and pocket formation.[2,3] In 1979, it was reported that there was not a correlation between splinting and reduced tooth mobility during initial periodontal therapy.[4] These findings indicated that a reduction in tooth mobility was the result of changes in occlusal relationships and a decrease in gingival inflammation.

It has been proven that while a splint is in place, there is a reduction in tooth mobility.[5,6] Once the splint is removed, the mobility is unchanged. What has been unclear is the role of splinting of periodontally diseased teeth as a part of initial periodontal therapy.[7,8]

Tarnow and Fletcher summarized the indications and contraindications for splinting of periodontally involved teeth.[9] They indicated that based on the dental literature, there are three primary rationales for controlling tooth mobility with periodontal splinting. These are:

Figure 1A—Facial view of preoperative mandibular anterior teeth with grade 2 mobility.

Figure 1B—Lingual view of the preoperative teeth.

Figure 2—Preoperative radiographs demonstrating 50% bone loss.

1. Primary occlusal trauma.
2. Secondary occlusal trauma.
3. Progressive mobility, migration, and pain on function.

Primary occlusal trauma is defined as injury resulting from excessive occlusal forces applied to a tooth or teeth with normal periodontal support while secondary occlusal trauma is injury resulting from normal occlusal forces applied to a tooth or teeth with inadequate periodontal support.[10] It is now accepted that clinical prognosis of periodontally compromised teeth many times hinges on the presence of tooth mobility.[11,12]

In many cases, the clinician wants to approach the decision to splint teeth with the most conservative technique possible, especially during active periodontal treatment. Pollack described 25 years of success with stabilization techniques without crowns and bridges using adhesive composite resins of mobile, periodontally involved teeth.[13] Most of the splints he followed over the 25-year period of time either had no additional reinforcement or they had wire reinforcement. His chief problem was that repairs were frequently needed because of fractured composite between the teeth. The problem was solved with the introduction of a high strength, bondable, biocompatible, esthetic, easily manipulated, colorless ribbon that could be embedded into a resin structure.[14]

Currently there are a number of fiber reinforcement materials available on the market. Fiber reinforcement materials affect the physical properties and behaviors of composite materials.[15] Glass fibers are treated with silane to allow them to be bondable to dental resins while polyethylene fibers are plasma treated to enhance their chemical bondability.[16]

One problem with the fiber reinforcement materials that have been available is their inherent thickness when embedded within composite resin in a splint. To overcome this problem, a lock stitched cross-linked weave of thinner strands of polyethylene fibers, Ribbond® THM Reinforcement Ribbon[a] was introduced. The thinner material still incorporated the ease of use of the original ribbon's lock stitch weave. Unlike braided fiber weaves that had a tendency to unravel and not hold their dimensional shape once they were cut to the desired length needed, the new material does not unravel and is dimensionally constant when embedded within composite materials. Another feature of the lock stitch weave of this material is the tight weave allows the ribbon to maintain a structural integrity that imparts a multidirectional reinforcement to restorative polymeric resins that acts as a crack stopper.[17,18] By changing the diameter of the polyethylene threads from a 215 denier thread to a thinner 100 denier thread, the same width ribbon has more than twice the volume fraction of threads. With this increased volume fraction, there is a 2.5 times increase in flexural strength of composite resin when compared to no fiber reinforcement and a 15% increase compared to the original Ribbond® ribbon.[19] In addition, the fibers of the woven ribbon have virtually no memory, they allow themselves to be adapted to the varied surface topography of teeth.

[a]Ribbond, Inc., Seattle, WA 98101; (800) 624-4554

Figure 3—The facial interproximal areas were prepared with a diamond rotary instrument.

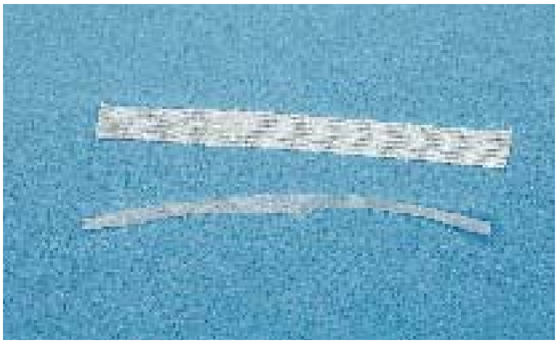

Figure 4—The 3-mm-wide ribbon was cut to the same length as the dental floss template.

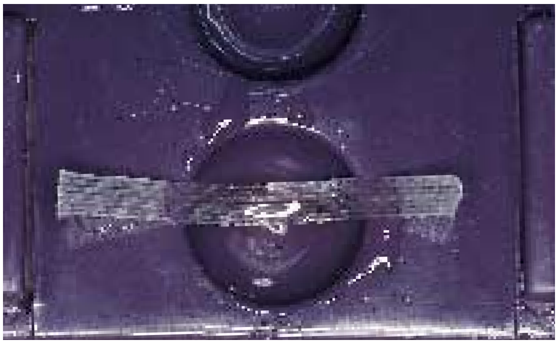

Figure 5—The ribbon was wetted with adhesive resin.

Figure 6—The teeth to be splinted were etched for 30 seconds with a phosphoric acid gel etchant on both the lingual and facial interproximal surfaces.

Case Report

This patient presented with the chief complaint of discomfort while functioning on the mandibular anterior teeth (Figures 1A and 1B). Radiographically, the mandibular incisors have over 50% bone loss (Figure 2) with a mobility of 2 according to the Miller's Index. The patient was referred for splinting by the treating periodontist as a result of secondary occlusal traumatism of the mandibular incisors. After consultation with the periodontist, it was decided to use a directly placed ribbon-reinforced composite resin-bonded splint to extend from canine to canine. The patient could not tolerate long dental appointments, and an advantage of the directly bonded splint was the one-visit procedure. The teeth were isolated for the clinical procedure with a dental dam. Besides providing for a high degree of isolation, the dental dam for patients with exposed root surfaces and root sensitivity acts as a barrier to air, water, and air-water spray during the splinting procedure, making the use of local anesthesia unnecessary. The teeth were cleaned on the facial and lingual surfaces using a prophylaxis cup with a nonfluoridated pumice paste. The teeth were then thoroughly rinsed and dried. Next, the interproximal surfaces of the teeth were cleaned and prepared with a CeriSander™,[b] a medium grit diamond finishing strip in a handle. To minimize bulk on the esthetic facial surface interproximally, a thin, round-end, chamfer diamond (Revelation, #854-016)[c] was used to barrel into the interproximal areas (Figure 3). Because of the thinness of the Ribbond® THM fiber ribbon, there was no need for a channel preparation on the lingual surface. Although this patient had no tooth sensitivity, it may be necessary to give bilateral mental blocks for anesthesia to patients with root sensitivity. It was decided the splint would extend from mandibular left canine to the mandibular right canine. Since the importance of the composite resin reinforcement is in the interproximal areas, the splint was to extend from the midlingual surface to midlingual surface of each canine. A piece of dental floss was laid onto the lingual surface at the level of the proximal contacts and cut to length. With the cut floss, a 3-mm-wide piece of ribbon was taken and cut to an equal length as the floss (Figure 4). The polyethylene ribbon is extremely tough. To cut the fiber ribbon, the manufacturer supplies a scissor with special

[b]Den-Mat Corporation, Santa Maria, CA 93456; (800) 433-6628
[c]SS White Burs, Inc., Lakewood, NJ 08701; (732) 905-1100

Figure 7A—Facial view of the gingival embrasures with the medium bodied polysiloxane impression materials blockout.

Figure 7B—Lingual view.

Figure 8—Application of the resin adhesive to the etched enamel surfaces being certain to cover both the lingual, facial, and interproximal areas.

Figure 9—The facial interproximal surfaces after sculpting the composite resin and light-curing. This composite resin will stabilize the teeth while the ribbon splint is placed on the lingual surface.

cutting blades as part of the product kit. Also, until the plasma-treated fibers are wetted with adhesive resin, they are susceptible to surface contamination. Therefore, when handling the ribbon before the resin is applied, clean cotton pliers must be used. The plasma-treated polyethylene fibers have an indefinite shelf life.

The cut ribbon was impregnated with adhesive resin from a fourth generation bonding system, Tenure® S[b] (Figure 5). Once wetted, the white opaque appearance of the ribbon changes to an esthetic translucency. The ribbon was then blotted to remove excess resin using a napkin. The ribbon should be only lightly wetted with adhesive resin. The ribbon was put aside and covered to block any light until it could be embedded in the composite resin on the teeth.

The teeth were etched for 30 seconds with a 32% phosphoric acid gel etchant (Uni-Etch®, [d]) being certain that the etchant flowed between all of the teeth to be splinted and onto the facial surfaces (Figure 6). The teeth were then rinsed with an air-water spray for 10 seconds and gently dried. The most distal tooth surfaces of teeth Nos. 22 and 27 had interproximal matrix strips placed to maintain separation. In the past, wedges were placed to minimize excess composite in the gingival interproximal embrasure areas. With wedges there is always the potential that highly mobile teeth could be splinted in a different position. Recently, an innovative technique for minimizing excessive composite resin in these areas has been described.[21] The technique is the placement of a medium viscosity polysiloxane impression material using an impression syringe in these gingival embrasure areas. It is important that the impression material be placed after tooth etching, rinsing and drying to avoid the trapping of moisture that can occur if the technique is performed earlier (Figures 7A and 7B). This use of elastomeric impression material assures a passive placement of the blockout. A resin adhesive was applied to the etched enamel surfaces including the interproximal surfaces and facial interproximal areas using a disposable brush (Benda®Brush[e]) (Figure 8). The adhesive should not be light-cured until the composite resin is applied. If dentin or cementum is included in the restoration, these areas must be

[d]Bisco Dental Products, Schaumburg, IL 60193; (800) BISDENT

[e]Centrix, Inc., Shelton, CT 06484; (800) 235-5862

Figure 10—Composite resin was applied to the lingual surfaces prior to placement of the woven polyethylene ribbon.

Figure 11—Placement of the ribbon into the composite resin on the lingual surface. Note the use of the cotton pliers and burnisher to embed the ribbon into the composite.

Figure 12—To avoid exposing the reinforcement ribbon when polishing the lingual surface, a flowable composite resin is thinly placed to cover the ribbon.

Figure 13—The polysiloxane impression material blockout has been removed. Note the minimal need for finishing in the gingival embrasure.

treated with an appropriate dentin primer from the adhesive being used. Although single component bonding agents can also be used for this technique, in most cases the preparation and restoration is in enamel only and there is no need for a dentin bonding component.

A medium viscosity hybrid composite resin in compule tubes (Prisma® TPH[f]) was dispensed onto the facial surfaces of all the interproximal areas of the teeth that were to be splinted. The facial surfaces were shaped and then light-cured for 20 seconds (Figure 9). The purpose of the facial composite resin was to seal the interproximal areas against recurrent caries, to provide a 180˚ wrap of composite resin to each of the splinted teeth, and to stabilize the teeth to prevent movement when the composite resin and ribbon are placed onto the lingual surface. This facial extension of composite resin functions as a cross-splint for each tooth to prevent tooth movement and breakage of the final splint. This step is important because once splinted, the interproximal surfaces of adjacent teeth cannot be cleaned adequately. The composite resin was then placed onto the lingual surface (Figure 10). The 3-mm-wide ribbon was placed into the composite resin starting at the midlingual surface of either canine and pushed into the composite resin. Cotton pliers and burnisher can be used to adapt and embed the ribbon into the composite resin (Figure 11). When the ribbon was pushed into the composite resin a slight excess of composite resin extended past the ribbon. This was smoothed and the excess beyond the lingual surfaces was removed before light-curing. The lingual surfaces were then light-cured for 60 seconds for each tooth. At this time, the ribbon will be visible and not completely covered with an adequate thickness of composite resin. For this reason a high strength, wear resistant, flowable composite resin (Virtuoso™,[b] Flowable) was applied to smooth the irregular surfacing on the lingual and provide an even thickness of composite covering the ribbon (Figure 12). The flowable composite resin on the lingual surface was light-cured for an additional 20 seconds for each tooth. The polysiloxane impression material blockout was removed from the gingival embrasure areas (Figure 13). Because of this blockout technique, there was very little finishing necessary for the splint.

[f]DENTSPLY/Caulk, Mildford, DE 19963; (800) LD-CAULK

Figure 14—An example of finishing of the gingival embrasure to a smooth surface using a Lamineer® tip in a Profin® reciprocating handpiece.

Figure 15—Final polish of the gingival embrasure with the V-shaped plastic tip.

Figure 16A—Facial view of the completed composite resin ribbon reinforced splint.

Figure 16B—Lingual view.

The dental dam was removed. At this point, if the composite resin needs further shaping, this can be accomplished with finishing burs or diamonds. The lingual surfaces were polished with an aluminum oxide abrasive point (Enhance®,[f]). In some cases, the facial surfaces need additional shaping. Facial shaping was done with abrasive Lamineer® tips mounted in the Profin® Directional Handpiece[g]. The Profin® has a reciprocating movement with the Lamineer® tips. These flat tips are excellent for creating the illusion of depth and separation on the facial interproximal and incisal embrasure areas. It may be necessary in some cases for the Lamineer® tips to be freely rotating for access. This can be done by not seating the tip completely into the reciprocating head of the handpiece. When a fixed position is desired, the Lamineer® tip can be fully seated in the handpiece head. This provides for convenient access and control needed for delicate and precise interproximal shaping of any resin materials in gingival embrasure areas. Also, access to the gingival margins on the proximal surfaces is limited when teeth are splinted. Finishing strips will not work well on rounded or concave root and interproximal surfaces. Likewise, rotary handpieces with rotating finishing diamonds and burs often used in these interproximal areas are contraindicated because they can create unnatural embrasures and notched irregular surfaces. Profin®, with its back-and-forth reciprocating motion, can be used to remove excess resin and finish the gingivointerproximate surfaces to natural form (Figure 14). The Lamineer® tips have a variety of abrasive grit particles ranging from diamond grit sizes of 150 mm to 15 mm to leave a smooth texture for polishing these surfaces to a high gloss. The final polishing and access to hard to reach areas for polishing is accomplished with composite resin polishing paste dispensed through a Lamineer® hollow plastic tips or with the deformable V-shaped tips[g]. The V-shape tips expand and conform to the shape of interproximal spaces (Figure 15). Final polishing was accomplished with a composite resin polishing paste. The final step was adjustment of the occlusion and esthetic appearance of the splint. The completed splint provided tooth stabilization, increased function without bulk, and fulfilled the patient's esthetic needs (Figures 16A and 16B). The radiographs of the completed splint verifies the joining of the periodontally involved incisors (Figure 17).

[g]Dentatus, USA, Ltd., New York, NY 10016; (800) 323-3136

Figure 17—Radiograph of completed splint demonstrates the x-ray visible woven ribbon embedded in the hybrid composite resin.

Discussion

Tooth mobility has been described as an important clinical parameter in predicting prognosis.[11,12] For this reason and for patient comfort, splinting has been the recommended therapy to stabilize teeth. In the past, direct stabilization and splinting of teeth using an adhesive technique required the use of wires, pins, or mesh grids. These materials could only mechanically lock around the resin restorative. Because of this there was the potential of creating shear planes and stress concentrations that would lead to fracture of the composite and premature failure. When the splint failed, the clinical problems that occurred included traumatic occlusion, progression of periodontal disease, and recurrent caries.[21] With the introduction of bondable, polyethylene woven ribbons, many of the problems with older types of reinforcement were solved.[22] Samadzadeh and coworkers reported significantly higher fracture strength of Ribbond® reinforced Provipont™ DC[h], a provisional restorative material similar to acrylic resin, and when a crack occurred in the reinforced Provipont™ DC, the crack did not propagate beyond the polyethylene fiber and the beam remained intact. Unreinforced Provipont™ DC beams fractured and demonstrated total separation between the two pieces.[18] Karbhari and Dolgopolsky have described the phenomenon of fatigue crack growth in short fiber reinforced composites with a zone of transformed (damaged) material. This damaged zone consumes energy and controls the fatigue fracture toughness and rate of crack growth. This explains the fracture toughness of a ribbon fiber reinforced composite resin splint.[22]

An evaluation of reinforcement fibers used for splinting teeth for both their effect on physical properties and clinical success demonstrated that all fibers improved the flexural strength and flexural modulus of composite resin. All splints fabricated using these materials were also clinically successful after one year.[23] Other clinical uses of fiber reinforcement have also been reported to be successful.[24-29] In a long-term clinical evaluation of splinting using the original Ribbond® Reinforcement Ribbon this author has found that over a period of 42 to 84 months, fiber reinforced composite resins are highly successful. Cases evaluated included periodontal splints, bridges with composite resin pontics and natural tooth pontics, and orthodontic retention. Of the 11 patients being followed, none have exhibited debonding or recurrent caries. Of those cases with only continuous tooth splinting or orthodontic retention, none of the periodontal splints or orthodontic retention has fractured. Only two pontics of nine natural tooth pontics or composite resin pontics fractured during the study and although the fracture of the composite resin was apparent, the pontic did not separate from the abutment tooth. The ribbon held it in place until the area could be repaired.

[h]Ivoclar Vivadent, Inc., Amherst, NY 14228; (800) 533-6825

Conclusion

This article described an innovative technique using a thin, bondable, ribbon-splinting material for reinforcing dental resins. By combining the chemical adhesive and esthetic characteristics of composite resin with the strength enhancement of a plasma treated, high modulus, reinforcing ribbon, dentists can provide patients with restorations and splints that will resist the load-bearing forces of occlusion and mastication. These fracture resistant restorations will be more durable than most alternative splinting materials of the past.

Disclosure

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