STABILIZATION OF THE NATURAL DENTITION IN PERIODONTAL CASES USING ADHESIVE RESTORATIVE MATERIALS

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Splinting teeth is a common practice in restorative dentistry used to stabilize teeth following acute trauma; to prevent mobility; as part of occlusal therapy; to prevent tooth drifting; as a replacement for missing teeth following orthodontic treatment; and as a treatment of secondary trauma from occlusion, to provide functional stability. Most conservative techniques available in restorative dentistry for splinting teeth involve the use of adhesives and composite resins. This article discusses two woven fiber ribbon products that can be used for directly placed, reinforced composite resin-bonded splints: Connect® (Kerr, Romulus, Michigan) and Ribbond® Reinforcement Ribbon (RIBBOND, Seattle, Washington). A case report is presented in which Ribbond material was applied. This bondable ribbon splinting material combined with chemical adhesive and composite resin provides the patient with a fracture-resistant restoration more durable than most alternative splinting materials used in the past.

Splinting teeth is a common practice in restorative dentistry, especially for stabilizing periodontally involved teeth. "Splint," as defined by the Glossary of Prosthodontic Terms, is "a device that maintains hard and/or soft tissue in a predetermined position." The use of splinting for patients with periodontal disease is controversial.

For many years there was a supposition that treatment of tooth mobility by splinting was necessary to control gingivitis, periodontitis, and pocket formation. It was thought that mobility directly 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] A number of periodontal clinical studies investigated these assumptions.[2-5] There is no doubt that splinting does reduce tooth mobility while the splint is in place.[6,7] Muhlemann et al and Renggli and Schweizer depict the unclear role of splinting as part of initial therapy.[8,9] The question then arises: When is periodontal splinting necessary? Lemmerman reviewed 94 articles and concluded that tooth stabilization was indicated: (1) following acute trauma, to prevent mobility; (2) as part of occlusal therapy; (3) to prevent tooth drifting; (4) as a replacement for missing teeth (following orthodontic treatment); and (5) as a treatment of secondary trauma from occlusion, to provide functional stability (although the relationship between trauma from occlusion and periodontitis is unclear).[10]

Based upon the dental literature, there are two main indications for periodontal splinting to control tooth mobility: (1) patient discomfort and (2) decreased occlusal and masticatory function.

There are many different techniques available in restorative dentistry for splinting teeth. The most conservative of these involve use of adhesives and composite resins. The challenge to place a thin but strong composite resin-based splint was met with the introduction of a high strength, bondable, biocompatible, esthetic, easily manipulated, colorless ribbon that could be embedded into a resin structure. Currently there are two manufacturers that produce a woven fiber ribbon that can be used for directly placed, reinforced composite resin-bonded splints. These products are Connect® (Kerr, Romulus, Michigan) and Ribbond® Reinforcement Ribbon (RIBBOND, Seattle, Washington). Both materials are woven with polyethylene fibers. The main difference between the two fiber materials is the type of weave used to create the ribbon. This has a direct effect on the handling characteristics of each product and the physical behavior of the ribbon once embedded in dental resins. Ribbond has a patented crosslinked, lock-stitch, leno-weave that holds its shape when cut and does not unravel. Connect is a braided weave that, once cut to the length needed, has the tendency to unravel and not hold its dimensional shape. When manipulated, the Connect ribbon becomes wider or narrower and the length varies depending on the forces placed on the ribbon as it is placed in a dental resin. This phenomenon of the braided weave of the Connect ribbon relates to Poisson's ratio. Poisson's ratio refers to the lateral contraction of bias weave fibers. Once

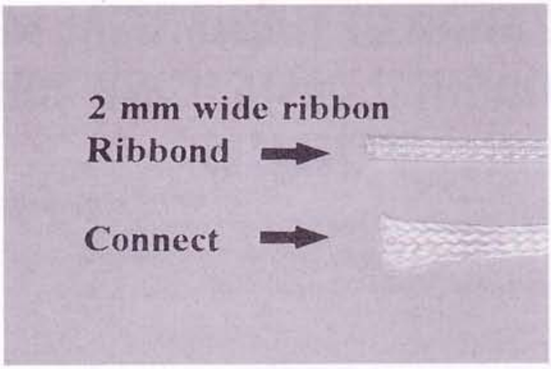

Figure 1 A 2-mm cut ribbon of Ribbond and Connect. Note the differences: edge fraying and width stability once cut.

stressed, these fibers become distorted and no longer have a consistent behavior.[11] Figure 1 demonstrates the comparison between the Ribbond and Connect reinforcement ribbons once cut.

Because of the authors' experiences with the greater ease in clinical manipulation of the Ribbond, this article focuses on this material for use in directly placed composite resin-bonded periodontal splints. The use of woven polyethylene fibers is based upon the excellent physical properties of this material. Polyethylene fibers are not chemically compatible with dental resins until they have been plasma-treated. The plasma treatment of the fibers ablates (etches) and chemically activates the fibers, to allow them to chemically bond with a high level of interfacial adhesion to dental resins, creating a polymeric hybrid that functions as a laminate. This hybrid exhibits the characteristics necessary for a load-bearing area even in a thin veneer. The development of the Ribbond bondable reinforcement ribbon, was an outgrowth of advanced materials and techniques that are used in industrial polymer composite laminate construction.

Ribbond is woven in the form of a ribbon with an open, lattice-like pattern that can be shaped to follow any contour required for restorative dentistry. The fibers of the woven ribbon have virtually no memory and allow themselves to be adapted to the varied surface topography of teeth. Ribbond is unlike braided or plain weave materials in its ability to resist unraveling once cut to size. The leno-weave of the Ribbond is crosslinked and lock-stitched, allowing it to maintain its structural integrity.[11] Because it is a ribbon, as opposed to a bundle of loose fibers or unbondable, rigid metal, the Ribbond imparts a multidirectional reinforcement to restorative polymeric resins. The Ribbond ribbon is available in a variety of widths and is only 0.4 mm thick. It can be custom cut to the desired length so that the clinician can select the size and width necessary for most clinical situations. For periodontal splints, the 2-mm or 3-mm wide ribbon is recommended.

Ribbond chemically bonds to any polymer used in restorative dentistry.[12,13] The plasma-treated woven polyethylene fiber has two unique handling features.[14] First, the extremely tough fiber ribbon should be cut only with special, treated scissors that are part of the product kit. Until the plasma-treated fibers are wetted with adhesive resin they are susceptible to surface contamination. Therefore, when handling Ribbond before the resin is applied, clean cotton pliers must be used. The plasma-treated polyethylene fibers have an indefinite shelf life.

Once cut to size, the Ribbond is saturated with a few drops of adhesive resin from any dentin-enamel bonding system. Do not use a single-component dental adhesive to wet the woven ribbon. The single-component dental adhesives contain both the adhesive and the primer with organic solvents. These are not indicated for ribbon wetting. The ribbon should then be blotted with a patient napkin to remove excess adhesive. Now the Ribbond can be handled like any resin material and can be placed into a composite resin, shaped, and polymerized for the desired clinical application.

Although this article describes the use of polyethylene ribbon for periodontal splinting, it also can be used for other clinical stabilization applications, such as: (1) creating a temporary fixed bridge, using a natural tooth or composite resin pontic; (2) creating a fixed orthodontic retainer; (3) embedding into provisional acrylic bridges, to increase strength and durability; and (4) stabilizing an avulsed tooth.[1,13-18] The only limitation to the use of this material as a bondable reinforcement is the imagination of the clinician.

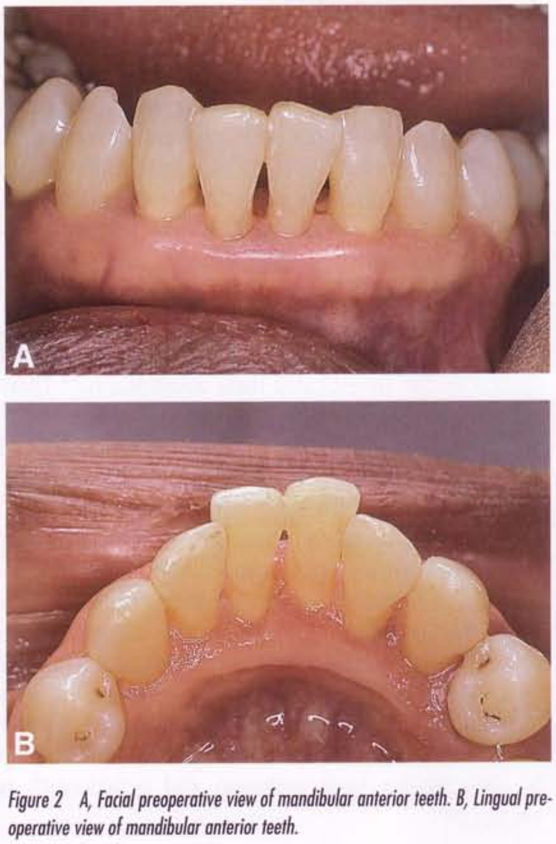

Figure 2 A, Facial preoperative view of mandibular anterior teeth. B, Lingual preoperative view of mandibular anterior teeth.

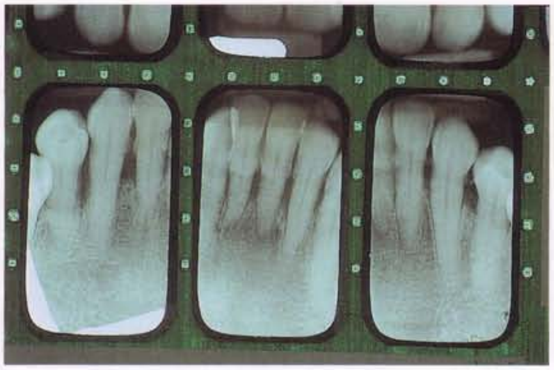

Figure 3 Preoperative radiograph.

Figure 4 After cleaning all accessible surfaces with pumice paste, the interproximal surfaces were cleaned with a diamond finishing strip mounted in a handle (CeriSander, Den-Mat).

Figure 5 Completed lingual channel extending to the midlingual of the mandibular left and right canines.

Figure 6 After shaping the facial interproximally placed composite resin, the surfaces were light-cured. This stabilizes the teeth and seals the interproximal surfaces. Note the colored anatomic wooden wedges that were placed to limit the flow of the composite resin into the gingival embrasures.

Fabrication of a Directly Placed Composite Resin-Bonded Ribbon Splint

Case Report: Periodontal Splint Fabricated by Direct Technique with Light-Cured Composite Resin

The patient presented with a chief complaint of discomfort while functioning on the mandibular anterior teeth (Fig. 2). Radiographically, the mandibular incisors had over 70% bone loss, with a mobility of 2, as per Miller's index (Fig. 3). The patient was referred for splinting by the treating periodontist, because of secondary occlusal trauma 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. One advantage of the directly bonded splint is that it is a one-visit procedure. The teeth were isolated for the clinical procedure with a dental dam. The teeth were cleaned on the facial and lingual surfaces, using a prophylaxis cup with a nonfluoridated pumice paste, and then thoroughly rinsed and dried. The interproximal surfaces of the teeth were cleaned and prepared with a CeriSander (Den-Mat, Santa Maria, California), a medium-grit diamond finishing strip in a handle (Fig. 4). To minimize bulk of the completed splint, a definite tooth preparation into the lingual surfaces of the right mandibular canine, the mandibular lateral and central incisors, and the left mandibular canine was done using a 330 bur to a depth of 0.5 mm. In most cases anesthetic is not necessary, because the preparation is only into the enamel; although for patients with root sensitivity it may be necessary to give bilateral mental blocks for anesthesia. The preparation channel extended through the mesial half of the canines (Fig. 5). A piece of dental floss or tape was laid into the lingual channel and cut to length. A 2-mm wide piece of Ribbond material was cut to the same length as the floss. The splint extended the full length of the prepared channel in the anterior teeth from the right mandibular canine, the mandibular lateral and central incisors, and the left mandibular canine. The Ribbond was impregnated with adhesive resin and blotted to remove excess resin as previously described. The ribbon should be only lightly wetted with adhesive resin, and then put aside and covered to keep light off it until it is placed on the teeth.

The teeth were etched for 30 seconds with a gel phosphoric acid etchant, with care, to be certain that etchant flowed between all the teeth to be splinted and onto the facial surfaces. The etchant was kept away from all exposed root surfaces, to avoid increasing root sensitivity. The teeth were then rinsed with an air-water spray, for 10 seconds, and gently dried. The most distal tooth surfaces of the mandibular left and right canines had interproximal matrix strips placed to maintain separation. Wedges were placed interproximally. (This is done passively, so as not to move the mobile teeth to a new position.) The wedges help limit the flow of the composite resin into the gingival embrasure area. A resin adhesive (Tenure, Den-Mat) was applied to the etched enamel surfaces, including the interproximal surfaces and facial interproximal areas, using a disposable brush (Benda-Brush, Centrix, Shelton, Connecticut). (Do not light-cure until the composite resin is applied.) If dentin or cementum is included in the restoration, these areas must be treated with a dentin primer appropriate for the adhesive being used. Single-component bonding agents also can be used for this technique, although most preparations are enamel only. If the preparation is into areas of dentin, a dentin primer should be used before the adhesive or a single-component dentin-enamel adhesive can be used alone.

A medium viscosity hybrid composite resin in compule tubes was dispensed onto the facial surfaces of all the interproximal areas of the teeth to be splinted. If the preferred medium viscosity hybrid composite resin does not come in predose tubes, composite resin tubes (Centrix) can be preloaded before treatment. The facial surfaces were shaped and then light-cured for 40 seconds (Fig. 6). The purpose of the facial composite resin is to seal the interproximal areas against recurrent caries, to provide for a 180-degree 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 into the lingual channel. 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 is then placed into the lingual channel. By placing the compule tube tip at right angles to the channel, the composite resin can be squeezed and flows easily into the channel (Fig. 7). The ribbon is placed into the composite-filled channel starting at the distal end of the channel of either canine and pushing the ribbon into the composite resin (Fig. 8). When the ribbon is pushed into the composite resin in the preparation channel a slight excess of composite resin extrudes from the preparation. This is smoothed, and excess beyond the lingual surfaces is removed before light-curing. The lingual surfaces are then light-cured for

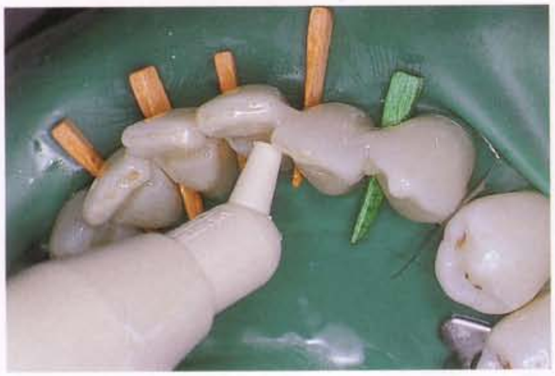

Figure 7 Composite resin is syringed into the channel. Note the right angle orientation of the tip of the compule tube.

Figure 8 A cotton pliers holds the ribbon in place as the burnisher pushes the ribbon into the composite resin-filled channel.

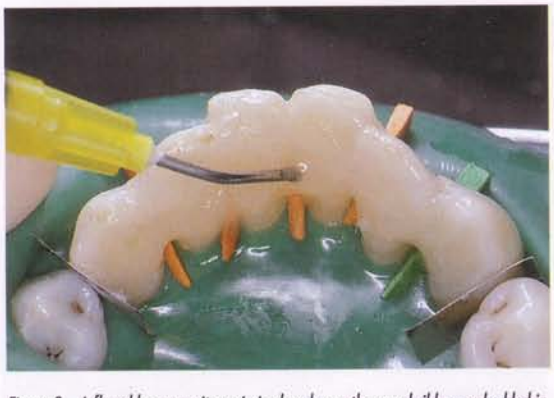

Figure 9 A flowable composite resin is placed over the cured ribbon embedded in the composite resin.

60 seconds for each tooth. The lingual composite resin ribbon-reinforced splint is checked before applying a high strength, wear resistant, flowable composite resin to smooth the irregular lingual surfacing. At this point, the ribbon in several areas minimally extends out from the channel and the composite resin is slightly irregular. The surface of the restoration must be surfaced to be smooth. This is accomplished with a syringe-needle-dispensed flowable composite resin (FloRestore, Den-Mat) (Fig. 9).

Figure 10 The Lamineer tip removes excess composite resin and smooths the root surfaces in the gingival embrasure.

Figure 11 The embrasure is polished using a V-shaped tip with composite resin polishing paste.

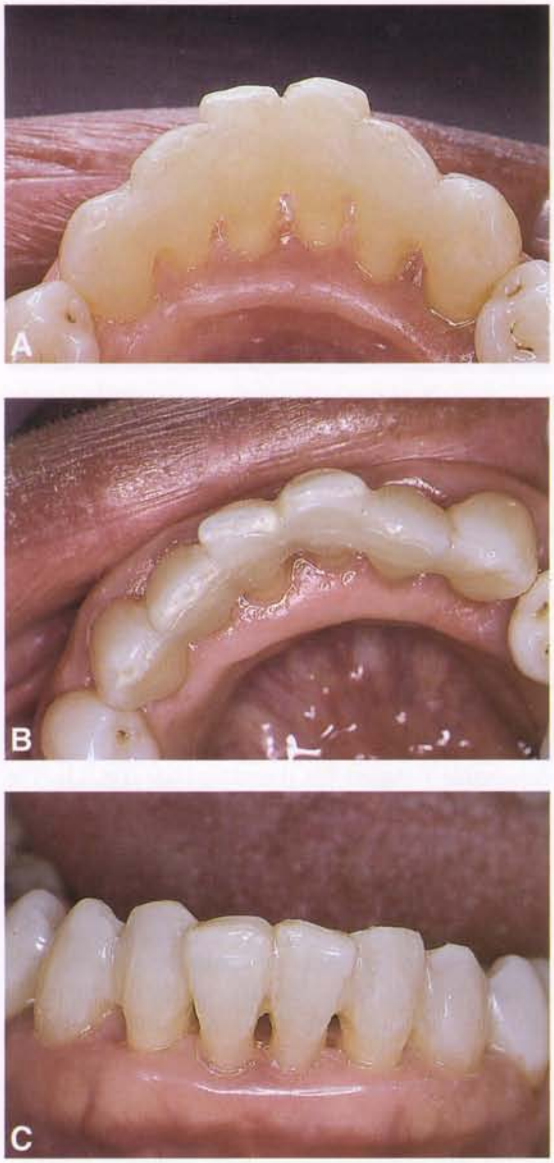

Figure 12 A, Lingual view of completed splint. B, Incisal view of splint. Note minimal bulk of composite resin due to the use of a lingual channel prepared in the abutment teeth. C, Facial view of splint.

The lingual surface is light-cured for 40 seconds for each tooth. The restoration is then finished and polished.

The rubber dam is removed. The composite resin is shaped, finished, and polished to remove excess bulk of restorative material and achieve an esthetic result. The lingual surfaces are finished and contoured with a football-shaped finishing bur (OS1F, Brasseler, USA, Savannah, Georgia) and polished with an aluminum oxide abrasive point (Enhance, Caulk/Dentsply, Milford, Delaware). The facial surfaces are shaped with abrasive Lamineer tips mounted in the Profin® Directional Handpiece (Dentatus USA, New York, New York). The Profin has a reciprocating movement with the Lamineer tips. Also, the Lamineer tips, when placed in the handpiece head, can be rotated and indexed for most convenient access and control needed for delicate and precise interproximal shaping of any composite resin or hardened excess luting materials. Recently, a new modified Lamineer tip was introduced. The Lamineer "S" series knife-edged tips can be used for creating the illusion of depth and separation on the facial interproximal and incisal embrasure areas. Access to the gingival margins on the proximal surfaces is limited because the teeth are splinted. Finishing strips do 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 as they invariably create unnatural embrasures and notched irregular surfaces. Profin, with its reciprocating motion, was used to remove excess resin and to finish the gingivointerproximal surfaces to natural form (Fig. 10). The Lamineer tips have a variety of abrasive grit particles ranging from diamond grit sizes of 150 microns to 15 microns, to leave a smooth texture, for polishing these surfaces to a high gloss. The final polishing and

Figure 13 Postoperative radiograph of completed splint.

access to hard-to-reach areas for polishing are accomplished with composite resin polishing paste dispensed through a Lamineer hollow plastic tip or with deformable V-shaped tips (Dentatus USA) (Fig. 11). The V-shape tips expand and conform to the shape of interproximal spaces. For the periodontist, dental hygienist, and general dentist, the Profin Directional Handpiece is a unique and useful instrument. Other periodontal and restorative uses for the Profin include reshaping anatomic forms and removing overhanging margins and excess hardened resin cements, which contribute to achieving excellent esthetic results while creating a healthy, accessible environment. Profin also has an assortment of Per-io-tor® tips that are used for root planing and debridement without damage to surfaces and surrounding soft tissues. Final polishing in the case presented here 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 met the patient's esthetic expectations (Fig. 12). The radiograph of the completed splint verifies the joining of the periodontally involved incisors (Fig. 13).

Discussion

Tooth mobility has been described as an important clinical parameter in predicting prognosis.[19,20] For this reason and for patient comfort, splinting has been recommended as a 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 mechanically lock only around the resin restoration; because of this, there was the potential of creating shear planes and stress concentrations that would lead to premature failure. When the splint failed, the clinical problems that occurred included traumatic occlusion, progression of periodontal disease, and recurrent caries. With the introduction of bondable, polyethylene woven ribbons, many of the problems associated with older types of reinforcement were solved. Most of the research to date has been with the Ribbond material, because it has been available since 1991. Nicholls, at the University of Washington, tested the physical properties of Ribbond embedded in autopolymerizing methyl methacrylate. The findings indicated an increase in fracture resistance of 22% (Personal communication). It was also found that when the test sample demonstrated fracture, the test bar remained intact and the fracture did not propagate past the Ribbond reinforcement ribbon. Ramos et al performed a similar study.[21] The data indicated a 28% increase in mean fracture strength of polymethyl methacrylate when a plasma-treated polyethylene fiber (Ribbond) was embedded in a bar. Based upon their observations, the researchers concluded that the treated bars (with Ribbond) never exhibited catastrophic failure. This was attributed to the fact that there was a resistance of the bar to crack propagation. The Ribbond stopped cracks from propagating throughout the bar, leaving the bar intact. Based upon these findings Ramos et al stated that, in clinical situations where acrylic resin fixed provisional restorations were reinforced with Ribbond, a reduced incidence of clinical failures due to fracture could be expected. Temporary bridges reinforced with Ribbond would remain intact even if fracture occurred and would be easily repairable in clinical situations. Samadzadeh and co-workers reported significantly higher fracture strength of Ribbond-reinforced Provipont DC (Ivoclar, Amherst, New York), a provisional restorative material similar to acrylic resin. When a crack occurred in the reinforced Provipont DC, it did not propagate beyond the polyethylene fiber, and the beam remained intact. Un-reinforced Provipont DC beams fractured and demonstrated total separation between the two pieces.[22] 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.[23]

Based upon the laboratory data, clinical trials have proceeded using the Ribbond reinforcement ribbon. Strassler and others have reported a clinical evaluation of a woven polyethylene ribbon used for splinting over 12 to 40 months.[24] Of the 54 teeth splinted using the Ribbond, none exhibited debonding or recurrent caries. All periodontal splints and fixed orthodontic retention were successful. Only one pontic of eight 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.

Conclusion

This article describes an innovative technique using a 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 are more durable than most alternative splinting materials used in the past.

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Reprint Requests

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