Test 45.2

PERIODONTICS

Stabilizing Periodontally Compromised Teeth With Fiber-Reinforced Composite Resin

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For those patients with moderate-to-severe periodontal disease, tooth mobility can contribute to discomfort when eating and decreased masticatory and occlusal function. Tarnow and Fletcher described the indications and contraindications for splinting periodontally involved teeth.[1] They stated that the rationale for splinting teeth should include the severity of periodontal disease as determined by the amount of radiographic bone loss and/or the measured tooth mobility. The literature indicates that the main reasons to reduce tooth mobility with periodontal splinting are (1) primary occlusal trauma, (2) secondary occlusal trauma, and (3) progressive mobility, migration, and pain on function.[1]

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.[2]

In the past, the splinting of periodontally compromised teeth was contentious. The presumption was that splinting to control tooth mobility was required to control gingival inflammation, periodontitis, and pocket formation. It was assumed that mobility had a direct relationship to attachment loss and formation of vertical osseous defects. Another assumption was that increasing tooth mobility was a direct consequence of traumatic occlusion, bruxism, and clenching. It was suggested that even normal physiologic function, including mastication and swallowing, could contribute to tooth mobility.[3]

In the last decade, research supports the use of periodontal splinting to improve long-term prognosis.

A number of clinical studies investigated these assumptions. When teeth were subjected to occlusal overloading and other variables that contribute to periodontal disease were

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Figure 1. Preoperative view of mandibular anterior teeth with grade 2 mobility. (A) facial; (B) lingual.

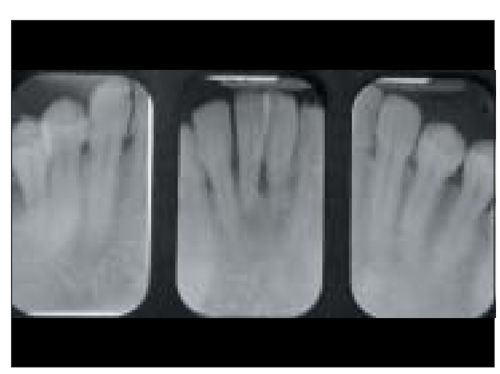

Figure 2. Preoperative radiographs demonstrating 40% bone loss.

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

Figure 4. Dental floss placed on the lingual surfaces of the anterior teeth to measure the required length of reinforcement ribbon.

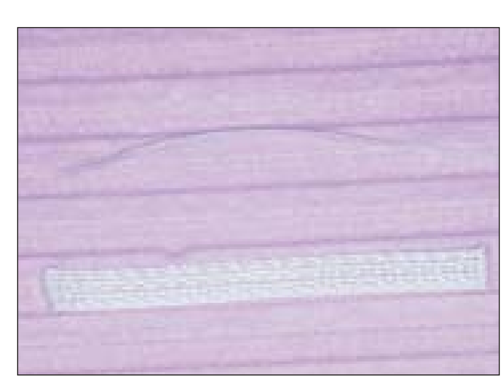

Figure 5. The 3-mm-wide Ribbond THM, cut to the same length as the dental floss template.

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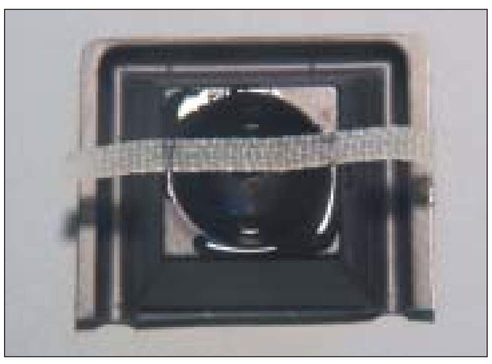

Figure 6. The Ribbond THM, wetted with an unfilled resin.

Figure 7. The teeth to be splinted, etched for 30 seconds with 35% phosphoric acid gel on both the lingual and facial interproximal surfaces.

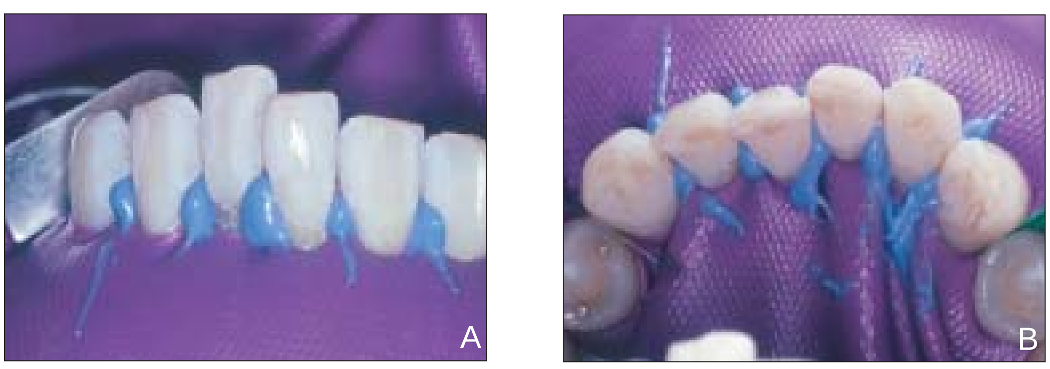

Figure 8. The gingival embrasures with the medium-bodied polysiloxane impression material blockout. (A) facial; (B) lingual.

Figure 9. The facial interproximal surfaces being sculpted. This composite resin will stabilize the teeth while the ribbon splint is placed on the lingual surface.

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

controlled, gingival inflammation, periodontitis, and pocket formation did not occur.[4,5] Another study reported the absence of a relationship between splinting and the reduction of tooth mobility during initial periodontal therapy.[6] Following periodontal osseous surgery, the control of tooth mobility with splinting did not reduce mobility of the individual teeth after the splint was removed.[7]

There is no doubt that splinting does reduce tooth mobility while the splint is in place.[8,9] In the last decade, research supports the use of periodontal splinting to improve long-term prognosis. Further, it is generally accepted that tooth mobility is an important clinical parameter for predicting tooth prognosis.[10-12] The reasons to stabilize periodontally compromised teeth include decreased patient discomfort, increased occlusal and masticatory function, and improved prognosis of mobile teeth. Also, regenerative procedures using membranes and bone grafts are far more predictable if tooth movement is eliminated prior to use of a barrier membrane.[13,14] In cases with mobility that cannot be eliminated by selective coronoplasty alone, splinting should be considered as an adjunct to provide additional tooth stability during the surgical and healing phases of guided tissue regeneration.

Many different restorative techniques have been used to splint teeth. Before adhesive restorative dentistry was introduced, the optimal choice for splinting teeth was full-coverage cast restorations. A crown was placed on each tooth to be splinted, and the crowns were joined together.[15,16] One advantage of this technique was that the teeth could be stabilized with an acrylic provisional restoration during periodontal treatment. At the completion of active therapy, the definitive cast restoration was completed. The major drawback of this treatment was that all teeth in the splint were reduced for restoration with crowns. A more conservative approach using a cast restoration on the lingual surfaces of the teeth (a cast gold indirect pin splint) was developed.[17] Later, a modification of this approach—a cast restoration using bonded adhesive resin—was introduced.[18,19]

The desire for more conservative single-visit techniques led to (1) the use of wire twisted around teeth and covered with resin,[20] (2) metal and nylon mesh embedded into resin,[21] and (3) in the posterior arch, channels prepared into the occlusal and proximal surfaces of teeth or existing amalgam restorations, with either cast bars or thick wires placed in the channels. The channel containing the bar or wire was then covered with resin.[22,23] Clinical failure of these materials was common due to loading stresses placed on the splint during normal function and parafunction.[20,24] To overcome the problem of fracture, clinicians would place more resin over the reinforcement materials, leading to overcontoured and overbulked restorations. These overcontoured restorations were difficult to cleanse and were associated with retention of food and plaque accumulation.[25]

In order to fulfill both the periodontal and restorative needs, ribbons and fibers were developed that could be reinforced with composite resin to form thin-but-strong splints (see Table). Both glass fibers and polyethylene fibers have been introduced for this purpose. Glass fibers are treated with a silane chemical coupling agent to allow dental resins to chemically adhere to the glass fiber strands. To improve the bonding of resin to polyethylene fibers, these synthetic polyethylene fibers are chemically treated with thorough surface etching called plasma treatment, which allows the resin to chemically bond to the polyethylene fibers. Without this treatment, there would be no surface wetting of resin and bonding between the 2 substrates. Studies have demonstrated that fiber reinforcement increases the flexural strength and flexural modulus of composite resins.[26,27] Since all reinforcement fibers provide composite resins with these improved properties, the primary criteria for selection of a particular fiber for use in a periodontal splint are ease of use and availability of an appropriate width. In a multiuser evaluation, ease of use was the primary criterion for selection of a bondable fiber reinforcement.[26] In addition, it has been shown that a woven fiber has an advantage over loose or twisted fibers because it imparts multidirectional reinforcement to polymeric restorative resins.[27-29]

CASE REPORT

Periodontal splint fabricated with a fiber reinforcement ribbon using an adhesive light cure composite resin.

The patient presented with the chief complaint of discomfort during functioning associated with the mandibular anterior teeth (Figure 1). Radiographically, the mandibular incisors had approximately 40% bone loss (Figure 2) with a grade 2 mobility. The patient was referred for splinting by the treating periodontist. In consultation with the periodontist, the treatment plan included a directly placed, ribbon-reinforced, composite resin-bonded splint extending from canine to canine. The advantage of the directly bonded splint is that it only requires a single visit. Before that visit, the teeth were scaled and root-planed to assure that all calculus and stain were removed. The teeth were isolated for the clinical procedure with a dental dam. In addition to providing isolation for patients with exposed root surfaces and root sensitivity, the dental dam acts as a barrier to air, water, and air/water spray during the splinting proce-

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Figure 11. Placement of the Ribbond THM 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 ribbon when polishing the lingual surface, a flowable composite resin covers the ribbon.

Figure 13. The polysiloxane impression material blockout after removal. The gingival embrasure areas require only minimal finishing.

Figure 14. The lingual surface polished with a Jiffy Point.

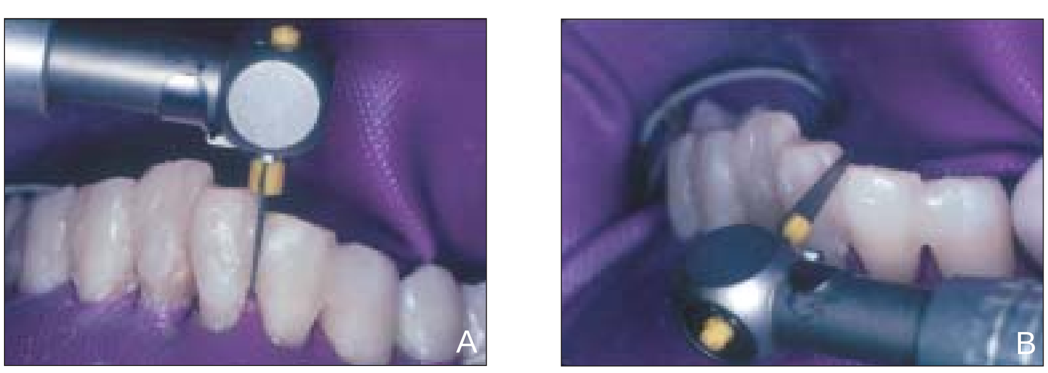

Figure 15. The facial interproximal (A) and incisal embrasures (B) aesthetically shaped with a Profin with a Lamineer tip.

Figure 16. The gingival embrasures finished to a smooth surface using the Profin handpiece with a Lamineer tip.

Figure 17. Completed composite resin ribbon reinforced splint, lingual view.

dure. This may eliminate the need for local anesthesia.

The teeth were cleansed on the facial and lingual surfaces using a prophylaxis cup with a nonfluoridated pumice paste. After the teeth were thoroughly rinsed and dried, the interproximal surfaces of the teeth were cleansed and prepared with a gapped, medium-grit diamond finishing strip (Gateway Vision strips, Brasseler). When the teeth have large interproximal spaces, a diamond abrasive on a handpiece can be used to cleanse the interproximal surfaces. To minimize the thickness of the splint on the aesthetic interproximal aspect of the facial surfaces, a thin, round-end, chamfer diamond (Revelation, No. 854-016, SS White Burs) was used to barrel into the interproximal areas (Figure 3).

Ribbond THM Reinforcement Ribbon (Ribbond) was selected for the splint. One problem with the fiber reinforcement materials that were available is their thickness, especially when embedded within the 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) was introduced. The thinner Ribbond still utilizes the original Ribbond ribbon's lock-stitch weave. Braided fiber weaves, when cut to the desired length, have a tendency to unravel and lose their shape. Ribbond will not unravel and will be dimensionally stable when embedded within composite resin. Another advantage of the lock-stitch weave of Ribbond is the tight weave, which allows the ribbon to maintain structural integrity and imparts a multidirectional reinforcement to restorative polymeric resins. This helps prevent cracks.[30,31] In addition, by changing the diameter of the polyethylene threads from a 215-denier thread to a > 50% 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 250% increase in flexural strength of composite resin when compared to resin without fiber reinforcement and a 15% increase compared to the original Ribbond ribbon.[27] The thinness of the Ribbond THM eliminates the need for a prepared channel on the lingual surface that would otherwise be needed to minimize overcontouring of the splint.

To measure the length of fiber ribbon needed, a piece of dental floss was placed on the lingual surfaces of the teeth, extending from the midpoint of the left mandibular canine to the midpoint of the right mandibular canine (Figure 4). The plasma-treated fibers are susceptible to surface contamination. Therefore, when handling Ribbond, clean cotton pliers should be used. Using the floss as a template, a piece of 3-mm-wide Ribbond THM was taken from its package using the cotton pliers and cut to an equal length with Ribbond scissors (Figure 5). (Note: Some of these products require special scissors that the manufacturers provide with their products. Splint-It (Pentron) is available with ceramic scissors, while both Ribbond and Connect (Kerr)—because they are woven from polyethylene fibers—use special serrated scissors.)

Once cut to length, the ribbon was wetted with an unfilled resin (PermaSeal, Ultradent, Figure 6). If a single-component adhesive resin is used, it is recommended that the solvent within the resin be evaporated from the adhesive with a gentle air stream applied for 10 seconds. Once the ribbon fibers were wetted, they were blotted using a paper napkin to remove excess unfilled resin. Once wetted with resin, Ribbond can be handled like any resin material. The ribbon was put aside and covered to avoid light until it was ready to be placed on the teeth.

The teeth were etched for 30 seconds with a 35% phosphoric acid gel (UltraEtch, Ultradent), being certain that etchant was placed on the lingual and facial surfaces and that it flowed between all the teeth included in the splint (Figure 7). 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. Interproximal matrix strips were placed at the most distal surfaces of teeth Nos. 22 and 27 to maintain separation.

In the past, wedges were placed to minimize excess composite in the embrasure areas. Use of wedges could result in movement of highly mobile teeth, and the teeth can be splinted in an altered position. Recently, an innovative technique for minimizing excessive composite resin in embrasures has been described.[32] It involves the use of an impression syringe to place medium- or heavyviscosity polysiloxane impression material into the gingival embrasures. The impression material is placed after the teeth are etched, rinsed, and dried, in order to avoid trapping moisture. The use of elastomeric impression material assures that the blockout is passive. For this case, a medium-bodied polyvinyl siloxane impression material (ExaMix, GC America) was used (Figure 8).

A resin adhesive (PermaQuick, Ultradent) was applied to the etched enamel surfaces, including the facial interproximal areas, using a disposable brush (Benda-Brush, Centrix). A medium-viscosity microhybrid composite resin in preloaded tubes (Vit-l-escence, Ultradent) was dispensed onto the facial surfaces of all the interproximal areas of the teeth to be splinted. The facial surfaces were shaped to minimize excess and then light-cured for 10 seconds with a full-spectrum LED curing light (UltraLume 5, Ultradent, Figure 9). The UltraLume 5 has 2 LED arrays—one diode predominantly in the 450-nm range and 4 surrounding diodes in the 400-nm range—allowing it to cure resins with a wide variation in photosensitivity to Ultradent's photointiators.[33] The facial composite resin serves to seal the interproximal areas against recurrent caries and provides a 180° wrap of composite resin to each of the splinted teeth. This will stabilize each tooth and prevent breakage of the final splint. This step is important because once splinted, the interproximal surfaces cannot be adequately cleansed.

The composite resin was then placed onto the lingual surface from midcanine to midcanine. By placing the preloaded tube tip at a right angle to the lingual surfaces of the teeth, the composite resin can be applied to the middle of the teeth, where the splint will be placed (Figure 10). Using a gloved finger wetted with adhesive resin, the 3-mm-wide Ribbond THM ribbon was embedded into the composite resin, starting at the canine and moving around the arch to the opposite canine. The ribbon was adapted on the lingual and interproximal surfaces using cotton pliers and a burnisher (Figure 11). Excess composite resin was removed before light-curing. The lingual surfaces were then light-cured for 20 seconds for each tooth, to be certain that the ribbon and composite resin were completely cured.

At this time, the ribbon may be visible and not completely covered with an adequate thickness of composite resin, as was the case with this patient. For this reason, a high-strength, wear-resistant flowable composite resin (PermaFlo, Ultradent) was applied to smooth the irregular lingual surface and provide an even thickness of composite covering the rib-

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Table. Fiber reinforcement materials for directly placed composite splints.

Product Manufacturer	Type of Fiber
Connect (Kerr, Orange, Calif)	2-mm, 3-mm open weave, polyethylene ribbon
EverStick Perio (Benco, Wilkes-Barre, Pa)	Prepreg* unidirectional glass fiber
Fibreflex (BioComp, Ventura, Calif)	Tufts of Kelvar, individual fibers
GlasSpan (GlasSpan, Exton, Pa)	Open weave glass fiber ribbon and rope
Ribbond Reinforcement Ribbon (Ribbond, (Seattle, Wash)	1-mm, 2-mm, 3-mm lock-stitch woven polyethylene ribbon
Ribbond THM (Ribbond, Seattle, Wash)	2-mm, 3-mm lock-stitch woven polyethylene ribbon
Splint-It (Pentron, Wallingford, Conn)	3-mm prepreg unidirectional glass fiber ribbon 2-mm open weave glass fiber ribbon 1-mm open weave braid polyethylene

*Preimpregnation of the fiber with resin by the manufacturer. Most of the fibers used have no resin.

bon (Figure 12). The flowable composite resin on the lingual surface was light-cured for an additional 10 seconds for each tooth. The polyvinyl siloxane impression material blockout was then removed from the gingival embrasure areas (Figure 13). There was very little finishing necessary for the gingival embrasure areas of the splint due to the blockout technique.

The composite resin was shaped, finished, and polished to remove any excess restorative material and achieve an aesthetic result. The lingual surfaces were finished and contoured with an egg-shaped finishing bur (SS White Burs) and polished with an aluminum oxide abrasive point (Jiffy Point, Ultradent, Figure 14). The facial surfaces were shaped with a reciprocating handpiece (Profin, Dentatus USA) and abrasive Lamineer tip (Dentatus USA). The Lamineer tips have a unique, flat, thin design and are safe-sided, with the diamond abrasive only present on one side. They are available in decreasing diamond abrasive grits to finish and then polish tooth and restoration surfaces. The thin Lamineer blade provides access for delicate interproximal shaping and polishing of the composite resin to create the illusion of tooth separation in the facial and incisal embrasure areas (Figure 15). If there is excess composite resin in the embrasure areas, access to these areas is limited due to the splinting. While finishing strips can be threaded between the teeth below the contact areas, it is far more effective to use the fine control afforded by the Profin handpiece with a Lamineer tip. The back-and-forth reciprocating motion of the abrasive tip allows for finishing and polishing the root surfaces without notching (Figure 16). If not used correctly, finishing burs in a handpiece can quickly notch a root surface.

Final polishing of the gingivoproximal areas was accomplished with a composite resin polishing paste with a V-shaped plastic tip in the Profin handpiece. The rubber dam was removed, and the occlusion and aesthetic appearances were checked. Oral hygiene procedures were demonstrated, and the importance of proper oral hygiene was emphasized. The completed splint provided tooth stability, improved function, and fulfilled the patient's aesthetic expectations (Figure 17).

CONCLUSION

Tooth mobility has been described as an important clinical parameter for predicting the prognosis of periodontally compromised teeth. For this reason, and for improved patient comfort and increased masticatory function, splinting as been recommended as a therapy to stabilize mobile teeth. In the past, splinting was accomplished with directly placed restorative resins with embedded wires, pins, and meshes. These materials could only lock mechanically around the resin restorative and were not chemically integrated within the splint. The interface created between the composite resin or acrylic resin and wire, pins, or grid mesh had the potential of creating shear planes and stress concentrations that would lead to premature failure.[20] If the splint fails, the clinical problems that can result include traumatic occlusion, progression of periodontal disease, and recurrent caries.

With the introduction of bondable, polyethylene woven ribbons, many of the problems encountered with previous approaches to splinting were solved. In a long-term clinical evaluation of splinting using the original Ribbond Reinforcement Ribbon, The senior author has found that over a period of 42 to 96 months (mean = 68.6 mos.), fiber-reinforced composite resins are highly successful.[29] Cases evaluated included (1) periodontal splints, (2) bridges with composite resin pontics and natural tooth pontics, and (3) 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 orthodontic retention or periodontal splints have fractured. Only 2 of 9 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.

This article has described a technique for splinting mobile mandibular anterior teeth. By combining the chemical, adhesive, and aesthetic characteristics of composite resin with the strength of a thin, plasma-treated, high-elastic-modulus reinforcing ribbon, dentists can provide patients with splints that will effectively resist the forces of occlusion and mastication. These restorations will be more durable than the approaches to splinting teeth that have been used in the past.

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Continuing Education
Test No. 45.2

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To submit Continuing Education answers, use the answer sheet on page 94. On the answer sheet, identify the article (this one is Test 45.2), place an X in the box corresponding to the answer you believe is correct, detach the answer sheet from the magazine, and mail to *Dentistry Today* Department of Continuing Education.

The following 8 questions were derived from the article *Stabilizing Periodontally Compromised Teeth With Fiber-Reinforced Composite Resin* by Howard E. Strassler, DMD, FADM, FAGD; Natalia Tomona, DDS; John K. Spitznagel, Jr., DDS, PhD, on pages 102 through 109.

Learning Objectives

After reading this article, the individual will learn:

- the reasons and methods for splinting periodontally compromised teeth.
- a technique for fabricating a periodontal splint using fiber reinforcement ribbon and direct placement adhesive composite resin.

1 The primary reason(s) for periodontal splinting of mobile teeth is (are):
(a) primary occlusal trauma.
(b) secondary occlusal trauma.
(c) progressive mobility.
(d) all the above.

2 In the past, direct adhesive composite resins embedded with wires, metal mesh, and nylon mesh had clinical failures because:
(a) they were too narrow for teeth.
(b) they were too wide for teeth.
(c) they were too thick for teeth.
(d) they were only mechanically locked around the resin restorative material and not chemically bonded to the resin.

3 The clinical technique for placing a fiber splint uses an adhesive acid etch technique. All the following are correct statements EXCEPT:
(a) before acid-etching, the facial and lingual surfaces for the teeth must be cleaned with an abrasive paste on a prophylaxis cup.
(b) before etching the interproximal surfaces of the teeth, they should be cleaned with abrasive strips or sometimes diamond abrasive burs to remove stain.
(c) no cleaning of the teeth is necessary; only etching the teeth before bonding.
(d) the teeth should be scaled and root-planed before fiber splint placement.

4 To make the Ribbond THM reinforcement ribbon bondable, the ribbon is:
(a) wetted with an unfilled resin.
(b) wetted with a flowable composite.
(c) etched with phosphoric acid.
(d) nothing needs to be done; it is usable right from the package.

5 The gingival interproximal areas are blocked out using a polyvinyl siloxane impression material to minimize excess composite resin in these areas when placing the splint. The block-out is placed:
(a) after cleaning the teeth.
(b) after etching the teeth.
(c) after application of the bonding resin.
(d) after application of the composite resin and fiber ribbon.

6 Composite resin is placed on the facial surfaces of the teeth before placing composite and fiber ribbon on the lingual in order to:
(a) seal the interproximal surfaces.
(b) provide for a "wrap" of composite around the teeth being splinted to provide additional cross splinting of the teeth.
(c) check the color match of the composite resin when placing the splint.
(d) a and b.

7 Sometimes when placing the splint, the fiber ribbon is at the surface and exposed. The recommended technique for managing the exposed fiber ribbon is to:
(a) finish and polish with burs and diamonds.
(b) cover with a flowable composite resin before removing the dental dam.
(c) coat the fiber ribbon with an unfilled resin.
(d) place a second fiber ribbon to protect the first.

8 In this article, it is recommended that when finishing excess composite resin from the gingival interproximal embrasures:
(a) a Profin reciprocating handpiece with a flat-bladed lamineer tip be used.
(b) a diamond strip be threaded into the interproximal areas to finish excess.
(c) a thin, fine needle diamond on a high-speed handpiece be used.
(d) a thin, fine needle finishing bur on a low-speed handpiece be used .

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