Sealing Ability of One-Up Bond and MTA With and Without a Secondary Seal as Furcation Perforation Repair Materials

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This study investigated the ability of One-Up Bond alone and mineral trioxide aggregate (MTA), with and without a secondary seal of One-Up Bond or SuperEBA to seal saucer-shaped perforation defects in human molars. Cusps were removed, roots were amputated, and endodontic therapy completed on 40 extracted teeth. A cylindrical hole was made in each tooth from the furcation area to the chamber, into which a section of steel tubing was cemented. Intracoronal saucer-shaped defects were created over the perforation. The teeth were restored with MTA, One-Up Bond, or MTA with a secondary seal of One-Up Bond or SuperEBA. The integrity of the seal was evaluated by fluid filtration. MTA alone leaked significantly more than One-Up Bond or MTA with either secondary seal at 24 h. At 1 month, MTA, MTA plus One-Up Bond, and One-Up Bond alone were equivalent.

Furcation perforations that occur during endodontic treatment often result in loss of periodontal attachment and ultimately the involved tooth. Difficulties encountered when repairing furcation perforations include inadequate sealing of the defect (1), extrusion of the repair material (2), and inadequate material biocompatibility (3). Various materials and techniques have been tested but have failed to produce a consensus recommendation among researchers (4).

For optimum results, the repair should be made immediately (5, 6), bacterial contamination minimized (3), and a repair material selected that is biocompatible, has good sealing properties, and can be controlled to prevent extrusion into the furcation region (7). A successful repair will result in the reattachment of the periodontal structures (8).

MTA has been recommended for the treatment of furcation perforations. Weldon et al. (9) determined that MTA produces a good seal to fluid flow at a physiologic pressure of 20 cm H₂O. Pitt Ford et al. (6) found that it is biocompatible and can be extruded without harmful sequelae. According to Schwartz et al. (10), it is the only restorative material that consistently allows for the overgrowth of cementum, and it may facilitate the regeneration of the periodontal ligament (PDL). Although resin restorative materials have been shown to bond well to pulp chamber dentin (11), their biocompatibility has not been fully evaluated.

The purpose of this in vitro study was to investigate the ability of MTA, One-Up Bond, and MTA with a secondary seal of One-Up Bond or SuperEBA to seal saucer-shaped furcation perforations in human molars using a fluid-filtration model operated at physiologic pressure.

MATERIALS AND METHODS

Fifty, extracted, human molars with nonfused roots were stored in physiologic saline with 0.2% sodium azide (Sigma Chemical Co., St. Louis, MO) until use: 10 teeth to be used as control teeth and 40 for use as experimental teeth. One investigator (I.H.) performed all procedures. Cusps were removed from all teeth perpendicular to their long axes and roots were amputated 3 mm below the furcation using an Isomet saw (Buehler Ltd., Lake Bluff, IL). Access openings were made, canals were prepared with Flexo-files (Dentsply Maillefer, Tulsa, OK), and obturated by lateral condensation with gutta-percha cones and Roth’s 801 sealer (Henry Schein Inc., Port Washington, NY).

A 1-mm deep, blind hole was made in the center of the furcation of each of the 40 experimental teeth from the PDL side with a #959 size 014 end-cutting bur (Brasseler USA, Savannah, GA). A short section of 18-gauge stainless steel tubing was forced into the hole and cemented with resin cement (C&B Metabond, Parkell, Farmingdale, NY). A #80 (0.34 mm) drill bit (SME Inc., Shanghai, China) was placed inside the 18-gauge tubing and used to perforate the floor of the chamber using a miniature drill press (Servo Products Co., Pasadena, CA), and a 1-mm deep, saucer-shaped defect was created over this hole in the chamber floor with a #10 round slow-speed bur (Brasseler USA). A 20-mm length of 20-gauge solid wire was temporarily placed into the 18-gauge tubing during the repair procedure to prevent furcation-repair material from flowing into the tubing.

The teeth were soaked in 5.25% NaOCl for 5 min, rinsed with copious amounts of water, dried to simulate the effects of endodontic irrigation during cleaning and shaping, and randomly divided into 4 groups of 10 teeth each. In group 1, MTA (ProRoot,
Dentsply/Tulsa) was mixed according to manufacturer's recommendations, placed into the broad, shallow defect with an Endogun (Medidenta Int. Inc., Woodside, NY), and compacted with Schilder pluggers until the material was flush with the chamber floor (Fig. 1A). A cotton pellet moistened with saline was placed in the pulp chamber against the MTA. In group 2, One-Up Bond (Tokuyama Corp., Tokyo, Japan) was mixed according to the manufacturer's recommendations and placed with the microbrushes included in the kit to a depth of 2 mm across the chamber floor and over the root canal orifices, and light-cured for 20 s (Fig. 1B). The perforations in group 3 were repaired with MTA in the same manner as group 1, after which 2 mm of One-Up Bond were placed over the MTA and light cured (Fig. 1C). Perforation repaired with MTA (black) and covered with 2 mm of Super-EBA (lighter black) as a secondary seal. (D) Perforation repaired with MTA (black) and covered with 2 mm of Super-EBA (lighter black) as a secondary seal. (Center) Close up schematic of the saucer-shaped perforation lesion.

RESULTS

All groups leaked significantly less than the positive controls (p < 0.05). All materials sealed the perforations well, both initially and during the 1-month duration of the study (Table 1). There was no significant difference between any of the groups and the negative controls. MTA alone leaked significantly more than One-Up Bond alone or when combined with One-Up Bond or SuperEBA at 24 h. (p < 0.05). There was no significant difference between MTA with a secondary seal of One-Up Bond or SuperEBA at 24 h. At 1 month, MTA with a secondary seal of SuperEBA leaked more than MTA with One-Up Bond; the other groups were statistically equivalent. With time, the seal of MTA improved, whereas that of One-Up alone or MTA with SuperEBA worsened. There were no significant differences in remaining dentinal thickness or in the thickness of the repair materials among the four groups.

DISCUSSION

To allow periodontal healing, a perforation material must provide a leak-proof seal to ensure that contaminants within the tooth cannot reach the periodontal ligament in which the resultant
flammation would compromise repair. The material also must be biocompatible, so that inflammation does not result as a reaction to the material itself (13). MTA has been shown to leak less than amalgam and Super EBA (14, 15) when used as a perforation repair material, and has been shown to be less cytotoxic (16, 17) and neurotoxic (18) than other repair materials. Bonded resins have the potential to provide a good seal through their intimate adherence to dentin (11), but may not perform well when used to repair perforations because of their exposure to moisture through the perforation site (19). Additionally, some of these materials may be more cytotoxic (20). Despite its advantages, MTA may be inconvenient to use clinically because the manufacturer’s directions require that it be covered by a wet cotton pellet and left for at least 3 to 4 h to set (21). Thus, repair of a perforation discovered or produced during endodontic therapy requires termination of the procedure and reappointment of the patient after the material has hardened, which is inexpedient for both the patient and the practitioner.

Clinical directions (21) recommend packing MTA into the perforation to give it mechanical support during the hardening process. However, many perforations created while searching for sclerosed canals present as broad, shallow, saucer-shaped lesions with pinpoint perforations that have no confining walls to stabilize the MTA. Therefore, unlike most in vitro perforation studies that use a hole drilled into the furcation area into which the repair material may be easily placed and retained, we designed our experimental perforations to simulate a saucer-shaped preparation without walls.

SuperEBA has good adhesive properties; however, histological studies have shown no PDL/cementum repair when this material is extruded into the PDL space (10, 22). In contrast, MTA has been shown to permit PDL/cementum repair (6), but shows little adhesion to dentin and has a very long setting time. One-Up Bond is a self-etching, self-priming, one-step material that does not require drying of the dentin before application, which avoids air-drying that could dehydrate the MTA and assures that the material will bond despite moisture. It also is extremely easy and fast to use, requiring less than 1 min from the time it is mixed until it is set. Its biocompatibility has not been investigated and will be the subject of future research. Recent reports of excellent sealing of root canals by the application of intracoronal secondary sealants (11, 23–25) suggested that they might also stabilize MTA at perforation sites. In our study, we attempted to combine the biocompatibility of MTA with the use of adhesive materials that would stabilize it in saucer-shaped lesions and allow root canal therapy to be continued if desired.

Clinically, the operator would immediately repair the defect with MTA, block out the canals with gutta-percha, place the secondary seal material over the MTA, remove the gutta-percha, and continue the endodontic therapy. Although the material would not be allowed to set under a wet cotton pledge for the recommended 3 to 4 h, this step may be unnecessary, because tissue fluid from the PDL side of the lesion would likely be accessible. Sulyk et al. (26) found that when used as a perforation repair material, there was no difference in the seal produced whether the MTA was covered with a wet or dry cotton pellet and concluded that sufficient moisture may be available from the periodontal tissues to ensure hydration and proper setting. We placed the MTA only in the defect, rather than covering the floor of the chamber, because a clinician would be unable to work through the wet MTA. We covered the floor with the other materials, however, because they could easily be temporarily blocked out of the canals with gutta-percha points.

Fluid filtration was chosen for leakage assessment in this study because it permits quantitative, nondestructive measurements of microleakage during longitudinal time periods. We attempted to simulate in vivo conditions by subjecting the repaired perforations to the physiologic pressures that exist in the marrow spaces of bone. Held and Thron (27) obtained a marrow space pressure of 10 to 20 mmHg (13.5–27 cm H2O), and Christiansen et al. (28) reported a mandibular marrow pressure in dogs of 20 ± 6 mmHg (15 ± 3 cm H2O). Therefore, because the filtration is in direct communication with alveolar marrow spaces via venules passing from the PDL to the marrow, we subjected the filtration repair to a pressure of 20 cm of H2O during microleakage testing. This is a much lower pressure than that used in previous fluid-filtration experiments measuring microleakage (29).

Filtration results indicated that MTA leaked more at 24 h than One-Up Bond, probably because the resin instantly bonded to the dentin, whereas the unset MTA, particularly without retaining walls against which it could be packed, was not yet stable. The 1-month leakage figures demonstrated that MTA can, if allowed to set undisturbed, provide a leak-proof seal even when used in saucer-shaped defects. The use of either adhesive material, One-Up Bond or SuperEBA, with the MTA provided an immediate seal equivalent to MTA that had been allowed to set, and would allow continuation of endodontic therapy. With time, the seal of the SuperEBA decreased slightly, whereas that of the One-Up Bond remained the same.

Sectioning the restored teeth through the plane of perforation to ensure that One-Up Bond or SuperEBA did not flow down through the MTA, thereby encapsulating or embedding it, revealed that the bottom half of the perforation contained only MTA. Therefore, because only the MTA is in contact with the periapical tissues, the perforations should heal normally, with the production of a cementum seal (6). Further in vivo tests of this procedure are indicated to ensure that MTA still promotes a biocompatible seal of furcation perforations in the presence of these adhesives.

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