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Bacterial Leakage with Mineral Trioxide Aggregate or a Resin-Modified Glass Ionomer Used as a Coronal Barrier

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The purpose of this study was to evaluate gray mineral trioxide aggregate (MTA), white MTA, and Fuji II LC cement as coronal barriers to bacterial leakage. Seventy-eight, matched, human teeth were obturated with gutta-percha. In group I, 18 pairs received a 3-mm barrier of gray or white MTA. In group II, 18 pairs received a 3-mm barrier of gray MTA or Fuji cement. Three pairs were used as positive (obturated without barrier) and negative (covered with epoxy resin) controls. A dual-chamber leakage model utilizing salivary microbes was used for the evaluation. Leakage was recorded when turbidity was observed. All controls behaved as expected. In group I, three gray MTA and three white MTA samples leaked. In group II, one gray MTA and three Fuji samples leaked. There was no statistically significant difference in leakage between gray and white MTA or gray MTA and Fuji at 30, 60, or 90 days. Gray and white MTA or Fuji II can be recommended as a coronal barrier for up to 3 months.

Leakage studies have shown that the loss of the coronal seal provides a route for bacterial recontamination of endodontically treated teeth (1–5). A lack of the coronal seal may lead to endodontic failure (6). Coronal microleakage might be the major cause of nonsurgical endodontic failure (7). Delay in placement of a permanent restoration, fracture of the coronal restoration and/or tooth, inadequate thickness of the temporary restoration, and preparation of the post space with inadequate remaining apical filling are potential means of coronal recontamination of obturated root canals (7). In addition, recurrent caries and restorations with inadequate margins may result in coronal leakage (8). The technical quality of the coronal restoration was concluded to be significantly more important than the technical quality of the endodontic treatment for periapical health, based on the radiographic evaluation of more than 1000 endodontically treated and restored teeth (6).

A variety of restorative materials have been used in an attempt to produce a coronal barrier with varying results and lack of agreement between the studies (8–14). One of these materials, mineral trioxide aggregate (MTA; Dentsply Tulsa Dental, Tulsa, OK) has been evaluated for a wide variety of applications (15). These include pulp capping, apical barrier, perforation repair, and root-end filling material. In addition, the use of MTA as an orthograde root-filling material has been suggested (16). One reason that MTA has gained attention is its superior ability to resist leakage (17). Such behavior may be explained by superior marginal adaptation of MTA (18).

Recently, a new MTA formulation that is white in color, rather than gray, has been made available. The only chemical difference between the gray and white MTA is the reduced iron content in white MTA, resulting from a difference in manufacturing process (personal communication with Dentsply, Tulsa Dental Co). Additionally, the particle size of the white MTA is smaller to enhance handling and placement characteristics.

Despite the wide range of potential applications, minimal attempts have been made to evaluate MTA as a barrier to prevent coronal leakage (13, 19). This study was designed to compare gray MTA, white MTA, and a resin-modified glass-ionomer cement as barriers to prevent coronal leakage.

MATERIALS AND METHODS

Seventy-eight, extracted, bilaterally matched, anterior, human teeth were used in this study. The teeth were stored in 0.2% thymol solution immediately after extraction. All teeth were carefully debrided of any soft tissue with a periodontal curette and decoronated at the CEJ using a model trimmer. An access opening was prepared using a high-speed handpiece and a #2 round bur with a constant water spray. A #10 file was used to establish working length and to maintain patency. Working length was determined by measuring the length at which a #10 file was first visible at the apical foramen and subtracting 0.5 mm. The canals were instrumented with 0.08 to 20 GT rotary files to working length (Dentsply Tulsa Dental). During instrumentation, each root canal was irrigated with a total of 5 ml of 5.25% sodium hypochlorite. A final irrigation was accomplished with 2.5 ml of 15% aqueous EDTA solution followed by 5 ml of 5.25% NaOCl irrigation. Canals were dried with paper points.

A 0.06 tapered Lexicon gutta-percha cone (Dentsply Tulsa Dental) was fitted in each canal. To simulate a poorly sealed root canal, Kerr EWT sealer (Kerr Dental, Orange, CA) was applied to only the coronal 2 to 3 mm of canal wall with a paper point. The prefitted, gutta-percha cone was placed in the canal and seared off with a heated plugger. The coronal aspect of the gutta-percha was adjusted to terminate 3-mm apical to the level of decoronation as measured by a periodontal probe. The coronal 3 mm of the canal was cleaned of gutta-percha and sealer with an alcohol-moistened pellet, rinsed with sterile saline, and dried with an air stream.

Thirty-six tooth pairs were divided into 2 experimental groups of 18 pairs. In group I, 18 teeth received a 3-mm barrier of gray MTA (Group Ia), and the matching teeth from each pair received white MTA (Group Ib). All materials were mixed to manufacturer's instructions. MTA was placed using an MTA carrier (Roydent Dental Products, Johnson City, TN) and condensed with a #5/7 endodontic plugger (Hu-Friedy, Chicago, IL). MTA was leveled with the coronal root surface using a moist cotton pellet. In Group II, 1 tooth in each of the 18 pairs (Group IIa) received a 3-mm barrier of Fuji II resin-modified, glass-ionomer cement in opaque A-3 shade (GC America, Inc., Alsip, IL). The matching tooth in each pair received gray MTA (Group IIb). All teeth were wrapped in wet gauze, placed in closed individual vials, which were placed in an incubator at 37°C for 24 h to allow for a complete set of the barrier materials. The remaining three pairs of teeth were used as controls. A positive control group consisted of three teeth obturated in the same manner as the experimental teeth without a coronal barrier. A negative control consisted of three matching obturated teeth without a coronal barrier, but with crowns and roots covered completely with epoxy resin (5 Minute Epoxy, Devcon, FL).

The assembly of a dual-chamber, bacterial-leakage model was adopted from Torabinejad et al. (1). The entire apparatus was sterilized with the Sterrad sterilization system (Johnson & Johnson, Irvine, CA). Sterile trypticase soy broth (TSB; BBL, St. Louis, MO) supplemented with yeast extract (5 g/L) was prepared and stored in 50-ml centrifuge tubes.

Five milliliters of TSB was aseptically placed into the lower chamber. The upper chamber was connected to it with the apical 2 to 3 mm of root end immersed into the TSB. The assembled leakage models were placed in the incubator and observed for 1 week to rule out any microbial contamination. If contamination was noted, these samples were excluded from the study. One hundred milliliters of TSB were inoculated with 2 ml of human saliva and incubated for 24 h. The following day, 0.8 ml of TSB turbid with bacteria was added to the upper chamber of each leakage model. The contents of the upper chamber were removed and fresh TSB turbid with bacteria was added twice per week for the duration of the experiment. The vials were placed in the incubator and observed for turbidity of the broth in the lower chamber daily for the first month and twice per week thereafter. Once turbidity was detected the sample was removed from the incubator and the day of leakage was recorded. The experiment was conducted for 90 days.

Fisher's exact test was used to show any significant differences in leakage between gray and white MTA or between gray MTA and Fuji II. Significance was established at $p < 0.05$.

RESULTS

During the 1-week observation period for contamination of the dual-chamber apparatus, four samples in group I and two samples in group II showed turbidity. Those samples along with their matched teeth were not included in the experiment.

In group I, leakage was observed in two gray MTA and three white MTA samples (Table 1). In group II, leakage was observed in one gray MTA and three Fuji samples. All positive controls demonstrated leakage. None of the negative controls leaked. Leakage did not occur until day 52 with Fuji II, day 56 with gray MTA, and day 59 with white MTA. There was no statistically significant difference in leakage between gray and white MTA or between gray MTA and Fuji II at 30, 60, or 90 days (Table 2).

DISCUSSION

A variety of tracers have been proposed to evaluate coronal leakage. Although most systems seem to be adequate for comparison of relative leakage, they do not simulate the type of microbial leakage that occurs clinically (1, 20). Using various leakage models, coronal microleakage has been evaluated using individual microorganisms, bacterial by-products, and whole saliva (1–5, 8, 20). TSB inoculated with whole saliva was chosen to test for coronal leakage in this study because whole saliva simulates clinical leakage and because bacterial species depend on each other to provide nutrients or other symbiotic functions (21).

Amalgam, Intermediate Restorative Material (IRM), TERM, glass-ionomers, resin-bonded cements, and recently, MTA have been tested for their ability to prevent microleakage when used as a barrier to augment the coronal seal or as a temporary restoration

TABLE 1. Material leakage time (days)

Matched Pair Group	GROUP I		Matched Pair Group	GROUP II	
	Gray MTA	White MTA		Gray MTA	Fuji II LC
1			19		
2			20		
*			21		
*			22		52
5			23		
6			24		
7			25		
8			26	80	
9			27		
10			28		
11	66	77	29		
12			*		
13	56	84	31		
*			32		
15			33		
16			34		66
*			*		
18		59	36		80

* Specimen pairs 3, 4, 14, 17, 30, and 35 were deleted because of microbial contamination. Group I has 14 remaining experimental pairs of teeth, and Group II has 16 experimental pairs of teeth.

TABLE 2. Leakage comparison per 30-day interval

Days	Gray MTA	White MTA	Gray MTA	Fuji II
0–30	0	0	0	0
31–60	1	1	0	1
61–90	1	2	1	2

MTA = mineral trioxide aggregate.
* Statistically significant difference ($p < 0.05$).

(1–5, 8–13, 19, 22). All studies differ in methodologic design, making comparison difficult.

Bonded resins and resin-modified glass ionomers (RMGI) seem to be promising materials to prevent coronal microleakage. None of the samples coronally sealed with Clearfil Liner Bond allowed bacterial leakage at 90 days (8). Clearfil also leaked significantly less than IRM, KetacFil, and CoreRestore during a 1-yr experiment, although at the end, there was no difference in number of leaking samples (11). C&B Metabond and Amalgabond provided a significantly better coronal seal at 90 days compared with One-Step Dental adhesive, Aelitflo composite, and IRM (23). Despite the success of the resin-bonded systems in preventing coronal microleakage, the actual application of the materials remains technically sensitive. Principle (RMGI) was compared with C&B Metabond, and it performed as well as C&B Metabond if placed over the pulpal floor, or better if placed in the canal orifice. The use of 3 mm of Vitrebond RMGI as a coronal barrier in post-prepared teeth significantly extended time to leakage (14). The superior performance of RMGI may be explained by water sorption by the material, resulting in setting expansion, and consequently, a better seal. RMGI requires no pretreatment of dentin and can adhere to it through the acidic functional groups. Another useful property of RMGI is the release of fluoride, which may decrease coronal microleakage even further through its antimicrobial activity.

In this study, Fuji II RMGI cement was easy to handle. No dentin pretreatment was necessary. The capsule was triturated and RMGI placed in one increment into the canal orifice. Not using a light cure prevents excessive shrinkage on polymerization, and any initial shrinkage during self-cure is counterbalanced by expansion of the material caused by water sorption (12).

Although MTA has been used in endodontics in a variety of applications (15), there are only two published studies on the use of MTA to augment the coronal seal (13, 19). When MTA was compared with IRM and ZnPO4 as a coronal barrier for internal bleaching, MTA demonstrated superior performance (19). However, that study did not test the efficacy of MTA as a coronal barrier against microbial microleakage. Another study showed that after 10 months, there were no demonstrable differences between periapical inflammation in dog teeth with conventional root fillings and those coronally augmented by MTA (13). It is unknown whether the prolonged setting time of MTA has any clinical significance.

Within the limitations of this study, gray MTA, white MTA, and Fuji II LC provided an acceptable coronal seal for up to 90 days. There were no significant differences in performance of materials at any time interval. All materials were easy to manipulate and place. Both gray and white MTA or Fuji II LC can be recommended as a coronal barrier to bacterial leakage for up to 90 days. The long-term health of the periapical region will rely on placing a well-sealing coronal restoration (6).

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