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Comparison of MTA and Glass-Ionomer Microleakage in Two Open and Closed Sandwich Techniques in Class II Composite Resin Restorations

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Abstract: In restorative procedures of subgingival cavities with tooth-colored restorative materials, it is necessary to choose a material with low technique sensitivity which is easy to use in such cavities because tooth-colored materials are highly technique sensitive. In the present study, microleakage of MTA and glass-ionomer was evaluated and compared in two open and closed sandwich technique procedures. Class II cavities were prepared on the mesial and distal surfaces of 24 human premolars. The cavities were filled with MTA and glass-ionomer up to 3 mm occluso-gingivally; in order to restore the remaining portion of the cavity with composite resin the teeth were randomly divided into two groups. In groups 1 and 2 closed and open sandwich techniques were used, respectively. Subsequent to thermocycling, the samples were immersed in 2% methylene blue for 24 h and sectioned under a stereomicroscope for microleakage evaluation. In the open sandwich group, microleakage was evaluated at dentin and junctional interfaces; in the closed sandwich group microleakage was evaluated only at dentin interface. Inter-group microleakage comparison (between open and closed techniques) was carried out by Mann-Whitney U test. Intra-group microleakage comparison (between MTA and glass-ionomer in the two open and closed techniques) was carried out by Wilcoxon signed-rank tests. Inter-group comparison did not reveal any significant differences in microleakage between the two open and closed sandwich techniques. In the intra-group comparison in the closed sandwich technique, no significant differences in microleakage were observed between MTA and glass-ionomer. In the open sandwich technique, MTA exhibited significantly less microleakage at dentin interface compared to glass-ionomer, however no significant differences were observed between the two materials at junctional interface. In composite resin restorations with open and closed sandwich techniques MTA can be as efficacious as glass-ionomer in decreasing microleakage.

Key words: Glass-ionomer, MTA, Sandwich technique, microleakage, junctional interface, Iran

INTRODUCTION

In restorative procedures of subgingival cavities with tooth-colored restorative materials, it is necessary to choose a material with low technique sensitivity which is easy to use in such cavities because tooth-colored materials are highly technique sensitive.

Adhesive systems form very strong and durable bonds with enamel; however when the substrate is dentin or cementum or weaker prognosis is anticipated for the bond (Pashley, 1991). The problem is manifested as gaps in subgingival cavities which extend to root surfaces (Roberson *et al*., 2006).

An alternative method in restoration of cavities with subgingival extension is the combined use of resin-modified glass-ionomers and composite resins which is referred to as the open/closed sandwich technique. The advantage of this technique lies in the unique properties of glass-ionomer: it forms a chemical bond with tooth structures in addition to the mechanical bond, releases fluoride and prevents recurrent caries (Yoshida *et al*., 2000). However in cavities with bleeding or other clinical conditions when proper isolation cannot be achieved, glass-ionomer cannot be used because moisture and contaminants not only influence the bond strength of glass-ionomer to tooth structures but they negatively influence the physico-mechanical properties of the material as well (Roberson *et al*., 2006).

MTA (Mineral Trioxide Aggregate) shares many properties with glass-ionomers. It forms a chemical bond

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with tooth structures (Sarkar *et al.*, 2005) and can repair itself (Sluyk *et al.*, 1998), its compressive strength is comparable to that of reinforced ZOE. It has a high sealing ability, is highly biocompatible and is radiopaque. The most important advantage of MTA in comparison with glass-ionomer is that it is not sensitive to moisture; in fact, moisture is necessary for its setting reaction (Roberts *et al.*, 2008; Torabinejad *et al.*, 1993) demonstrated in 1994 that sealing ability of MTA is not influenced by contamination with blood and it exhibited a better seal compared to other materials under study.

Another disadvantage for MTA is its long setting time. Although some manufacturers claims that the setting time of their MTA is 15 min, the majority of studies have demonstrated that the final setting continues for 24-72 h (Roberts *et al.*, 2008) which is similar to that of glass-ionomer.

Comparison of glass-ionomer and MTA gives rise to the impression that in sandwich technique restorative procedures, MTA can be used as an alternative to glass-ionomer. Use of MTA has entered the realm of operative dentistry. MTA is used in the coronal tooth structure for direct pulp capping and filling of mal-directed pin holes or pin holes which have resulted in perforations (Summitt *et al.*, 2006). However, further studies are necessary to find more applications for this valuable material in the coronal tooth structure.

Since, no studies to date have evaluated microleakage between MTA and composite resin, the present study attempted to evaluate microleakage at the interface of these two materials and compare it with microleakage between composite resin and glass-ionomer.

MATERIALS AND METHODS

About 24 sound human premolars were stored in 1% thymol solution and were transferred into distilled water at 4°C 1 week before the study. On the mesial and distal surfaces of the teeth one Class II cavity was prepared 4 mm bucco-lingually and 2 mm mesio-distally. The gingival floor was placed 1 mm apical to the CEJ. No bevels were placed on the cavity margins.

All the distal cavities were filled with MTA (Angelus, Solucose Odontologic, Londrina, Brazil) up to 3 mm occluso-gingivally. A metal matrix bond was secured around each tooth. MTA powder was mixed with distilled water at a ratio of 1:1. MTA was placed in the cavity and condensed with a condenser. The material was covered with a moist cotton pellet and dressed with a temporary dressing material. Then the samples were incubated at 37°C and 100% relative humidity for 24 h. After 24 h when MTA setting was completed the mesial cavities of the teeth were restored with resin-modified glass-ionomer (GC Corporation, Tokyo, Japan) up to 3 mm occluso-gingivally. At first, all the cavity walls were conditioned with the cavity conditioner in the Glass-ionomer kit for 20 sec. After the application of a transparent matrix band, glass-ionomer powder was mixed with its fluid at a powder-to-liquid ratio of 1:1 and placed in the cavity. Light curing procedure was carried out for 40 sec (Coltolus Coltene/Whaledent Inc., USA). After glass-ionomer setting, the teeth were randomly divided into two equal groups for composite resin restoration: In groups 1 and 2 closed and open sandwich techniques were used, respectively (n = 12).

In the closed sandwich group, 1 mm of the external surface of MTA and glass-ionomer was removed with a bur with a diameter of 1 mm so that sufficient space was provided for a layer of Z100 composite resin (3M ESPE, Dental Products, USA) which covered the base surface. In group 2, open sandwich technique was used therefore MTA or glass-ionomer remained intact.

In order to carry out the composite resin restorative procedure all the cavity walls were etched with 35% phosphoric acid (3M ESPE, Dental Products, USA) for 30 sec and rinsed for 10 sec. Then Single Bond adhesive system (3M ESPE, Dental Products, USA) was applied in two layers. Each layer was subjected to a gentle air current for 5 sec to evaporate the solvent. After curing each layer of the adhesive for 20 sec, a metal matrix band was applied and Z100 composite resins was placed in the cavities using oblique incremental technique (3 layers). Each layer was cured for 20 sec. All the samples were stored in water at 37°C for 24 h. Then the samples underwent 500 rounds of thermocycling at 5/55°C with a dwell time of 60 sec. Tooth surfaces were dried and covered with two layers of nail varnish up to 1 mm from the restoration margins. Subsequent to storage in 2% methylene blue for 24 h, the teeth were rinsed under running water for 30 sec. The teeth were sectioned it two with cylindrical fissure burs in a high-speed handpiece in a mesiodistal direction at the junction of a line crossing the buccolingual dimension of restorations.

Microleakage was measured ×40 under a light stereomicroscope by one operator. In the open sandwich group, microleakage was measured both at dentin interface (cervical dentin-restorative material interface) and at junctional interface (composite resin-glass-ionomer and MTA-composite resin interfaces). In the closed sandwich group, microleakage was only measured at dentin interface. On the whole, six interfaces (subgroups) were formed:

C-M/D = MTA-dentin interface in the closed technique

C-G/D = Glass-ionomer-Dentin interface in the closed technique
O-M/C = MTA-Composite resin interface in the open technique
O-G/C = Glass-ionomer-Composite resin interface in the open technique
O-M/D = MTA-dentin interface in the open technique
O-G/D = Glass-ionomer-Dentin interface in the open technique

Microleakage was scored as follows:
0 = No microleakage
1 = Dye penetration up to half the axial depth
2 = Dye penetration up to more than the axial depth with no axial wall involvement
3 = Dye penetration up to the axial wall

Two statistical comparisons were used. Mann-Whitney U test was used to compare microleakage between the open and closed sandwich techniques (inter-group comparison). Wilcoxon signed-rank tests were used to compare microleakage between the two materials in each group (intra-group comparison).

RESULTS AND DISCUSSION

Table 1 shows frequency of microleakage scores at various interfaces. Table 2 shows means and standard deviations. Mann-Whitney U test was used to compare microleakage of MTA and glass-ionomer between the two open and closed sandwich techniques (Table 3). MTA did not exhibit any significant differences in microleakage between the open and closed sandwich techniques. In addition, glass-ionomer microleakage did not demonstrate any significant differences between the two open and closed techniques ($p>0.050$).

Wilcoxon signed-rank tests were used to compare microleakage of MTA and glass-ionomer in each open or closed sandwich technique (Table 4). In the closed technique, MTA and glass-ionomer did not exhibit any significant differences in microleakage. In the open technique, comparison of MTA and glass-ionomer microleakage at junctional interface did not reveal any significant differences. However, there were significant differences in microleakage between the two materials at dentin interface ($p<0.050$), MTA exhibited less microleakage at dentin interface in the open technique compared to glass-ionomer. In composite resin restorations in order to reduce the effect of polymerization shrinkage and in cavities in which the gingival margin is in dentin or cementum with no possibility of the proper use of adhesive, it is possible to use an intermediary bonding base material, usually glass-ionomer instead of directly bonding the composite resin to dentinal walls. This technique is referred to as sandwich technique which is implemented in two open and closed procedures.

Table 1: Frequency of microleakage scores at various interfaces

Microleakage score	C-M/D	C-G/D	O-M/C	O-G/C	O-M/D	O-G/D
1	8	6	8	12	8	2
2	4	4	0	0	3	4
3	0	0	3	0	0	1
4	0	2	1	0	1	5

Table 2: Means and standard deviations of microleakage at various interfaces

Interface	C-M/D	C-G/D	O-M/C	O-G/C	O-M/D	O-G/D
No. of samples	12.00	12.00	12.00	12.00	12.00	12.00
Mean	0.33	0.83	0.75	0.00	0.41	1.75
SD	0.49	1.11	1.13	0.00	0.66	1.21

Table 3: Comparison of microleakage between the open and closed techniques at de4ntin interface (inter-group comparison)

	Mann-Whitney U test	
Interface	C-M/D, O-M/D	C-G/D, O-G/D
p-value	0.932	0.078

Table 4: Comparison of MTA and glass-ionomer microleakage in each open and closed technique group (intra-group comparison)

	Wilcoxon signed-rank tests		
Interface	C-M/D, C-G/D	O-M/C, O-G/C	O-M/D, O-G/D
p-value	0.234	0.059	0.007*

*Statistical significance; C-M/D: MTA-Dentin interface in the closed technique; C-G/D: Glass-ionomer-Dentin interface in the closed technique; O-M/C: MTA-Composite resin interface in the open technique; O-G/C: Glass-ionomer-Composite resin interface in the open technique; O-M/D: MTA-Dentin interface in the open technique; O-G/D: Glass-ionomer-Dentin interface in the open technique

What makes glass-ionomer an appropriate material for such procedures is its proper physical properties, its potential to adhere to tooth structures, good sealing ability, its potential to repair itself and its fluoride-releasing potential. Glass-ionomer has a durable chemical bond with tooth structures, bonds properly with the overlying composite resin and protects the pulp and reduces the potential of recurrent caries due to fluoride release. On the other hand, polymerization shrinkage decreases because composite resin volume decreases (Roberson *et al*., 2006).

Regarding limitations in the use of glass-ionomer, it should be pointed out that glass-ionomer is technique-sensitive. In areas in which proper isolation can not be achieved, glass-ionomer cannot be used. Tooth surfaces should be treated with acid and dentin moisture should be meticulously controlled (Summitt *et al*., 2006).

MTA is a kind of Portland cement which shares many properties with glass-ionomer, however it has low sensitivity to moisture and contamination. Moisture is necessary for its setting reaction. Other positive features of MTA include proper sealing ability, ease of manipulation, chemical bond with tooth structures and self-repairing potential (Sarkar *et al*., 2005; Sluyk *et al*., 1998; Roberts *et al*., 2008; Torabinejad *et al*., 1993). Poggio *et al*. (2007) reported that MTA is an insoluble material (Camilleri *et al*., 2006).

There are portland cements with very short setting times (<7 min). Now-a-days, super-plasticizers and silica particles are added to cements to improve their compressive strengths without increasing their setting time. There are hopes that such materials will be used for the fabrication of cores in the future (Camilleri *et al*., 2006). Comparison of MTA mechanical properties with those of base materials indicates that it can be used as a base material. On the other hand, an important factor in selecting a base material for the sandwich technique is its ability to prevent microleakage. MTA's superior sealing ability in dental radicular structures has been established (Roberts *et al*., 2008; Torabinejad *et al*., 1993).

Researchers concluded from a pilot study that MTA can be used as easily as glass-ionomer is; it does not have the technical sensitivity such as the need for the use of a cavity conditioner and meticulous control of dentin. In the closed sandwich technique in composite resin/MTA subgroup, MTA exhibited proper behavior. Either microleakage had not occurred or was confined to the area between the dentin and the composite resin. In other words in these samples microleakage was confined to composite resin and had stopped at MTA. This view under the microscope demonstrated the sealing ability of MTA. The same behavior was observed in the glass-ionomer/composite resin subgroup with no significant differences between the two subgroups. In other words, MTA was as efficacious as glass-ionomer in preventing microleakage in the closed sandwich technique.

In the open sandwich technique, MTA exhibited less microleakage compared to glass-ionomer at dentin interface which was statistically significant. Better seal of MTA compared to resin-modified glass-ionomer might be attributed to two factors. First, the setting reaction rates of the two materials are different. As a general rule, the lower the setting reaction rates, the less the stress produced as a result of the reaction (Summitt *et al*., 2006). The setting reaction of MTA which involves the formation of an insoluble colloid gel in the presence of water is very slow.

In contrast, resin-modified glass-ionomer is under the influence of polymerization shrinkage of the resin component. Therefore, dimensional changes of MTA with slower setting reaction is less than those of glass-ionomer which results in a better adaptation with cavity walls. Second, MTA is hydrophilic and as a result, has a proper compatibility with dentin structure and can form chemical bonds with the tooth structure (Sarkar *et al*., 2005; Roberts *et al*., 2008).

In the open sandwich technique in addition to dentin interface, junctional interface was also evaluated which is formed between the restorative material and the base. At the glass-ionomer-composite resin interface in the open sandwich technique, the samples exhibited a very proper seal which is attributed to the presence of resin component in the resin-modified glass-ionomer and its co-polymerization with the resin matrix of composite resin, resulting in a chemical bond between the two materials. In contrast, greater microleakage was observed at MTA-composite resin interface in this group.

There is controversy over which technique, open or closed sandwich is better. In a study, several restorative materials were used to restore Class II cavities with dentinal margins. The results showed that closed sandwich technique is more efficacious than the open sandwich technique, regarding resistance to silver nitrate microleakage (Stockton and Tsang, 2007). On the other hand, Reid *et al*. (1994) evaluated microleakage and the amount of gap formation in the two open and closed sandwich techniques with cavity margins in enamel or dentin. The closed sandwich technique (in both conditions of cavity margins in the enamel and dentin) exhibited the greatest microleakage and gap formation in comparison with the open sandwich technique.

In the present study, both open and closed sandwich techniques exhibited similar resistance to microleakage, with no significant differences between the two techniques.

In comparison of microleakage of the two materials (MTA and glass-ionomer), significant differences were only observed at dentin interface in the open technique.

In the present study, dye penetration technique was used to evaluate the sealing ability. The most important advantage of dye penetration technique is its low cost and ease. However, it is possible that dye penetration will not be uniform at all the interfacial areas and sectioning might take place at an area with the least and greatest microleakage (Taylor and Lynch, 1992; Kidd, 1976; Camps and Pashley, 2003). On the other hand, the majority of studies on MTA microleakage have used this technique (Torabinejad *et al*., 1993, 1994; Bortoluzzi *et al*., 2006; Torabinejad *et al*., 1993). Therefore, the same technique was used so that the results could be compared with those of previous studies. There are no published studies on microleakage of MTA in the coronal structures of teeth. The bulk of studies on microleakage of MTA and its comparison with those of other materials are confined to the root and pulp chamber perforations (Roberts *et al*., 2008). On the other hand, a limited number of studies have simultaneously evaluated MTA and glass-ionomer. In a study by De Bruyne *et al*. (2005), Fuji IX conventional glass-ionomer exhibited the best results compared to Super-EBA and MTA. In a study carried out by Pichardo *et al*. (2006), geristore exhibited less microleakage compared to MTA and Super-EBA. Xavier *et al*. (2005) showed a better apical seal with MTA compared to Super-EBA and Vitremer. In a study by Pereira *et al*. (2004), MTA yielded the best results in comparison with Vitremer, Super-EBA and amalgam as a root-end filling material. Similar results were reported by in repair of furcation perforations of premolars, MTA exhibited less microleakage in comparison with hydroxyapatite, calcium sulfate and glass-ionomer (Krupalini *et al*., 2003). An important consideration in the present study was the fact that since glass-ionomer and dentin have closely matching colors, its cut-back is difficult for closed sandwich technique, however such a problem does not exist in the case of MTA. In addition, contrary to MTA, glass-ionomer cannot be packed into the cavity to improve its adaptation with cavity walls.

CONCLUSION

Under the limitation of the present study, it can be founded that:

- In the closed sandwich technique, MTA and glass-ionomer exhibited similar microleakage, therefore MTA can be used as an appropriate alternative to glass-ionomer in closed sandwich technique
- In the open sandwich technique, MTA exhibited less microleakage compared to glass-ionomer. Therefore, MTA is preferable in the open technique
- No significant differences were observed in resistance to microleakage between the open and closed sandwich techniques

Of course, use of MTA in restorative procedures should be evaluated in future studies and microleakage studies are not sufficient.

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REFERENCES

Bortoluzzi, E.A., N.J. Broon, C.M. Bramante, R.B. Garcia and I.G. de Mores, N. Bernardineli, 2006. Sealing ability of MTA and radiopaque Portland cement with or without calcium chloride for root-end filling. J. Endod., 32: 897-900.

Camilleri, J., F.E. Montesin, V.C. Richard and T.R. Pitt Ford, 2006. Characterization of Portland cement for use as a dental restorative material. Dental Mater., 22: 569-575.

Camps, J. and D.H. Pashley, 2003. Reliability of the dye penetration studies. J. Endodontics, 29: 592-594.

De Bruyne, M.A., R.J. De Bruyne, L. Rosiers and R.J. De Moor, 2005. Longitudinal study on microleakage of three root-end filling materials by the fluid transport method and by capillary flow porometry. Int. Endod. J., 38: 129-136.

Kidd, E.A.M., 1976. Microleakage: A review. J. Dent., 4: 199-206.

Krupalini, K.S., Udayakumar and K.B. Jayalakshmi, 2003. A comparative evaluation of medicated calcium sulphate, hydroxylapatite, Mineral Trioxide Aggregate (MTA) as barrier and their effect on the sealing ability of furcation perforation repair material: An *in vitro* study. Indian J. Dent. Res., 14: 156-161.

Pashley, D.H., 1991. Dentin bonding: Overview of the substrate with respect to adhesive material. J. Esthet Dent., 3: 46-50.

Pereira, C.L., M.S. Cenci and F.F. Demarco, 2004. Sealing ability of MTA, super EBA, vitremer and amalgam as root-end filling materials. Braz. Oral. Res., 18: 317-321.

Pichardo, M.R., S.W. George, B.E. Bergeron, B.G. Jeansonne and R. Rutledge, 2006. Apical leakage of root-end placed Super-EBA, MTA, and Geristore restorations in human teeth previously stored in 10% formalin. J. Endod., 32: 956-959.

Poggio, C., M. Lombardini, C. Alessandro and R. Simonetta, 2007. Solubility of root-end-filling materials: A comparative study. J. Endodontics, 33: 1094-1097.

Reid, J.S., W.P. Saunders, S.W. Sharkey and C.E. Williams, 1994. An *in vitro* investigation of microleakage and gap size of glass ionomer/composite resin sandwich restorations in primary teeth. ASDC J. Dent. Child., 61: 255-259.

Roberson, T.M., H.O. Heymann and E.J. Swift, 2006. Sturdivants Art and Science of Operative Dentistry. 5th Edn., Mosby, Philadelphia, Pages: 570.

Roberts, H.W., J.M. Toth, D.W. Berzins and D.G. Charlton, 2008. Mineral trioxide aggregate material use in endodontic treatment: A review of the literature. Dental Mater., 24: 149-164.

Sarkar, N.K., R. Caidedo, P. Tirwik, R. Moiseyeva and I. Kawashima, 2005. Physicochemical basis of the biologic properties of mineral trioxide aggregate. J. Endodontics, 31: 97-100.

Sluyk, S.R., P.C. Moon and G.R. Hartwell, 1998. Evaluation of setting properties and retention characteristics of mineral trioxide aggregate when used as a furcation perforation material. J. Endodontics, 24: 768-771.

Stockton, L.W. and S.T. Tsang, 2007. Microleakage of class ii posterior composite restorations with gingival margins placed entirely within dentin. J. Can. Dental Assoc., 73: 255-255.

Summitt, J.B., J.W. Robbins, T.J. Hilton, R.S. Schwarts and J. Santos, 2006. Fundamentals of Operative Dntistry: A Contemporary Approach. 3rd Edn., Mosby, Philadelphia, Pages: 115.

Taylor, M.J. and E. Lynch, 1992. Microleakage. J. Dental, 20: 3-10.

Torabinejad, M., T.F. Watson and T.R. Pitt Ford, 1993. Sealing ability of a mineral trioxide aggregate when used as a root-end filling material. J. Endod., 19: 591-595.

Torabinejad, M., R.K. Higa, D.J. McKendry and T.R. Pitt Ford, 1994. Dye leakage of four root end filling materials: Effect of blood contamination. J. Endodontics, 20: 159-163.

Xavier, C.B., R. Weismann, M.G. de Oliveira, F.F. Demarco and D.H. Pozza, 2005. Root-end filling materials: Apical microleakage and marginal adaptation. J. Endod., 31: 539-542.

Yoshida, Y., B. van Meerbeek, Y. Nakayama, J. Snauwaert and L. Hellemans *et al*., 2000. Evidence of chemical bonding at biomaterial-hard tissue interfaces. J. Dent Res., 79: 709-714.