The Effectiveness of Different Thickness of Mineral Trioxide Aggregate on Coronal Leakage in Endodontically Treated Deciduous Teeth

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ABSTRACT

Purpose: The purpose of this study was to evaluate coronal dye leakage of mineral trioxide aggregate (MTA) when placed in different thicknesses over endodontically treated deciduous teeth.
Methods: Fourty-four extracted primary molar teeth were prepared for root canal treatment, and the canals were obturated with a paste including iodoform and calcium hydroxide. The teeth were randomly divided into 4 experimental groups, one for each material used for the coronal seal. Primary molar teeth were sealed with different thicknesses (1, 2, 3, 4 mm) of mineral trioxide aggregate (N=11) for each group. After a clearing procedure, data were statistically analyzed using the Kruskal-Wallis test, with differences of $P<.05$ considered to be significant.
Results: All positive control teeth showed dye penetration and all negative control groups showed no leakage. Statistically significant differences between the means of each group are identified. Group 1 (1 mm MTA) had a significantly greater percentage of dye penetration than the other groups ($P<.05$). Group 4 (4 mm MTA) had the lowest mean leakage (4%); it did not differ significantly from group 3 (3 mm MTA; $P>.05$).
Conclusions: The 4-mm thick mineral trioxide aggregate had the lowest dye penetration, and there was no significant difference between this group and the 3 mm group. The 1-mm thick MTA showed the greatest percentage of dye penetration among the groups. The depth increase of MTA placed as a barrier following root canal treatment of deciduous teeth reduced the coronal leakage.
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Coronal leakage is an important cause of failure of root canal treatment.[1,2] Micro-organisms can penetrate from the coronal to the apical portion easily. Sealability testing in a coronal direction is considered to be more clinically relevant than in the apical direction.[3-5]

The ideal properties of a coronal barrier have been proposed by Wolcott JF et al[6] to include the following characteristics: easily placed, bonds to tooth structure, seals against microleakage, distinguishable from natural tooth structure, and no interference with the final restoration. Many restorative materials have been used for a coronal barrier with varying results and lack of agreement between the studies.[7-10] One of them is mineral trioxide aggregate (**MTA**), which has been found to have very good biological properties.[11-13] It was also shown to have very good sealing properties when placed apically.[14-16] The effectiveness of MTA when placed over a root canal filling to maintain the coronal seal, however, is a new concept.

In a study,[17] MTA was compared with IRM and ZnPO4 as a coronal barrier for internal bleaching, MTA demonstrated superior performance. Another study[18] showed that there was no demonstrable differences between periapical inflammation in dog teeth with conventional root fillings and

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those coronally augmented by MTA. Tselnik et al[19] evaluated gray MTA, white MTA, and a resin-modified glass ionomer cement as coronal barriers to bacterial leakage and found acceptable results for all the materials. Barrieshi-Nusair and Hammad[20] found in their studies that MTA would be preferred over glass ionomer as a seal intracoronally following root canal treatment to prevent coronal microleakage. But all of these studies had no standardization in placing the thickness of MTA when used as a coronal barrier. Also, no study could be observed including the effectiveness of MTA when placed as a coronal barrier following root canal treatment in deciduous teeth.

The purpose of this study was to evaluate coronal dye leakage of mineral trioxide aggregate, when placed in different thicknesses over endodontically treated deciduous teeth.

METHODS

Fourty-four extracted primary molar teeth with caries and physiological initial root resorption (not exceeding one third of the root length) were used. Extracted teeth were stored in saline, to which 4% thymol was added. Caries was removed with a carbide bur and low-speed handpiece. Coronal access preparation was made with a straight fissure bur in a high-speed handpiece under water coolant. Working length was established 1 mm short of the file length at the point where it exited the root. Canals were prepared sequentially with size 15 to 40 K-files.

The irrigant solution was 2% NaOCl, and a final irrigation with saline was performed. Canals were dried with paper points and obturated with a paste, including iodoform and calcium hydroxide (Metapex, Meta Biomed Co, Chungcheongbuk-do, Korea). The apical foramen of the teeth was sealed with a composite resin. The access opening was closed with cotton pellet. Teeth were placed into a humidor at 37°C for 1 day to allow the sealer to set. The teeth were randomly divided into 4 experimental groups, one for each material, used for the coronal seal. Each group had 11 specimens (N=11). The positive control group was not treated with a restorative material, while the negative control group was treated with amalgam (N=2). A periodontal probe was used to measure the thickness of the materials.

In group 1, white mineral trioxide aggregate (ProRoot MTA, tooth-colored formula, Tulsa Dentsply, Weybridge, UK) was prepared according to the manufacturer's instruction, and 1 mm MTA was placed in the pulp chamber. The access was closed with a moistened cotton pelet (N=11).

In group 2, 2 mm of MTA was placed into the coronal access (N=11). In group 3, 3 mm of MTA was placed into the coronal access (N=11). In group 4, 4 mm of MTA was placed into the coronal access (N=11).

Teeth were placed in a humidor at 37°C for 24 hours to ensure that the material was properly set. All root surfaces and the crowns of all experimental groups and positive controls were covered with 2 layers of sticky wax, leaving only the access openings uncovered. The teeth in the negative control group were covered completely with sticky wax.

All teeth were aligned vertically in glass tubes and immersed in Indian ink (Pelikan 4001 Fountain Pen Ink, PEL-329144-Brilliant Black, Iowa, USA) for 48 hours. The sticky wax was removed following dye exposure. Teeth were decalcified in 5% nitric acid for 72 hours with a fresh solution used daily. After a 4-hour wash in running water, teeth were dehydrated gradually. First, they were immersed in 80% ethanol overnight, then in 90% ethanol in 2 1-hour washes, and then in 100% ethanol in 3 1-hour washes. All teeth were then cleared in methyl salicylate overnight. The cleared specimens were placed in glass tubes and kept moistened with methyl salicylate. Two operators independently measured the maximum point of coronal dye penetration from the cementoenamel junction. All measurements were taken using a stereomicroscope at X10 magnification. The total length of the root and the greatest depth of dye penetration along each canal were recorded in millimeters. These measurements were converted into percentages of microleakage related to the total length of the root filling for each tooth.[21] The mean measurement of both readings was recorded for each tooth. Data were statistically analyzed using the Kruskal-Wallis test, with differences of $P<.05$ considered to be significant.

RESULTS

The mean percentage extent of leakage for each group is presented in Table 1. All positive control teeth showed dye penetration, and all negative control groups showed no leakage. Statistically significant differences between the means of each group are identified. Group 1 (1 mm MTA) had a significantly greater percentage of dye penetration than the other groups ($P<.05$). Group 4 (4 mm MTA) had the lowest mean leakage (4%), which did not differ significantly from group 3 (3 mm MTA; $P>.05$).

Table 1. Mean Percentages of Microleakage for Each Group*

Group no. (mm MTA)	Mean microleakage (%)*
1 (1)	37a
2 (2)	14b
3 (3)	6bc
4 (4)	4c

** Different letters in superscript (a–c) mean statistically significant differences (P<.05).*

DISCUSSION

The success of a root canal treatment is not entirely dependent on sufficient debridement and good obturation. A restoration that provides a good coronal seal has been shown to be important. Galvan et al[9] compared the sealing effectiveness of 5 restorative materials used to create an intracoronal seal. They concluded that all 4 resins were effective in decreasing coronal leakage, with Amalgambond producing the best seal. Shindo et al[7] evaluated the sealing ability of materials filled in the orifice after root canal treatment. Their study indicated the advantageous sealing abilty of adhesive and flowable materials. Wells et al studied[10] 2 different cements as double-sealing materials, and both materials showed good sealing ability over a 4-week period. Barrieshi-Nusair and Hammad[20] concluded that, when MTA is placed coronally over gutta percha, it sealed the canal content significantly better than did glass ionomer.

There are various studies in the literature including coronal seal of materials, but there is a problem in the standardization of the thickness of them. It is known that 2-mm thickness of the material is suitable, but there isn't any information about MTA thickness when used as a coronal barrier. In a study including permanent teeth, 2-mm thickness of zinc oxide eugenol showed less coronal microleakage than glass ionomer and a dentin bonding agent.[21] Another study reported that 4 mm of glass ionomer cement leaked significantly more than MTA when used as a seal intracoronally folllowing root canal treatment of permanent teeth.[20] Different MTA thicknesses have been tested for their ability to prevent microleakage when used as a barrier to augment the coronal seal. This study's results are consistent with the findings of previous authors, who found that an intracoronal barrier significantly reduced microleakage.[9,19-22]

It has been shown that the 4-mm thick MTA had the best results (4%) among the groups, while the 1 mm thick MTA had the worst scores (37%). That result is consistent with Maloney et al,[8] who preferred to place a thicker barrier as dictated by the restorative considerations.We can presume that the coronal seal's success after root canal treatment may be affected by the material's thickness, but no comparison could be done in the literature because there was no related study including primary teeth.

The MTA's sealing ability used in the study is attributable to its hydrophilic nature and expansion when cured in a moist environment.[12,23] In recent decades, the majority of techniques for assessing leakage have been associated with the use of a tracer such as dyes, radioactive isotopes, or bacteria. The most common tracer used is dye, however, due to its its sensitivity, ease of use, and convenience.[24] In the evaluation of depth of dye, a clearing method was selected in this study because it allows specimens to be examined in 3 dimensions, so that the extent and adaptation of the filling material can be observed and evaluated.[25]

A considerable limitation of the great majority of in vitro microleakage tests is the assessment of caries-free teeth. In the clinical situation, restorative procedures are performed upon teeth that are carious,[26] so we preferred to use teeth with caries in the study.

It is reported that the only chemical difference between the gray and white MTA is the reduced iron content in white MTA, resulting from a difference in the manufacturing process.[27] White MTA was used in the study because the particale size of the white MTA is smaller to enhance handling and placement characteristics. In addition, MTA had ease of handling, which is advantageous in case of child's treatment. This is in contrast to some other materials, which have long chairtime applications, such as light curing, conditioning of the dentin, washing, and a special application technique.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. The 4-mm thick mineral trioxide aggregate (MTA) had the lowest dye penetration, and there was no significant difference between this group and the 3 mm group.
2. The 1-mm thick MTA showed the gretaest percentage of dye penetration among the groups.
3. The depth increase of MTA placed as a barrier following root canal treatment of primary teeth reduced the coronal leakage.

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