Scientific Article

An In Vitro Comparison of Marginal Microleakage of Alternative Restorative Treatment and Conventional Glass Ionomer Restorations in Extracted Permanent Molars

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Abstract: ***Purpose:*** *The objective of this study was to compare the marginal leakage of cervical restorations made using alternative restorative treatment (ART) and conventional glass ionomer restorations.* ***Methods:*** *Sixteen permanent maxillary and mandibular first and second molars extracted for periodontal reasons with Class V carious dentin on the buccal surfaces were prepared using ART, while a second set of 29 noncarious molars had Class V preparations made with a high-speed handpiece. The occlusal margin was located in the enamel, and the gingival margin was located in the dentin/cementum. All teeth were restored with glass ionomer cement (GIC). The teeth were thermally stressed for 300 cycles and stained with methylene blue. Samples were sectioned and evaluated for microleakage.* ***Results:*** *One-way analysis of variance on ranks revealed no significant difference in leakage at both the dentin and enamel margins between the conventional and ART groups. The microleakage at the dentin margin, however, was significantly greater (P<.001) than at the enamel margins in the conventional group.* ***Conclusion:*** *Alternative restorative treatment with GIC provides enamel and dentin margins that show comparable marginal leakage to conventionally restored permanent teeth. For the conventional restorations, leakage at the dentin margins occurs to a significantly higher extent than at the enamel margins. (Pediatr Dent 2007;29:303-7)*

KEYWORDS: MICROLEAKAGE, ATRAUMATIC RESTORATIVE TREATMENT, DENTIN MARGINS, ENAMEL MARGINS, GLASS IONOMER

The alternative restorative treatment (ART), formerly known as atraumatic restorative treatment, was introduced primarily in response to the need to stop progression of dental caries in countries where access to conventional dental care was limited.[1] Pioneered in the mid 1980s as part of a primary oral health care program in Tanzania, this technique has gained recognition in many developing countries and disadvantaged communities where skilled human and other resources such as electricity and water are not readily available or affordable.[2] This intervention has enabled the treatment of large numbers of children affected by caries and led to retention of teeth that would otherwise have been extracted. The American Academy of Pediatric Dentistry (AAPD) recognizes ART as a useful and beneficial technique in the treatment of dental caries in:

1. young patients;
2. uncooperative patients;
3. persons with special health care needs (PSHCN); and
4. situations where traditional cavity preparation and placement of a traditional dental restoration is not possible.[3]

Careful selection of hand instruments from those commonly found in dental kits has been made to allow excavation of decayed tooth structure while simultaneously "preparing the cavity" to receive the restoration.[4] These instruments include a: (1) mouth mirror; (2) probe; (3) cotton pliers excavator; (4) dental hatchet; and (5) ball burnisher. Glass ionomer cements (GICs) with enhanced physical properties have been specifically formulated for ART. These materials chemically bond to enamel and dentin, thus reducing the need to cut sound tooth tissue to prepare a cavity.[5] Other unique advantages include:

1. their ability to release fluoride into the tooth tissue, saliva, and plaque;[6-8]
2. low-setting shrinkage; and
3. pulpal biocompatibility.[9]

Compared to other adhesive restorative materials, however, GICs have low mechanical properties.[10] Their low abrasion resistance and flexural/tensile strength limit their application to relatively low stress-bearing areas.[10,11]

In principle, ART should yield outcomes similar to those achieved through conventional restorative dentistry, including the: (1) potential for minimal intervention; (2) conservation of sound tooth structure; and (3) longevity of the affect-

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ed teeth. Clinical outcomes of the ART approach have been based on a 1- to 3-year evaluation of restorations.[12,13] Most of these studies have reported on occlusal wear and retention of the restoration as the primary outcome measure of the treatment.[14-16] Some studies have evaluated the development of secondary caries along the margins of previously placed restorations.[17] None has developed a protocol comparing the marginal integrity and microleakage of ART restorations to conventional restorative technique, although marginal integrity and microleakage are recognized as an important factor in evaluating the clinical success of restorations. Dimensional changes and poor adaptation of the restoration to cavity walls can lead to marginal leakage, with ingress of bacteria, fluids, molecules, and ions between the teeth and the restoration.[18,19] The sequelae to microleakage include: (1) tooth discoloration; (2) accelerated deterioration of restorative materials; (3) recurrent decay; (4) pulpal irritation; and (5) postoperative tooth sensitivity.[20-22] In vitro microleakage studies provide a mechanism for investigating the adaptation of restorative materials and their ability to seal and prevent leakage along cavity margins.

The purpose of this in vitro study on extracted permanent molars was to compare the marginal leakage of cervical restorations made using alternative restorative treatment and the conventional glass ionomer technique.

Methods

Sixteen extracted human permanent molars with Class V carious dentin on the buccal surfaces were: (1) cleaned with distilled water to remove debris; and (2) stored in deionized water. Since the teeth used were pooled from several dental offices and had no identifying characteristics, the study was exempted from approval by the Institutional Review Board. Decay was removed using the ART approach. A spoon excavator was used to remove decayed tooth structure from buccal carious lesions. Decay removal was verified by tactile examination with a sharp explorer. All teeth had cavities with occlusal margins located in the enamel and gingival margins located in the dentin/cementum.

A second set of 29 extracted human permanent molar teeth without decay were: (1) cleaned with distilled water to remove debris; and (2) stored in deionized water. Class V cavities measuring 4 mm in length and 1.5 mm wide were prepared on the buccal surface to a depth of 1.5 mm. A high-speed handpiece with water spray was used with a no. 330 carbide bur to: (1) obtain the depth of the preparation; and (2) provide consistency. The occlusal margin was located in the enamel, and the gingival margin was located in dentin/cementum.

All teeth were restored with Ketac-Molar (3M ESPE, Minneapolis, Minn) according to manufacturer's instructions. A thin coat of petroleum jelly was applied to the restoration surface. Restored teeth were stored in 100% relative humidity at 37°C for 24 hours. The teeth were then subjected to 300 thermal cycles between 4°C and 60°C, with a dwell time of 15 seconds.

Teeth were:

1. coated with nail polish, except for 2 mm surrounding the restoration margins;
2. immersed in 1% methylene blue for 4 hours;
3. rinsed with distilled water; and
4. sectioned in a buccolingual direction through the center of each restoration with a low-speed diamond saw (Buehler, Lake Bluff, Ill).

Samples were evaluated for microleakage at enamel and dentin/cementum margins using a magnifying glass. The most severe degree of dye penetration along the tooth-restoration interface was recorded according to this ordinal score:

a. 0=no leakage;
b. 1=leakage extending to half the depth of preparation;
c. 2=leakage extending to entire depth of preparation;
d. 3=leakage extending to axial wall;

One-way analysis of variance (ANOVA) on ranks of the leakage scores at the enamel and dentin margins was performed using statistical software (Sigma Stat, Jandel Scientific Software, San Rafael, Calif). Multiple comparisons were made using Dunn's test to determine significant differences between test groups.

Table 1. MEDIAN MICROLEAKAGE VALUES OF CONVENTIONAL VS ALTERNATIVE RESTORATIVE TECHNIQUE (ART) RESTORATIONS ON PERMANENT MOLARS

GROUP	MEDIAN	25TH PERCENTILE *	75TH PERCENTILE †
Conventional enamel margins	1.00	1.00	1.00
Conventional dentin margins	2.00	1.75	3.00
ART enamel margins	2.00	1.00	2.00
ART dentin margins	2.00	2.00	3.00

* 25th percentile: 25% of samples scored this value or lower

† 75th percentile: 75% of samples scored this value or lower.

Results

Table 1 summarizes the median microleakage scores for the experimental conditions evaluated. For conventionally restored teeth, the median score for enamel margins was 1. Seventy-five percent of the samples scored microleakage values of 1 or less at the enamel margin. Dentin margins of conventionally restored teeth had a median score of 2, and 75% of samples had leakage scores below 3. ART-restored teeth had a median score of 2 at the enamel margins, and the 75th percentile score was 2. The median microleakage score at the dentin margins of ART-restored teeth was 2, and 75% of teeth scored 3 or lower. A statistically significant difference was found between leakage values among the treatment groups ($P<.001$). Multiple pairwise comparisons of restoration margins of ART restorations and conventionally prepared restorations are shown in Table 2.

Table 2. DIFFERENCES IN MARGINAL LEAKAGE OF ART RESTORATION VS CONVENTIONALLY PREPARED ESTORATIONS (PAIRWISE MULTIPLE COMPARISON PROCEDURES, DUNN'S METHOD) ON EXTRACTED PERMANENT MOLARS

COMPARISON	DIFFERENCE OF RANKS*	P†	Q‡	*P*-VALUE
ART dentin vs conventional enamel margins	41.27	4	5.35	.001
ART dentin vs ART enamel margins	21.75	3	2.48	.095
ART dentin vs conventional dentin margins	4.92	2	0.64	.913
Conventional dentin vs conventional enamel margins	36.34	3	5.59	<.001
Conventional dentin vs ART enamel margins	16.83	2	2.18	.078
ART enamel vs conventional enamel margins	19.52	2	2.53	.126

* Difference of ranks: Size of the difference between the groups compared.

† P=difference in ranks of groups compared.

‡ Q=test statistic value to determine if the difference between groups is significant.

There was no significant difference in leakage at the enamel margins between the conventional and ART groups ($P=.126$). There was also no significant difference in leakage at the dentin margins between the conventional and ART groups ($P=.913$). Among teeth that were restored conventionally, a significantly higher leakage ($P<.001$) was found at dentin margins when compared to enamel margins. In the ART group, there was no difference ($P=.095$) between leakage at the enamel and dentin margins.

Discussion

The maintenance of a marginal seal is integral to the longevity of a restoration and the avoidance of clinical problems associated with microleakage and secondary caries.[23] In their search for a better seal of restoration margins, many studies have focused on mechanical and chemical properties of various materials and adhesive agents on cavities prepared using the conventional restorative technique. The ART approach, however, while still in its infancy, has not been clinically evaluated to determine its effectiveness in maintaining a marginal seal over time. Evaluation of the quality of margins is necessary to provide indications of clinical performance of the ART restoration or morphology.[24]

In this study, dye penetration into the interface between the restoration and the tooth was used to assess the microleakage of the ART vs the conventional technique. ART technique provided enamel and dentin margins that were comparable in marginal integrity to conventionally restored teeth. In agreement with previous studies,[25,26] there was a significant difference observed in the microleakage between the enamel and dentin margins in the conventional technique, which indicates that the enamel margin has better adaptation with the GIC. This may be due to a difference in the quality of the bond between GIC and enamel and dentin structures. A higher bond strength of GIC materials to enamel than dentin is well documented.[25] On the contrary, leakage at the enamel margin and dentin margin were comparable in ART. The lack of superiority of enamel margins compared to dentin margins in ART may be explained by the different approach to margin preparation. Cavity cleaning with hand instruments alone may leave contaminated or rough enamel surfaces in ART. Probably for similar reasons as well as the reported high bond strength of GICs to enamel margins,[25] the conventionally prepared enamel margins showed significantly lower leakage when compared to the ART-prepared dentin margins.

Marginal leakage can also be affected by properties of a dental restorative material, such as: (1) bonding to tooth structure[25]; (2) water sorption[26]; (3) curing shrinkage[27]; and (4) linear coefficient of thermal expansion.[28,29] Some limitations in this study include a lack of:

1. naturally formed Class V caries lesions for ART restorations that exactly match the conventionally prepared restorations; and
2. an in vivo environment.

In vitro studies do not reflect all the variables present in an individual's mouth. Although thermocycling has been used extensively to simulate oral conditions, there is no consensus on its effectiveness in mimicking oral conditions. The number of cycles used in previous studies range from 300 to 5,000.[30-33] Other studies suggest that microleakage occurs more in vivo than in vitro, whether or not samples are thermocycled.[34] Further studies are needed to clearly define the role of thermocycling in simulating oral conditions and predicting the clinical performance of restorations.

ART is more commonly used by pediatric dentists in carious primary teeth in very young patients. Therefore, the ideal comparison with the conventional technique should be performed on primary teeth. Finding extracted primary teeth with ideal Class V lesions and an intact pulp chamber, however, has proved challenging. In a comparison of microleakage of conventionally restored primary and permanent molars restored with glass ionomer, Castro and Feigal[35] reported that permanent teeth showed more leakage than primary teeth. The finding that the ART technique provided enamel and dentin margins that were comparable in marginal integrity to conventionally restored teeth is encouraging to pediatric dentists who often find themselves in circumstances that do not permit conventional restoration and need to apply an alternative restorative treatment.

This is a major step forward for the ART, considering its combined approach to preventive and restorative dental care for populations that cannot withstand or afford conventional restorations. Clinical studies of the ART technique are needed to confirm the performance of the technique.

Conclusions

Within the context of this in vitro study, the following conclusions can be made:

1. The enamel margins of permanent teeth restored with GICs using ART have comparable marginal leakage to teeth restored conventionally with the same materials.
2. The dentin margins of permanent teeth restored with GICs using ART have comparable marginal leakage to teeth restored conventionally with the same materials.
3. The enamel margins of permanent teeth restored with GICs using conventional techniques show less microleakage than dentin margins.

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