Marginal Microleakage of Alternative Restorative Treatment and Conventional Glass Ionomer Restorations in Extracted Primary Molars

R.O. Wadenya, BDS, MS, DMD C. Yego, BS, DMD
F.K. Mante, PhD, DMD

ABSTRACT

Purpose: The objective of this study was to compare the marginal leakage of cervical glass ionomer restorations made using alternative restorative treatment (ART) and conventional restoration techniques.

Methods: Twenty primary molars with Class V carious dentin on the buccal surfaces were prepared using ART, and a second set of 20 noncarious molars had Class V preparations made with a high-speed handpiece. The occlusal margin was located in enamel and the gingival margin in dentin/cementum. All teeth were restored with high-density glass ionomer cement (GIC; Fuji IXgp) according to manufacturers' instructions, thermally stressed for 300 cycles, and stained with methylene blue. Samples were sectioned and evaluated for microleakage.

Results: One-way analysis of variance revealed no statistically significant difference between leakage at margins of ART and conventional restorations. (P=.92) There was no significant difference between leakage at the enamel and dentin margins.

Conclusions: Alternative restorative treatment with high-density glass ionomer cement provides enamel and dentin margins that show marginal leakage comparable to conventionally restored primary teeth. These results show the potential of ART in conjunction with high-density GIC in providing treatment for children and adolescents in situations where traditional cavity preparation and restoration is not possible.

(J Dent Child 2010;77:32-5)

Received November 7, 2008; Last Revision December 10, 2008; Revision Accepted December 11, 2008.

KEYWORDS: MICROLEAKAGE, ATRAUMATIC RESTORATIVE TREATMENT, DENTIN MARGINS, ENAMEL MARGINS, GLASS IONOMERS, DENTAL MATERIALS

Initiated in the mid 1980s as part of a primary oral health care program in communities with limited resources in Tanzania, atraumatic restorative treatment—also referred to as alternative restorative technique (ART)—has benefited large numbers of children who would otherwise have lost their teeth.[1-3] ART involves manual caries removal with hand instruments and restoration of the cavity with an adhesive fluoride releasing material. It presents a low-cost, minimally invasive, and patient-friendly approach to the management of dental caries that has been found to be well received by patients who have not previously received restorative care.[4] In 2004, the American Academy of Pediatric Dentistry recognized ART as a useful and beneficial treatment of dental caries in situations where a traditional cavity preparation and restoration is not possible, including very young, uncooperative, and special health care needs patients.[5]

Glass-ionomer cement (GIC) material was originally recommended for ART due to its physical properties,

Dr. Wadenya is assistant professor, School of Dental Medicine, and Dr. Mante is associate professor, Department of Preventive and Restorative Sciences, both at University of Pennsylvania, Philadelphia, Pa; Dr. Yego is an associate dentist, Dental One Associates, Fayetteville, Ga.
Correspond with Dr. Wadenya at wadenya@dental.upenn.edu

such as: chemical bond to enamel and dentin; fluoride release; biocompatibility with pulp tissue; and coefficient of thermal expansion that is similar to teeth.[6,7] To date, most ART investigations have focused on survival rates of restorations placed under field studies. Van't Hoff and colleagues,[8] in their meta-analysis on survival of ART restorations in primary and permanent teeth, found higher survival rates for single-surface ART restorations compared to multiple surface restorations. The noted failures were mainly due to excessive wear, defective margins, and loss of restoration.

Despite the beneficial properties of GICs, their low fracture toughness, and poor wear resistance have limited their use by most clinicians and led to the development of a new generation of high-density GICs. These materials have greater flexural strength and better wear resistance, largely due to smaller mean particle size and increased viscosity.[9] In addition, they are easier to handle.[10] Thus, Fuji IXgp (GC America Inc, Alsip, Ill), a new high-density GIC, may offer significant benefits when used in conjunction with ART in the management of early childhood caries and patients who are unable to tolerate conventional treatment.

Though ART is gaining more recognition globally as an alternative method of treatment, there is paucity in the literature regarding the marginal integrity of ART restorations in primary teeth. This is especially important, as microleakage is a common cause of restoration failure, and may lead to secondary caries and pulpal irritation.[11-13] Most microleakage studies have focused on conventional restorations using various restorative materials.[14-16] Castro and Feigal investigated leakage of high-density GICs and compared it with traditional GICs in conventionally prepared primary and permanent teeth and showed significantly lower leakage around high-density GIC restorations.[17] There are no reported laboratory studies that have looked at the marginal seal of ART restorations in primary teeth.

The aim of this study was to compare the marginal leakage of a high-density glass ionomer cement restoration in extracted primary molars prepared using alternative restorative treatment and conventional preparations.

METHODS

Forty extracted human primary molars (carious and noncarious) were debrided and stored in 0.5% chloramine T solution at 23°C. Twenty teeth with Class V carious dentin on the buccal surfaces were prepared 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. A second set of 20 non carious teeth had Class V preparations made on the buccal surface using the conventional technique. A high-speed handpiece with water spray was used with a no. 330 carbide bur to obtain the depth of the preparation. The preparations measured 3 mm in length and 1.5 mm in width and had a surface depth of 1.5 mm. All cavity preparations had occlusal margins located in enamel and gingival margins in dentin/cementum.

The teeth were restored according to manufacturers' instructions. Restored teeth were stored in 100% relative humidity at 37°C for 24 hours. The teeth were then:

1. thermocycled for 300 cycles between 4°C and 60°C with a dwell time of 15 seconds;
2. coated with nail polish, except for 2-mm surrounding the restoration margins; and
3. immersed in 1% methylene blue for 4 hours.

Samples were rinsed with distilled water to remove excess dye then sectioned in a buccolingual direction through the center of each restoration with a low-speed diamond saw (Buehler, Lake Bluff, Ill). The 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:

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

A Kruskal Wallis 1-way analysis of variance was performed to compare microleakage between experimental groups using Sigma Stat 3.5 statistical software (Jandel Scientific Software, San Rafael, Calif).

RESULTS

Table 1 summarizes the raw microleakage scores for the experimental conditions evaluated. For conventionally prepared teeth, the median score for enamel margins was 0. Table 2. Seventy-five percent of the samples scored values of 1 or less at the enamel margin. Dentin margins of conventionally restored teeth had a median score of 0, and 75% of samples had leakage scores of 1 or lower. ART restored teeth had a median score of 0 at the enamel margins, and 75% of the teeth scored 1 or less.

Table 1. Microleakage scores of conventional vs ART restorations with FUJI IXgp in primary molars

Group	Leakage scores			
	0	1	2	3
ART-enamel margin	13	5	2	0
ART-dentin margin	13	2	5	0
Conventional-enamel margin	12	7	1	0
Conventional-dentin margin	11	6	3	0

Table 2. Median microleakage scores of conventional vs ART restorations with FUJI IXgp in primary molars

Group	N	Median	25th percentile	75th percentile
ART-enamel margin	20	0.00	0.00	1.00
ART-dentin margin	20	0.00	0.00	1.50
Conventional-enamel margin	20	0.00	0.00	1.00
Conventional-dentin margin	20	0.00	0.00	1.00

** Groups are not statistically significantly different (P=.92).*

The median marginal leakage score at the dentin margins was 0. The 75 percentile score was 1.5. There was no statistically significant difference between leakage at the margins of ART and conventional restorations. There was also no significant difference between leakage at the enamel and dentin margins.

DISCUSSION

A major goal of restorative dentistry is the maintenance of a marginal seal over a long period of time. This seal can be affected by a variety of factors, including: adhesive bonding to the tooth structure[18]; linear coefficient of thermal expansion[19]; curing shrinkage[20]; and water sorption.[21] Many studies have focused on the physical and chemical properties of restorative materials and adhesive agents applied using the conventional restorative technique to limit microleakage. Others have investigated cavity preparations using air abrasion, laser techniques, and margin modification through beveling. The ART approach, still in its infancy, has not been evaluated to determine its effectiveness in maintaining a marginal seal in primary teeth. Unlike the conventional technique of cavity preparation where cavity margins can be refined and modified to achieve optimal adaptation and retention of restorative materials, the ART technique involves use of hand instruments. Therefore, cavity design is dictated by the extent of decay. There is strong reliance on the restorative material to achieve optimal adaptation and seal the cavity margins which may be rough due to finishing with hand instruments.

The ART technique in primary teeth provided enamel and dentin margins that were comparable in marginal integrity to conventionally restored teeth. These findings agree with a recent microleakage study comparing microleakage of GIC restorations prepared using the ART and conventional techniques in permanent teeth.[6] In both studies, high-density GICs were used. The improvements[9,10] associated with this material are especially important, since ART-prepared teeth have rough margins and walls compared to conventionally prepared teeth[22] and rely on the optimal adaptation and seal of cavity margins by the restorative material.

While it is important to do these in vitro studies but clinical studies are needed to substantiate the results as in vitro studies do not accurately reproduce conditions found in the oral cavity. Thermocycling has been used in this study to simulate oral conditions, however, there is no consensus on its effectiveness in mimicking oral conditions. The number of cycles reported in previous studies range from 300 to 5,000.[23,24] Other studies suggest that microleakage occurs more in vivo than in vitro, whether or not samples are thermocycled.[25] In the absence of a definitive recommendation for number of cycles needed to simulate oral conditions, 300 cycles was applied in this study. Further studies are needed to define the role of thermocycling in simulating oral conditions and predicting the clinical performance of restorations.

A variety of methods—including silver nitrate, air pressure, and radioactive isotopes—have been used to assess microleakage around restorations.[26] In this study, a widely used dye penetration test was used. Since the size of oral bacteria are many orders of magnitude larger than dye particles, the penetration of the dye can be regarded as an early indication of a compromised margin.[27]

This study provided a comparison of microleakage rates between ART and conventional restorations in primary teeth. This is vital, as ART is increasingly being recognized as a useful and beneficial technique in the treatment of dental caries in populations that cannot endure or afford conventional restorations. Improved materials such as the high-density GIC (Fuji IXgp) provide a major step for the ART, considering its combined approach to preventive and restorative dental care.

CONCLUSIONS

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

1. The enamel margins of primary teeth restored with high-density glass ionomer cement using alternative restorative treatment have comparable marginal leakage to teeth restored conventionally with the same material.
2. The dentin margins of primary teeth restored with high-density GIC using ART have marginal leakage comparable to teeth restored conventionally with the same material.
3. Leakage at the enamel and dentin margins of teeth restored with high-density GIC using ART are not different.

REFERENCES

1. Schriks MC, van Amerongen WE. Atraumatic perspectives of ART: Psychological and physiological aspects of treatment with and without rotary instruments. Community Dent Oral Epidemiol 2003;31:15-20.

2. Frencken JE, Makoni F, Sithole WD, Hackenitz E. Three-year survival of one-surface ART restorations and glass-ionomer sealants in a school oral health programme in Zimbabwe. Caries Res 1998;32:119-26.
3. Holmgren CJ, Lo EC, Hu D, Wan H. ART restorations and sealants placed in Chinese school children: Results after three years. Community Dent Oral Epidemiol 2000;28:314-20.
4. Mjor IA, Gordan VV. A review of atraumatic restorative treatment (ART). Int Dent J 1999;49:127-31.
5. American Academy of Pediatric Dentistry. Clinical guideline on pediatric restorative dentistry. Reference Manual 2004-05. Pediatr Dent 2004;26:106-14.
6. Wadenya R, Mante FK. An in vitro comparison of marginal microleakage of alternative restorative treatment and conventional glass ionomer restorations in extracted permanent molars. Pediatr Dent 2007;29:303-7.
7. Silva RC, Zuanon AC, Esberard RR, Candido MS, Machado JS. In vitro microhardness of glass ionomer cements. J Mater Sci Mater Med 2007;18:139-42.
8. van't Hof MA, Frencken JE, van Palenstein Helderman WH, Holmgren CJ. The atraumatic restorative treatment (ART) approach for managing dental caries: A meta-analysis. Int Dent J 2006;56:345-51.
9. Frankenberger R, Sindel J, Kramer N. Viscous glass-ionomer cements: A new alternative to amalgam in the primary dentition? Quintessence Int 1997;28:667-76.
10. Smales RJ, Gao W, Ho FT. In vitro evaluation of sealing pits and fissures with newer glass ionomer cements developed for the ART technique. J Clin Pediatr Dent 1997;21:321-3.
11. Brackett WW, Gunnin TD, Johnson WW, Conkin JE. Microleakage of light-cured glass-ionomer restorative materials. Quintessence Int 1995;26:583-5.
12. Sidhu SK. Sealing effectiveness of light-cured glass ionomer cement liners. J Prosthet Dent 1992;68:891-4.
13. Douglas WH. Clinical status of dentine bonding agents. J Dent 1989;17:209-15.
14. Casagrande L, Brayner R, Barata JS, de Araujo FB. Cervical microleakage in composite restorations of primary teeth: In vitro study. J Dent 2005;33:627-32.
15. Aysegul O, Nurhan O, Haluk B, Dilek T. Microleakage of compomer restorations in primary teeth after preparation with bur or air abrasion. Oper Dent 2005;30:164-9.
16. Myaki SI, Rodrigues CR, Raggio DP, Flores TA, Matson MR. Microleakage in primary teeth restored by conventional or bonded amalgam technique. Braz Dent J 2001;12:197-200.
17. Castro A, Feigal RE. Microleakage of a new improved glass ionomer restorative material in primary and permanent teeth. Pediatr Dent 2002;24:23-8.
18. Frencken JE, Songpaisan Y, Phantumvanit P, Pilot T. An atraumatic restorative treatment (ART) technique: Evaluation after one year. Int Dent J 1994;44:460-4.
19. Puckett AD, Fitchie JG, Bennett B, Hembree JH. Microleakage and thermal properties of hybrid ionomer restoratives. Quintessence Int 1995;26:577-81.
20. Yap AU, Lim CC, Neo JC. Marginal sealing ability of three cervical restorative systems. Quintessence Int 1995;26:817-20.
21. Thornton JB, Retief DH, Bradley EL. Marginal leakage of two glass ionomer cements: Ketac-fil and Ketac-silver. Am J Dent 1988;1:35-8.
22. Grossman ES, Mickenautsch S. Microscope observations of ART excavated cavities and restorations. SADJ 2002;57:359-63.
23. Duangthip D, Lussi A. Microleakage and penetration ability of resin sealant versus bonding system when applied following contamination. Pediatr Dent 2003;25:505-11.
24. de Morais PM, Rodrigues Junior AL, Pimenta LA. Quantitative microleakage evaluation around amalgam restorations with different treatments on cavity walls. Oper Dent 1999;24:217-22.
25. Pardi V, Sinhoreti MA, Pereira AC, Ambrosano GM, Meneghim Mde C. In vitro evaluation of microleakage of different materials used as pit-and-fissure sealants. Braz Dent J 2006;17:49-52.
26. Fuks AB, Shey Z. In vitro assessment of marginal leakage of combined amalgam-sealant restorations on occlusal surfaces of permanent posterior teeth. J Dent Child 1983;50:425-9.
27. Van Meerbeek B, De Munck J, Yoshida Y, et al. Adhesion to enamel and dentin: Current status and future challenges. Oper Dent 2003;28:215-35.