The atraumatic restorative treatment (ART) approach for primary teeth: review of literature

Roger J Smales MDS, DDSc, FDSRCS, FADM, FHKAM (Dental Surgery) Hak-Kong Yip BDS, PhD, MEd, MMedSc

Dr. Smales is visiting research fellow at the University of Adelaide, Adelaide, South Austrailia, and Dr. Yip is is assistant professor in Conservative Dentistry at the University of Hong Kong, Hong Kong SAR, China. Correspond with Dr. Smales at roger.smales@adelaide.edu.au

Abstract

There is widespread interest in and increasing usage of the atraumatic restorative treatment (ART) technique or approach for the restoration of primary teeth, especially in developing countries. However, most of the published reports of the clinical performance of newer, more-viscous esthetic conventional glass ionomer restorative cements marketed for the technique have been from short-term studies, and there have been very few reports comparing different types of restorative materials and methods of cavity preparation. After 12 months, Class II/multisurface and Class III/IV ART restorations have generally shown success rates of approximately 55-75% and 35-55%, respectively. Failures were usually from restoration losses and fractures. Class I & V/single-surface ART restorations have had much better short-term success rates of approximately 80-90%. Recurrent caries was not a concern at this time, but occlusal wear was relatively high. Further improvements in the mechanical and adhesive properties of the newer cements are still required, together with further clinical investigations of the remineralization of shallow open preparations as an alternative to placing restorations. The ART approach is readily accepted by children and has resulted in the retention of many teeth that would otherwise have been extracted. (Pediatr Dent 22:294-298, 2000)

The atraumatic restorative treatment (ART) technique or approach has achieved considerable interest worldwide, especially for its application in developing countries where skilled human and other resources are not readily available or affordable to treat dental caries by more conventional means.

The ART approach involves the use of hand instruments only to remove carious tooth substance and then restoring the cavity and sealing any adjacent enamel fissures with usually a conventional glass polyalkenoate (ionomer) restorative cement (GIC).[1] GICs demonstrate sustained fluoride release,[2] pulpal biocompatibility,[3] and chemical adhesion to tooth substance.[4] The minimally-invasive procedure is largely pain-free and readily accepted by children;[5,6] and is also gaining increasing acceptance in more developed countries for the management of early childhood caries. A recent study demonstrated the dramatic improvements in oral health achieved in both the primary and permanent dentitions of children when the ART approach replaced the use of conventional instrumentation in mobile dental clinics.[7] Even in some developed countries, many children are deprived of adequate dental care because of fear and for economic reasons.

The GICs used in earlier field trials were not specifically developed for the ART technique, and the relatively high failures found may have been partly related to the materials and to the technical skills of the operators[8,9] Recently, several more-viscous esthetic conventional GICs with improved handling and physical properties,[10-13] largely due to smaller mean particle sizes, have been marketed specifically for the ART approach. The products release similar amounts of fluoride ions to a metal-modified GIC (Ketac-Silver - ESPE GmbH, Seefeld, Germany), which is less than for older conventional esthetic restorative GICs.[14,15]

The importance of close attention to details during cavity preparation and placement of the cements when using the ART approach, together with aspects of preventive dental care, have been emphasized.[1,16] Control of moisture is with cotton wool rolls, supplemented with suction if available. Access to underlying carious dentin and the removal of unsupported demineralized enamel is by hatchets. Sharp excavators are used to remove soft necrotic dentin and to expose harder tissue at the dentin-enamel junction (DEJ). If available, the use of slow-speed rotary burs with light pressure can supplement cleaning along the DEJ. It is not necessary or desirable to remove all softened, minimally infected and sensitive dentin in close proximity to the dental pulp in the absence of signs and symptoms of pulpitis. Following cleaning and then conditioning of the cavity with dilute polyacrylic acid, the correctly dispensed GIC is placed in close contact with the cavity walls. The excess material is then pressed firmly into the cavity and adjacent enamel fissures with a lubricated gloved finger, before

Fig 1. Art cavity preparation in primary first molar (original mag. x 1).

Received July 27, 1999 Revision Accepted May 12, 2000

Fig 2. GIC restoration placed. Cavity overfilled to include fissure (original mag. x 1).

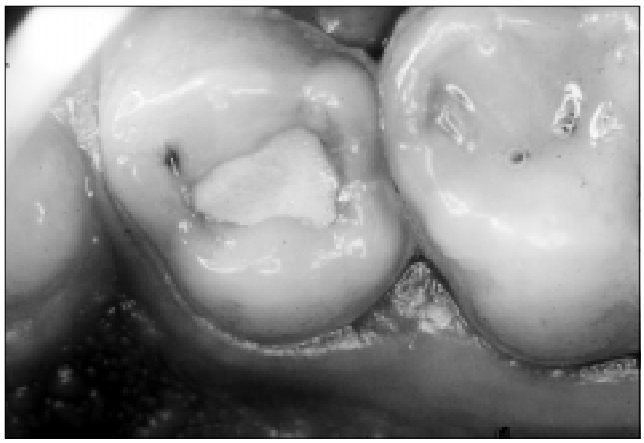

Fig 3. GIC restoration at 12 months. Some loss of marginal excess of material and from fissure (original mag. x 2).

Fig 4. GIC restoration at 24 months showing little change from at 12 months (original mag. x 2) (photographs supplied by Dr Yu Chang, School of Stomatology, Beijing Medical University).

adjusting the occlusion and sealing the restoration with a varnish (Figs 1-4).

Restoration survivals

Although the newer more-viscous GICs appear promising for the restoration of caries in primary teeth,[17] most of the published reports are only of 12 month's duration, and very few have compared different types of restorative materials[18-20] or methods of cavity preparation.[20] Of concern have been the percentages of short-term GIC failures reported for shallow and multisurface load-bearing restorations.

In particular, as shown in Table 1, even with the newer GIC materials, Class II/multisurface and Class III/IV ART restorations generally have low success rates after 12 months, of approximately 55-75% and 35-55%, respectively. After 24 months, one study reported a success rate of 45%[18] and, after 30 months, another study reported a success rate of 54%[21] for Class II/multisurface ART restorations. After 30 months, only 14% of Class III/IV ART restorations were successful.[21]

The use of a high powder: liquid ratio mix of 3.6:1.0[20] for an autocure resin-modified GIC (Fuji Plus - GC Int. Corp., Tokyo, Japan), has demonstrated results over 6 months of approximately 78% for Class II/multisurface restorations.[19] These initial, improved results may have been due to better fracture resistance and adhesion to tooth structure of the resin-modified GIC when compared to conventional GICs.[22] But, the relatively higher wear rates of the resin-modified GICs[12,13,23] may lead subsequently to lower success rates. Although studies investigating the use of compomers for ART restorations in the primary teeth are reported to be underway,[16] there are no published results in literature. The Class I & V/single-surface ART restorations have shown much better success rates after 12 months of approximately 80-95%. Recurrent caries has not been noted as a cause for restoration failures in the short-term studies.

Occlusal wear

There is very little information available on the occlusal wear of the newer more-viscous esthetic GICs in primary molars. One recent study[24] reported cumulative net mean wear rates after 12 months of 66.5 ± 40.4 m (Fuji IX GP - GC Int. Corp., Tokyo, Japan), and 70.3 ± 48.2 m (ChemFlex - Dentsply/DeTrey, Konstanz, Germany). These wear rates were higher than for similar occlusal restorations in the permanent teeth of the same subjects, and higher than the 50 m per year recommended by the American Dental Association guidelines. [25]

Cavity preparations

There are also very few reports of studies investigating the adequacy of different methods of cavity preparations for the newer GICs, either in the primary[20,26] or permanent[27-29] dentitions.

After 6 months, in one small study of two encapsulated viscous esthetic GICs placed in primary molars,[26] success rates for Class I preparations were 94% (one failure) for conventional, and 100% for ART instrumentation methods. However, success rates for Class II preparations were 100% for conventional, and 75% (seven failures) for ART instrumentation methods. After 12 months,[20] the success rates for Class I preparations were approximately 92% for both conventional and ART instrumentation, but for Class II preparations the success rates were 87% for conventional and 79% for ART. Failures occurred from restoration losses because of inadequate retention and mechanical properties of the GICs. Lack of retention is also commonly found with Class III/IV ART preparations, as shown in the Table, and where the cements are used to restore shallow occlusal preparations and to seal occlusal pits and fis-

Table. Percentage Survivals of GICs Placed Using the ART Technique for Primary Teeth

Study	*Duration*	*Material*	*Manufacturer*	*Class I & V/ single-surface*	*Class II/ multisurface*	*Class III & IV*
WHO report 1993*	12 mths	ChemFil Amalgam	Dentsply (not stated)	79.3 94.3	55.0 73.1	
Phantumvanit et al. 1994[18]	24 mths	ChemFil Amalgam	Dentsply (not stated)		45.0 59.0	
Ewoldsen et al. 1997[43]	10±4.8 m	Fuji Duet	GC Int.	91.0 (no classes given)		
Terada et al. 1998[19]	6 mths	Fuji IX Fuji Plus	GC Int. GC Int.	89.6 90.9	 78.4	
Basso & Edelberg 1997[44]	12 mths	Fuji IX	GC Int.	94.4	93.7	20.0
Franca et al. 1998[45]	12 mths	Fuji IX	GC Int.	75.3 & 90.0	39.1	72.9 & 55.6
Lo & Holmgren 1998[46] & 1999[21]	12 mths & 30 mths	Ketac-Molar	ESPE GmbH	86.1 76.0 & 74	62.5 54.0	36.6 14.0
Yu et al.1998[20]	12 mths	Fuji IX GP cap. Ketac-Molar cap. GK amalg. cap.	GC Int. ESPE GmbH CI & SR Inst.	93.8 90.0 100.0	81.8 76.5	
Luo et al. 1999[24]	12 mths	Fuji IX GP ChemFlex	GC Int. Dentsply	89.7 96.4	64.3 42.9	
Hu et al. 1999[47]	12 mths	(not stated)	(not stated)		88.9 (no classes given)	

* Unpublished data Thailand, WHO Collaborating Centre for Oral Health Services Research, Groningen 1993

sures.[30] It is sometimes difficult to achieve adequate bulk of cement and macromechanical retention form using the ART hand instruments.

One three-year study of an earlier conventional GIC placed as proximal restorations in primary molars, using conventional instrumentation, found similar cumulative success rates of 75% for microcavities, and 68% for modified G.V. Black's Class II cavities.[31] Another study over 5-14 months of two earlier conventional GICs also found no clear differences in the success rates between proximal cavities in primary molars prepared with (81%), and without (79%, an occlusal dovetail, when using conventional instrumentation.[32] Generally, the success rates of earlier conventional GICs placed in Class II preparations have been very low,[33-36] with median survival times of approximately 2-3 years, and amalgam restorations have performed better. Because of their low fracture resistance, care must be taken to avoid premature occlusal contacts on the cements, especially on the marginal ridges of Class II restorations. The use of conventional GICs as posterior restorations has been reviewed recently[37] and, rather than restoring primary teeth which have shallow open preparations, it may be preferable to attempt remineralization by the saliva and with topical fluorides in various forms.[38-41] Because of the high losses found with ART restorations placed in the anterior teeth, the suggestion has also been made to just chip off undermined enamel to make the carious lesions self-cleansing.[42] However, such non-restorative options may not be acceptable in some circumstances.

Conclusions

Although the newer, more-viscous GICs are recommended by manufacturers as definitive restorations for cavity preparations in primary molars, some clinical problems have become apparent over the short-term. These include the early loss of sealant material, the loss of restorations from shallow and non-macromechanically retentive preparations, bulk fracture of multisurface restorations, and restoration wear. Recurrent caries has not been shown to be a problem at this time, but further improvements in the mechanical and adhesive properties of the newer GICs are required for their optimal clinical performance. Further investigations are also required of methods for the remineralization of shallow open carious lesions as an alternative to restorations, and of longer-term clinical studies for the cost-effectiveness of the ART approach. Although there is the need for continued evidence-based research, the ART approach has clearly demonstrated a very high acceptance by children, and has also resulted in the retention of many teeth that otherwise would have been extracted.

References

1. Frencken J, Pilot T, van Amerongen E, Phantumvanit P, Songpaisan Y: Manual for the Atraumatic Restorative Treatment Approach to Control Dental Caries, 3rd Ed. Groningen: WHO Collaborating Centre for Oral Health Services Research, 1997.
2. Forsten L: Short- and long-term fluoride release from glass ionomers and other fluoride-containing materials in vitro. Scand J Dent Res 98:179-85, 1990.
3. Goldberg M, Stanislawski L, Bonte E, Daniau X, Las Farques J-J: Biocompatibility of glass-ionomer cements. In Advances in Glass-Ionomer Cements, 1st Ed. CL Davidson, IA Mjor EDS. Chicago: Quintessence Pub., 1999, pp 103-120.
4. Beech DR: A spectroscopic study of the interaction between human tooth enamel and polyacrylic acid (polycarboxylate cement). Arch Oral Biol 17:907-11, 1972.

5. Frencken JE, Songpaisan Y, Phantumvanit P, Pilot T: An atraumatic restorative treatment (ART) technique: evaluation after one year. Int Dent J 44:460-64, 1994.
6. Frencken JE, Makoni F, Sithole WD: Atraumatic restorative treatment and glass-ionomer sealants in a school oral health programme in Zimbabwe: evaluation after 1 year. Caries Res 30:428-33, 1996.
7. Mickenautsch S, Rudolph MJ, Ogunbodede EO. The impact of the ART approach on the treatment profile in a Mobile Dental System (MDS) in South Africa. Int Dent J 49:132-38, 1999.
8. Mallow PK, Durward CS, Klaipo M: Restoration of permanent teeth in young rural children in Cambodia using the atraumatic restorative (ART) technique and Fuji II glass ionomer cement. Int J Paediatr Dent 8:35-40, 1998.
9. 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 32:119-26, 1998.
10. Mather E, Walls AWG, McCabe JF: The physical properties of a glass ionomer cement used for ART. J Dent Res 74:881 (Abstr 476), 1995.
11. Powers JM, Burgess JO: Performance standards for competitive dental restorative materials. In Proceedings of Conference on Clinically Appropriate Alternatives to Amalgam: Biophysical Factors in Restorative Decision-Making. Munich: Academy of Dental Materials, 1996, pp 68-76.
12. Graf A, Sindel J, Kramer N, Petschelt A: Wear and cyclic fatigue of new glass ionomer cements. J Dent Res 76:317 (Abstr 2427), 1997.
13. Kishimoto Y, Peters MCRB, Richards LC, Kaidonis JA: In-vitro wear study of glass ionomer cements for restorative fillings. J Dent Res 76:939 (Abstr 41), 1997.
14. Gao W, Smales RJ, Lam WTC: Fluoride release and weight loss from ART technique GICs. J Dent Res 76:316 (Abstr 2419), 1997.
15. Yip HK, Lam WTC, Smales RJ: Fluoride release, weight loss and erosive wear of modern aesthetic restorations. Br Dent J 187:265-70, 1999.
16. Frencken JE, Holmgren CJ: Atraumatic Restorative Treatment (ART) for Dental Caries, 1st Ed. Nijmegan: STI Book b.v., 1999, pp 39-54.
17. Frankenberger R, Sindel J, Kramer N: Viscous glass-ionomer cements: a new alternative to amalgam in the primary dentition. Quintessence Int 25:667-76, 1997.
18. Phantumvanit P, Songpaisan Y, Frencken JE, Pilot T: Atraumatic restorative treatment (ART): evaluation after two years. J Dent Res 73:1014 (Abstr 24), 1994.
19. Terada RSS, Sousa EM, Rodrigues CC, Seabra BG, Navarro MFL: Clinical evaluation of the atraumatic restorative treatment (ART) in primary teeth. J Dent Res 77:965 (Abstr 2667), 1998.
20. Yu C, Gao XJ, Deng DM, Smales R: Evaluation of atraumatic restorative technique for the treatment of primary molars: 12-month controlled clinical study. 4th National Academic Conference on Pedodontics, Wuhan, China (Abstr 12), pp 14-15, 1998.
21. Lo ECM, Holmgren CJ: ART fillings placed in Chinese preschool children – results after 30 months. IADR (SE Asian Divis):33 (Abstr 9), 1999.
22. Ewoldsen N, Covey D, Lavin M: The physical and adhesive properties of dental cements used for atraumatic restorative treatment. Spec Care Dent 17:19-24, 1997.
23. de Gee AJ, van Duinen RNB, Werner A, Davidson CL: Early and long-term wear of conventional and resin-modified glass ionomers. J Dent Res 75:1613-19, 1996.
24. Luo Y, Wei SHY, Fan MW, Lo ECM: Clinical investigation of an experimental glass ionomer restorative: one year results. 14th Annual Scientific Meeting, Faculty of Dentistry, The University of Hong Kong 14:24 (Abstr 17), 1999.
25. American Dental Association Council on Scientific Affairs: American Dental Association Acceptance Program Guidelines for Composite Resins for Posterior Restorations, November 1989.
26. Yu C, Gao XJ, Deng DM, Smales R: Evaluation of atraumatic restorative technique for the treatment of deciduous teeth. Chinese J Contemp Oral Med 13:33-35, 1999.
27. Mandari GJ, Truin GJ, Forsten L, van't Hof MA: The clinical performance of class I amalgam and GIC restorations placed in posterior permanent teeth in Tanzania. J Dent Res 76:1180 (Abstr 12), 1997.
28. Hong W, Gao W: An evaluation of the ART technique with glass ionomer fillings for the treatment of shallow caries of permanent molars. J Beijing Med Univ 30:535-37, 1998.
29. Gao W, Peng D, Smales RJ, Gale MS: Clinical trial of ART technique restorative GI cements: initial findings. J Dent Res 77:636 (Abstr 40), 1998.
30. Ho TFT, Smales RJ, Fang DTS: A 2-year clinical study of two glass ionomer cements used in the atraumatic restorative treatment (ART) technique. Community Dent Oral Epidemiol 27:195-201, 1999.
31. Andersson-Wenckert IE, van Dijken JWV, Stenberg R: Effect of cavity form on the durability of glass ionomer cement restorations in primary teeth: a three-year clinical evaluation J Dent Child 62:197-200, 1995.
32. Forsten L, Karjalainen S: Glass ionomers in proximal cavities of primary molars. Scand J Dent Res 98:70-73, 1990.
33. Hickel R, Voss A: A comparison of glass ionomer cermet cement and amalgam restorations in primary molars. J Dent Child 57:184-48, 1990.
34. Ostlund J, Moller K, Koch G: Amalgam, composite resin and glass ionomer cement in Class II restorations in primary molars – a three year clinical evaluation. Swed Dent J 16:81-86, 1992.
35. Kilpatrick NM, Murray JJ, McCabe JF: The use of reinforced glass ionomer cermet cement for the restoration of primary molars: a clinical trial. Br Dent J 179:175-79, 1995.
36. Qvist V, Laurberg L, Poulsen A, Teglers PT: Longevity and cariostatic effects of everyday conventional glass-ionomer and amalgam restorations in primary teeth: three-year results. J Dent Res 76:1387-96, 1997.
37. Naasan MA, Watson TF: Conventional glass ionomers as posterior restorations: a status report for the American Journal of Dentistry. Am J Dent 11:36-45, 1998.
38. Craig GC, Powell KR, Cooper MH: Caries progression in primary molars: 24-month results from a minimal treatment programme. Community Dent Oral Epidemiol 9:260-65, 1981.
39. Ogaard B, Seppa L, Rolla G: Professional topical fluoride applications – clinical efficacy and mechanism of action. Adv Dent Res 8:190-201, 1994.

40. Gotjamanos T: Safety issues related to the use of silver fluoride in paediatric dentistry. Austr Dent J 42:166-68, 1997.
41. Schwarz E, Lo ECM, Wong MCM: Prevention of early childhood caries – results of a fluoride toothpaste demonstration trial on Chinese preschool children after three years. J Pub Health Dent 58:12-18, 1998.
42. Holmgren CJ. Discussion from the 1998 IADR symposium: The state of ART (atraumatic restorative treatment) – a scientific perspective. Community Dent Oral Epidemiol 27:454-60, 1999.
43. Ewoldsen N, Covey DA, Froeschle M, Kent D: Caries control restorations: report of outcomes and survival estimates. J Dent Res 76:88 (Abstr 595), 1997.
44. Basso ML, Edelberg MH: Atraumatic restorative treatment– one year clinical report (temporary teeth restorations): J Dent Res 76:381 (Abstr 2938), 1997.
45. Franca MTC, Bolinelli A, Seabra BGM, Rodrigues CC, Navarro MFL: One year evaluation of ART technique. J Dent Res 77:636 (Abstr 38), 1998.
46. Lo ECM, Holmgren CJ: Provision of atraumatic restorative treatment (ART) in Chinese pre-school children – one year results. J Dent Res 78:1175 (Abstr 47), 1999.
47. Hu D, Li X, Tong G, Wan H, Fan X: ART for using in restoration in primary dentition in China: evaluation after one year. J Dent Res 78:392 (Abstr 2289), 1999.

Letter to the Editor

Information on the Web

In regard to the age one dental visit: information on the web (Pediatr Dent 22:163-164, 2000), Dr. Edelstein must be commended for drawing attention to a very significant issue. Health care information available on the web is unregulated. The ease of designing a basic Web site and the availability of free web hosts has encouraged all and sundry to set up shop on the web to purvey health care information and that too on a global scale. The downside of this web-equalization has been the sidelining of leading national organization. As Dr. Edelstein points out "only a very informed and dedicated consumer" would conduct a meticulous search for authoritative information that "is available on the web but is not readily accessible." However, most individuals lack the time and the patience to conduct a proper search. Indiscriminate and impatient surfing between Web sites has led to the notion of "eyeball hang time" i.e., the amount of time spent at a Web site.

This disconcerting state of the information must be addressed twofold:

1. As Dr. Edelstein notes, organizations such as the AAPD must formulate "their Web sites in a way that search engines readily recognize authoritative consumer information."
2. AAPD must consider a partnership with like-minded organizations for creating a Web site to provide consumer information. This must be a dot-com address (URL) rather than a dot-org address, as even on the web, location matters. Web browsers are partial to a dot-com address. For example, simply keying yahoo leads to the yahoo.com site. The Web site must be no more than a simple index with buttons highlighting the various items. These buttons can be linked to the already existing information on the organizations' Web sites. A suitably coined catchy dot-com address must be publicized through a media campaign.It is prudent to address this issue now rather than later respond to charlatan-generated information or "scares" on the web.

S.M. Hashim Nainar, BDS, MDSc
Hamilton Ontario, Canada