Clinical Evaluation of the ART Technique Using High Density and Resin-Modified Glass Ionomer Cements

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Purpose: The aim of this study was to evaluate the performance of two different glass ionomer cements using the Atraumatic Restorative Treatment (ART) technique in permanent teeth.

Materials and Methods: A total of 473 ART restorations were placed in 208 schoolchildren (7–12 years of age) by two previously trained operators, using high density and resin-modified glass ionomer cements. All the restorations were photographed at baseline and the patients were asked about postoperative sensitivity. After a period of 8 months, 193 patients were present after recall and 428 restorations were evaluated and photographed. Two independent examiners carried out the evaluation.

Results: The results showed a success rate of 86.2% for occlusal restorations with Fuji IX and 88.4% for those restored with Fuji Plus. A total of 86.7% of the approximal restorations with Fuji Plus were also judged to be successful after 8 months. No association was found between the materials and the clinical performance of the ART restorations in class I cavities.

Conclusion: The type of restorative material did not influence the success or failure rates in class I cavities within this period. Fuji IX showed promising performance for occlusal ART restorations and Fuji Plus is also a promising material for occlusal and approximal ART restorations.

Key words: glass-ionomer cements, atraumatic restorative treatment, ART

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Although dental caries has declined in many industrialized countries, this disease has escalated in less developed countries, where a large part of the population has no access to restorative dental care. In these countries, the maldistribution of oral health personnel remains a problem, especially for the rural population, and the predominant oral care procedure provided is extraction (Phantumvanit et al, 1996). Moreover, conventional restorative treatments require sophisticated and expensive equipment, which are not available or affordable in many of these locations (Horowitz, 1996).

Searching for a new approach that could make oral care available for the majority of the population in less-industrialized countries, Frencken et al (1996) developed a restorative technique called the Atraumatic Restorative Treatment (ART). This technique is based on the removal of decalcified tooth tissue using only hand instruments, and the cavity is restored with an adhesive filling material, which is a chemically cured glass ionomer cement

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(Frencken et al, 1996). The advantages of ART include: the use of easily available and inexpensive hand instruments rather than the more expensive electrically-driven dental equipment; sound tooth tissue conservation due to the chemical adhesion of glass ionomers; limitation of pain; minimizing the use of local anesthesia; and low cost. Another major advantage of the technique is that it can reach people who otherwise would never receive any oral care (Frencken et al, 1996).

The ART technique was developed as part of a community-based primary oral health program carried out in Tanzania, in the mid-1980 s. Some years later, other oral health projects using ART were introduced in countries such as Zimbabwe and Thailand. In the Zimbabwe study, the survival rate of one-surface ART restorations in permanent teeth was 98.6% after one year, 93.8% after two years, and 88.3% after 3 years (Frencken et al, 1998). The Thailand trial showed equally favorable survival rates of 93%, 83% and 71%, in one, two and three years, respectively (Phantumvanit et al, 1996). However, the results were less favorable for restorations with two or more surfaces placed in primary and permanent teeth, showing 55% and 67% success rates, respectively, after one year (Frencken et al, 1994).

The availability of glass ionomer cements reinforced with resin components resulted in a considerable improvement of physical and adhesive properties, making it possible for them to be used in areas where failures previously occurred. *In vitro* studies demonstrated increased diametral tensile strength (McCarthy and Hondrum, 1994; Uno et al, 1996) and bond strength to enamel and dentin (Ewoldsen et al, 1997) of resin-modified glass ionomer cements, when compared with conventional glass ionomer cements. However, clinical trials are needed to prove that these resin-modified glass ionomer cements are really appropriate or better than conventional glass ionomers cements for the ART technique.

The aim of this study was to evaluate the performance of two different glass ionomer cements: a high-density and a resin-modified cement, using the Atraumatic Restorative Treatment technique in permanent teeth.

MATERIAL AND METHODS

The study was carried out in suburban public schools of Bauru, in the northwest of São Paulo, Brazil and was approved by the local Ethic Committee. Two hundred and eight children aged 7 to 12 years presenting carious lesions in posterior permanent teeth were included in the project. Inclusion criteria for the participants were the presence of one or more carious lesions involving dentin and a cavity entrance large enough to be accessed with small excavators. The exclusion criteria were teeth with pulpal exposure, a history of pain, or the presence of a swelling or fistula (Phantumvanit et al, 1996). During the selection of the participants, the name, address, age, school, and medical and dental history were obtained. The participants were included in the study only after parental or guardian consent was confirmed by their respective signature on the consent form.

The working team consisted of two operators, both PhD students of the Bauru Dental School, and two chairside assistants. Prior to applying the technique in the field, operators and assistants had undergone a two-day instruction period.

Treatment was carried out inside classrooms at the schools included in the trial. Patients were positioned on a table supplemented by a foldable cushion and a soft headrest in order to achieve a proper patient-to-operator position. The table faced an open window, which served as the only light source (Mallow et al, 1998). Since suction of saliva was not available for the ART procedure, cotton rolls were used to isolate the tooth. The tooth surface was cleaned with a wet cotton pellet for removal of debris and plaque allowing the extent of the lesion and any unsupported enamel to be easily identified. For small cavities, the entrance to the lesion was widened with a dental hatchet, rotating it backwards and forwards. The next step was removal of decalcified tissue with an excavator, first at the dentin-enamel junction and then from the floor of the cavity. Thin unsupported enamel was carefully broken away with a hatchet placed on the enamel. The cavity was then cleaned with water on a small cotton pellet. When necessary, pulpal protection with calcium hydroxide cement was used in deep cavities. The conditioning of the tooth structure was carried out with a cotton pellet saturated with dentin conditioner (GC Corp., Tokyo, Japan), and the cavity walls and remaining pits and fissures were rubbed for 10 to 15 seconds. The conditioned surfaces were then washed several times with wet cotton pellets and dried with dry cotton wool pellets. The manipulation and mixing of glass ionomer cements were carried out according to manufactur-

Table 1 Criteria used for evaluating ART filings.

Score	Definition	Description
0	Successful	Present, correct
1	Successful	Present, slight marginal defect, needs no replacement
2	Failed	Present, marginal defect, needs replacement
3	Failed	Present, gross defect, needs replacement
4	Failed	Not present, needs treatment
5	Failed	Not present, other treatment performed elsewhere
6	Excluded	Tooth absent because of exfoliation
7	Excluded	Tooth absent because of extraction
8	Successful	Wear and tear, needs no replacement
9	Failed	Wear and tear, needs replacement

er's instructions. Because of a low success rate with conventional or high-density glass ionomer cement in class II restoration, Fuji IX (GC Dental Corp., Tokyo, Japan) was used only in occlusal cavities and Fuji Plus (GC Dental Corp., Tokyo, Japan) was used in occlusal and approximal cavities. Fuji Plus was used because it is a resin-modified glass ionomer luting cement. This is a chemically cured glass ionomer that is appropriate for the ART technique because it does not require electrical equipments to cure it. The powder:liquid ratio used was 3.0:1.0 g that was obtained with 2 spoons of powder and 1 drop of liquid. Such consistency was previously determined. All the participants had at least one restoration of each material in their mouth. The selection of material for class I restorations was done in a randomized manner. The filling material was inserted into the cavity using an applicator and plugged into the corners of the cavity with the smooth side of an excavator. The material was also placed over the previously conditioned pits and fissures. Petroleum jelly was used to coat the operator's gloved finger and a slight pressure was applied on top of the entire occlusal surface for approximately 30 seconds. Any excess material was removed with a carver and the bite was checked using an articulating paper. Two coats of varnish (GC Dental Corp. Tokyo, Japan) were applied over the restoration to prevent cracks and the patient was instructed not to eat for at least one hour. Within 2–4 weeks after ART treatment, students were interviewed by the dentists using a standardized questionnaire (Annex A). Questions dealt with the presence or absence of post operative sensitivity, satisfaction with the treatment received and desire to be treated via ART in the future.

A total of 473 fillings were placed in 208 individuals and photographed at the baseline. After a period of 8 months, 193 patients were present for recall and 428 restorations were evaluated and photographed at the same location where the treatment had been carried out. Two independent examiners evaluated the restorations according to the criteria showed in Table 1 (Frencken et al, 1994).

The examiners had experience in assessing the restorations and the final assessment was based on consensus (Frencken et al, 1998). The analyses of the data were performed using Sigma Stat 2.0 statistical package. The difference between results was tested using the Chi-square test at 5% significance level.

RESULTS

At the baseline evaluation, only one child reported postoperative sensitivity and all the patients were satisfied with the treatment. After 8 months, 45 restorations were not examined because the participants were absent.

The results are presented in Tables 2, 3 and 4. Occlusal fillings showed a success rate of 86.2% with Fuji IX and 88.4% with Fuji Plus. For the approximal fillings a success rate of 86.7% was found. Examples of each observed score can be seen in Figs. 1 to 4. The statistical analysis showed no dif-

Table 2 Eight-month evaluation results of ART fillings by material and type of cavity.

Material	Type of cavity	Number of Fillings Placed	Evaluated (%)	Successful (%)
Fuji IX	occlusal	239	217 (90.8)	187 (86.2)
Fuji Plus	occlusal	204	181 (88.7)	160 (88.4)
	approximal	30	30 (100)	26 (86.7)

Table 3 Operator effect on 8-month survival of class I and class II ART restorations

Restorations	Number	Operator 1	Operator 2
Evaluated	428	225	203
Failed	55	28	27

Table 4 Scores observed on 8-month evaluation of class I and class II ART restorations

Material	Score 0	3	4	5
Fuji IX	187	21	3	6
Fuji Plus	186	14	7	4

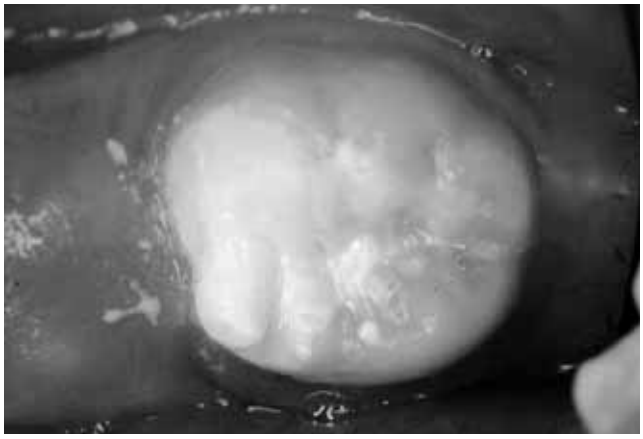

Fig 1a Class II restoration with Fuji Plus (baseline).

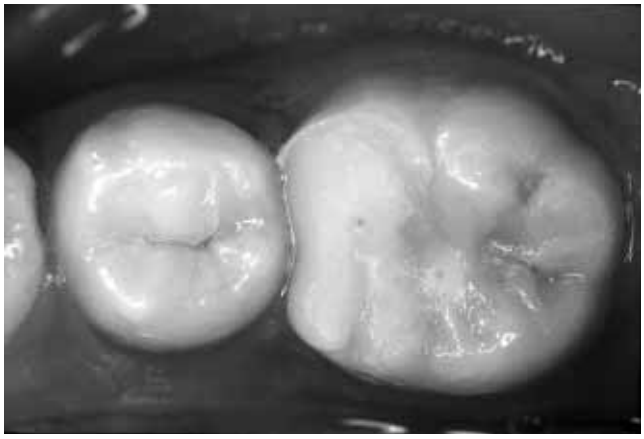

Fig 1b Score 0 of Class II restoration seen in Fig 1a (8 months).

ference between operators (Chi-square test, $p<0.05$). No association between materials and cavity type and the clinical performance of the ART restorations was found (Chi-square test, $p<0.05$).

DISCUSSION

Single-surface lesions were by far the most prevalent lesion for this study, since the participants were children 7–12 years of age and a large percentage of the multi-surface lesions found during the selection process had some history of pain or pulpal involvement. After 8 months 90.5% of the restorations were evaluated. All approximal restorations were assessed.

Although the present research is a short-term study, data are significant because there are no ART clinical studies in the literature using resin-modified glass ionomer cements. The results of the 8-month evaluation showed encouraging success rates, despite the material and type of cavity involved. The resin-modified glass ionomer (Fuji Plus) was the only material used for approximal res-

Fig 2a Class I restoration with Fuji Plus (baseline).

Fig 2b Score 2 of Class I restoration seen in Fig 2a (8 months).

Fig 3a Class I restoration with Fuji IX (baseline).

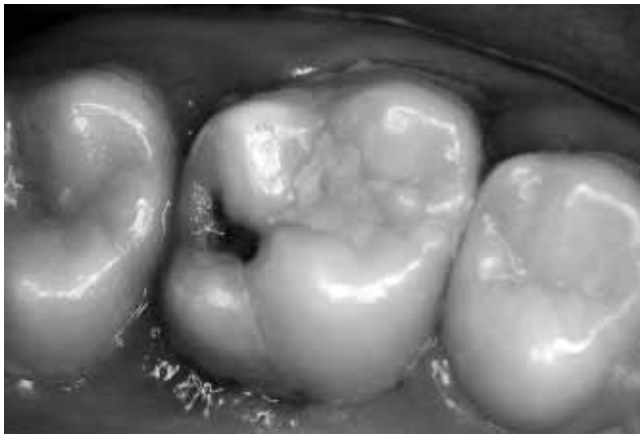

Fig 3b Score 4 of Class I restoration seen in Fig 3a (8 months).

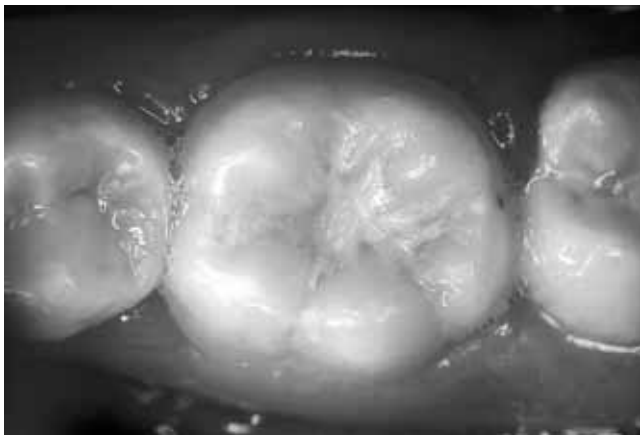

Fig 4a Class I restoration with Fuji IX (baseline).

Fig 4b Score 5 of Class I restoration seen in Fig 4a (8 months).

torations, since former studies reported low success rates of conventional glass ionomers when used in this situation. Frencken et al (1994) found that the success percentage of ART restorations involving two or more surfaces was very low (67%) after 1 year. Lo and Holmgren (2001) also found lower survival rates of class II restorations (75% and 51% after 12 and 30 months, respectively) than class I restorations (91% and 79% after 12 and 30 months, respectively). It may be stated that the greatest reason for failures of conventional ART GICs such as Fuji IX is their lower shear bond strength to enamel and dentin when compared with that of a resin-modified GIC (Ewoldsen et al, 1997). Ewoldsen et al tested Fuji Plus at increased powder:liquid ratio. They concluded that the data of the *in vitro* study suggest that fewer failures due to loss of restoration are possible when resin modified glass ionomer cements are used in place of conventional GICs as ART restoratives. The authors also reported 2 clinical cases using Fuji Plus at restorative consistency. The restorations were in good condition after 6 and 27 months. Moreover, resin-modified ionomers have shown higher diametral tensile strength than the conventional glass ionomers (McCarthy and Hondrum, 1994; Uno et al, 1996). In addition, caries removal, especially at the dentine-enamel junction, is also a challenge and a cause of failure of ART restorations. If the cavity is not cleaned properly, demineralized enamel and dentine will not provide a good substrate for adequate retention of glass-ionomer cement. Inadequate retention form will be observed in these cavities. Fig 3b shows the carious lesion that was not properly removed from the distal-occlusal cavity of the upper first molar and caused failure of the restoration (Fig 3a). Small excavators should be used in different directions for caries removal in conservative cavities, after initial opening with hatchets. The replacement of the glass-ionomer cement by amalgam restorations represented 10 out of 55 failed restorations in the present study. However, it is difficult to know the real reason for the replacement because the practitioners could have replaced the glass-ionomer with amalgam based on their judgment that the latter would be a better performing restorative material.

Carious lesions located on approximal surfaces of posterior teeth are a challenge for the ART operator. Access to the lesion is sometimes difficult without a bur and the saliva contamination is hard to avoid in the cervical area. The failures of class II restorations in this study were related to absence of the restorations. The lack of retention form in these cavities again seems to be the main cause of the failure. Moreover, insertion of the filling material without a syringe can lead to air entrapment and incomplete filling of the preparation. These features could reduce the longevity of ART restorations.

During the excavation, only outer carious dentine is removed, but particular care must be taken to free the enamel and enamel-dentinal junction from caries to enhance the bonding to the restorative material and prevent secondary caries (Frencken et al, 1998). Since the ART technique advocates the use of only hand instruments, some demineralized dentin may be left behind. Recent studies have demonstrated a marked reduction in the number and viability of microorganisms in carious dentine under glass ionomer restorations (Weerheijm et al, 1993).

CONCLUSION

Highly acceptable retention rates for ART restorations using a conventional and a resin-modified glass ionomer cement were found for occlusal and for approximal restorations in this study. The survival percentage of class II resin-modified glass ionomer cement restorations at eight months showed promise and appeared to be as successful as conventional glass ionomer cements. The results showed a promising performance of the ART technique with both materials tested. Therefore, the ART technique can be considered one of the modern approaches for treatment and prevention of dental caries in less developed countries.

Further evaluations after two and three years and other related investigations are needed to confirm these conclusions.

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ANNEX A

QUESTIONNAIRE

Name:

School:

1. Did you feel any pain in the tooth after the treatment?

☐ Yes ☐ No

2. Would you recommend the treatment to your best friend?

☐ Yes ☐ No

3. Would you like to have another tooth treated the same way in future?

☐ Yes ☐ No