The ART of GIC proximal restorations in primary teeth

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Chapter 12

General discussion

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There is still a demand for dental materials and restorative techniques that can be used for proximal cavities in primary teeth under field circumstances, where the facilities of a dental office are not available. The main reasons for restoring cavitated carious lesions in primary teeth are to keep the teeth symptom-free, to enable access for dental plaque removal, to safeguard natural exfoliation with no discomfort to the child, and to provide the space for the permanent successor (1, 2). Proximal surfaces are hard to reach for oral hygiene measures, and when proximal cavities are not restored, even under strict caries-prevention control, these lesions often tend to progress (3, 4).

Initially the Atraumatic Restorative Treatment (ART) seemed to be an ideal technique for restorations in remote areas. Because of the combination of using hand instruments and an auto-curing glass-ionomer cement (GIC), ART restorations can be placed all over the world, without the need for electricity and a dental chair, resulting in low costs. However, the survival of an ART restoration depends greatly on proper cavity selection. Though many studies have shown the effectiveness of ART over conventional cavity preparation using amalgam in occlusal cavities (5-8), ART is much less effective when applied to cavities involving multiple surfaces of the tooth (9-11), presenting low survival rates.

Studies show that different factors are responsible for the failure of ART restorations (Chapter 1) (7, 10, 12, 13), revealing that ART is an extremely sensitive technique. As chapter 3 shows, different GIC brands seemed to have no influence on the survival rate of GIC proximal-ART restorations. Neither was the two-layer technique significantly better than the conventional insertion technique (chapter 10). The application of a flowable GIC layer prior to the application of a conventional layer of GIC does not increase proximal-ART restoration longevity overall. In the studies of this thesis, the material and its different applications did not reduce the sensitivity of the ART technique.

Nevertheless, restoration survival improved from the first to the last clinical study described in this thesis. Comparison between the one-year survival rate in the first clinical study (chapter 3) and the other two clinical studies (chapters 5 and 10) showed an increase in overall survival rates (Figure 1), regardless of the groups in each study (log-rank test, $p<0.001$). Both the first (chapter 3) and the last study (chapter 10) had one group receiving Fuji IX restorations under the same conditions (ART preparation of the cavity in a school setting and GIC mixed according to the manufacturer's instructions). We found no statistically significant difference between the groups within each study, and therefore we combined the results from each study. In this way the survival rate of the studies were compared.

The difference might be explained by the level of training of the operators. Though the trainers for all the operators were the same, their training skills may have improved in time. The operators in the last study may have benefit from this.

The failure of ART restorations has been mainly attributed to the restorative material, the high-viscosity GIC. However, studies using composite resin and amalgam as restorative materials have not shown that the survival of multi-surface restorations made using ART in primary teeth was significantly worse (1, 9, 14, 15). Table 1 shows studies that

evaluate the survival rate of proximal-ART restorations in primary teeth made in field settings with various restorative materials. The studies in this table have a follow-up of at least 24 months and were performed with hand instruments only. The study by van den Dungen *et al*. (16) used mobile rotating equipment for the conventional preparations and found no difference in survival rates of the GIC restorations in relation to the preparation method. The only material other than GIC used in the selected studies was composite resin [in the study of Ersin *et al*. (9)]. Nonetheless the use of composite resin (SureFil, Dentsply, GE) in combination with an adhesive technique (Xeno III, Dentsply, GE) did not result in significantly different longevity of the restorations. It is important to note that Ersin's study was the only one performed exclusively by dentists and produced relatively good survival rates (9).

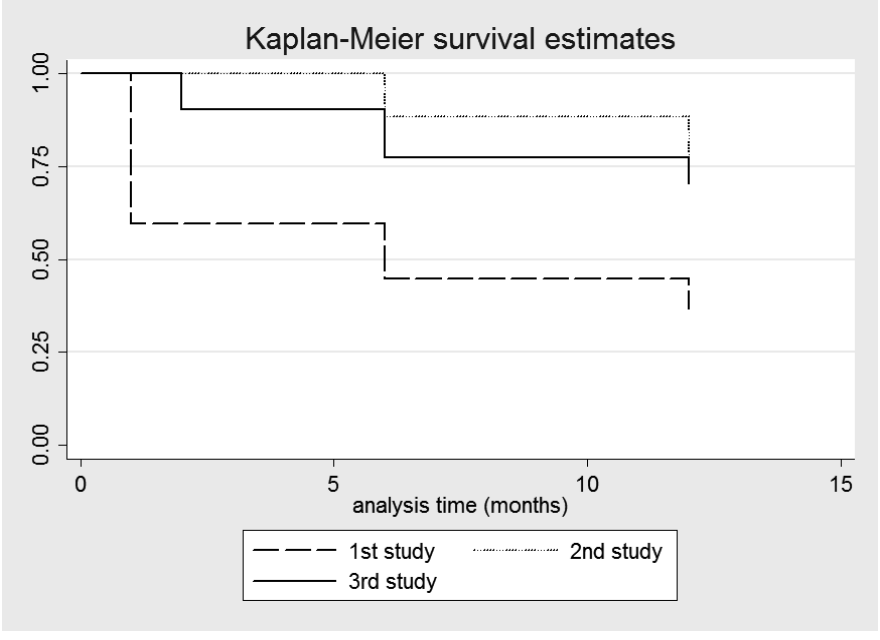

Figure 1: Kaplan-Meier survival analysis of survival rate of the restorations from the three clinical studies of this thesis, regardless of the groups (Log-rank test, $p<0.001$).

Table 2 summarises studies that compared the survival rate of proximal restoration in primary teeth made in a clinical setting either with ART or conventional cavity preparation techniques. The studies had a minimum follow-up of 24 months. None of these studies found significant differences in the longevity of the restorations. Although the study of Honkala *et al*. (14) presented relatively high survival rates, it had only 9 pairs of restorations. Furthermore the two dentists act as both operators and evaluators, which may question the reliability of the results.

In permanent teeth, the survival rate of proximal-ART restorations seems to be better than in the primary teeth. Table 3 shows studies performed in dental clinic settings or in field settings, using the ART approach for cavity preparation and GIC or amalgam as

restorative materials. The studies had a minimum follow-up of 24 months. The survival rates seem to be acceptable up to 5 years (18) but decrease dramatically in the longer term (17). Only one study compared resin-modified GIC and high-viscosity GIC in permanent teeth used in proximal-ART restorations, made under field conditions (19). The follow-up period was 12 months, reason why this study is not included in Table 3 but the results showed an excellent survival rate for the resin-modified GIC (100%), which were not statistically different from the ones of the high-viscosity GIC (93%). The use of resin-modified GIC in proximal-ART restorations should be also investigated in primary teeth under field conditions. A drawback of using resin-modified GIC as restorative material infield situations is the need for light curing. Furthermore the high content of hydrophilic monomers would lower the biocompatibility of the restorative material with the tooth structures.

In general, independent of the restorative technique or material, the longevity of the restoration is influenced by its size, location in the dental arch and in the tooth. Multi-surface restorations in primary and permanent teeth show shorter longevity than occlusal restorations (20-22). The lower survival rates in occluso-proximal compared to occlusal restorations can be explained by the presence of less tooth structure to distribute the stress in class II (23). The surrounding sound tooth structure will have a protective effect on the restoration. Besides that, the low strength of GIC limits its applicability to temporary restorations or single-surface permanent restorations (24).

In outreach areas, where the ART approach is mainly applied, the prevalence of caries is usually higher and the severity and extension of the lesion are greater than found in clinical settings in developed countries. Additionally, the healthcare system in these areas is often insufficiently equipped to provide the necessary care (25). Patients search for a dental office only when the cavity is large and causes unbearable pain and extraction is the usual solution (25). When a cavity can be restored, the resources and materials available may not be the ideal ones, and the low survival rates of the GICs in proximal cavities make it unlikely that the placement of a restoration with a probable short survival would be helpful (26). On the other hand, a negative influence of untreated dentin lesions and their consequences in children's quality of life are reported by Leal *et al.* (27), reinforcing the need of restoring dentin lesions in such cases. The results from chapter 3 show that even after the failure of an ART restoration, the tooth can survive without discomfort to the child. Corroborating with that, Boon *et al.* (28) found hard dentine in 92% of the molars that had lost their ART restorations after 12-18 months of placement. These findings suggest that even if not remaining for long, ART restorations might be helpful. To be able to investigate that properly, a research comparing the use of ART with "no treatment" in a field setting would be of interest.

The main failures of proximal-ART restorations are partial or complete loss of the material. Even well-trained operators who should be able to improve the survival rate should exercise caution when extending the indication of ART to large, multi-surface restorations. It may not be possible to improve the success rate of proximal-ART restorations made under field conditions to the point that they are as successful as those made under ideal conditions in private practices (24, 29).

Still the need of improving GIC restorations remains. The use a nano-filled resin (G-Coat Plus) to protect the GIC restoration made by ART (chapter 11) showed to reduce the wear and increase the flexural strength of Fuji IX GP Extra, what makes this coat interesting

for further field investigations. One retrospective study performed in a clinical setting using Fuji IX Extra and G-Coat Plus in permanent dentition reported satisfactory results for occlusal and small occluso-proximal restorations, but no control group was included in this study (29). We are currently performing a study in 3 different cities, using the combination of Fuji IX and G-Coat Plus and will hopefully be able to answer this question soon.

The restorative treatment of proximal cavities under field conditions should involve less sensitive materials and techniques. Less technical demanding treatment to the primary dentition would safeguard the place for the permanent teeth without discomfort to the child in a more effective way than with the ART approach. A treatment that not only "ARTists" are able to perform would probably benefit a wider share of the population. Nevertheless, it is also important not to dissociate these treatments from the preventive strategies and the approach to caries management introduced by ART. In this way, even when a restoration fails, caries progression can be controlled by the improved hygiene and new habits of the patient.

A restorative treatment that has high potential for treating multi-surface cavities in primary teeth in underprivileged areas is the Hall technique, as it does not require any electrically driven equipment. It consists of filling a preformed metal crown with GIC and placing it on the decayed tooth. Because it does not involve any tooth preparation, anesthesia or caries removal, it is also considered a minimal intervention technique. Although few studies to date have evaluated the Hall technique, the results seem to be promising (30-32). However, in remote areas, the costs of the treatment are of extreme importance and the metal crowns are usually very expensive. On the other hand metal crowns rarely need to be repaired or replaced and, therefore, the cost-effectiveness of the Hall technique and the ART technique should be further investigated.

Table 1: Studies that evaluated the survival rate of proximal-ART restorations in primary teeth made with different materials

Authors (Country)	Sample (n)	Age (years)	G1	G2	Operators	Follow-up (months)	Success rate (%)	Evaluation criteria
da Franca et al., 2011 (Brazil)	97	7	ART + GIC	-	2 students	24	27.6	ART
Lo and Holmgren, 2011 (China)	32	5.1	ART + GIC	-	7 students	30	53	ART modified
van Gemert-Schriks et al., 2007 (Suriname)	342	6	ART + GIC		4 dentists	36	12.2	ART
Carvalho et al., 2010 (Brazil)	232	6.3	ART + GIC	ART + GIC + RD	4 students	24	GIC 18 GIC(RD) 32.1	ART
Ersin et al., 2006 (Turkey)	213	6 - 10	ART + GIC	ART + CR	3 students	24	GIC 76.1 RC 82	USPHS (Ryge)
van den Dungen et al., 2004 (Indonesia)	394	6.5	ART + GIC	CONV + GIC	4 students	36	ART 31 CONV 33.6	ART

RD = rubberdam; CR = composite resin; CONV = conventional preparation using burs

Table 2: Studies that evaluated the influence of the preparation and restoration techniques on the survival rate of proximal restorations in primary teeth made by the ART approach or by rotating instruments (conventional), in a dental clinic setting.

Authors (Country)	Sample (n)	Age (years)	G1	G2	Operators	Follow-up (months)	Success rate (%)	Evaluation criteria
Honkala et al., 2003 (Kuwait)	18	5.7	ART + GIC	CONV + AG	2 dentists	24	ART 88.9 CONV 100	ART
Taifour et al., 2002 (Syria)	1035	6 - 7	ART + GIC	CONV + AG	8 dentists	36	ART 42.9 CONV 48.7	ART
van de Hoef and van Amerongen, 2007 (Suriname)	408	7.5	ART + GIC	CONV + GIC	2 nurses; 1 student; 1 dentist	30	ART 25 CONV 43	ART

RD = rubberdam; CR = composite resin; CONV = conventional preparation using burs and rotationing instruments

Table 3: Table 3:Studies that evaluated the survival rate of proximal ART restorations in permanent molars.

Authors (Country)	Sample (n)	Age (years)	G1	G2	Operators	Follow-up (months)	Success rate (%)	Evaluation criteria
Farag et al., 2010 (Eqypt)	30	14.6	ART + GIC		1 dentist	60	77	ART
Zanata et al., 2011 (Brazil)	107	19	ART + GIC		1 dentist	120	30.6	ART
Monse-Schneider et al., 2003 (Philippines)	14	7.2	ART + AG		2 dentists 2 health workers	27	85.7	ART

AG = amalgam

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