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Influence of local anaesthesia on the quality of class II glass ionomer restorations

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Objective. To investigate the influence of local anaesthesia on the quality of class II glass ionomer restorations with discomfort as cofactor.

Material and methods. The study population consisted of 6- to 7-year-old schoolchildren in Paramaribo and its environs. To be included, each child needed to have a proximally situated cavity in a primary molar that was accessible to hand instruments and where no pulp exposure was expected. They were randomly divided into four treatment groups: conventional method with and without local anaesthesia and atraumatic restorative treatment method (ART) with and without local anaesthesia. The restoration quality was scored using the evaluation criteria for ART restorations (successful if restoration is correct or has a minor defect and fails if defects are larger than 0.5 mm, if secondary caries is observed, if the restoration is fractured, partly or totally lost or if the pulp is involved) at 6 and 30 months after treatment. The extent of discomfort was registered by assessing the behaviour (modified Venham score) and observing the heart rate during treatment.

Results. For this study 153 children were treated with hand instruments (ART) and 146 children with rotary instruments (conventional method). A total of 198 restorations were evaluated during follow-up periods. There were no significant differences in patient discomfort between the ART and the conventional group and between the anaesthesia and the non-anaesthesia group. The conventional restorations demonstrated significantly higher success rates than ART restorations after 6 ($P = 0.001$) and 30 months ($P = 0.032$). There were no significant differences in success rate between the anaesthesia and the non-anaesthesia group.

Conclusion. Local anaesthesia has no influence on discomfort during treatment. Furthermore, discomfort during treatment does not affect the success rate of restorations.

Introduction

The atraumatic restorative treatment method (ART), which was developed in the 1980s, involves the removal of infected tooth tissue with hand instruments. The cleaned cavity is then restored with an adhesive material, mostly glass ionomer[1–3]. Comparing ART and the conventional approach using rotary instruments, the ART method has several advantages, i.e. largely pain free, readily accepted by children, simple and rather inexpensive[1]. Therefore, several authors suggested that ART is the choice of approach in countries where dental personnel and electricity is not readily available. Furthermore, the method may also be suitable for the treatment of apprehensive children and disabled patients in developed countries[1,2,4].

In the last years, several studies demonstrated that after 3 years, an around 88% survival rate of single-surface ART restorations in the permanent dentition can be achieved. The success rate of ART restorations placed in primary teeth has been reported to be lower[5–9]. Frencken *et al*. demonstrated in their meta-analysis[10] that there is no quality difference between ART restorations using glass ionomer and conventional amalgam restorations over the first 3 years. Because of the different materials used for these restorations (i.e. glass ionomer and amalgam) and the different preparation techniques (i.e. hand and rotating instruments), it is difficult to make a good

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comparison between the ART and the conventional method. For both variables can have a confounding effect on each other. Therefore, Van den Dungen *et al*.[11] compared the success rates of Class II glass ionomer restorations placed with the ART approach and with a conventional cavity preparation method. They found no differences in the restoration quality after 3 years. The results of studies by Yip *et al*.[12,13] demonstrate that there is a strong trend for relatively better survival rates for the conventional cavity preparation method than for the atraumatic restorative treatment method for Class II cavity preparations in the primary and permanent dentition after 1 year. Yu *et al*. found similar differences after 2 years[14]. To draw firm conclusions on the differences in success rate between these two treatment modalities, more conclusive studies are needed.

A subject often associated with ART is discomfort. In studies dealing with dental treatments, discomfort is defined as an emotion mainly caused by pain and anxiety, which are both associated with highly invasive procedures such as 'drilling' and 'injections'. Some studies reported that the ART method is accompanied by little discomfort. Comparison of ART with a modified ART procedure using rotary instruments only to provide access to the cavity (minimal cavity preparation) showed that subjects in the ART group experienced significantly less discomfort than patients in the modified ART group[15,16]. In their study, Schriks and coworkers[3] explored a possible difference between the extent of discomfort experienced during dental treatment of multisurface cavities in deciduous molars according to the ART approach and a method using rotary instruments. The results clearly show that patients treated according to the ART method experience less discomfort than those treated with rotary instruments. These studies concerned the influence of dental treatment on discomfort. Less attention was paid to the influence of local anaesthetics on discomfort and its possible relationship between the quality of the restorations made. A study on behaviour during the administering of LA displays muscle tension, crying, verbal protest and body movement in response to the injection[17]. In the Suriname study Van Bochove *et al*.[18] found that children treated according to the ART approach without local anaesthesia experienced the least discomfort during the whole treatment and those treated according to the conventional method with anaesthetics the most. This tendency is fortified when children were treated for the second time. Apparently, the knowledge prior to the treatment of getting anaesthetics again made the children more uncomfortable.

Discomfort experienced during treatment can result in restless behaviour of the patients, which in turn influences the accuracy of the operator in treating caries, i.e. overlooking caries or contamination of the preparation with saliva. Consequently, the quality of the restoration may decrease. As mentioned above there is a relation between giving local anaesthesia by the dentist and the measure of discomfort as experienced by the patient. There is, however, no information available concerning the relation between anaesthesia and the quality of restorations in general. The present study investigates the influence of anaesthesia on the quality of ART and conventional class II glass ionomer restorations with discomfort as cofactor.

Patients and methods

Study population

The target population for the current study was 6- to 7-year-old schoolchildren in good mental and physical health. The children were selected from different schools in Paramaribo and its environs, in the first instance for the benefit of the study of Van Bochove *et al*.[17] In order to be included in the study, each child needed to have at least one small proximally situated cavity in a primary molar that was accessible to hand instruments from the occlusal surface and where no pulp exposure was expected. Some of the children received a second restoration (element 2) placed in another molar than the first one (element 1). In these cases the same treatment protocol for both restorations was used. The measurements of the cavity should not be bigger than *c*. 1 mm mesio-distally and *c*. 2 mm in bucco-lingual/

palatinal direction, measured with a CPITN probe. If one of these dimensions was exceeded, the molar was excluded for selection. The antagonist (i.e. the opposing tooth) had to be present. Also, there should not have been any complaints concerning pain, swelling or fistulas. Written informed consent was obtained from all parents. Ethical approval was given by the Ministry of Health in Suriname.

Treatment

The children were randomly divided into four treatment groups: control – two groups treated with rotary instruments (conventional method) of which one with and the other without local anaesthesia (LA); experimental – two groups treated according to the ART approach; also with or without LA.

The randomization list was obtained by means of SPSS.

Children in the experimental group were treated according to the ART approach using only hand instruments (i.e. hatchets and spoon excavators; GC Corporation, Leuven, Belgium). Patients in the control group were treated with rotary instruments, i.e. stainless steel round burs in a slow hand piece without water cooling. After access to the cavity was obtained, at first the enamel-dentine border was cleaned and after that the remaining caries was removed. After finishing the preparation a piece of metal matrixband (Matricodent) was applied and fixed with a wooden wedge. In all cases hand mixed glass ionomer (Fuji IX, GC Corporation) was used as restoration material. Septanest SP® (blue, 0.01 mg/mL with adrenaline; Septodont, France) was used as local anaesthetic.

The treatments were performed by two dental nurses of the Foundation of Youth Dental Care–Paramaribo (Suriname), a final year dental student of the Academic Centre for Dentistry Amsterdam (ACTA), and a just-graduated dentist from the Catholic University Nijmegen.

If a patient, assigned to a treatment group without LA, complained about pain during preparation, no LA was administered. With behavioural management techniques, aiding the patient in coping with pain, the treatment was made as comfortable as possible for the patient.

Table 1. Quality measurement scores.

00	Restoration present, correct	**S**
10	Restoration present, slight marginal defect < 0.5 mm	**S**
11	Restoration present, marginal defect > 0.5 mm	**F**
12	Restoration present, under filled > 0.5 mm	**F**
13	Restoration present, overfilled > 0.5 mm	**F**
20	Secondary caries, discoloration within dentine, no tissue loss	**F**
21	Secondary caries, discoloration within dentine, tissue loss	**F**
30	Restoration not present, bulk #, loose part	**F**
40	Inflammation of the pulp; pain, fistula	**F**
50	Element not present due to extraction	**N**
60	Element not present due to shedding	**N**
70	Element not present due to shedding or extraction	**N**
90	Patient not present	**N**

S, success; F, failure; N, not included in results.

Measurements

The restoration quality was scored using the evaluation criteria for ART restorations according to Frencken[1] (Table 1). The restorations were evaluated by two final-year dental students of ACTA (who did not perform any treatment) after 6 months and by two other students after 30 months. A baseline evaluation was omitted due to other objectives to be investigated[18]. In addition, it was expected that immediately after the restorations had been placed, hardly any failures would have been observed. Prior to the field evaluations, the intra- and interevaluator consistency of the evaluators was determined based on the quality assessment of 24 restored, extracted molars/premolars. Their ability to score restorations independently was calculated by comparing their evaluations with those of a golden standard. This golden standard was achieved by the consensus of two experienced evaluators during the assessment of the same 24 restorations. The intraevaluator consistency values range from 0.73 to 0.84 (Cohen's kappa). During the follow-up, the first 30 restorations were evaluated separately by both students who carried out the evaluations after 6 and 30 months. With these data, the interevaluator consistency was calculated: 0.72 for the 6 months evaluators and 0.93 for the evaluation couple after 30 months.

Table 2. Modified 6-point scale according to Venham.

0	Relaxed; smiling, willing, able to converse, displays behaviour desired by the dentist
1	Uneasy; concerned, may protest briefly to indicate discomfort, hands remain down or partially raised. Tense
2	Tense; tone of voice, questions and answers reflect anxiety. During stressful procedure verbal protest, crying hands tense and raised, but not interfering very much. Protest more distracting and troublesome. Child still complies with request to cooperate.
3	Reluctant; pronounced verbal protest, crying. Using hands to try to stop procedure. Treatment proceeds with difficulty.
4	Interference; general crying, body movements sometimes needing physical restraint. Protest disrupts procedure.
5	Out of contact; hard loud crying, swearing, screaming.

The extent of discomfort, as defined in the introduction, was registered by assessing the behaviour (modified Venham score, Table 2) and observing the heart rate at seven fixed moments during dental treatment: (i) when the child entered the treatment room, (ii) when LA was given, (iii) at the start of preparation, (iv) at the moment of deepest excavation, (v) at the moment of application of the matrix band and wedges, (vi) at the moment the restoration was applied, and (vii) after completion of the treatment.

In the present study, the Venham scores during deep excavation and the moment the restoration was applied were of special interest because these moments are considered to be very important for the final quality of a restoration. Venham scores '0' and '1' were classified as 'not moving' during treatment, whereas the other scores were classified as 'moving' during treatment. Movement was associated with discomfort.

The Venham scoring was carried out by a trained observer who did not participate in the treatments[17].

Statistics

For the statistical analysis (SPSS 11.5), a chi-squared test with a two-sided significance level of 0.05 was used. Confidence intervals were estimated with a 95% level.

Results

For this study, 299 children (144 boys and 155 girls), mean age 7.5 years (range 6.0–12.9), were selected from 33 schools in Paramaribo and its environs. Although the children were recruited in classes for 6- to 7-year-old children, there appeared to be also some older children in this group who were not excluded only because of their age. A total of 153 children (67 boys and 86 girls) were treated with hand instruments (ART) and 146 children (77 boys and 69 girls) with rotary instruments (conventional method). Each operator treated about the same number of patients in each group. No relations could be found between treatment method and either gender or operator (Pearson Chi-square). The patients were divided randomly over the four treatment groups and over the four operators. Altogether the operators made 408 class II restorations in primary molars. This indicates that 109 children received a second restoration (element 2) as there are only 299 patients.

After 30 months 211 restorations (51.8%) were left for evaluation. The majority of the dropouts concerned absent patients and shed teeth.

Influence of LA on discomfort

To investigate the influence of LA on discomfort, patients receiving LA were compared with patients who did not receive LA prior to treatment. Comparison was performed within the ART group as well as within the conventional group, both during treatment of the first and second element. As mentioned earlier, discomfort was defined as movement of the patient during treatment. Movement was measured during the moments of 'deep excavation' and 'start of the restoration'. As demonstrated in Tables 3 and 4, there were no significant differences in patient movement between the ART and the conventional group and between the anaesthesia and the non-anaesthesia group for both the first (El 1) and the second (El 2) element. Striking is though, that more children seemed to be lying still during excavation of the second element in

Table 3. Influence of anaesthesia on movement casu quo discomfort, during deep excavation. % (no.).

		ART		Conventional	
	Moving	**Anaesthesia**	**Non-anaesthesia**	**Anaesthesia**	**Non-anaesthesia**
El 1	Yes	86.8 (66)	81.8 (63)	83.8 (62)	86.1 (62)
	No	13.2 (10)	18.2 (14)	16.2 (12)	13.9 (10)
El 2	Yes	46.2 (12)	30.8 (8)	41.2 (14)	21.7 (5)
	No	53.8 (14)	69.2 (18)	58.8 (20)	78.3 (18)

El 1 and El 2 are the first and second treated element.

Table 4. Influence of anaesthesia on movement casu quo discomfort, during restoration. % (no.).

		ART		Conventional	
	Moving	**Anaesthesia**	**Non-anaesthesia**	**Anaesthesia**	**Non-anaesthesia**
El 1	Yes	15.8 (12)	27.3 (21)	21.6 (16)	36.1 (26)
	No	84.2 (64)	72.7 (56)	78.4 (58)	63.9 (46)
El 2	Yes	11.5 (3)	11.5 (3)	14.7 (5)	17.4 (4)
	No	88.5 (23)	88.5 (23)	85.3 (29)	82.6 (19)

Table 5. Success rates of the conventional method vs. ART. % (no).

		6 months		30 months	
		Conventional	**ART**	**Conventional**	**ART**
El 1	Success	60.7 (64)	39.1 (52)	41.3 (33)	24.6 (17)
	Failure	39.3 (48)	60.9 (81)	58.8 (47)	75.4 (52)
El 2	Success	61.8 (34)	36.5 (19)	48.6 (17)	25.9 (7)
	Failure	38.2 (21)	63.5 (33)	51.4 (18)	74.1 (20)

comparison with the first element. Although not significant (Pearson chi-squared), this difference is more obvious when no LA was used.

Differences in success rate

The results for the success rates according to the follow-up periods of 6 and 30 months are presented in Table 5. For the first element, conventional restorations demonstrated significantly higher success-rates than ART restorations after 6 (60.7% vs. 39.1%, respectively; Pearson chi-squared $P = 0.001$) and after 30 months (41.3% vs. 24.6%, respectively; Pearson chi-squared $P = 0.032$). For the second element, this tendency was continued concerning the evaluation after 6 months (61.8% vs. 36.5%, respectively; Pearson chi-squared $P = 0.009$). Conventional management compared to ART during the treatment of the second element did not show significant higher success rates after 30 months. At the 6 months evaluation, the conventional method scored more successes than failures. With ART, the opposite was demonstrated. Both restoration modalities resulted in more failures then successes after 30 months, although not significant.

Influence of anaesthesia on the success rate of restorations (6 months' follow-up)

Both the first and the second element show that more than half of the restorations placed according to the conventional method were successful (Table 6). This contrasts with the results in the ART group: more than half of the restorations have failed. Regarding the first element, the conventional method showed significantly higher success rates than ART in both the anaesthesia and the non-anaesthesia group (Pearson chi-squared $P = 0.015$). For the second element, this tendency of significance was only continued for the non-anaesthesia group (Pearson chi-squared $P = 0.029$).

There were no significant differences in success rate between the anaesthesia and the non-anaesthesia group for both elements.

Table 6. Success-rates of the non-anaesthesia vs. the anaesthesia group (6 months follow-up) % (no.).

		El 1		El 2	
		Non-anaesthesia	Anaesthesia	Non-anaesthesia	Anaesthesia
Conventional	Success	59.0 (36)	62.3 (38)	69.6 (16)	56.3 (18)
	Failure	41.0 (25)	37.7 (23)	30.4 (7)	43.8 (14)
ART	Success	37.7 (26)	40.6 (26)	38.5 (10)	34.6 (9)
	Failure	62.3 (43)	59.4 (38)	61.5 (16)	65.4 (17)

Table 7. Success-rates of the non-anaesthesia vs. the anaesthesia group (30 months follow-up) % (no.).

		El 1		El 2	
		Non-anaesthesia	Anaesthesia	Non-anaesthesia	Anaesthesia
Conventional	Success	30.8 (12)	51.2 (21)*	57.1 (8)	42.9 (9)
	Failure	69.2 (27)	48.8 (20)	42.9 (6)	57.1 (12)
ART	Success	31.6 (12)	16.1 (5)	30.8 (4)	21.4 (3)
	Failure	68.4 (26)	83.9 (26)	69.2 (9)	78.6 (11)

*significant higher success-rate compared to ART ($P = 0.002$).

Influence of anaesthesia on the success rate of restorations (30 months' follow-up)

Comparison between the ART and the conventional group demonstrated that when LA was used, the conventional treatment resulted in significantly (Pearson chi-squared $P = 0.002$) higher success rates (first element, Table 7). Without LA, there was no difference in success rate between both treatment modalities. Using the conventional method, success rates seem to be higher when LA was applied (first element). This difference is not significant though (Pearson chi-squared $P = 0.063$). For the treatment of the second element, there were no differences in success rate between the patient groups (Table 7).

Influence of discomfort on the success rate of restorations

The success rates of all restorations do not significantly differ, irrespective of the measure discomfort, the study element or the follow-up period (6 or 30 months, Pearson chi-squared). Discomfort was measured during excavation and restoration and is expressed by moving or not moving of the patient.

Discussion

Not all children were at the start of the study 6 or 7 years of age. It was, however, not useful to investigate age influences on the measure of discomfort because the number of children younger than 6 or older than 8 were too few to assure reliable statistical analysis.

At the evaluation session after 30 months 79 patients with 108 restorations were absent due to several reasons like graduation, moving or emigration and sometimes illness. Fifty-seven teeth were lost due to the increasing age of the children and therefore shedding of the study element. The evaluators noticed that in general children in Suriname seemed to shed their teeth in an earlier stage than children of a Caucasian origin. Twenty-nine teeth had been extracted, while of three cases it is uncertain whether the tooth disappeared due to shedding or extraction. In total 211 restorations (51.8%) were consequently left for evaluation. The high dropout entails that sometimes too few elements were left for proper statistical analysis. This concerned in particular the second element. However, in most of the cases enough data were left to draw firm conclusions in spite of this relatively high percentage of dropouts. This

is supported by the results of the survival rate after 30 months. These are in line with the findings after 6 months.

Because all restorations were placed in the primary dentition, many of the ones that had a so-called failure can also be assigned as success. When shedding was nearby, not all restorations that failed had to be repaired. Only in case a failed restoration could cause any harm to the permanent dentition or the patient himself, repair is in fact justified.

Van Bochove *et al.*[18] investigated a possible relationship between discomfort and anaesthesia. Hence, emerged that in general the least discomfort was experienced using the ART method without LA and the most using the conventional method with LA. In this study, however, there is no significant difference in the measure of discomfort irrespective whether LA is used. This can be explained by the fact that in this study only two out of the seven moments are used for calculation, i.e. the moment of deep excavation and that of restoration (immediately after placement of the metal matrix), because these are thought to have the most chance to influence the discomfort and consequently the success of the restorations as explained elsewhere. These two moments were expected to be the most interfering for the patient and most directly related to the quality of the restoration. In these calculations, discomfort is translated into moving during treatment.

Where to draw a line between moving and not moving seems somewhat arbitrarily. In this study, Venham scores '0' and '1' are labelled as not moving. At Venham score '2', the child starts to protest physically and its behaviour can be distracting to the operator. Although 253 children were considered as moving and 46 as not moving during treatment, no significant difference in movement is found between the LA and the non-LA group. In search of a relationship between movement and LA, Venham score '2' could also be labelled as not moving; the child still complies with the request to cooperate. Using this classification, now only 46 children are moving and 253 children are lying still. Pearson chi-squared test still showed no significant results (both during excavation and restoration), which means that it does not matter whether to draw the line between the scores '1' and '2' or between '2' and '3'. Irrespective where the demarcation line will be drawn, a number of patients in the LA group demonstrated some kind of discomfort. This could be explained as a result of improper administering of the LA. However, if this would be the case, there is no reason why the same effect is not also observed with the treatment of the second tooth (E2). Because here in much less cases movements were registered in the LA group, it is likely to presume that the operator's influence on the quality of the LA as such is much less than it seemed at first glance.

As can be observed in Tables 3 and 4, there is no difference in movement by children in the ART and in the conventional group. This seems to be in contradiction with other studies[3,16,18]. However, because of the choice to combine the different Venham scores to 'moving' and 'not moving', a comparison with discomfort, based on a six point scale, as used in other studies, is not possible anymore.

The results show that more children were lying still during excavation of the second element. This can be explained by the fact that they may feel more comfortable once they know what the treatment is going to be like. This result is more obvious in the non-anaesthesia group; the inconvenience of getting LA again probably had its repercussion during the whole treatment.

Comparing excavation and restoration, more movement is to be measured during excavation. This tendency is most explicit for the first element but whether this is significant, could not be calculated due to too small numbers of elements in the different groups (the conditions of the Pearson chi-squared test are not fulfilled). In itself, that result goes without saying since excavation can cause more pain and take along noises that a child might experience as being unpleasant.

Besides the influence of LA on movement, the success rates of the restorations in the different treatment groups are calculated. For this, the results from the 6 and the 30 months of follow-up are used. When saliva contamination of the preparation occurs or the operator cannot be that accurate due to movement of

the patient, the restoration may fail. Factors like diet could also be of some significance when success or failure of restorations is at stake. The influence of specific local fruit with very hard stones, for instance, can possibly be dramatic for the survival rate of glass ionomer restorations. Because this statement is based on personal experience of one of the authors, research on this issue is necessary.

Regarding the first element, the conventional method shows significantly higher success rates than ART, as well after 6 as after 30 months. The same holds good with regard of the second element at the 6 months follow-up; after 30 months there is no significant difference though. This may be due to the small amount of restorations left after 30 months in this group. Together with the fact that there are more successes than failures in the conventional group after 6 months, it seems obvious that in this study the conventional method is more successful than the ART method.

Because of the use of the same restoration material in all treatment groups, i.e. Fuji IX, the difference in success rate between these groups could have something to do with the preparation method. With burs, it is easier to accomplish a good accessibility to the cavity than with hand instruments. Moreover a better retention of the restoration can be obtained.

In conclusion, LA has no influence on the measure of movement during treatment. Furthermore, movement or discomfort during treatment does not affect the success rate of restorations. Therefore, one would expect that LA does not have any influence on the success rate of a restoration, which is supported by the 6 months results: there are no significant differences in success rate between the anaesthesia and the non-anaesthesia group for both elements. On the other hand, the 30 months' results demonstrate that within the LA group the conventional method shows significantly higher success rates than the ART method concerning the first element. Compared to the results of Van Bochove *et al.*[18], this is a quite striking outcome because that study showed that LA in combination with the conventional method caused the most discomfort during treatment. Apparently the measure of discomfort during the entire treatment is not comparable with the measure of movement during two moments of the treatment session, in particular if related to the success rate after 30 months. Also because these results are in accordance with other studies[12–14], the conclusion is justified that in this study LA did not influence the quality of glass ionomer restorations. More research, however, is necessary to confirm these findings.

What this paper adds

- ART suggest to be atraumatic compared to other, more conventional methods.
- However, because ART only gives a reduction in the measure of discomfort when compared to conventional methods without using LA, this study, where LA is combined with both techniques, gives new information about the effect on discomfort.

Why this paper is important to paediatric dentists

- This study shows that the use of LA does not have to decrease the measure of discomfort.
- However, using LA or not has no influence on the success rate of glass ionomer restorations.
- Thus, within the new developments regarding caries removal as minimal intervention approach, the use of LA has to be part of the discussion on this subject.

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References

1 Frencken JE, Holmgren CJ. *Atraumatic Restorative Treatments (ART) for Dental Caries*. Nijmegen, The Netherlands: STI Books, 1999.
2 Smales RJ, Yip HK. The atraumatic restorative treatment (ART) approach for the management of dental caries. *Quintessence Int* 2002; **33**: 427–432.
3 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.
4 Ho TF, Smales RJ, Fang DT. A 2-year clinical study of two glass ionomer cements used in the atraumatic restorative treatment (ART) technique. *Community Dent Oral Epidemiol* 1999; **27**: 195–201.

5 Phantumvanit P, Songpaisan Y, Pilot T, Frencken JE. Atraumatic restorative treatment (ART): a three-year community field trial in Thailand – survival of one-surface restorations in the permanent dentition. *J Public Health Dent* 1996; **56**: 141–145; discussion 161–163.
6 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**: 314–320.
7 Frencken JE, Makoni F, Sithole WD. ART restorations and glass ionomer sealants in Zimbabwe: survival after 3 years. *Community Dent Oral Epidemiol* 1998; **26**: 372–381.
8 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**: 119–126.
9 Taifour D, Frencken JE, Beiruti N, van't Hof MA, Truin GJ, van Palenstein Helderman WH. Comparison between restorations in the permanent dentition produced by hand and rotary instrumentation – survival after 3 years. *Community Dent Oral Epidemiol* 2003; **31**: 122–128.
10 Frencken JE, Van't Hof MA, Van Amerongen WE, Holmgren CJ. Effectiveness of single-surface ART restorations in the permanent dentition: a meta-analysis. *J Dent Res* 2004; **83**: 120–123.
11 van den Dungen GM, Huddleston Slater AE, van Amerongen WE. [ART or conventional restorations? A final evaluation of proximal restorations in deciduous molars]. *Ned Tijdschr Tandheelkd* 2004; **111**: 345–349.
12 Yip HK, Smales RJ, Yu C, Gao XJ, Deng DM. Comparison of atraumatic restorative treatment and conventional cavity preparations for glass-ionomer restorations in primary molars: one-year results. *Quintessence Int* 2002; **33**: 17–21.
13 Yip KH, Smales RJ, Gao W, Peng D. The effects of two cavity preparation methods on the longevity of glass ionomer cement restorations: an evaluation after 12 months. *J Am Dent Assoc* 2002; **133**: 744–751.
14 Yu C, Gao XJ, Yip HK, Smales RJ. Survival of glass ionomer restorations placed in primary molars using atraumatic restorative treatment (ART) and conventional cavity preparations: 2-year results. *Int Dent J* 2004; **54**: 42–46.
15 Rahimtoola NS, van Amerongen WE. Comparison of two tooth-saving preparation techniques in a treatment approach of one-surface cavities: design of a study. *ASDC J Dent Child* 1997; **64**: 334–339.
16 van Amerongen WE, Rahimtoola S. Is ART really atraumatic? *Community Dent Oral Epidemiol* 1999; **27**: 431–435.
17 Versloot J, Veerkamp JSJ, Hoogstraten J. Computerized anaesthesia delivery system versus traditional syringe: comparing pain and pain related behavior in children. *Eur J Oral Sci* 2005; **113**: 488–493.
18 van Bochove JA, van Amerongen WE. The influence of restorative treatment approaches and the use of local analgesia on children's discomfort. *Eur Archives Paediatr Dent* 2006; **7**: 11–16.