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The dilemma of selecting suitable proximal carious lesions in primary molars for restoration using ART technique.

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Objective: To determine the examiner's accuracy in selecting proximal carious lesions in primary molars for restoration using the atraumatic restorative treatment (ART) approach. ***Basic research design:*** Intervention study. ***Clinical setting and participants:*** A total of 804 six to eight year-olds from 30 rural schools in Kenya participated in the study. ***Intervention:*** Three examiners selected a total of 1,280 suitable proximal carious lesions in primary molars after examining 6,002 children from 30 schools randomly selected out of 142 schools in two divisions. Seven operators randomly paired on a daily basis with eight assistants restored the lesions. An explanation was provided for any cavity that was not restored. Pre-and post-operative radiographs of the cavities were also taken for evaluation. ***Main outcome measures:*** The examiner's choice of suitable proximal cavities restorable using the ART approach was related to the decision made to either restore or not during the operative stage. The radiographic findings of the selected cavities were also compared to the decision made by the operator. The results obtained were used to determine the examiner's accuracy in selecting suitable proximal cavities for restoration using the ART approach. ***Results:*** The majority of the children recruited in the study were excluded due to absenteeism, pulpal-exposure or anxiety during the operative stage. Only 804 children received one restoration in their primary molars. The examiner's accuracy in selecting suitable ART-restorable cavities clinically was 94.9% and based on radiographic analysis was 91.7%. ***Conclusions:*** A trained and diligent examiner has a very good chance of selecting proximal carious lesions restorable with the use of ART approach, without the threat of dental pulpal-involvement during the excavation of caries.

Key words: ART, cavity selection accuracy, primary molars, proximal lesions.

Introduction

Atraumatic restorative treatment (ART) technique is one of the approaches used in the management of dental caries, particularly in susceptible poor communities with very low dental restoration rate (Frencken *et al*., 1994), in anxious and handicapped patients. The approach combines the use of hand instruments in cavity preparation and glass ionomer cement (GIC) as the restorative material (Mjör and Vaeria, 1999; Pilot, 1999; Holmgren and Frencken, 1999). Glass ionomer cement (GIC) is the preferred restorative material for use with the technique, as it is biologically compatible with the oral tissues, chemically bonds with the tooth tissues and leaches fluoride that has a cariostatic effect (McLean, 1974). Unfortunately, GIC has low tensile and compressive strength that makes it inapplicable in very large cavities where masticatory forces are high (Frencken *et al*, 2004).

The enamel and dentine in the primary dentition is very thin. Proximal dentinal lesions in the primary molars present difficulties in accessibility and visibility when treating them using only hand instruments. In addition, there is a heightened likelihood of pulpal exposure due to the thin dentine and enamel layers. Coupled with these factors is the low compressive material-strength of GIC that is likely to result in early restoration failure, particularly for the large restorations. Consequently, the choice of proximal cavities for restoration using the ART approach has to be done carefully if the longevity of the restoration is to be enhanced. Unfortunately, there is little information available on the influence of the choice of cavities as related to their adequate preparation and restoration without the threat of pulpal exposure while using the ART approach. The purpose of the present study was to determine the examiner's accuracy of choosing suitable proximal cavities in the primary molars restorable using the ART approach.

Method

This study formed part of a larger two-year prospective study on the survival rate of proximal ART restorations in school-children in Matungulu and Kangundo divisions in Kenya. A total of 142 public primary schools from the two divisions with a total of 22,105 eligible children were targeted. Using random numbers, provided the school had a minimum of 50 eligible children, 30 schools with 6,002 eligible children were selected and examined for suitable proximal cavities restorable using the ART approach. Two final-year dental students and one paediatric dental specialist examined the children for the suitable proximal cavities. Only the children who were 6 to 8 years of age, in good general health, resident of the area of study for the past year, having at least one

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proximal carious lesion in the primary molar, with a bucco-lingual opening of approximately 0.5 mm to 1.0 mm and assented to the examination were recruited in the study. The size of the cavity-opening was considered for allowance of entry of the dental hatchet tip and or smallest excavator needed to excavate dental caries. The tooth selected was without signs or symptoms of pain or mobility, and only the smallest of the cavities considered to be suitable was selected for the study. To obtain the required number of appropriate proximal dental lesions, a large number of children needed to be examined. Considering that a short interval between the selection of the teeth and their restoration was needed, a decision was made to have one group to select the teeth and another to restore them. One tooth per child was also preferred so as to minimize patient-related factors as the side commonly used in chewing etc. All the examiners and operators had been trained and pre-tested in the process of tooth-selection and restoration of the dental cavities using the ART approach. They were also calibrated by the chief investigator regarding the selection of the cavities and also carried out inter-examiner reliability (mean Kappa coeffient range 0.80 to 0.92, mean n=20 to 30) and intra-examiner reliability (ranging kappa 0.78 to 0.86 on re-examination of 10% of the cavities). The parent or guardian gave a written consent for the child's participation in the study. Approval to conduct the research was sought and obtained from the University of Nairobi and the Kenyatta National Hospital Research and Ethical Committees.

Initially, 1,560 children were selected based on the presence of the appropriate proximal cavity, out of which 1,280 (82.05%) children fulfilled all criteria for the selection. The remaining 280 (17.9%) children were disqualified for lack of informed consent from their parents allowing them to participate in the study. As there were many possible factors for investigation in the study, a higher figure of 1,200 subjects as the study population was agreed upon in order to improve on the statistical power of the study. This figure was higher than the pre-study sample calculation of 382. All the children in the study were from a low socioeconomic background with limited access to dental health services. The male to female ratio was 1.3:1, a mean age of 7.6 (SD 0.95) years, a mean baseline dmft of 4.0 (SD 2.4), and a DMFT of 0.2 (SD 0.5). The missing teeth component of the DMFT/dmft included only teeth expected to be in the oral cavity but missing with a history of caries or trauma. Those deciduous teeth with an oral history of natural exfoliation (age-appropriate) were excluded.

Two months following the selection process, seven operators, who had not participated in the initial selection process, restored the selected carious lesions at each child's school. The operators who consisted of two dentists, four final-year dental students and one community oral health officer (COHO), were randomly paired on a daily basis with 8 dental assistants (one COHO and 7 dental assistants). One assistant rested on each operative day. The operators and the assistants had been trained in the ART approach based on a five-module WHO approved ART training programme by Frencken *et al* contained on a compact disc (Frencken *et al*, 1998). After the training each operator and assistant underwent further clinical practice under supervision in various clinics and in the field. Prior to the operative stage of the study, an operator who had made at least 50 ART restorations (half of them proximal restorations and the rest of any other class) was categorized as "experienced", and the one who had done less than 10 but more than five of any class after the training was categorized as "inexperienced" in the ART approach. The assistants were similarly categorized but based on their assisting roles in producing similar number of restorations.

Using random numbers, the children were assigned to a randomly paired operator and assistant. During the operative stage, the operator could make the decision to restore or reject with reasons any of the cavities that had been chosen by the examiner. The reasons for rejection ranged from the presence and appropriateness of the cavity selected, relationship to the pulp chamber and the cooperation of the child during the treatment. A pre-and post-operative bitewing radiograph of the tooth was also taken. The radiographs were taken in a standard manner using *kwik-bite* (Pinnacle product Inc, USA part no. 270 US) with a ring centering film holder and a portable X-ray machine (Philips Oralix 50, 65kV 7.5mA, set at 0.3s). This procedure allowed for almost identical radiographs to be taken. Due to the busy schedule for the study and unavailability of facilities to process the radiographs in the field, the radiographs were not available to the operator at the time of restoring the teeth. They were evaluated later by one independent examiner, who had been calibrated with a local dental radiologist (inter-examiner mean kappa, 0.83, n=50, and intra-examiner mean kappa, 0.8.4, on 10% of the evaluated radiographs). The radiographs were evaluated for the cavity/restoration extent within the dentine and its relationship with the pulp chamber. During the assessment of the radiographs, restorations were categorized as "within dentine" when radiographically they were over one millimetre away from the pulpal lining, "close to the pulp" when they were one or less millimeters from the pulpal lining and "involving the pulp" when they were continuous with the pulp chamber.

All the clinical and radiographic results of the evaluations were analysed using the SPSS version 14.0 computer programme (SPSS Inc Chicago IL), and descriptive statistics used to compare the examiners' cavity choices with the final results of the operator and the radiographic findings.

Results

After the examination of the 6,002 children targeted, the results were as given in Table 1. Each of the 804 children out of the 1,280 children who met all the criteria for inclusion in the study, received one proximal restoration in their primary molar using the ART approach. Of the 476 cavities excluded from the study during the operative stage, 99 experienced pulpal exposure, 37 were inappropriate (very large) and 30 lacked the reasons for their disqualification. The children with these cavities were from schools where radiographs were either not taken or were of poor quality. The remaining 310 cavities were for children who were absent on the day of the operation, children with anxiety or pre-operatively had

lost the tooth or the tooth had been restored elsewhere or the child had been transferred from the school prior to the start of the operative stage of the study (Table 2). After adjusting for the discrepancies mentioned, the possible number of cavities that were available to the operator during the operative stage were 970 cavities. Out of this number, the examiner made incorrect choice of 166 cavities: pulpal exposure (99), inappropriate cavity-size (37), no explanation given (30), as shown in Table 2. The incorrect choices of cavities made here were added to the incorrect choices made of 33 cavities seen after the analysis of the pre-operative radiographs (i.e. 7 + 26 cavities as shown in pre-operative radiographic results columns in Table 3). The examiner had, therefore, made a total of 199 inappropriate cavity-choices of the possible 970 cavities available for selection. The probability of the examiner making the appropriate cavity selection suitable for restoration was then 771 out of 970 cavities or 79.5%.

Out of the 804 cavities restored in the study, only 648 (80.6%) cavities had pre-operative radiographs of good quality for the study, and of this number 507 (78.2%) had both pre-and post-operative radiographs. The remaining 141 radiographs lacked the corresponding post-operative radiographs. The missing radiographs were a result of spoilt radiographs, missing due to truancy by the child or lack of electricity power during the restoration process. The results of the evaluations of the good quality radiographs that were available for the study, were categorized as shown in Table 3. The 648 cavities, whose

Table 1. The selection process and the proximal cavities restored in the study using the ART approach.

Findings during the selection stage	*The number of children from the 30 schools*
Number of children examined	6,002
Children had unsuitable cavities	2,809
Children who had no dental cavities	720
Children who were absent on the day of the examination	870
Children with inappropriate age	43
Children selected on the basis of having a suitable proximal dental cavity	1,560
Children who fulfilled all the criteria of inclusion into the study	1,280
Children who had one proximal restoration placed in their primary molar during the operative stage	804
Children with suitable proximal cavity, but were absent or were anxious, or the tooth experienced pulpal exposure during the restoration stage	476

Table 2. Analysis of the 476 children excluded from the study.

Reason for failure to restore	*Number of children*	*Percentage of the total number of children who met the study requirements*	*Percentage of the total number of children who had been excluded from the study*
Absent at time of restoring	192	15	40.3
Anxiety and fear	25	2.0	5.3
Pulpal exposure during preparation	99	7.7	20.8
Already exfoliated/mobile at day of restoration	42	3.3	8.8
Inappropriate cavity size (error of selection mainly very large cavity)	37	2.9	7.8
Already filled before day of restoration	1	0.08	0.2
Age problem (child not within 6 to 8 years)	47	3.7	9.9
Children already transferred from the school	3	0.2	0.6
No explanation given	30	2.3	6.3
Total number of children excluded from study	476	37.19	100.0

Table 3. Results of the radiographic evaluations.

Cavity category	*Pre-operative radiographic results*		*Post-operative radiographic results*
	Radiographs without corresponding post-operation radiographs	*Radiographs with corresponding post-operation radiographs*	
Pulpal cavity surface within sound dentine	103	411 (81.1%)	348 (68.7%)
Pulpal cavity surface close to the pulp	31	70 (13.8%)	91 (17.9%)
Cavity involves the pulp	7	26 (5.1%)	68 (13.4%)
Total	141	507 (100%)	507 (100%)

pre-operative radiographs were evaluated for the relationship of the pupal-walls of their dental cavities with the pulpal-chambers, had 514 (79.3%) cavities with pulpal-walls within sound dentine, 101 (15.6%) cavities had pulpal-walls close to the pulpal chamber and 33 (5.1%) cavities had pulpal-walls involving the pulp chamber. The most desirable cavities for restoration should have their pupal-walls not involving the pulp chamber. According to the present results, the probability of the examiner to choose the preferred cavities based on the pre-operative radiographic evaluations was therefore 94.9%.

It should be noted that the 33 cavities (i.e. 7+26 cavities as shown in the pre-operative radiographic results column in Table 3) had pulpal involvement, yet they had been restored by the operator, and a further 35 cavities were detected on the post-operative radiographs as involving the dental pulp, after the excavation of dental caries. Of the 141 cavities that did not have corresponding post-operative radiographs, only thirty one cavities had their pulpal-walls close to the pulp and seven involved the pulp, and all these cavities had been restored, as shown in Table 3 Column 2 (first section). The 166 cavities excluded during the operative stage could not be fully assessed radiographically, as they all lacked the two pairs of radiographs. Those cavities had pulpal involvement (post-operatively) were followed at all evaluation moments, and in one case the child the tooth was extracted after the child complained of pain. The other cases either exfoliated or were lost due to drop-outs.

The results of the radiographic evaluation of the 507 cavities that had satisfactory corresponding pre-and post-operative bitewings are also shown in Table 3 Column 2 (second section). It was apparent that after the excavation of the cavities, 348 (68.6%) cavities had their pulpal-walls ending within sound dentine (from 411 pre-operatively), 91 (17.9%) cavities had their pulpal-walls close to the pulp (70 pre-operatively) and 68 (13.4%) involved the pulp chamber (26 pre-operatively). Of the 411 cavities with pulpal-walls in sound dentine (pre-operatively), 60 cavities ended up being very close to the pulp chamber and three were involving the pulp chamber, after instrumentation (post-operatively). Of the 70 cavities that were close to the pulp chamber (pre-operatively), 39 cavities involved the pulp chamber after instrumentation (post-operatively). These results were categorized as follows: S – cavities diagnosed by the examiner as having their pulpal-walls in dentine and radiographically confirmed so, T- cavities diagnosed by examiner with their pulpal-walls within dentine but which were not, V- cavities diagnosed by the examiner as involving the pulp and radiographically confirmed so and W- cavities diagnosed by the examiner as involving the pulp but which were not. Using these symbols, the examiner's diagnosis of a cavity not involving the pulp was:

S+V/S+V+T+W for accuracy, S/S+W for sensitivity and V/V+W for specificity (Andreasen *et al,* 1987).

In the present study, S = 348+91, T = 39+ 3, V = 26 and W =0. The results obtained from these calculations, and which were based on the outcomes of the initial clinical findings and the pre- and post-radiographic findings of the available radiographs, gave an accuracy of 91.7%, sensitivity of 100% and specificity of 100% (negative predictive value).

A comparison of the cavity-choices made by the operator with the survival rate of the restorations after two years indicated that cavities that were "within dentine" had the highest survival rate. The difference between the survival rate of these cavities and the combined survival rate for the cavities whose pupal-walls were less than one millimetre from the pulp chamber or involving the pulp was statistically significant (Chi-square 27.596, 2df, $p<0.0001$). In general, there was no statistically significant difference in the choice made by the "experienced" or "inexperienced" operators in relation to the survival rate of the restorations (Chi-square, 5.011. 9df, $p= 0.833$). However, one operator who had longer experience with the ART approach even before this study, had placed restorations whose survival rates were statistically significant (Ch-square, 30.78, 5df, $p<0.0001$) when related to those placed by the other operators. This operator had also the least number of restorations involving the pulp chamber.

Discussion

The selection of the cavities to be restored was based exclusively on the clinical assessment by the examiner, and even at the time of restoring them, the operator had not seen the radiographs taken, which were evaluated later after restoring the cavities. The present study took place in a poor rural area in Kenya, with moderately high caries prevalence. The area largely lacked basic dental health facilities, electricity and piped water to the majority of the population (Frencken *et al*, 1996), and it would be an appropriate site for the application of the ART technique (Frencken and Holmgren 1999) if the facilities were available.

In the present study, the selection of suitable carious proximal lesions for restoration using the ART technique was simple, and dependent on visual estimation of the size of the lesion. After the initial selection by the examiners, the operators were only required to restore or reject them on the basis of the criteria that had been set. All the examiners and the operators had general experience in treating dental patients. For the operators in the present study, it was assumed that a relatively simple technique as the ART approach would not form an unacceptable risk for the patient in case the operator had only little experience with the ART technique as such. Although only 507 (78.2%) of the radiographs were available for analysis of pre-and post-operative status of the cavities, the results may not be conclusive. However, they do provide some idea on the challenges faced when selecting these proximal cavities. The operator's decision, pre- and post-operative radiographs were used to determine the examiner's accuracy to choose good cavities. The criterion of a cavity being close to the pulp was to be able to establish the possibility of such cases being able to be restored or not and also what proportion end up involving the pulp chamber. Unfortunately, not all the radiographs were available due to the numerous technical difficulties in the field.

From the study, majority of the eligible children excluded at all levels of selection was essentially due to absenteeism, besides the initial lack of informed consent.

This phenomenon could be attributed to the prohibitively long distances travelled by the majority of the children to school and the hunger experienced due to the general food scarcity as observed in the area. The high poverty levels seen in the community could imply that the majority of the parents were possibly having low-education level and spending most of their time fending for the family needs as not to be bothered with their children maintaining regular school-attendance. Unfortunately, this could only be speculated, as it could not be established in the present study.

With the cavity selection accuracy of 94.9% (pre-operatively) and 91.7% (post-operatively) for the examiner choosing acceptable ART restorable proximal cavities, it is indicative that a trained examiner has the capability of making reasonably good cavity-choices (not involving the pulp chamber) for the technique unaided by radiographs. A good cavity-choice is likely to lead to a restoration with enhanced survival rate. Obviously, some cavities were lost after instrumentation either as a result of diagnostic errors or poor instrumentation technique that could lead to pulpal exposures, hence reducing the number of correct cavity choice (Kidd, 2004). This could be possible reasons for the reduced clinical and post-treatment accuracy, probably if the pre-operative radiographs were available to both the examiner and the operator before restoring the cavities, the situation could have been different. It is apparent from the analysis of the radiographs that the number of cavities involving the pulp increased after restoring the cavities, possibly a result of operator errors, unnecessary excessive removal of dentine during the instrumentation stage or other diagnostic errors.

ART remains an operator dependent process, with the operator making decisions based on clinical experience and skills in choosing the cavities for restoration, removal of carious material within the cavities, correct manipulation and application of the materials used and the tooth-isolation technique applied during the placement of the restoration. While there are many radiographic (when available) and biological factors that could influence the correct diagnosis of a suitable cavity for the ART restoration, the present study did indicate that the accuracy of the examiner in selecting the appropriate cavities (without bite-wing radiographs), for the ART technique was very good.

Conclusion

It is possible that even without the benefit of a bitewing dental radiograph, a trained, skilled and diligent examiner is capable of making a good choice of ART- restorable proximal carious lesion in primary molars.

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