Effect of dental caries and treatment strategies on oral and general health in children
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Atraumatic Perspectives of ART:
Psychological and physiological aspects of treatment with and without rotary instruments

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Abstract

Atraumatic Restorative Treatment, ART, is a method of minimal caries intervention that uses only hand instruments. The aim of the present study was to explore a possible difference between the extent of discomfort experienced during dental treatment according to the ART approach and a method using rotary instruments.

Materials and methods:
The study was performed in Indonesia. 403 children were randomly divided in two groups. In each child one class-II restoration in a deciduous molar was made. One group received treatment, using rotary instruments (750 rpm). The other group was treated according to the ART approach. Glass ionomer cement was used for restoration in both groups. Discomfort scores were determined using both physiological measurements (heart rate) and behavioral observations (Venham) on specific moments during the treatment.

Results:
Venham scores showed a marked difference between the two groups on most time points. Heart rate measurements were different at deep excavation. Also, a clear relation between Venham scores and heart rate measurements could be found at all time points. Confounding could be shown for operating dentist, gender of the patient and initial anxiety, not for age. No effect modification could be shown.

Conclusion:
It can be concluded that children treated according to the ART approach using hand instruments alone, experience less discomfort than those treated using rotary instruments.
Introduction

A new approach for the treatment of dental caries, Atraumatic Restorative Treatment (ART), was introduced in 1985. ART is a minimal intervention technique, based on removing carious tooth tissue using hand instruments and restoring the cleaned cavity with an adhesive material, currently glass ionomer [1-3]. The choice for glass ionomer is based on its self-curing and caries preventive properties [4, 5]. The often cited low wear resistance of glass ionomers was not observed in the last generation of these restorative materials [6, 7]. This is because of the improvement in the physical composition of the material and the relatively small cavity preparations, whereby only the affected tooth tissue is removed and no mechanical retention has to be obtained [3, 8].

ART was initially intended to make preventive and curative oral care more available for the majority of people in economically deprived countries. Prior to the introduction of ART, tooth extraction was the only option for the treatment of dentinal caries due to the lack of sophisticated dental equipment, electricity and financial resources. The straightforwardness and simplicity of ART and the relatively low cost compared to a treatment approach using rotary instruments, are attractive advantages of this new method.

In the last decade, several ART-studies have been carried out in a number of countries such as Thailand, Zimbabwe, Pakistan and China. These studies reported the survival of single-surface restorations in the permanent dentition and show good results on the short term, on average 88% after three years [9–11].

An interesting advantageous aspect of ART is its claim to be “atraumatic” towards the patient. Several studies have shown that dental anxiety is mainly associated with highly invasive procedures such as “drilling” and “injections” [12, 13]. Neither procedure is usually needed in the ART approach.

A 1995-study in Indonesia [14] compared ART to a modified ART-procedure using rotary instruments only to provide access to the cavity. After completion of the treatment subjects were asked if they had experienced any discomfort during treatment. Answers were given dichotomously (yes or no). The subjects in the ART-group indicated significantly less discomfort (6.3%) compared to the modified ART-group (12.4%).

In another study, ART was compared to a more usual treatment method that uses rotary instruments (MCP). Subjects were asked whether or not they felt pain during the treatment session. Subjects in the ART group reported significantly less pain; 19 % compared to 36% in the conventional group [8]. These studies both concerned one-surface restorations in the permanent dentition.
Discomfort is defined in this study as an occurrence of emotions felt during (dental) treatment, mainly caused by pain or anxiety. This implies that discomfort is a multidimensional construct, consisting of a behavioral, a cognitive and a physiological component [15, 16]. In order to get an impression of the extent of discomfort felt during dental treatment, measurements should model this multidimensional aspect. For the purpose of this study, both the physiological and the behavioral (psychological) aspect are considered to be representative indicators.

The aim of the present study is to explore a possible difference between the extent of discomfort experienced during dental treatment of multi-surface cavities in deciduous molars according to the ART approach and a method using rotary instruments.

Materials and methods

The target population for the current study was 6-year-old school children from deprived communities. Children from randomly selected elementary schools in various districts in Bandung, Indonesia were selected. In order to be included in the study each child needed to have at least one multisurface-cavity in a deciduous molar that was accessible to hand instruments as prescribed for the ART approach [17] and where no pulp exposure was expected. A signed parental consent form was received from each participant prior to the study’s commencement.

The study compared two treatment groups. Children in the control group were treated with rotary instruments. Excavation of the demineralized tooth material was carried out by means of stainless steel round burs in a hand piece (750 rpm), without water-cooling (Minimal Cavity Preparation, MCP). Children in the experimental group were treated according to the ART approach using only hand instruments i.e. hatchets and excavators. In both groups only the demineralized carious tooth tissue and unsupported enamel were removed. After cleaning the cavity, a matrix band and wooden wedges were applied. Cotton wool rolls were used to isolate the cleaned cavity from contamination with saliva and/or blood. After conditioning the dentin for 15 seconds, hand-mix glass ionomer (Chemflex, Dentsply/deTrey) was placed into the cavity in both groups. No local anesthesia was used in either group. Treatments were allocated randomly, the patients could be considered blinded. Four operators carried out the treatments: two 4th year dental students from the Netherlands (University of Groningen) and two Indonesian dentists from the Pedodontic Department of the University of Bandung, Java.

The extent of discomfort, as defined in the introduction, was assessed by measuring the behavioral (psychological) and the physiological aspect; represented by respectively a modified Venham score and the heart rate of the children at six fixed moments during dental treatment:
1) when the child entered the treatment room, 2) at the start of excavation, 3) at the moment of deepest excavation, 4) at the moment of application of the matrix band and wedges, 5) at the moment the restoration was applied and 6) after completion of the treatment.

The heart rate of the patients was measured using a Polar® Tempo bandage around the chest. For children, aged 6-7 years, normative values for the average of the heart rate in rest vary between 100-95 bpm [18]. The children participating in this study were in good health and therefore the heart rates could be assumed to be comparable to normative standards. The behavior of the children was classified according to a six-point modified Venham- scale [19, 20]. (Table 1) The general behavior of the child during the whole treatment was also registered on the modified Venham- scale as the Venham Overall score, and the highest observed score was noted as the Venham Peak score.

<table>
<thead>
<tr>
<th>Table 1 Venham index; Modified 6-point scale</th>
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<tbody>
<tr>
<td>Venham - Index</td>
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<tr>
<td>0 = relaxed, smiling, willing, able to converse, displays behaviour desired by the dentist</td>
</tr>
<tr>
<td>1 = uneasy; concerned, may protest briefly to indicate discomfort, hands remain down or partially raised. Tense facial expression, &quot;high chest&quot;. Capable of cooperating</td>
</tr>
<tr>
<td>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</td>
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<tr>
<td>3 = reluctant; pronounced verbal protest, crying. Using hands to try to stop procedure. Treatment proceeds with difficulty</td>
</tr>
<tr>
<td>4 = interference; general crying, body movements sometimes needing physical restraint. Protest disrupts procedure</td>
</tr>
<tr>
<td>5 = out of contact; hard loud crying, swearing, screaming. Unable to listen, trying to escape. Physical restraint required</td>
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</tbody>
</table>

Both the recording of the heart rate and the observations were carried out by one of the authors, not taking part in the actual patient treatment. Prior to the current study, the observer was trained in using the Venham behavior scale by scoring 42 videotapes of children in a dental situation. These observations were compared to the consensus score of two calibrated observers, who scored the same tapes for another study [20]. This resulted in a Cohen’s Kappa of 0.87, implying a good agreement.

To analyze a difference in the Venham scores between both treatment groups, a Chi-square test for trend was used. Student’s T-test was used to analyze the heart rate of the patients recorded in both treatment groups. The relationship between the heart rate and the Venham score was estimated by Pearson’s correlation coefficient.
To investigate the effect of potential confounding variables on the relation between treatment method and outcome measurement, two-way analyses of variance were done at each time point. Each analysis tested three effects: the influence of the treatment method (main effect for treatment), the influence of the confounding variable (main effect for confounding) and the effect modification, i.e. the influence the confounding factor may have on the relation between treatment and outcome (interaction). Potential confounders/modifiers employed were age (using a cut point at 6 years, 4 months), gender, operating dentist, and the behavior of the children at entrance of the operating room, classified into 3 groups, according to the Venham score at that moment: no (VS=0, n=141), low (VS=1, n=206) and high (VS>1, n=56) anxiety.

For all tests a two-sided significance level of 0.05 was used. Confidence intervals were estimated with a 95%-level. SPSS 8.0 was used for all statistical testing.

**Results**

For this study, 403 children, 208 boys and 195 girls, mean age 6.3 yrs (range 4.9-7.9) were selected from 49 elementary schools in Bandung. The children were in good health and used no special diet, according to medical reports from the hospital. Each dentist treated about the same number of patients in each group. 201 Children (99 boys, 102 girls) were treated with rotary instruments (MCP) and 202 children (109 boys, 93 girls) with hand instruments (ART). No relations could be found between the treatment and either gender or operator in numbers of patients.

<table>
<thead>
<tr>
<th></th>
<th>Venham score p-value</th>
<th>Heart rate p-value</th>
<th>Correlation r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance</td>
<td>0.153</td>
<td>0.256</td>
<td>0.614</td>
</tr>
<tr>
<td>Start</td>
<td>0.000*</td>
<td>0.153</td>
<td>0.464</td>
</tr>
<tr>
<td>Deep excavation</td>
<td>0.000*</td>
<td>0.030*</td>
<td>0.369</td>
</tr>
<tr>
<td>Matrix</td>
<td>0.054</td>
<td>0.296</td>
<td>0.324</td>
</tr>
<tr>
<td>Restoration</td>
<td>0.028*</td>
<td>0.483</td>
<td>0.403</td>
</tr>
<tr>
<td>End</td>
<td>0.051</td>
<td>0.521</td>
<td>0.387</td>
</tr>
<tr>
<td>Peak</td>
<td>0.002*</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Overall</td>
<td>0.000*</td>
<td>-----</td>
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</tr>
</tbody>
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* significant at p=0.05
The results of the Venham observations and the heart rate measurements during the specific phases of the treatment session are summarized in Table 2.

At the entrance of the children into the operating room no significant difference between the treatment groups for Venham score and heart rate could be found (resp. $p=0.153$ and $p=0.256$).

During all five treatment time points, the Venham scores of the children in the ART group were lower than those of the children in the MCP group (most $p<0.05$). During the application of the matrix and at the end of the treatment the differences were marginally non-significant though ($p=0.054$ resp. $p=0.051$). A strong significant interaction was found for the observations at the start and during deep excavation (both $p=0.000$).

The Venham Overall score showed that children treated with ART were significantly more comfortable and relaxed than children in the MCP group. The Venham Peak scores are significantly higher in the MCP group, indicating the children felt less comfortable compared to those in the ART group.

Student’s T-test on the heart rate measurements of the children during the treatment shows no significant differences between both treatment groups, except for the moment of deep excavation ($p=0.03$, Table 2). These results are visualized in Figure 1. Although not significant, there is a systematic difference between the heart rate of the children in both groups.

To investigate the role of confounding on the relation between treatment method and outcome measurement, two-way analyses of variance were done at each time point. The influences of the confounding variables can be summarized as follows (Table 3):

![Figure 1](heart_rate.png)

**Figure 1** Heart rate of the children during the treatment according to the ART method (●) and with MCP (■). 95% confidence interval indicated.
The influence of the operator appears to be strong on both Venham score and heart rate of the child. No significant interaction could be found between the dentist and the treatment method during the treatment. This implies that the influence a dentist has on the behavior and the heart rate of the child, is irrespective of the treatment method he or she uses. Gender seems an important factor as well. Significant differences were found at almost all time points. Girls showed higher scores on the Venham scale and their heart rates were higher compared to those of the boys. The age of the children had a significant influence on the Venham score only during the restoration of the cavity. The older children showed a lower score. The initial anxiety level (as defined by the Venham Score at entrance) also showed a strong influence on the outcome measurements: the less anxious the children were, the lower their heart rate and Venham score during treatment.

**Discussion**

According to the results of this study Atraumatic Restorative Treatment appears to be less stressful for children in comparison to the more usual method as observed with behavioral measurements. Physiological measurements (heart-rate) did show a less clear influence from the treatment method: only during deep excavation, the heart rate of the children in the ART group was significantly lower.

| Table 3 Two way analysis of variance; p-values for main effects of the confounding variables on the heart rate (H) and the behaviour of the child (V) |
|-----------------|----------|----------|-----------------|
| Gender          | Age      | Dentist  | Initial anxiety level |
| H-entrance      | 0.000*   | 0.538    | 0.135            | 0.000*          |
| H-start         | 0.000*   | 0.630    | 0.010*           | 0.000*          |
| H-deep exc.     | 0.007*   | 0.290    | 0.044            | 0.000*          |
| H-matrix        | 0.000*   | 0.090    | 0.002*           | 0.000*          |
| H-restoration   | 0.000*   | 0.018    | 0.009*           | 0.000*          |
| H-end           | 0.000*   | 0.371    | 0.336            | 0.000*          |
| V-entrance      | 0.000*   | 0.844    | 0.098            | -----           |
| V-start         | 0.010*   | 0.878    | 0.010*           | 0.000*          |
| V-deep exc.     | 0.013*   | 0.494    | 0.223            | 0.000*          |
| V-matrix        | 0.168    | 0.166    | 0.000*           | 0.000*          |
| V-restoration   | 0.091    | 0.013*   | 0.001*           | 0.000*          |
| V-end           | 0.001*   | 0.127    | 0.000*           | 0.000*          |

* significant at p=0.05
The Venham score and heart rate were moderately correlated during all phases of the treatment. The operator did have an effect on the behavior of the child. Also gender and age were confounding factors, as was the initial anxiety. Boys scored lower on both psychological and physiological measurements, irrespective of the treatment method used. Younger children scored higher on the Venham scale during restoration in both treatment groups. None of these factors showed a significant influence on the differences between treatment groups for Venham score or heart rate.

As mentioned in the introduction, research suggests that dental anxiety is mainly associated with the injection-needle and the bur [12, 13]. Both instruments were absent during the ART approach and this could be a suitable explanation for the higher acceptance of this method. Studies on this subject [8, 14], including the present study in particular, focused on the bur as variable. None of the studies drew attention to the fact that no local anesthetics are used. This could be an interesting subject for further research.

To assess dental anxiety in children, many measurement techniques have been proposed and tested for validity and reliability [16]. No consensus was established for any method to be preferred. Also for the measurement of pain several methods have been investigated and applied, without reaching consensus about a preferred technique [21, 22]. Venham (1977) made a distinction between behavior and fear scores and found a high correlation. This finding was replicated in subsequent research [20, 23]. Benjamins [24] found that heart rate is positively correlated to both dental anxiety and pain. Correlation to other physiological reactions such as blood pressure, skin conductance and increase of salivary cortisol were found to be inconsistent. Based on these latter findings the authors consider the Venham score and the heart rate as suitable indicators to represent the extent of discomfort felt during dental treatment.

In this study, the Venham score shows a significant difference between the treatment methods, while the heart rate did not show the same result. An explanation for this finding might be that both criteria measure different manifestations of discomfort. This confirms the multidimensional aspect of this entity.

Gender is a confounding factor with respect to the behavior of children during dental treatment. In this study both heart rate and Venham score of the boys appeared to be lower than those of the girls, irrespective of the treatment method used. This finding could be the result of cognitive dissonance: a contradiction between a person’s feelings, knowledge and actual behavior [25]. This behavior pattern is probably due to a difference in both psychological development and the socialization process. Gender differences according to fear and anxiety have been reported in several studies [26-29].
The effect of the factor age could be explained by the fact that younger children do not have
the same coping capacities compared to the older children, because of their psychosocial
development [25, 28]. It cannot be explained, however, why this influence was only observed
during restoration. Assumptions can be made, though, that the younger children might get tired
or lose control at this time.

From the results of this study it appears that the operating dentist influenced the behavior of the
child. This might be caused by cultural differences, language problems or even technical skills.

Cultural influences are expected to effect the results of this study. Different cultures might have
different coping strategies in certain situations [30, 31]. Although the values for discomfort can
be different in other cultures or populations, the tendency is expected to be the same as in this
study.

In this study, the Venham score was observed by one of the authors, not participating in the
treatments, though aware of the treatment method that was randomly chosen for the child. This
could bias the results, favoring one of the treatment methods. Yet, this is very unlikely because
four operators were treating patients at the same time, so four children had to be observed
accurately. There was no time to make considerations favoring one of the treatment methods.

It can be concluded that children experience less discomfort receiving dental treatment using
only hand instruments than children who are treated using burs, when no local anesthetics are
used. Gender and initial anxiety level appear to have an important effect on the behavior of the
child, while also operating dentist might a role. None of these confounding variables seems to
have a measurable effect on the difference in treatment effect, though.

The lower degree in discomfort experienced during dental treatment could make a good case for
the widespread increase in the use of hand instruments as with the ART approach.

Further research should focus on cultural aspects and child coping behavior to optimize the use
of the ART method.

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