Clinical Performance of Heat-Cured High-Viscosity Glass Ionomer Class II Restorations in Primary Molars: A Preliminary Study

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Objectives: *The present preliminary study evaluated the clinical and radiographic performances of heat-cured high viscosity glass ionomer (HCHVGI) in class II restorations of primary molars.* ***Study design:*** *A retrospective study on a cohort of patients who had dental caries restored at a private practice was conducted. Restorations were evaluated radiographically and photographically by two separate examiners.* ***Results****: Ninety-three Class II restorations in 44 patients (average age: 108 months ± 25.3, 24 males, 20 females) were examined. Average recall time was 22.2 months ± 4.2. All but three restorations (96.8%) were present and intact, with no incidents of secondary caries. Three additional restorations had occlusal defects that required retreatment, resulting in an overall success rate of 93.5%. Ninety-seven percent of the restorations were rated optimal for marginal integrity with no staining of the restoration surfaces. No patients complained of post-operative sensitivity. The most common flaw found was a concavity on the proximal wall of the cavity box (27%, mean age 16 months ± 3.9).* ***Conclusion:*** *The findings in this preliminary study suggest that heat cured high viscosity glass ionomer cement may be an effective restorative material for Class II restorations in primary molars that are a year or two from shedding.*

Key words: *Glass ionomer, Primary Teeth, Dental Materials*

INTRODUCTION

Caries management in children requires a careful selection of the restorative materials, keeping in mind that restorations should last until the exfoliation of the teeth [1,2]. Class II restorations, used to restore proximal caries, are the predominant type of restoration in primary teeth [1,2] and have lower longevity than Class I restorations [1]. Although the cost of restoring primary teeth is high and increases when general anesthesia or conscious sedation techniques are needed [3], evidence- based data on the best restorative material for the primary dentition is lacking [4].

While for decades amalgam has been the preferred restoration in pediatric dentistry due to its tolerance of moisture contamination, ease of placement, resilience and low cost, increasing demand for improved esthetics and concern over the potential harmful effects of mercury have led to the widespread use of composite resin (CR) and glass ionomer cement (GIC) [5,6].

CR materials bond well to both enamel and dentin, reinforce residual tooth structure and are highly esthetic but the fact that they remain technique- sensitive renders their use in primary teeth problematic, as tooth isolation is often difficult and completion of such restorations can be very time consuming [7]. In addition, CRs are less bacteriostatic than amalgam, undergo polymerization shrinkage and may result in micro-leakage, marginal discoloration, poor marginal adaptation and secondary caries if not placed properly [8,9]. Furthermore, recent reports suggest that resins may contain toxic materials that could pose a health risk to children[10-12].

GICs consist of an aluminofluorosilicate glass powder and an aqueous polyacrylic acid that set in an acid-base reaction to form insoluble polysalt [13]. Traditional GI systems do not contain any resin monomers and are biocompatible. They have a thermal expansion coefficient similar to that of natural tooth structure, undergo minimal shrinkage, and form a physicochemical bond to enamel and dentin (7). An additional advantage very significant to pediatric patients is the material's ability to tolerate moisture and release of fluoride for uptake by associated enamel and dentin [14,15]. However, early GI cements lacked sufficient compressive strength and wear resistance for Class II restorations in primary teeth: a meta-analysis found conventional GIC had only 75% success rate in primary class II

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restorations while CR and resin-modified GIC had success rates of 83% and 89%, respectively [16]. An eight-year study found that 50% survival time for GI restorations was 3.6 years, while that of amalgam restorations exceeded 7.8 years [17]. This low wear resistance of GIC restorations was due to the fact that during the initial stage of setting, which produces the clinical set and occurs within the first 10 min after mixing, the material is very sensitive to water uptake [18].

High-viscosity glass-ionomer (HVGI), containing fiberglass particles, anhydrous polyacrylic acid of high molecular weight and high powder-to-liquid mixing ratio has improved compressive strength and wear resistance properties and facilitated handling, advocating its use for posterior restorations [17,19]. Temperature enhances the reaction rate but does not change the mechanical properties of the GICs [18]. These changes may be attributed to changes in molecular kinetic energy that may subsequently lead to a rearrangement of the molecules in the material, providing improved adhesion to tooth tissues[20]. Heat is generated in photo-sensitive dental materials as a byproduct of LED light curing which may be used as a source for heating glass ionomer in vivo [21]. In addition to enhancing the physical properties of GI, heat has also been shown to increases the release of fluoride ions[22], but it is important to note the temperature rise in the glass ionomer cements[23].

Laboratory studies that assessed the effect of heat application on the mechanical properties of glass ionomer cements differed in their conclusions: while some [24,25] found no effect, others [23,26] found significant increase of micro-hardness and biaxial flexural strength, decreased micro leakage and improved strength of restoration wall adherence to enamel [20,27]. Clinical research on HVGI in class II cavity in primary teeth has been limited [28], and much of it is related to HVGI's application in Interim Therapeutic Restoration (ITR) procedures [29] formerly known as the Atraumatic Restorative Technique (ART). While HVGI perform well in class I cavities [1,25], they have been less successful in class II restorations, with 7% cumulative failures reported for these restorations in primary teeth over a three-year period [30]. The application of heat during initial curing of the GI materials may allow their use as permanent proximal restorations. The purpose of the present preliminary study was to test, both clinically and radiographically, the performance of heat-cured high viscosity glass-ionomer (HCHVGI) in class II restorations in primary molars.

MATERIALS AND METHOD

The experimental protocol was approved by the Institutional Human Subjects Ethics Committee of Hebrew University- Hadassah School of Dental Medicine, Jerusalem, Israel (Reference number 0413-14-HMO). Informed consent was obtained from all parents/legal guardians of participating subjects to allow their information to be used in the study.

Of 274 HCHVGI class II restorations (EQUIA, GC America INC, Alsip, IL) placed over a period of two years at a private clinic, 94 restorations in 44 patients who had at least one 12-month recall examination were included in the study.

Inclusion criteria: The study sample was comprised of patients who had carious primary molars with involvement of proximal surfaces requiring treatment (i.e. the carious lesion reached the DEJ or beyond it) and had at least one 12-month recall examination.

The study group included 24 males and 20 females, aged 6.2-11.8 years (average age =108 months ± 25.3). Average recall time was 22.2 months ± 4.2.

The principal investigator (A.K) used a standardized protocol of the operative procedure to place all of the restorations.

Treatment procedure

After a local anaesthetic with 2% Xylocaine DENTAL with epinephrine 1:100,000 (lidocaine HCl and epinephrine Injection, USP. DENTSPLY Pharmaceutical, USA) was administered, a rubber dam was placed. Access to the proximal surface was gained with a high-speed 330 SSW diamond bur (SS White® Burs, Inc. USA) under an air–water coolant. Dental caries was removed using low-speed, round steel burs (Emil Lange, Engelskirchen, Germany): partial removal of carious dentin on the pulp wall was performed to avoid pulpal exposure.

The prepared cavity was restored using EQUIA GIC (EQUIA, GC America INC, Alsip, IL) according to manufacturer's orders. A metal T Band matrix (T-Band, Pulpdent Corp, Watertown, MA USA) with wooden wedges was applied to the tooth and the cavity was filled with the EQUIA GIC material.

Heat was applied with GCP Carbo LED thermo-heating unit (GCP Dental, Netherlands), with a heat curing power of 1500 mW/cm², at 50- 60ºC. Immediately after heat curing, occlusal interferences were checked and corrected using high-speed finishing and polishing diamond burs (Intensiv SA, Switzerland), under air–water coolant. Figures 1 to 4 illustrate the clinical and radiographic procedures.

Ninety-three Class II restorations in 44 patients (average age, 108 months ± 25.3, 24 males, 20 females) were examined. Recall examination comprised of bitewing radiographs and a clinical examination that included photographing the treated teeth.

The use of photographs to assess clinical situations has recently been studied by Boye *et al*, [31] who found no clinically significant differences between photographic scores and visual assessments and stated that the photographic approach confers considerable advantages in terms of examiner bias reduction, remote scoring and archiving[31]. This approach was used in the present study: Photographed restorations and bitewing radiographs were assessed by two independent examiners without the presence of either the patient or operator. The restorations were evaluated for five different clinical parameters and four radiographic parameters using a dichotomy scale as detailed in Table 1.

Each evaluator rated the images independently. When ratings were not in agreement the two examiners reviewed the photograph or radiograph together and reached a consensus rating. Overall failure rates were calculated as the percentage of restorations requiring retreatment over the number of restorations evaluated during the two year time period. In the event of a restoration being unsatisfactory, details of the mode of failure were recorded and the necessary remedial work carried out.

Table 1. Parameters, criteria and restorations ratings.

Parameters	Clinical criteria used to evaluate restorations	Restoration Ratings	
		Number	%
Clinical parameters			
Retention of restoration	Full retention (or very slight partial loss of material: no retreatment necessary)	90	96.8%
	Partial or total loss requiring retreatment	3	3.2%
Margin integrity	Continuous throughout occlusal table and marginal ridge	87	96.5%
	Visible evidence of missing material or discoloration at cavo-surface angle	3	3.5%
Occlusal wear/defects	None present or present but no retreatment required	87	96.5%
	Present and requiring retreatment	3	3.5%
Marginal ridge evaluation	Intact	80	89%
	Defective: Ditching or cracks	10	11%
Contact point	Present	82	91%
	Missing contact	8	9%
Radiographic parameters			
Homogeneity of the material	Good	86	96%
	Poor	4	4%
Integrity of proximal wall and box	No voids present, adaptation to vertical wall and floor complete	86	96%
	Voids, gaps present at restoration/ tooth interface	4	4%
Concavity defect of proximal wall (loss of material in the proximal contact region)	Not present	65	72%
	Present	25	28%
Secondary caries	None	93	100%
	Present		

Figure 1: Pre-operative clinical view of lower right first primary molar.

Figure 2: Lower right first primary molar after caries removal and cavity preparation.

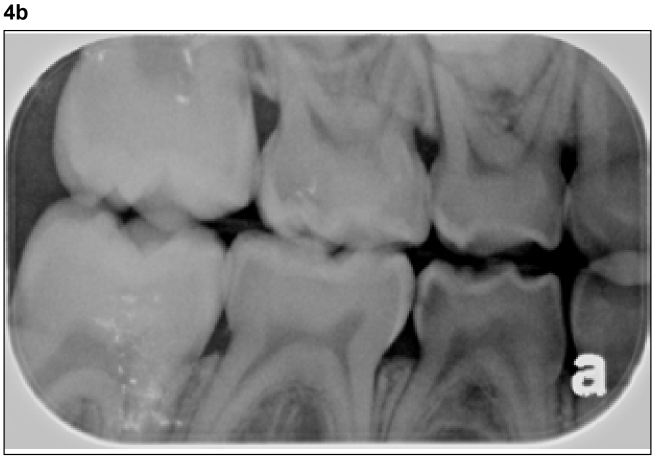
Figure 3: Lower right first primary molar restored with heat-cured high viscosity glass ionomer

Figure 4a-d shows an example of a HCHVGI restoration immediately following placement on first primary molar and after 24 months.

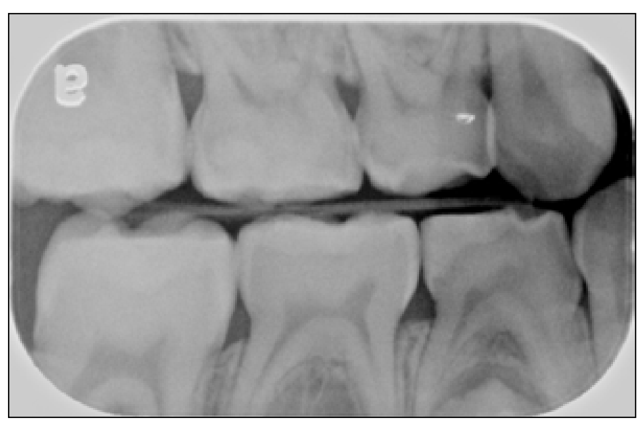
4a

4d

4b



4c



Statistical analysis

Descriptive statistics were used to analyze the ratings of the restorations. An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among examiners.

RESULTS

A total of 93 Class II restorations in 44 patients (average age, 108 months ± 25.3, 24 males, 20 females) were examined. The average recall time of the restorations was 22 months ± 4.2. Figure 4a-d shows an example of a HCHVGI restoration at placement and after 24 months. Mean ratings and failure rates are shown in Table 1. All but three restorations were found to be present and intact (96.8%); there were no incidents of secondary caries. Three additional restorations were found with occlusal defects that required retreatment resulting in an overall success rate of 93.5%.

Figure 5 shows an example of a radiograph from an 18-month recall. The most common flaw found was a concavity on the proximal wall of the cavity box as seen radiographically (27%) (Figure 6). However, over 90% of the restorations were judged clinically as having good contact points and intact marginal ridges. The condensation and homogeneity of the restorative material was radiographically assessed as being excellent (96%). Ninety-seven per cent of the restorations were rated optimal for marginal integrity and no staining of the restoration surfaces was recorded. No patients complained of post-operative sensitivity.

The inter-rater reliability for the examiners was found to be Kappa = 0.789 ($p < 0.001$).

DISCUSSION

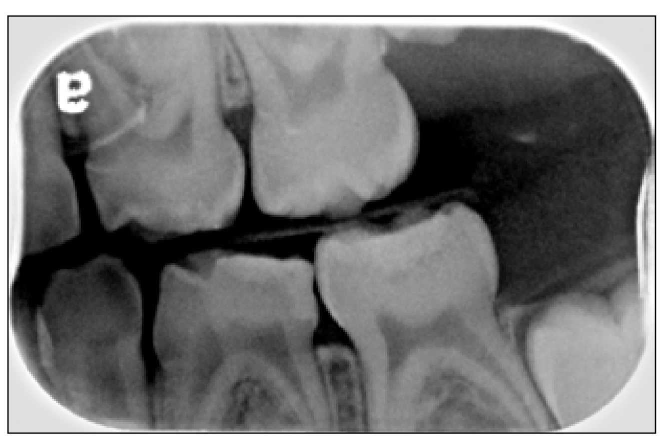
In the present study no restoration failed due to secondary caries. This striking result is contrary to several other studies [17-19] and is even in contrast to restorative studies of more durable materials such as composite or amalgam[1]. Possible reasons for the current results may be good oral health in the study population[4], increased release of fluoride ions from heat-cured HVGI[22], or other reasons, such as a study population of extremely low-risk for carries. We suggest that the results may be due to heat application shortening the vulnerable initial stage in the setting reaction. As stated, the major weakness of GI cements is their low fracture toughness. Although this shortcoming improves as the material maturates [32,33], incomplete chemical reactions and sensitivity to water during the first stage of the setting reaction of glass-ionomer cements results in softening and cracking of the cement surface and subsequently to reduction of its wear resistance and fracture toughness [26]. To overcome this shortcoming the manufacturer introduced the concept of coating the restoration with a layer of resin, recommending immediate application of a light-cured varnish. However, as it is impossible to apply the varnish to the proximal wall of the box in class II restorations, the contact point is never accessible, rendering the contact area unprotected from water uptake after the initial hardening phase. Indeed, the most common defect found in a recent study using this system was loss of material at the unglazed proximal contact point, while the glazed occlusal surfaces did not show wear or disintegration[34]. In addition, as mentioned before, resins may contain toxic materials that could pose a health threat especially in children[10-12].

Shortening the vulnerable initial stage in the setting reaction [19] with fast setting GI restorative cements did not satisfactorily improve the materials mechanical and physical properties to allow their use in class II restorations [18]. We suggest that in the present study heat transmitted through the metal matrix may have accelerated the setting time of the susceptible proximal areas. This phenomenon may explain the success rate of over 90% of the restorations that demonstrates a significant improvement over non-heated HVGIC proximal restorations. Studies in high caries risk populations are needed to determine if indeed this is the case. We emphasize that a longer surveillance time is imperative to determine if our results do not stem from very specific conditions.

An important issue to address is the effect of heat elevation on tooth tissues: As mentioned in the introduction, temperature rise was noted in the heat-cured GIC restorations[23]. Recently published papers on heat generation with laser device found that the blood circulation of the pulp tissue might avoid extensive heat-caused damages[35]. This issue cannot easily be dealt with in a clinical study, but deserves further attention.

Figure 5: Lower second primary molar was restored on mesial aspect: 18 month postoperative bitewing. Note excellent adaptation along axial wall and floor of cavity preparation. The radiopacity of the restoration is similar to that of the tooth structure.

Figure 6: The most common flaw found was a concavity on the proximal wall of the cavity box as seen radiographically with loss of material in the proximal contact region. The lower first primary molar shows evidence of this flaw 15 months following placement.



The limitations of this study derive from its design (no control group with other types of restorations). This is thus an observational study, with results that deviate from the general failure patterns of GICs in other studies. Yet, being one of the first clinical studies on HCHVGI, we believe that these results are worth noting.

Based on our preliminary results we suggest HCHVGI cement may be adequate for Class II restorations in primary molars that are a year or two from shedding. In such teeth, this material should be further investigated as an alternative to amalgam and resin-based composites for proximal restorations due to its many benefits and advantages. In spite of controversial evidence, GIs are widely used by clinicians as their biocompatibility, one- stage bulk placement and fluoride release [17,18,26] render them especially valuable in treatment of the primary dentition.

CONCLUSION

The findings of the present preliminary observational study suggest that heat cured high viscosity glass ionomer cement may be an effective restorative material for Class II restorations in primary molars that are a year or two from shedding.

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