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Comparison of the remineralisation effect of a glass ionomer cement versus a resin composite on dentin of primary teeth

ABSTRACT

Aim *The aim of this study was to investigate the interaction of a high viscosity glass ionomer cement (GIC) and a composite resin with caries affected dentin and to determine the remineralization levels.*
Materials and Methods *In a split mouth design 24 GIC and composite resin atraumatic restorative treatment restorations were made* in vivo *and the teeth were collected after 2 years and subsequently sectioned and examined using Vickers microhardness test; the latter was performed starting from the dentin surface adjacent to the restoration. Repeated Measure ANOVA and Bonferroni statistical methods were used for data analysis.*
Results *The microhardness adjacent to the GIC restorative material resulted to be significantly higher.*
Conclusion *GIC resulted to be a better restorative material for the remineralization of caries affected dentin, though further studies are necessary for the corroboration of this finding. The GIC restored primary molar dentin had a higher level of remineralization and GIC could be the material of choice in pediatric dentistry.*

Keywords *Atraumatic restorative treatment; Composite; Glass ionomer cement; Microhardness, Remineralization.*

Introduction

Many new caries removal techniques have been recently developed aiming at a better preservation of sound and remineralisable tissues [Mount, 2008]. The idea of preserving the affected dentin has resulted in the development of new systems of caries removal for saving sound and remineralisable tissues [Fusayama, 1991]. Atraumatic restorative treatment (ART) is a minimally invasive technique for removing the infected layer of soft and demineralised dental tissues using hand instruments [Frencken and Holmgren, 1999], leaving only the caries affected partially demineralised dentin layer. This technique includes the use of GIC: the remineralisation underneath the restoration and the formation of a hardened layer from the initial demineralised dentin is its main advantage [Smales and Gao, 2000; Randall and Wilson, 1999; Weerheijm and Groen, 1999]. GIC, in fact, have various repairing capacities towards caries affected and infected dentin [Hotta et al., 2001; Itota et al., 2006; ten Cate and van Duinen, 1995], the need for preparing larger cavities might be avoided and the remaining tooth structure would be stronger if caries affected dentin can be remineralised successfully [White and Eakle, 2000; Gao et al., 2000]. It is reported in many studies that GIC enhances dentin remineralisation through fluoride ion release which may imply that a surgical approach may be unnecessary and can be replaced by a biological or a therapeutic approach in many cases [Hotta et al., 2001; Ngo et al., 2006; Smales et al., 2005].

Studies on the influence of other restorative materials on caries affected dentin left under the ART restorations are limited. Therefore, the remineralisation effects of a GIC and a composite resin on caries affected dentin in cavities prepared by ART in primary molars were investigated in this clinical study.

Materials and methods

Three dentists performed a total of 419 ART restorations in 219 children. Each patient received two restoration: a high-viscosity GIC (Fuji IX, GC Europe NV, Leuven, Belgium) and a packable resin-based composite (SureFil, Dentsply/DeTrey GmbH, Konstanz, Germany) along with a dentin bonding system (Xeno III, Dentsply/DeTrey GmbH). Complete details of the application procedures of the restorations have been published previously [Ersin et al., 2006]. The parents were asked to return their children at the end of 2-year period. However, from 419 restorations, just 24 suitable primary molars from 12 subjects were available for evaluation. The restorations stayed in the mouth for 24-28 months before obtaining them.

The teeth collected were sectioned mesiodistally through the center of the restorations and then two sections (vestibular and lingual) were obtained, which were embedded in polyester resin.

The Vickers microhardness (Hv) was determined after polishing the surfaces of each specimen. Indentations were made, by means of a hardness tester (TIME Technology Europe HVS-1000), starting from the restoration-dentin

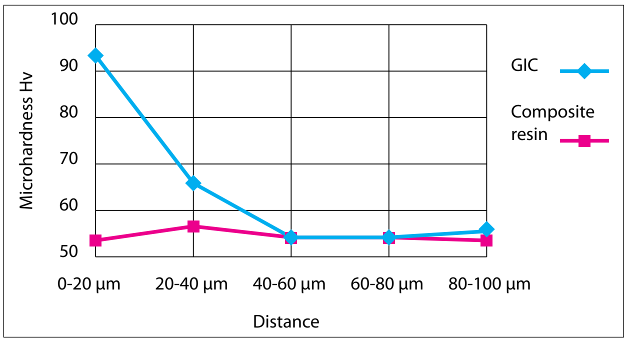

FIG. 1 The variation of microhardness in the 100 µm thick dentin layer for both GIC and composite resin restorations.

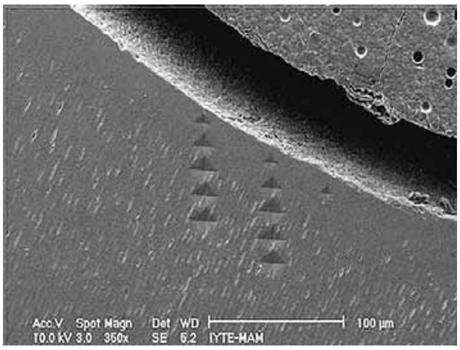

FIG. 2 Scanning electron micrograph of indendations in the GIC restorated dentin.

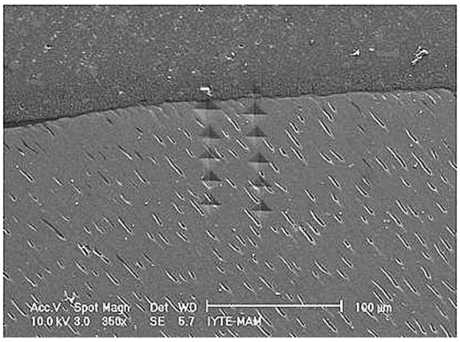

FIG. 3 Scanning electron micrograph of indentat- ions in the composite resin restorated dentin.

interface and at 20 µm intervals in the underlying sound dentin to a different region of 100 µm. The microhardness measurements were conducted under 0.098 N with a loading time of 15 s. These measurements were performed three times along parallel directions on each specimen forming at least three indentation lines. Since the variation of the hardness was expected to occur in the close vicinity of the restorations, the interactions between the traces were ignored. All specimens were mounted on a circular aluminium stub and gold coated in a sputtering unit after microhardness determinations. SEM morphological analysis was conducted on a Philips XL 30 SFEG system. Repeated Measure of ANOVA with Bonferroni Correction was used for parametric analysis of the data in SPSS 13.0 (SPSS Inc., Chicago) program.

Results

The average microhardness at 5 different regions from the interface to the underlying dentin is shown in Figure 1. The average microhardness of the dentin underneath GIC varied in a range of 93.43-54.10 Hv. Data showed a significant difference in hardness between the first (0-20 µm) and the other subsequent regions ($p<0.05$). The mean microhardness (Hv) of the second region was also higher when compared with those of the 3rd, 4th and 5th regions ($p<0.05$). The average dentin microhardness underneath the Surefil restorative material showed a similar microhardness for all regions. The average microhardness values of these five regions ranged from 53.53 to 56.45 Hv.

The SEM images of the indentations on dentin samples underneath the restorative materials are shown in Figures 2 and 3, where the morphologies of the traces and the tubules in the investigated dentin surfaces are clearly visible. The presence of a denser remineralised layer adjacent to the restoration surface with a lower number of tubules for GIC restoration can be seen in Figure 2. The sizes of the traces in the SEM pictures can be inversely correlated with microhardness. The compositions of all regions were similar in the samples restored with composite resin.

Discussion and conclusion

Microhardness testing is an indirect method to evaluate the mineral content of the tissue, and to determine the mineral loss or gain in density through the demineralisation and remineralisation process [Davidson et al., 1974; Feagin et al., 1969, 15,16]. The load used to make the indentations in this study was 10 g, which was similar to what Santiago et al. used [2005]. The use of relatively high loads during microhardness testing of dentin may lead to incorrect measurements due to crack formation during testing that's why lower load was used in this study. The average dentin microhardness underneath the composite restorative material was very similar for all regions. The caries affected dentin microhardness under composite resin might be increased by the sealing ability of the restoration. In vivo remineralisation of artificially demineralised dentin beneath non GIC and non-fluoride releasing materials has been shown in dogs [Kato and Fusayama, 1970] and in monkeys [Tatsumi et al., 1992]. These two animal studies attributed the remineralisation process essentially to physiological processes occurring in vital pulps. This phenomenon may also affect the microhardness of the adjacent dentin layer to the composite resin. The microhardness underneath the composite resin might also be attributed to an operator effect; excavation of almost all of caries affected dentin or the 2 year period of time factor might be the reasons for the determination of similar microhardness for all regions although it was not possible to determine the baseline microhardness levels of the caries affected dentine under the ART restorations in this work. This may be due to the recovery of the dentin layer adjacent to the restoration for the 2-year period of time or excavation of the caries affected dentin during ART by the operators.

The data demonstrates a significant difference in microhardness between the first and the other subsequent regions and also between the second and the 3rd to 5th regions for GIC restorations. In an in vivo study, the microhardness of the dentine under GIC restored ART restorations increased over time although this increase was not sufficient for the microhardness to reach a value similar to that of healthy dentin. The authors characterised the restorations in four definite time intervals and significant differences were determined in Zone 1 (just below the restoration) and Zone 2 (intermediate region between 1 and 3); however Zone 3 (as close as possible to the pulp) did not indicate a difference in time [Santiago et al., 2005]. The differences between the results of the above and this work may be due to basically two factors. The first of these being the restoration lifetime which was over two years in the current work and for six months in the other study and the second factor is the presence of thicker carious dentin layer as was clearly seen in the SEM micrographs of the dentin interface in Santiago et al.'s study. Excavation of more carious dentin in ART cavities was most likely conducted in the current work, whereas during the ART application on the 29 teeth chosen in the work reported by Santiago et al. [2005] the carious tissue was partially removed. Lo and Holmgren also reported that, when an ART restoration was missing, the exposed dentine surface of the cavity was usually found to be hard and this could be due to the removal of all soft caries during the ART cavity preparation, the area being made self-cleansing, the healing effect of the GIC through hypermineralisation [Lo and Holmgren, 2001]. The increase of microhardness of the dentine adjacent to the GIC which was observed in this work agrees with their findings on hardness increase with time and this common observation may be attributed to the ionic exchange of fluorine and strontium process causing remineralisation as was previously described [Ngo et al., 2006; Smales et al., 2005]. It was seen that GIC had a better performance in the remineralisation process compared to the composite resin. Hotta and Sekine investigated mineralisation in conventional GIC and polyacid resin composite restored bovine teeth and they reported a significant increase in hardness between the first 20 μm thick layer and the other layers under GIC restorations and concluded that hypermineralisation occurred within the superficial dentin cavity wall [Hotta et al., 2001]. These are similar with the findings of this work. Yang et al. also compared the remineralisation of human natural caries and artificial caries-like dentin lesions treated by restoring with an experimental ART composite and a resin modified GIC. The authors indicated that resin modified GIC and the ART composite showed a similar high level of remineralisation in artificial dentin lesions but not in natural dentin lesions [Yang et al., 2011]. The experimental ART composite which contains HA (Hydroxyapatite) cement forming compounds had a significant remineralisation effect on both natural and artificial dentin lesions. The primary molar dentin restored with GIC had a higher level of remineralisation compared to their composite resin counterparts in this work. This can be clearly seen in the SEM pictures, where a hypermineralised layer was formed and some dentin tubules were blocked with mineral deposits underneath the GIC restorations. The same GIC and the resin-based composite restorative materials placed with the ART approach under field conditions exhibited satisfactory results after two years and there was no statistically significant difference between their clinical success rates as previously reported [Ersin et al., 2006].

It can be concluded that not only the remineralising ability but also a good sealing ability and adequate mechanical properties of the restorations are required for better clinical survival rates. The development of restorative materials possessing all these properties in the near future would be a breakthrough in restorative dentistry.

Conflict of interest

The authors declare that they have no conflict of interest.

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