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Surface Hardness Properties of Resin-Modified Glass Ionomer Cements and Polyacid-Modified Composite Resins

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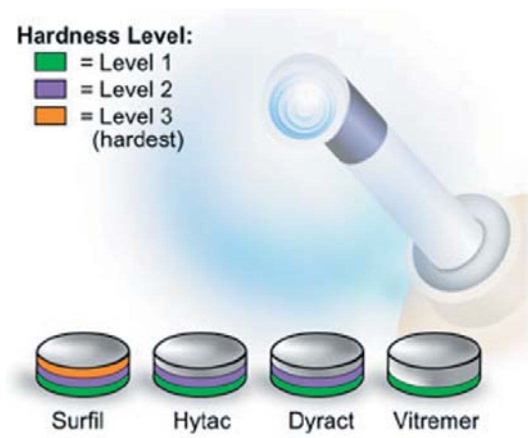

Abstract

In this study the top and bottom surface hardness of two polyacid-modified composite resins (PMCRs), one resin-modified glass ionomer cement (RMGIC), and one composite resin were evaluated. The affect of water storage on their hardness was also investigated. The study was conducted using four different groups, each having five specimens obtained from fiberglass die molds with a diameter of 5 mm and a height of 2 mm. Measurements were made on the top and bottom surface of each specimen and recorded after 24 hours and again at 60 days. All tested materials showed different hardness values, and the values of top surfaces of the specimens were found to be higher than the bottom surface in all test groups. There was no statistical difference in the Vickers hardness (HV) values when the test specimens were kept in water storage. In conclusion Hytac displayed microhardness values higher than Vitremer and Dyract. We found the order of HV values to be Surfil > Hytac > Dyract > Vitremer, respectively. Vitremer presented the lowest microhardness level and Surfil the highest.

Keywords: Composite resin, microhardness, polyacid-modified composite resin, resin-modified composite resin

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Introduction

Until recently, the two primary esthetic restorative dental materials were glass ionomer cements (GICs) and composites. Over the last decade, manufacturers have developed further materials in an attempt to combine some of the properties of GICs (such as adhesion and fluoride release) and the mechanical characteristics of composites. These relatively new materials are the resin-modified glass ionomer cements (RMGICs) and compomers (or polyacid-modified composites).[1-3]

RMGICs have both glass ionomer and resin components. In some RMGICs the monomer resins are separate to the polyalkenoic acid molecules which form the basis of the ionomer. In other materials a number of carboxylic acid moieties from the polyalkenoic acid have been substituted by vinyl groups. In both cases photo-initiation of the resin components allows the materials to form a working set through the formation of a polymer skeleton. A continuing acid-base reaction establishes the hydrogel matrix of glass ionomers so the set materials contain both polymer and hydrogel elements. The RMGICs retain an adhesive potential through the carboxylic acid moieties. Compomers (or polyacid-modified composites) are basically dimethacrylate resins with carboxylic acid groups grafted into the molecule. They would react with the basic glass. The predominant setting reaction is polymerization. After placement, over a number of months, the materials absorb water from the oral environment. This activates the acid which reacts with the basic glass particles in an ionomer-type reaction.[4-7]

These materials are intended to overcome the disadvantages of conventional GICs such as a short working time, long setting time, and sensitivity to water in the early stage of setting, while preserving their clinical advantages which are esthetics, self-adhesion to dental tissue, fluoride release, and thermal insulation. Restorative filling materials used in dentistry are required to have long-term durability in the oral cavity. Curing dental composite restoratives in the oral cavity with visible light is the standard method of polymerizing composites. An inherent disadvantage of resin composites is that sufficient polymerization depends on some factors such as light intensity, curing time, and material thickness during light polymerization.[8-10]

Microhardness testing can be performed to evaluate the setting reaction of the resin-modified glass-ionomers and polyacid-modified composite resins (PMCRs). The increase in microhardness levels indicates the cement setting reaction continues after light curing. This increase is an indicator of the maturity of the reaction or its stage.[11-13]

The objective of the present study is two-fold: (1) to investigate the surface hardness properties of two PMCRs, one RMGIC, and one composite resin and (2) to analyze the influence water has on the microhardness of the tested materials.

Materials and Methods

Table I illustrates the materials used in this study, including two PMCRs, one RMGIC, and one dental composite resin. Both Dyract (DENTSPLY DeTrey, Konstanz, Germany) and Hytac (ESPE Dental, Seefelt, Germany) are PMCRs; Vitremer (3M Dental, St. Paul, USA) is RMGC; and Surfil (DENTSPLY DeTrey, Konstanz,Germany) is dental composite resin.

The effectiveness of curing may be assessed directly or indirectly. Direct methods that assess the degree of conversion, for example laser Raman spectroscopy[14] and infrared spectroscopy[15], have not been accepted for routine use because they are complex, expensive, and time consuming. Surface hardness was used as a more sophisticated (indirect) method of measur-

Table 1. Materials used.

Materials	Manufacturer	Classification
Surfil	Dentsply	Composite resin
Hytac	ESPE	Polyacid-modified Composite Resin
Dyract	Dentsply	Polyacid-modified Composite Resin
Vitremer	3M Dental Products	Resin-modified Glass Ionomer Cement

ing the degree of polymerization, which plays important roles determining the success of a dental restoration. Surface hardness testing has been used in many studies because of its relative simplicity and good correlation to the degree of conversion using infrared spectroscopy.[16-18] Therefore, we used the hardness to evaluate the curing performance of water storage for two PMCRs, one RMGIC, and one composite resin.

The study was conducted using four different groups, each having five samples, obtained from fiberglass die molds with a diameter of 5 mm and a height of 2 mm. The specimens were light-cured for 40 seconds at 450-500 mw/cm^2. The light tip was in close contact with the restoration surface during polymerization. (Hilux Dental Curing Light Unit/Benlioglu Dental Inc., Turkey). The cured specimens were then separated from the molds. The intensities during the curing modes were monitored by means of a curing radiometer (Hilux, Benlioglu Dental Inc., Turkey).

All test specimens were stored in a dark container in 37˚C-distilled-water for 24 h. A Vicker's diamond identor was used in a microhardness tester (Micromet-2001, Buehler, Dusseldorf, Germany) for specimen indentation. Twice indentations of microhardness were made randomly in each specimen's top and bottom surface at 1 day and 60 days, using a load of 10 g for 15 s. The diagonal impressions were measured and the hardness Vickers $HV=1.854P/d^2$, where P is the indentation load, and d is the diagonal length impression (Figure 1).

The analysis of variance (a one-way ANOVA) was employed to compare the restorative materials (two PMCRs, and one dental composite resin), times (1 day and 60 days), locations (top and bottom), and their interaction effects. This was followed by Duncan's multiple comparison test ($\alpha = 0.05$), which compared microhardness values at all time periods. The statistical analysis was made by SPSS 10.0 software.

Results

Figure 2 shows the mean microhardness values including standard deviation and Duncan's multiple comparison test results of the four test materials investigated.

Figure 3 shows mean Vickers hardness (HV) values and standard deviation of the tested materials' top and bottom surfaces.

The ANOVA showed significant differences for restorative materials ($P<0.05$) and location ($P<0.05$), but no significant differences were shown for water storage.

Comparisons of the mean microhardness values for each material by the Duncan test showed statistical differences among all the materials. Surfil showed the highest hardness value at both 1 day and 60 days. Hytac was found to have the highest microhardness value among hybrid ionomers. Vitremer was found to be as hard as Dyract.

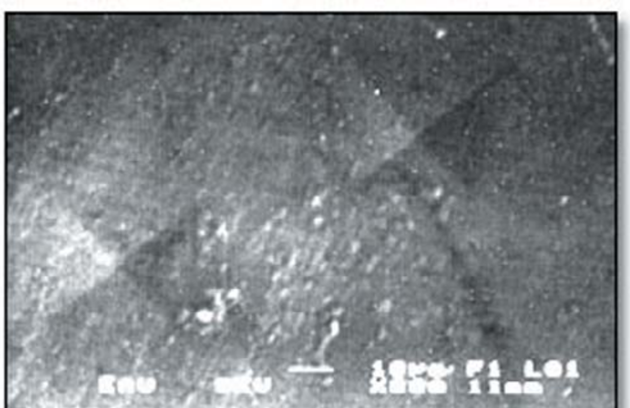

Figure 1. Vickers pyramids on microscope.

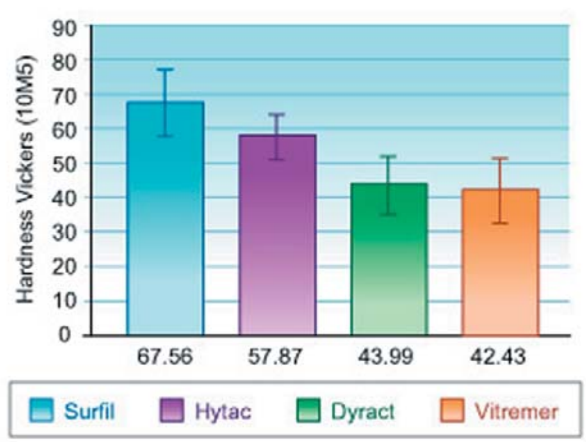

Figure 2. Mean Vickers hardness values and standard deviations of the tested materials (p<0.05).

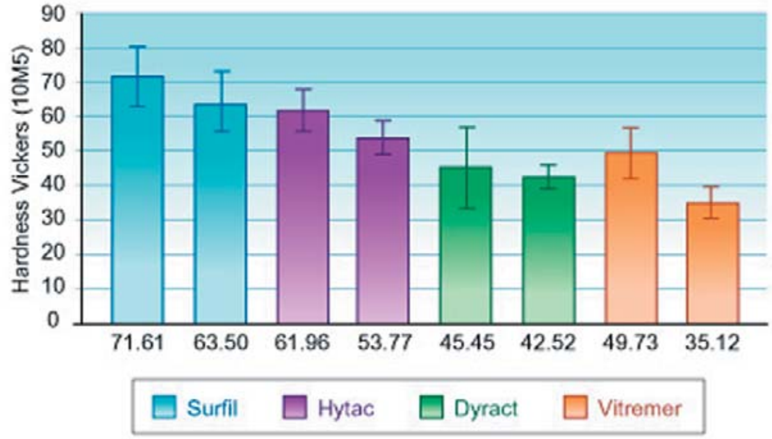

Figure 3. Mean Vickers hardness values and standard deviations of the tested materials' top and bottom surface ($p<0.05$).

Discussion

In the present study all test materials showed different hardness values; the top surface values were found to be higher than the bottom surface values in all test groups. There was no significant difference in the HV value when the test specimens were kept in water ($P>0.05$). Vitremer showed the lowest microhardness level, followed by Dyract, and then Hytac. Surfil showed the highest microhardness values. Hytac had the highest hardness value among the hybrid ionomers; its hardness was highly comparable to modern composite (Figure 2).

Peutzfeld et al.[19] found the order of microhardness among resin-based materials to be composite>compomer>RMGIC, respectively. In another study, Hytac had microhardness values higher than Vitremer, Dyract, and Compoglass. However, all products tested showed the values significantly lower than Z100 composite resin.[20] Our results were similar to these studies.

In this study we found significantly different top and bottom surface hardness values. When the curing light is applied to composite resin, the light is absorbed and scattered by the composite resin with the intensity decreasing below the top surface. It was noted the curing light generally cures the macrofill and heavy filled hybrids (like Surfil) better than other composites.[21-24]

In the present study it was found there was no statistical difference in the HV values when the test specimens were kept in water storage. Tsuruta and Vohl[25] reported the influence of humidity on hardness of light cured polyalkenoate cements stored in air. In their report hardness increased with time when test specimens were stored in dry conditions, but in high humidity and in water no increase occurred. Cattani-Lorente et. al.[26] investigated the affect of the water sorption upon the mechanical characteristics of a RMGIC and PMCR. Dyract showed higher mechanical properties than Fuji II LC. For the two materials, aging time did not significantly influence their properties. Munack et al.[27] pointed out surface microhardness and structure of the investigated compomers were not significantly deteriorated by the tested intraoral condition in a long-term period. In the present study, there was no statistical difference in the HV values when the test specimens were kept in water storage. These results support our findings.

In this study similar observations have been made with composite resin and PMCR; especially Hytac was found to be as hard as Surfil but RMGICs were not.

Recent studies have focused on reporting that PMCRs such as Dyract, Geristore, and Variglass more closely approximate resin composites, and Fuji II LC, Ionosit-fil, Photac-fil, and Vitremer are true RMGICs that more closely approximate the conventional GICs.[28-30]

Conclusion

Surfil showed higher microhardness than the others, consequently, Surfil has a more complete polymerization among the tested materials. Hytac displayed microhardness values higher than Vitremer and Dyract. There was no statistical difference in the Vickers hardness (HV) values when the test specimens were kept in water storage. Restorative materials technology is rapidly improving. It is important to choose the best restorative for ease of use by clinicians and durability that reduce long-term cost of dental treatment for patients.

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