Comparative evaluation of microhardness between giomer, compomer, composite and resin-modified GIC

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Abstract

Aim: Aim of this study was to evaluate microhardness of of a relatively new material Giomer as compared to other commonly used resin based restoratives; Compomer, Hybrid Composite and Resin modified glass ionomer (RMGIC).

Material and Methods: Ten sample discs were made from each of the four restorative materials using stainless steel moulds. The surface microhardness of the Giomer, Compomer, Hybrid Composite and RMGIC were measured on each side using a Vicker's microhardness tester at a magnification 500X. A 100g load with a holding time of 15 seconds was used for all the samples. The size of the indentations was used to measure the microhardness of the test materials.

Statistical Analysis: The data was analysed using the one-way ANOVA (Analysis of variance) test. The result is considered statistically significant if the 'p' value obtained is <0.05 level of significance.

Results: The microhardness of all the four materials differed significantly from each other (p<0.001). The highest value was given by Giomer which was significantly harder than Hybrid Composite which in turn was significantly harder when compared to RMGIC. The Compomer showed the lowest value among the four test materials.

Conclusion: The order of hardness from highest to lowest is as follows: Giomer> Composite> RMGIC> Compomer.

Keywords: Giomer, Resin based restorative materials, Vicker's Hardness Test.

Introduction

The property of hardness is of major importance in the comparison of restorative materials. It is defined as the resistance of a material to indentation[1] and is related to the materials strength and rigidity. The final surface hardness of a dental restoration is crucial for its resistance to wear. It has been suggested that materials with lower surface hardness suffer more abrasive wear and a recent in vitro study has proven a strong relationship between hardness and wear of materials.[2]

Giomer is a relatively new innovative filler technology of resin composite as an esthetic direct restorative material for anterior and posterior teeth restoration. Similar to a traditional methacrylate-based composite, the chemical composition encompasses inorganic filler particles and organic-resin matrix.[3,4] In place of applying purely glass or quartz as the typical fillers, the Giomer incorporates inorganic fillers (ranges between 0.01 and 5μm) that are derived from the complete or partial reaction of ion-leachable fluoroboroaluminosilicate glasses with polyalkenoic acids in water before being interfaced with the organic matrix.[3,4] This created a stable glass-ionomer phase on a glass core in which they induced an acid-base reaction between acid reactive fluoride containing glass and polycarboxylic acid in the presence of water and developed as a pre-reacted glass ionomer (PRG) filler.[5] The pre-reaction can involve only the surface of the glass particles called surface reaction type PRG (S-PRG)) or almost the entire particle termed full reaction type PRG (F-PRG).[5] Beautifil uses S-PRG (surface reaction type) where only the surface of the glass filler is attacked by polyacrylic acid and a glass core remains.[4]

Glass ionomers have several advantages like ability to bond to dental hard tissues, fluoride release and co-efficient of thermal expansion similar to tooth structure. Resin Modified Glass Ionomer Cements (RMGIC) were introduced in 1990s to overcome the drawbacks of conventional GIC, by possessing a prolonged working time, improved translucency, faster set and attainment of early strength.[9] Compomers are best described as composites to which some glass ionomer components have been added. Overall, their physical properties are superior to traditional glass ionomers and resin modified glass ionomers but inferior to those of composites. They are mainly used for class V restorations. Although Compomers are capable of releasing fluoride, the release is not sustained at a constant rate.[6-8] Composite resins are the most commonly used direct restorative materials that meet the requirements of preservation of tooth structure, high esthetic appearance, and longevity. Microhybrid composites give high polishability and good mechanical properties and they are considered as all-purpose universal composite resins.[10,11] Thus the aim of the study was to compare the microhardness of Giomer with other common esthetic restorative materials; Compomer, Hybrid Composite and RMGIC.

Material and Methods

This study was conducted at Government Dental College, Thiruvananthapuram, Kerala, India. The Giomer used for the present study was Beautifil (Shofu Inc, Kyoto Japan); an S-PRG giomer. The Compomer used in this study was Dyract® (De Trey, Dentsply) which is supplied as single light curing component, without necessity of mixing. The composite material

used in the study was a hybrid composite material – Spectrum® TPH® (De Trey, Dentsply); a visible light activated radiopaque sub- micron hybrid composite. The RMGIC used in the study was Fuji II improved (GC Corp: Tokyo, Japan); supplied as a powder and liquid.

The compositions of the materials used are given below [Table 1, 2]. All materials were dispensed, manipulated, and polymerized according to manufacturer's instructions.

Table 1: Composition of Giomer, Compomer and Hybrid Composite

Material	Category	Filler size	Filler content (% volume)	Composition
BEAUTIFIL Shofu Inc, Kyoto, Japan	Giomer	0.01-5μ	66.3	Bis GMA, TEGDMA, S-PRG based fluoroboro-aluminosilicate glass fillers.
DYRACT® DeTrey, Dentsply	Compomer	0.8μ	45	UDMA resin, TCB resin, strontium-fluoro-silicate glass, strontium fluoride, photo initiators, stabilisers
SPECTRUM® TPH® DeTrey, Dentsply	Hybrid composite	0.04 - 5μm	57	Bis GMA- adduct, Bis EMA, TEGDMA, photo initiators, stabilizers, Barium aluminium borosilicate, highly dispersed silicon dioxide.

Table 2: Composition of RMGIC

Material	P/ L ratio(g/g)	Category	Composition
FUJI II LC GC Corp: Tokyo, Japan	3.2 :1	Light cured glass ionomer	**Powder:** Aluminosilicate glass, pigments **Liquid:** Polyacrylic acid, distilled water, HEMA(17%), Dimethacrylate monomer, camphoroquinone

i. **Sample Preparation:** The microhardness of Giomer, Compomer, Hybrid Composite and RMGIC was tested according to ASTM guidelines (Spec. No: E 384-89). The samples for microhardness testing were made using a stainless steel mould with cylindrical holes having 3 mm height and 6 mm diameter. Ten specimens were made for each group and thus a total of 40 samples were prepared. The Giomer, Compomer and Composite materials were all single component pastes and were packed tightly into the cylindrical holes in the mould. For RMGIC, the powder and liquid were mixed as per manufacturer's instructions and then tightly packed into the mould. Both sides (top and bottom) of the mould were covered with cellophane sheets and a glass plate was pressed on the top to extrude the excess material which was then removed. The materials were cured using a Tungsten Halogen light (Spectrum, Dentsply) curing unit. The tip of the visible light curing unit was placed against the cellophane sheet and the samples were cured for 60 seconds from both top and bottom sides. The samples were taken out and an additional 20 second exposure was given at the sides to ensure

uniform curing. The specimens were removed from the mould and visualized for any bubbles or defects. Defective specimens were discarded. The samples were then stored in distilled water in an incubator (NSW, Mumbai) maintained at 37°C for 23 hours.

At the end of 23 hours, they were transferred to the laboratory and kept at the testing temperature for 1 hour. The specimens were then blotted dry and were subjected to microhardness testing. The Vicker's microhardness test was done for assessing the microhardness test.

ii. **Vickers Microhardness Test:** For each testing 10 specimens from each group were used. The surface microhardness was measured on each side using a Vicker's microhardness tester (Micromet-2001, Buehler, Dusseldorf, Germany) for specimen indentation. All the measurements were done at a magnification 500X. A diamond indenter which is a square based pyramid is used for Vicker's microhardness measurements. The specimen was placed flat on a glass slide and mounted on a holder on the microscope stage. The specimen surface was examined microscopically and the indenter was then moved into position and the microscope stage was

raised steadily until the required load was applied by the indenter on the specimen [Fig. 1]. In all cases a load of 100g was used. The load was held for 15 seconds before the microscope stage was steadily lowered. The indenter was then replaced with the objective lens and the image of the indentation was focused. The size of the diagonal of the indentation was measured. Vicker's hardness was calculated by dividing the load by the area of the pyramidal impression.

$HV = 1.854 \, p/d^2$ where p is the indentation load and d is the diagonal length impression.
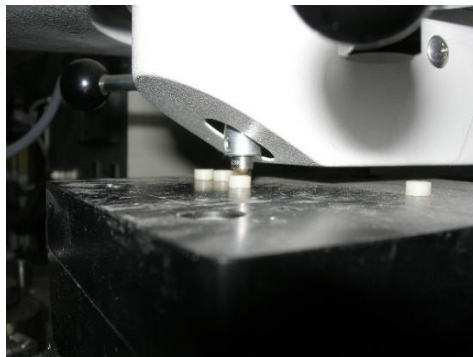
Fig. 1: Specimens on microscope stage with indenter in position

Statistical Analysis

The means and standard deviations were calculated by averaging the individual values of each sample. The results were analyzed using one-way ANOVA (Analysis of variance) test. The result is considered statistically significant if the 'p' value obtained is <0.05 level of significance. A result indicating 'p' value<0.01 implies highly significant difference between the variables under study. The inter group comparisons were made using Duncan's Multiple Range Test.

Results

The microhardness values were obtained from Vickers microhardness tester with a load of 100 grams for 15 seconds (Vickers hardness, or HV, 0.1/15). 10 indentation measurements were made for each material on each specimen. The mean hardness value of each material is shown in Table 3. The Giomer showed the highest mean microhardness value (53.833) of all the materials tested. This was followed by Hybrid Composite (52.450) and RMGIC (50.77). The least value was shown by the Compomer (40.667).

Table 3: Microhardness values of test materials

Test materials (n=10)	Mean microhardness values
Giomer	53.833
Compomer	40.667
Hybrid Composite	52.450
RMGIC	50.700

The mean microhardness values of the Giomer, Compomer, Hybrid Composite and RMGIC along with their standard deviations, F value and P value are given in Table 4. The microhardness of all the four materials differed significantly from each other. The highest value was given by Giomer which was significantly harder than Hybrid Composite which in turn was significantly harder when compared to RMGIC (p<0.001). The Compomer showed the lowest value. It was significantly less hard when compared to the other three test materials (p<0.001). The order of hardness from highest to lowest is as follows: Giomer> Hybrid Composite> RMGIC> Compomer.

Table 4: One-way ANOVA comparing microhardness of test materials

Material	Mean*	± SD	F value	P value
Giomer	53.833[c]	0.965		
Compomer	40.667[b]	0.812	347.088	< 0.001
Composite	52.450[a]	0.689		
LC GIC	50.700[d]	0.633		

a, b, c, d: Means with same superscript do not differ each other (Duncan's Multiple Range Test) * Mean of 10 observations per material

Discussion

Hardness is an important mechanical property of a dental restorative material. The term refers to stiffness or temper of a material. Hardness is also used to give an indication of the abrasion resistance of the material, particularly where the wear process is thought to include scratching as in abrasive wear. The property of hardness is of major importance in the comparison of various restorative materials. It is defined as the resistance of a material to indentation and is related to the materials strength and rigidity [1]. It has been suggested that materials with lower surface hardness suffer more abrasive wear and a recent in vitro study has proven a strong relationship between hardness and wear of materials.[2,13] **Ulvestad** suggested that one of the methods of evaluating a material's resistance to attrition is to apply a hardness test.[12] The value of hardness often referred to as hardness number depends on the method used for its evaluation. Common methods used for hardness evaluation include Vickers, Knoop and Brinell. The Vickers test is suitable for determining the hardness of quite brittle materials and was therefore used for the measurement of hardness of test materials in the study.

Vickers hardness measurement involves the use of a diamond pyramid indenter that has a square base. The hardness is a function of the distance across the diagonal axes of the indentations made. Allowance is naturally made for the magnitude of the applied loads. Measurements are normally made using a microscope since the indentations are often too small to be seen with the naked eye. For those methods involving the measurement of an indentation with a microscope, like the Vickers test, after the indenting force has been removed, the hardness value is related to the degree of permanent deformation produced in the surface of the test material by the indenter under a given load.

In the present study the samples for microhardness measurements were made according to the ASTM guidelines. Light curing was done on both top and bottom surfaces of the disc specimens to ensure complete curing of the restorative material.[14] The results of the Vickers hardness test showed that Giomer (Beautifil) had the highest hardness value **(53.83)** followed by Hybrid Composite (Spectrum TPH - **52.45)** and RMGIC (Fuji II LC - **50.70)**. The Compomer (Dyract) had the lowest mean value for hardness **(40.66)**. The differences in hardness values between all the four materials were statistically significant.

A positive correlation has been established between the hardness and the inorganic filler content of materials tested. This is in accordance with the previous findings that micro indentation hardness of composites is directly related to the volume fraction of the inorganic filler component and is less related to the hardness of the filler.[15,16] Microhardness is also affected by the powder: liquid ratio of the components.[17] This is true regarding the microhardness shown by light cured glass ionomer in the present study. Giomer which is the most highly filled was the hardest material. Likewise, the Compomer is the least filled material and showed the lowest hardness values. There are other factors that can also affect the microhardness of resin based materials like, degree of polymerization of the resin matrix, presence of organic acids in the environment, polishing techniques etc.[18-20]

In a study by MA Mohamed et al[21] the effect of pH on the microhardness of resin based materials were compared. It was found that eventhough giomer showed the highest value at normal pH, at lower pH levels, hybrid composite retained the hardness better than giomer. But giomer performed better than compomer at lower pH levels. The unreacted fluoroaluminosilicate glass ionomer particles in resin matrices are easily attacked by acids. They suggested that the pre-reacted glass ionomer particles in giomer were better able to resist acid degradation compared to compomers.

In summary, eventhough giomer showed the highest microhardness value in the present study, other environmental factors should also be considered.

Limitation

The mechanical property of a restorative material, like microhardness is also affected by various environmental factors like pH of plaque, beverages consumed, aging of restoration, water sorption of the material etc. Such parameters were not included in the study.

Conclusion

Within the limitations of the present study, it was concluded that among the four resin based materials tested Giomer gave a significantly higher microhardness value than all the other materials tested and Compomer gave the lowest value. Further research is required to find the in vivo behaviour of these restorative materials and possibly to explore the fundamental mechanisms for the observed differences.

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