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Surface Roughness and Micro-Hardness of Different Glass Ionomer Materials

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ABSTRACT

Aim of the Study: To observe the surface roughness and micro-hardness of different selected glass ionomer restorative materials.
Materials and Methods: 30 discs of three different glass ionomer materials were packed according to their manufacturer instructions then tested for surface roughness and micro-hardness. Each material was divided into two subgroups which are, coated and non-coated discs.
Results: Between the three different glass ionomer materials, Equia Fil Plus showed superior micro-hardness above the other glass ionomer materials. For surface roughness in general, the non-coated material showed lower mean surface roughness compared to the coated material.
Conclusion: In this research project, we concluded that Equia fil Plus holds the highest micro-hardness results followed by Ketac Fil Plus, then SDI glass ionomer.
The surface roughness testing showed that, in the subgroup of the coated materials, the SDI glass ionomer holds the lowest mean surface roughness value followed by Ketac Fil Plus then Equia Fil Plus. In the non-coated subgroup, Ketac Fil Plus showed the least value than the SDI then Equia Fil Plus.

Key words: surface roughness, micro-hardness, glass ionomer cement (GIC)

INTRODUCTION

Glass ionomer types of cement (GIC) are tooth-colored materials that bond chemically to dental hard tissues and release fluoride for a relatively long period. They have therefore been suggested as the materials of choice for the restoration of carious primary teeth. (Shiu-yin Cho, Ansgar C. Cheng)

Wilson and Kent (Wilson AD, Kent BE) (1970) were trying to overcome shortcomings of silicate cements and to retain or improve their advantages when they developed GIC. This material was developed by combining strength, rigidity, and fluoride release properties of a silicate glass powder with the biocompatibility and adhesive characteristics of a polyacrylic acid liquid. This turned out to be a hybrid cement of silicate/polycarboxylate consisting of calcium fluoroaluminosilicate glass powder and polyacrylic and itaconic acid liquid. When first developed, the GIC was labeled ASPA for its basic ingredients: "A"lumino "S"ilicate powder and "P"olyacrylic-"A"cid liquid. (Kovarik RE, et al)

In general, glass ionomer cements are classified into three main categories: conventional, metal-reinforced and resin-modified. (Wilson AD, McLean JW. Burgess J, et al) Conventional glass ionomer cements were first introduced in 1972 by Wilson and Kent. (Wilson AD, Kent BE)

Metal-reinforced glass ionomer cements were first introduced in 1977. The addition of silver-amalgam alloy powder to conventional materials increased the physical strength of the cement and provided radiopacity. (Williams JA, et al)

Subsequently, silver particles were sintered onto the glass, and several products then appeared where the amalgam alloy content had been fixed at a level claimed to produce optimum mechanical properties for a glass cermet cement. (Williams JA, et al. McLean JW, Gasser O) In 1992, resin-modified glass ionomer cements were developed that could be light-cured. In these materials, the fundamental acid-base reaction is supplemented by a second resin polymerization usually initiated by a light-curing process. (Sidhu SK, Watson TF. Burgess J, et al)

Glass ionomer types of cement exhibit a number of advantages over other restorative materials. (Shiu-yin Cho, Ansgar C. Cheng)

Adhesion; by bonding a restorative material to the tooth structure, the cavity is theoretically sealed, protecting the pulp, eliminating secondary caries, and preventing leakage at the margins. This also allows cavity forms to be more conservative and, to some extent, reinforces the remaining tooth by integrating restorative material with the tooth structures. (Erickson RL, Glasspoole EA)

Margin adaptation and leakage; The coefficient of thermal expansion of conventional glass ionomer cements is close to that of dental hard tissues and has been cited as a significant reason for the good margin adaptation of glass ionomer restorations. (Wilson AD, McLean JW. Burgess J et al)

Fluoride release; Fluoride is released from the glass powder at the time of mixing and lies free within the matrix. It can therefore be released without affecting the physical properties of the cement. (Mount GJ) Since it can also be taken up into the cement during topical fluoride treatment and released again, the cement may act as a fluoride reservoir over a relatively long period. (Forsten L)

Physical strengths; properties such as compressive and flexural strength and fracture toughness will limit glass-ionomer use as a restorative material to areas not subject to occlusal stress unless well-supported by surrounding tooth structure. wear resistance improves markedly as the restoration matures. (Mount GJ)

Water sensitivity; early water sorption causes swelling (hygroscopic expansion) of the immature material and dissolution of reactive component, while dehydration allows loss of some of the water critical for the continuation of the setting reaction. both situations result of disruption of the setting reaction and resultant non-mature cement with unacceptable properties such as crazing, cracking, and loss of translucency. (Anusavice KJ)

MATERIALS AND METHODS

Study Design: This is an in-vitro study, with three different groups of glass ionomer restorative materials which are:

Equia Fil Plus
Ketac Fil Plus
SDI

Sample size: Each group contains 10 discs of the material and divided into two subgroups, coated and non-coated discs. Therefore, the sample size of this study is 30 discs.

Data Collection: All of the selected glass ionomer restorative materials were prepared according to their manufacturer's instructions, then packed using metal rings with an inner diameter of 12mm and thickness of 3mm. Microscopic slides were used to press the material on both sides of the metal ring to give it a naturally smooth surface. The packed material then left for a complete set, Fig. (1).

The coated discs subgroups then glazed using their specific coating material with a micro brush, blown by air, and then light-cured for 20 seconds.

The packed discs then were carried to The Advanced Technology Dental Research Laboratory (ATDRL) in King Abdulaziz University (KAU) to be tested for their;

· Surface roughness test using The Profilometer Device, Fig. (2).

· Micro-hardness test using The Diamond Vicker Hardness Device, Fig. (3).

RESULTS

Surface roughness

After the surface roughness tests are done, the Equia fil plus has shown general mean as presented in Table (1).

Table (1): Ra values for Equia fil plus coated samples

Equia fil plus coated						general mean	SD
sample	1	2	3	4	5		
Ra	1734.675	3386.796	2483.802	3011.719	3019.641	2727.3266	641.4608454

Where the coated sub-group showed general mean as followed table(2).

Table (2): Ra values for Equia fil plus non-coated samples

equia fil plus non-coated						general mean	SD
sample	1	2	3	4	5		
Ra	323.134	955.011	910.418	1471.272	954.584	922.8838	407.0079533

On the other hand, Ketact Fill plus showed quite different values, as illustrated in the table for non-coated and coated sub-group. (table3-4).

Table (3): Ra values for Ketac fil plus coated samples

Ketac fil plus coated						general mean	SD
sample	1	2	3	4	5		
Ra	1957.745	2044.179	2495.588	2478.522	2160.423	2227.2914	247.8692577

Table (4): Ra values for Ketac fil plus non-coated samples

ketac fil plus non-coated						general mean	SD
sample	1	2	3	4	5		
Ra	909.889	1165.491	869.758	459.941	343.529	749.7216	339.8130927

The SDI glass ionomer showed quite similar results on both subgroups. table. (5-6).

Table (5): Ra values for SDI coated samples

SDI coated						general mean	SD
sample	1	2	3	4	5		
Ra	699.037	1313.618	943.847	847.423	712.677	903.3204	250.5931257

Table (6): Ra values for SDI non-coated samples

SDI non-coated						general mean	SD
sample	1	2	3	4	5		
Ra	1447.025	1139.836	579.134	617.461	633.222	883.3356	390.2956969

Micro-hardness

After five indentations with a 50 gf of load cycles in 10 seconds, Fig (1) the outcomes for the Equia fil plus were 81.63 as the mean HV. Table (7)

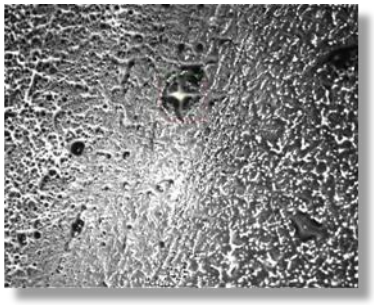

Fig. (1) microscopic view of the diamond indenter in Equia fil plus disc

Table (7): Mean and Standard deviation of Equia fil plus samples

Equia Fil Plus						Mean	SD
sample	1	2	3	4	5		
1	127	124	126	115	120	122.4	4.93
2	71	69	60	68	65	66.6	4.28
3	64	69	60	70	69	66.4	4.28
4	70	68	82	73	78	74.2	5.76
5	73	79	80	79	75	77.2	3.03
SD						23.42	
General Mean						**81.36**	

And for the Ketac Fil Plus, the results showed slightly fewer values of hardness, Fig (2). 75 was the mean HV for the material as illustrated below. Table (8)

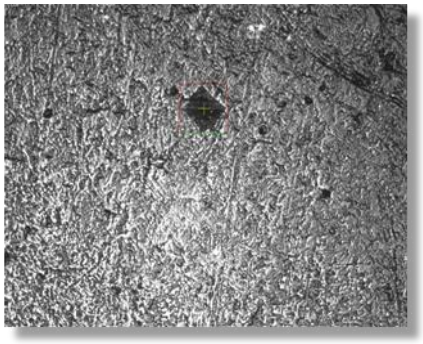

Fig. (2): a microscopic view of the diamond indenter in Ketac fil plus disc

Table (8): Mean and Standard deviation of Ketac fil plus samples

Ketac						Mean	SD
sample	1	2	3	4	5		
1	61	60	67	65	69	64.4	3.85
2	74	74	72	70	73	72.6	1.67
3	72	71	73	70	75	72.2	1.92
4	98	101	92	95	90	95.2	4.44
5	67	74	71	70	71	70.6	2.51
SD						11.76	
General Mean						**75**	

The last group was the SDI, which showed much fewer values of hardness, Fig. (3). The mean HV for this group was 58.2. Table (9)

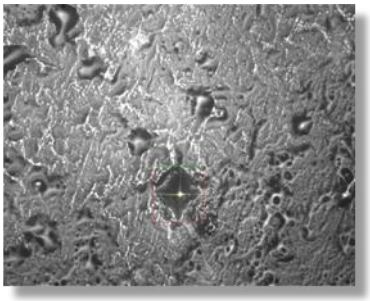

Fig. (3): a microscopic view of the diamond indenter in SDI disc

Table (9): Mean and Standard deviation of SDI samples

SDI						Mean	SD
sample	1	2	3	4	5		
1	44	44	47	43	41	43.8	2.17
2	51	54	56	55	56	54.4	2.07
3	59	62	63	64	64	62.4	2.07
4	63	65	66	65	62	64.2	1.64
5	65	67	64	68	67	66.2	1.64
SD						9.21	
General Mean						**58.2**	

DISCUSSION

Discussion of materials and methods

- **Micro-Hardness Test**

Micro-hardness testing is a method of determining a material's hardness or resistance to penetration when test samples are very small or thin, or when small regions in a composite sample or plating are to be measured. The micro-hardness test can measure surface to core hardness on carburized or case-hardened parts (case depths), as well as surface conditions such as grinding burns, carburization, or decarburization.

There are two forms of micro-hardness testing:

1. Knoop Hardness Test.
2. Vicker Hardness Test.

During micro hardness testing, a Vickers (DPH) or Knoop (KHN) diamond indenter is pressed into the material's surface with a penetrator and a light load of up to 1000 grams. The result of applying the load with a penetrator is an indent or permanent deformation of the material surface caused by the shape of the indenter.

Both the Knoop hardness test and Vickers hardness test methods use specific measurements from the indent, in conjunction with formulas, to calculate material hardness. Accurate measurement of the resulting indentation requires the use of a special micro hardness testing microscope because the indents are so small.

The Vicker Hardness Test is the test that we conducted on our sample. By applying controlled pressure for a standard length of time, but with a square-based diamond pyramid indenter. The diagonal of the resulting indention is measured under a microscope, then this measurement and the test load are used in a specific formula to calculate the Vickers hardness value. (Laboratory Testing Inc**.** 2331 Topaz Drive, Hatfield, PA 19440)

- **Surface Roughness Test**

We conducted this test using the Profilometer Device, there are two types of profilometers:

- Stylus
- Optical

Stylus profilometers use a probe to detect the surface, physically moving a probe along the surface in order to acquire the surface height. This is done

mechanically with a feedback loop that monitors the force from the sample pushing up against the probe as it scans along the surface. A feedback system is used to keep the arm with a specific amount of torque on it, known as the 'setpoint'. The changes in the Z position of the arm holder can then be used to reconstruct the surface. (Nanoscience Instruments 2017)

The Optical profilometry is the one we used to test our samples with, which uses light instead of a physical probe. This can be done a number of ways. The key component to this technique is directing the light in a way that it can detect the surface in 3D.

Discussion of results

- **Surface roughness:**

The results revealed mostly similar results, but the Ketac fil plus glass ionomer was of the lowest surface roughness. And that's attributed to the micron-sized alumina and silica glass particles and their morphology and integrity. And it is known that the longevity of dental restorations depends on the durability of the material and its properties, such as surface roughness. (Rios D et al. 2008)

- **Micro-hardness:**

The Equia fil plus showed superior micro-hardness readings because according to the manufacturer, EQUIA glass ionomer improved with higher flexural strength, and higher acid and wear resistance. It's been reinforced with highly reactive fluoro-alumino-silicate (FAS) < 4 μm size fillers to the standard particles. With increasing the release of metal ions, the micron-sized filler particles improved their overall physical properties. (Mark L. Pitel Feb 2017)

CONCLUSION

Looking at the results in our study, we can conclude that:

- The Ketac fil plus glass ionomer's surface roughness was outstanding the other two types of glass ionomer restorative materials. Followed by the SDI which has close readings for the coated and non-coated subgroups, then at last the Equia fil plus. So, the Equia fil plus glass ionomer has the highest roughness.
- We did the surface roughness tests without any finishing or polishing of the materials. So, these were the results of their natural surface.
- In the micro-hardness tests, the Equia fil plus showed superior micro-hardness readings to the other two types. Following that, the Ketac fil plus wasn't showing much lower hardness readings to the Equia's. And the SDI had the lowest micro-hardness values.

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