IN-VITRO ASSESSMENT OF PHYSICO-MECHANICAL PROPERTIES OF NANOPARTICLE GLASS CARBOMER

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ABSTRACT

Aim: This study was conducted to evaluate and compare the shear bond strength, water sorption, solubility, microhardness, and compressive strength of a recent product of glass ionomer (Glass Carbomer) compared to conventional glass ionomer.

Materials and Methods: Twenty primary molars were utilized for assessment of shear bond strength (SBS) test. Crown surfaces of the selected teeth were fixed in acrylic blocks then, ground with water-cooled silicon carbide papers to obtain a flattened dentin surfaces. The specimens (n=20) were distributed into two equal groups according to the type of glass ionomer cement (GIC) bonded to the dentin surface (10/ each group): group I (Fuji IX GP) and group II (Glass Carbomer). To measure shear bond strength (SBS) a universal testing machine was used. For measurement of water sorption (WS) and solubility (SL) 10 specimens of each material were prepared and immersed in artificial saliva of pH 7 for seven days. The difference between initial and final weight was estimated. Microhardness was estimated using a Vickers microhardness tester. Compressive strength was evaluated using a universal testing machine.

 Results: No significant difference in shear bond strength and microhardness between both materials. The water sorption, solubility and compressive strength of CAR (Glass Carbomer Fill) were significantly greater than that of Fuji IX.

Conclusions: Glass Carbomer demonstrated some favourable results. Among these include the higher compressive strength and comparable shear bond strength and microhardness of glass carbomer, compared to conventional GIC. On the other hand glass carbomer showed higher water sorption and solublity than conventional GIC. Thus, glass carbomer holds a promise to be used as a potential restorative material particularly in pediatric dentistry.

Keywords: Glass Ionomer; Restorative Material; Glass Carbomer cement; Shear bond strength; Water Sorption, Solubility; Microhardness and Compressive Strength.

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INTRODUCTION

The recent state of cariology based on many concepts of minimal intervention (MI) for the treatment of carious lesions and tied to this concept is the atraumatic restorative treatment (ART) [1]. The ART restores cavities, needs no electricity or conventional dental chair and preserving dental structure [2]

Nowadays, glass ionomer is one of the most appropriate restorative materials for ART providing less hypersensitivity reaction or toxicity and great appearance [3]. The term glass ionomer cement (GIC) ought to be used only with a material that includes a significant acid-base reaction as a part of its setting reaction, where the acid is a water soluble polymer and the base is a special glass [4]. The original GICs comprises of an aqueous solution of poly acrylic acid at a concentration of approximately 45% which reacts with a powder consisting of calcium fluoroaluminosilicate glass [5].

Since GICs were introduced, these materials have experienced several formula changes in order to make it more appropriate for clinical use and to improve its physical and mechanical properties. Therefore, wide categories of GICs are available nowadays such as, conventional, metal-modified and resin-modified GICs. The last mentioned two categories were introduced in an attempt to overcome the problems of moisture sensitivity and low mechanical properties associated with the conventional materials but at the same time to preserve some of their clinical advantages. On the other hand, improvements within the conventional GICs have delivered a subgroup of high viscosity GICs [6].

The advancement of glass ionomer cements centered on a higher powder-to-liquid ratio, lower water content, and nano particles leading to the high viscosity glass ionomer cements which might be packable like amalgam and reveal enhanced flexural strength characteristics [7-9].

One of the most important recent advances in dentistry is the application of nanotechnology. Rastelli et al [10] described nanotechnology as "the production and manipulation of materials and structures with particles size in the range of about 0.1 – 100 nm by various physical or chemical approaches" providing an aesthetically acceptable restoration with excellent mechanical properties. These interesting advances led to the development of glass-ionomer based filling material called glass carbomer cement (CAR) [11]

Glass carbomer cement (CAR) contains nano-sized powder particles and hydroxyapatite (HAp) and fluorapatite (FAp) as secondary filler and has been introduced with claims of improved physical characteristics in comparison with conventional GIC [12]. It was reported that, the incorporation of (Hap) and (FAp) into the CAR combined with the light-curing sources with a high output range results in an improved mechanical properties of the GICs [13-16].

Utilizing bonded restorations in children has a noteworthy importance in the present day restorative dentistry. Since they are adhesive to the tooth surface, they extraordinarily lessen the removal of the tooth structure and furthermore decrease microleakage thus minimizing discolorations, post-operative pain and secondary caries formation [17]. It was stated that the chemical bonding of GIC to enamel and dentin is attained by reaction of phosphate ions in the enamel and dentin with carboxylate groups from the polyacrylic acid and it has been mentioned as the most important advantage of the GICs [18].

Adhesions are generally assessed by the determination of tensile and shear bond strength (SBS) and defined the bond strength as the load needed for fracturing the bond interface divided by the cross-sectional area of the bonded area. Many factors influence the bond strength values such as, the dentin substrate, the storage conditions and the test method [19].

Dentin Bonding has been less expected because

of the wet tubular ultra-structure and organic component of the dentin substrate. Also, there are numerous reasons which lead to lower bond strength of primary teeth such as, lower concentrations of calcium and phosphorus in the primary teeth than for permanent teeth, the concentration of the tubule is greater in permanent teeth than deciduous teeth and the diameter of dentinal tubules is larger close to the pulpal surface (0.4-0.5 mm) in permanent teeth than in deciduous teeth, leading to diminished dentinal permeability in deciduous teeth [20].

Shear bond strength adopts much importance to restorative materials clinically as the major dislodging forces at the tooth restoration interface have shearing effect. Therefore, high shear bond strength infers better bonding of the material to the tooth [21,22].

Since there is limited published data on the clinical performance of CAR, laboratory tests may contribute with valuable insights into the physico-mechanical properties of this material [23]. Therefore, this study was conducted to evaluate and compare the shear bond strength, water sorption, solubility, microhardness, and compressive strength of a recent product of glass ionomer (Glass Carbomer) compared to conventional glass ionomer.

MATERIALS AND METHODS

The materials used in this study are shown in table (1):

TABLE (1): Material, Manufacturer and Composition

Materials	Manufacturer	Composition
Glass carbomer	Glass Carbomer Fill, GCP Dental Products, Leiden, Netherlands	Nano filled carbomised glass ionomer restorative cement in capsules. - Treated Fluoro Alumino Silicate glass powder with a poly dialkylsiloxane having terminal hydroxyl groups where in the alkyl groups contain 1-4 carbon atoms -an aqueous polyacrylic acid solution.
Glass Carbomer Surface Gloss	Glass Carbomer Products, Leiden, Netherlands	Monomer Free Silicone based
Fuji IX GP	GC Co, Tokyo, Japan	*Powder*: 95 % strontium fluoroalumino-silicate glass, 5 % polyacrylic acid *Liquid*: 40 % aqueous polyacrylic acid
G-Coat Plus	GC Co, Tokyo, Japan	50 % methyl methacrylate, 0.09 % camphorquinone, colloidal silica
GC Dentin conditioner	GC Corporation, Tokyo, Japan	10% polyacrylic acid
Artificial saliva	Was Prepared in Chemistry Department , Faculty of Pharmacy, Tanta university.	prepared by mixing 500 ml distilled water with 1.2 g potassium chloride, 0.843 g sodium chloride, 0.051 g magnesium chloride, 20 ml stock solution of tri-calcium phosphate 1% (10.5 g TCP and 200ml of 1.0 M hydrochloric acid) and Carboxy-methylcellulose. Sodium hydroxide (0.05 M) was added to the mixture to have a pH 6.8.

Shear bond strength test :

Twenty primary molars indicated for serial extraction were collected from the pedodontic clinic, Faculty of Dentistry, Tanta University. The purpose of this study was explained to children's parents and informed consents were obtained to use their extracted teeth on the research according to the guidelines on human research published by the research ethics committee at Faculty of Dentistry, Tanta University.

The collected teeth were kept in saline for maximum 3 months as recommended by the International Standards Organization (ISO) until required for use [22]

Periodontal curettes were used for cleaning the collected teeth from tissue remnants and debris and then polished with slurry of pumice and water then they were examined using a magnifying lens. Any teeth with cracks or developmental defects were excluded [24]

Crowns of the teeth were splitted from the roots at cemento-enamel junction. Customized cylindrical metallic molds with a diameter of 14 mm and a length of 20 mm had been filled with chemically cured acrylic resin. Each crown was horizontally fixed in the acrylic resin making the buccal surface looking upwards. After polymerizing the acrylic resin, the specimens were separated from the molds and the convex buccal surfaces of the crowns were mechanically ground with silicon carbide papers (400-,600-,800- and 1200- grit sandpaper) with water coolant to obtain a flattened dentin surface [25].

The prepared specimens were randomly assigned into two equal experimental groups according to the material bonded to the dentin surface as follow:

Group I : (control group): Fuji IX GP (GC Corporation, Tokyo, Japan),

Group II: (test group) glass carbomer (Glass Carbomer Products, Leiden, Netherlands) was the material used (Table 1).

To standardize the bonding area for both materials, a hole of 3 mm diameter was punched in a double sided adhesive tape which then adhered to the ground dentin surface. A plastic cylindrical mold with a diameter of 3mm and a height of 2 mm was placed coinciding with the central hole, defining the area to be bonded [26]

Both materials had been activated, mixed and applied according to the manufacturer's instructions included a pre conditioning step with 10% poly acrylic acid (GC Dentin conditioner GC Corporation, Tokyo, Japan) to the dentin surfaces then, the mixed capsules were placed in the applicator and extruded from the capsules into the plastic mold and were packed until it was full. After that application of the specific surface coat of each material was done on the surface of the restoration using a mini brush. High intensity light curing device (Elipar S100 , 3M ESPE) was used for 60-90 seconds as recommended by the manufacturer [27].

For both groups, samples were kept in artificial saliva for 24 hours in an incubator at 37ºC [28]. Shear bond strength test (SBS) was measured utilizng a universal testing machine(Instron, UK). The specimens were directed so that the stainless steel knife of the universal testing machine was perpendicular to the tooth -material interface. A crosshead speed of 0.5 mm/min was utilized until debonding occured. Then, shear bond strength was estimated in Mega Pascal (MPa) according to the following relation [24]:

bond strength(MPa)=N (load) / A (surface area in mm^2)

The surface area (A) was calculated from the following equation: $A = \pi r^2$

Mode of failure assessment

All deboned surfaces of the specimens were examined under a stereomicroscope (SZ-CTY Olympus, Japan) at magnification 40× to record the mode of failure. Failure mode was identified as [29-31]:

1. Adhesive failure, if no observable glass ionomer remained on the dentin surface.

2. Cohesive failure, if remnant of glass ionomer remained on the dentin surface.

3. Mixed failure, if a mixture of both modes of failure was detected.

Water sorption and solubility test

Ten disc-shaped specimens (10 mm diameter and 3 mm height) were prepared in a plastic mold between two glass slides and covered with a matrix strip. The GIC specimens were prepared as mentioned previously and the surfaces protected according to the manufacturer's instructions in order to avoid dehydration. After that, the specimens were kept in a desiccator at 23°C ± 1°C for 1 h and were weighed until verification of mass stabilization, considering this measure as the initial mass (M1). Thereafter; they were stored separately in 10 mL of artificial saliva at 37°C for 7 days. Then, they were dried with absorbent paper and received an air jet for 15 s; each disc was weighed to obtain the mass after saturation with water (M2). After that, all the specimens were stored in the desiccator again at 37°C and reweighed until a constant weight was obtained (M3). Weighing was achieved using a scale with an accuracy of 0.0001 g (Sartorius, Germany). The volume (V) of each specimen was estimated by the following equation: [32-33]

$$V = pr2h,$$

Where, p = 3.1415; r is the radius and h is the thickness of the specimens.

Thickness and diameter were calculated using a digital micrometer with an accuracy of up to 0.01 mm. (Digimatic QuantuMike Micrometer; Mitutoyo Corp.,Kawasaki, Japan) Water sorption (WS) and solubility (SL), expressed in μg /mm^3, had been calculated for each specimen using the following equations: [34]

$$WS = (M2 - M1)/V$$

$$SL = (M1 - M3)/ V.$$

Microhardness Test

Ten cylindrical specimens were made with dimension of 6 mm height and 4 mm diameter using custom made Teflon molds, 5 specimens from each material. Preparation of the materials was made according to the manufacturer's instructions. Celluloid strip was placed on top of the filled mold. Light pressure was exerted on the filled mold using a microscopic glass slide to extrude the excess material. The glass slide was removed and the gloss material was applied and cured using a light curing unit (3 M ESPE, Elipar, Light-cure, Germany). After setting, all specimens were separated from their molds and kept in distilled water for 24 hours. Microhardness measurements were done using a Vickers microhardness Tester (ZwicRoell, west Midlands, England). Vickers diamond pyramid was used to apply aload of 25 gf for 5 sec producing surface indentation on the specimen. Five readings were taken for each specimen. Total mean Vickers microhardness (VHN) was computed using the following equation [35]:

VHN: HV=1.854 P/d2

Where, HV was Vickers hardness in Kgf/mm^2, P was the load applied in Kgf and d was the length of the diagonals in mm and 1.854 was a constant number.

Compressive Strength Test

A total of 10 cylindrical specimens were prepared (6 mm in height and 4 mm in diameter) using Teflon molds according to the manufacturer's instructions. After setting the specimens were separated from their molds and kept in distilled water for 24 hours. Compressive strength was determined with a universal testing machine (Instron, UK). Prior to testing, the diameter of the specimens were calculated using a digital micrometer with an accuracy of up to 0.01 mm. (Digimatic QuantuMike Micrometer; Mitutoyo Corp., Kawasaki, Japan). Afterwards, each specimen was placed with the flat surface

between the plates of the testing machine, so that, the load was applied on the long axis of the specimens. The maximum load at fracture of the specimen was recorded in (N). The compressive strength was calculated using this formula: [35]

Compressive strength = $4P/\pi d2$ (MPa).

Where P is the maximum applied load (N) and d is the diameter of the specimen (mm). Cylinders were loaded at a rate of 1 mm/min

Statistical Analysis

Data were collected, tabulated and statistically analyzed using SPSS program version 22.0. Quantitative Data were subjected to independent t-test. Chi-square test was used to measure association between qualitative variables. Monte Carlo correction was carried out when indicated. All analysis were performed with a significance level set at 5%.

RESULTS

Comparing the shear bond strength (MPa) between the two groups the results of the present study revealed that Fuji IX GP group (group I) was slightly bit higher in the mean shear bond strength values (6.663±0.0991) than glass carbomer group

(group II) (6.655±0.114) with no statistical significance difference (p=0.4196) (table 2). Comparison between the two groups regarding the three modes of failures, revealed no statistically significance difference between them. (Table 3)

Water sorption and solubility test

Table (4) shows a comparison between the mean of water sorption (µg /mm³) of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill) The mean value of water sorption of Fuji IX GP and Glass Carbomer Fill were 0.097±0.00192 and 0.144±0.0011 respectively. The results showed that the mean value of water sorption of CAR (Glass Carbomer Fill) is significantly greater than that of Fuji IX GP (P =0.0154).

Table (5) shows a comparison between the mean of solubility(µg /mm³) of conventional GIc (Fuji IX GP) and CAR (Glass Carbomer Fill). The mean of solubility of Fuji IX GP and Glass Carbomer Fill were 0.035±0.00112 and 00.06±0.007 respectively. The results showed that the solubility of CAR (Glass Carbomer Fill) is significantly greater than that of Fuji IX GP (P = 0.00289).

TABLE (2): Comparison between the mean of shear bond strength (MPa) of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill).

Material	N	Mean ±SD	T	p-value
Group I (Fuji IX GP)	10	6.663 ± 0.0991	2.9199	0.4196
GroupII (Glass Carbomer Fill)	10	6.655 ± 0.114		

Statistically significant at p ≤0.05

TABLE (3) : Comparison between the two groups regarding the three modes of failure

	Adhesive	Cohesive	mixed	Test of significance
Group I (Fuji IX GP)	1 (10%)	6 (60 %)	3 (30%)	$X^2 = 0.4242$
Group II (Glass carbomer fill)	2 (20%)	5 (50%)	3 (30%)	$P_{(MC)} = 0.80887$

X2 : Pearson Chi-square   *MC : Monte Carlo correction*

TABLE (4): Comparison between the mean of water sorption (μg /mm³) of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill)

Material	N	Mean ±SD	T	p-value
Fuji IX GP	10	0.035±0.00112	17.857	*0.00289
Glass Carbomer Fill	10	0.06±0.007		

Statistically significant at p ≤0.05

TABLE (5) : Comparison between the mean value of solubility (μg /mm³) of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill)

Material	N	Mean ±SD	T	p-value
Fuji IX GP	10	0.097±0.00192	22.09	0.0154*
Glass Carbomer Fill	10	0.144±0.0011		

Statistically significant at p ≤0.05

Microhardness test

A comparison between the mean value of microhardness of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill) are shown in table (6).

The mean value of microhardness of Fuji IX GP and Glass Carbomer Fill were 59.312±1.461 and 59.429±1.631 respectively. The results showed that the microhardness of CAR (Glass Carbomer Fill) is slightly higher than that of Fuji IX GP. Independent t- test showed no significant difference among the tested materials (P =0.908).

TABLE (6) : Comparison between the mean value of microhardness of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill)

Material	N	Mean ±SD	T	p-value
Fuji IX GP	10	59.312±1.461	0.0142	0.908
Glass Carbomer Fill	10	59.429±1.631		

Statistically significant at p ≤0.05

Compressive Strength test

A comparison between the mean value of compressive strength (MPa) of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill) are shown in table (7). The mean value of compressive strength of Fuji IX GP and Glass Carbomer Fill were 104.89±7.684 and 120.279±7.505 respectively. The results showed that the compressive strength of CAR (Glass Carbomer Fill) is significantly higher than that of Fuji IX GP (P =0.0125)

TABLE (7): Comparison between the mean value of compressive strength (MPa) of conventional GIC (Fuji IX GP) and CAR (Glass Carbomer Fill)

Material	N	Mean ±SD	T	p-value
Fuji IX GP	10	104.89±7.684	10.264	0.0125*
Glass Carbomer Fill	10	120.279±7.505		

Statistically significant at p ≤0.05

DISCUSSION

This study was conducted to evaluate and compare the shear bond strength, water sorption, solubility, microhardness, and compressive strength of a recent product of glass ionomer (Glass Carbomer) compared to conventional glass ionomer.

Glass carbomer is a relatively new material which is a modification of glass ionomers. It is used as a fissure sealant that is proposed to remineralize in the mouth. Glass carbomer contains calcium fluorapatite nanocrystals, which can serve as nuclei for the remineralization and initiate the formation of fluorapatite. It possesses a much finer particle size when compared to conventional glass ionomer cements [36,37] . The nano-sized particles leads to strengthening of the material through increasing particle surface area contacting the glass-carbomer liquid and would facilitate its dissolution and conversion to fluorapatite [38,39]. This could improve the compressive strength and wear resistance of the material [40]. Addition of hydroxyapatite and fluorapatite are also reported to enhance the mechanical properties of the material [15, 36] .

The reactive glass is treated with dialkyl siloxanes described in Cehreli et al., 2013[41]. According to the manufacturer, setting of glass carbomer is done by chemical reaction and is optimized for heat curing. An advantage of glass carbomer is that it is moisture tolerant and is easy to use in children in whom moisture control can be a challenge.

This material appeared with a specific guidelines, which stated that on top of the material, a gloss should be used, and that the material should be thermocured. The GCP gloss composed of a silicone-based coat. It protects the surface from exposure to moisture and saliva in the first reaction step and prevents dehydration in the second phase .In addition, it may also aid in the improvement of surface characteristics and sealing properties.

Saito et al., 1999 [43] reported that, Fuji IX was introduced in the mid-1990s and known as condensable or high viscous GIC.   They have superior strength, better wear resistance and flexural strength than conventional GIC. In addition, they are less sensitive to moisture contamination and leach more   fluorides and hence Fuji IX was used as reference material as it is the   most frequently reported material in the in-vivo and in-vitro studies

Upon comparing the two groups, there was no statistical significant difference in the values of shear bond strength of the two used materials and this result was in accordance with a study done by Carvalho et al [44] who revealed that, the shear bond strength of Fuji IX GP was lower than Ketac Molar with statistical significance difference. This difference in the results could be due to using Ketac Molar while in our study we used Glass Carbomer cement.

On the other hand, a study by Olegario et al., 2015 [12]. Shebl et al., 2015 [22] who evaluated the shear bond strength of glass carbomer, resin modified glass ionomer (Ketac Nano) and one conventional glass ionomer (Ionofil) to enamel surfaces of permanent teeth and the results revealed that, glass carbomer recorded the lowest values of shear bond strength compared with the other two materials tested.

The high SBS of glass carbomer as compared to the previous studied could be due to the application of dentin conditioner. Pre- conditioning step may influence the results as the bond strength of the glass-carbomer cement to tooth structure can be enhanced greatly by the use of appropriate enamel and dentin conditioners. These substances contain a variety of functional groups capable of hydrogen bonding to tooth material, which ensure effective cleaning and wetting of the substrate surfaces [8]

According to Meerbeek et al, 2002 [45] Fuji IX and glass carbomer has two-fold bonding mechanism as, the short polyalkenoic acid pre-treatment cleans the tooth surface; it eradicates the smear layer and also exposes collagen fibrils up to about 0.5-1 m depth, components of glass-ionomer then inter-diffuse and produce a micro-mechanical bond. This is in

addition to the chemical bonding gotten by ionic reaction of the carboxyl groups of the polyalkenoic acid with calcium ions of hydroxyapatite that persists attached to the collagen fibrils which in turn increase the resistance to hydrolytic degradation [46].

The high SBS of glass carbomer may be attributed to the fact that it is able to mineralize into fluoroapatite and hydroxyapatite and it has been generally reported that apatite-enriched cements achieve higher bond strength to both enamel and dentin [38]. This is accomplished by Moshaverinia, 2011 [47] who examined the influences of hydroxyapatite and fluoroapatite nanobioceramics incorporation into glass ionomer cements. Also, warming of glass carbomer by the high intensity light cure, as the manufacturer recommends, has been proved by Van Duinen , 2004 [48] to improve mechanical properties of the cement.

Considering the association between the different modes of failure found in the result of the current study it was noticed that, the 3 mode of failures were detected by mean of stereomicroscope and there was no statistically significance difference between the two groups regarding the 3 modes of failure detected in both group.

From the previously cited studies, one can find out that, glass carbomer can resist the dislodging forces in the oral cavity especially in the atraumatic restorative treatment cases due to its high shear bond strength recorded values. Also, regarding glass carbomer a preconditioning step was needed to improve its adhesion to dentin.

Solubility or leaching of cement components has a pronouncing effect on both its structural biocompatibility and stability. The rate of dissolution can be infuenced by the conditions of the test. Other variables may include time of dissolution, concentration of solute in the dissolution medium, pH of medium, specimen thickness and shape, and finally powder/liquid ratio of cement [49].

In this study, the method used for evaluating the solubility followed ISO 4049 [50]. For standardization purpose, all specimens were kept in artificial saliva after removal from mould. The chemical structure of solutions used for in vitro tests is important because it has to simulate the complexity of the oral environment [49]. The in- vitro tests made are just static solubility tests because they do not simulate the pH and temperature changes of the oral cavity [51]. In studies regarding dental cements; solvents such as water and acids have been used to act as food-simulating liquids [52]. Levine et al,1987 [53] suggested the use of artificial saliva to produce a setting similar to the oral medium. Lower pH values increase the solubility of cements. [54]. Walls et al, 1988 [55] obtained highest solubility at pH 4, whereas no dissolution was observed in a buffer solution at pH 10 even after 24 hours for glass ionomer cements. Therefore, artificial saliva of pH values at 7 were prepared for this study [50].

In the present study glass carbomer exhibited an increase in water sorption when compared to glass ionomers. This result may be due to the basic components of glass ionomer cement are polycarboxylic acids and ion leachable glass, bind water molecules. As the glass carbomer composition is 100% glass, an increased concentration of glass may lead to water absorption and hence increased weight. This could lead to poorer clinical performance as usually a serious warpage and dimensional change in the material are associated with water absorption [56]. As the material was kept in artificial saliva, weight increase may be due to uptake of calcium and phosphate released by the artificial saliva. It may have also been due to the formation of fluorapatite crystals. However, a study performed on the characterization of remineralizing ability of Glass Carbomer by MAS-NMR Spectroscopy found that the apatite in this cement was not fluorapatite but largely hydroxyapatite [38]. Therefore, further investigations should be done to define the nature of remineralization of glass carbomer.

The investigation of the microhardness, compressive strength are vital for confirmation and comparison of mechanical properties of different dental materials and may suggest what material is best suitable to perform clinical functions and resisting to the masticatory forces [57].

Microhardness test is a parameter regularly used to evaluate the material surfaces resistance to plastic deformation by penetration [58]. As regard to hardness, the current study exhibited that there was no significant difference between glass carbomer and conventional glass ionomer. The highest hardness was detected in the conventional glass ionomer. Previous investigations revealed that increasing the filler size and content increases the mechanical properties of the material, the nano-filled materisls has a higher significant value when compared with conventional glass ionomer [35]

In the dental field, compressive tests are utilized for laboratory simulation of the stress that may result from forces applied clinically to a restorative, base/liner or core build material. Most mastication forces are compressive in nature, but exact critical value is obscure [59]. Therefore, it is important to examine whether compressive force contributes to failure during chewing process [60].

The present study used Carbomer glass fill which filled with nano hydroxyapatite and fluorapatite showed significantly higher compressive strength than that of the conventional glass ionmer. The compressive strength values mainly governed by the types of nano-filled particles [61]. A previous study showed that the compressive strength of the conventional glass ionomer would be enhanced by addition of nano-filler such as nano-sized TiO_2 [62]

Some author indicated that compressive strength of resin modified glass ionomer gives low reading when adding bioactive glass (BAG) particles [39]. Although, other studies revealed that the addition of nano hydroxyapatite and fluorapatite improved the compressive strength when compared to the conventional glass ionomer [15]. Other study suggested

that addition of nano TiO_2 particles increased the compressive strength [62]

CONCLUSIONS

Within the limitation of this study, the investigations on glass carbomer demonstrated some favourable results. Among these include the higher compressive strength and comparable shear bond strength and microhardness of glass carbomer, compared to conventional GIC. On the other hand glass carbomer showed higher water sorption and solublity than conventional GIC .Thus, glass carbomer holds a promise to be used as a potential restorative material particularly in pediatric dentistry .However, further in vitro and in vivo investigation is needed to validate the potential use of this material in clinical dentistry

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