ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 7, Issue – 6, November – 2024, Page No. : 73 - 81

Effect of Incorporation of Chicken Egg Shell Powder to Conventional Hybrid GIC As Permanent Restorative Material To With stand Masticatory Loads in Class II Restorations An in Vitro Study

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Citation of this Article: Dr.Megavarnan Ravi, Dr.Bharanidharan S, Dr.Kerenhap Winsy Gnanodhaya.J, "Effect of Incorporation of Chicken Egg Shell Powder to Conventional Hybrid GIC As Permanent Restorative Material To With stand Masticatory Loads in Class II Restorations An in Vitro Study", IJDSIR- November – 2024, Volume –7, Issue - 6, P. No. 73 – 81.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Glass-Ionomers have certain advantages over composites as fissure sealants, specifically that they are hydrophilic and dimensionally stable. The significant properties of the Glass-Ionomers are anticariogenic, chemical adhesion and biocompatible material which has a refractive index similar to that of enamel and dentin. Despite of all these advantages, GIC has low mechanical strength properties that can compromise its durability in stress bearing areas. The addition of using filler, like calcium carbonate, can lead to low capillary porosity and might also increase early strength and decreases the setting time. Incorporation of chicken egg shell powder to hybrid GIC may increase the compressive strength of the material and this research was done to evaluate the compressive strength of chicken egg shell powder incorporated Hybrid GIC as permanent restorative material in Class II cavities.

Materials and Method: Conservative cavity was prepared using handpiece with defined width and depth. Dentin conditioner was applied using applicator tip and rinsed after 2 minutes. The cavity was restored with two groups. Group I was Conventional Hybrid GIC, mixed using agate spatula and restored using plastic instrument. Group II was Chicken egg shell incorporated GIC, mixed using agate spate and restored using plastic instrument. Then the restored tooth was sent for testing the compressive strength using universal testing machine.

Results: The test resulted in statistically significant differences seen between the compressive strength of the two materials with t statistics (-8.914) with degree of freedom (68) p-value of 0.001*. The mean compressive strength of egg shell incorporated hybrid GIC (222.806) is higher than the conventional hybrid GIC (151.346). **Conclusion:** Within the limitation of the study, incorporation of chicken egg shell powder to conventional Hybrid GIC has enhanced its compressive strength of the material and there is a stastically significant difference when compared to that of Conventional Hybrid GIC.

Keywords: Glass Ionomer cement, Compressive strength, Permanent restoration, Chicken egg shell powder, Calcium carbonate, Dental caries, Cavity preparation.

Introduction

Dental materials can be classified into two major groups: (a) materials that will remain in intimate contact with the oral tissues and (b) auxiliary materials that are used as an adjunct to restorative materials and do not remain in direct contact with the oral structure [1]. The tooth is majorly categorized as coronal and radicular portion in which, the crown comprises of enamel, dentin and pulp and the root comprises of cementum, dentin and pulp. Enamel is the hardest tissue in the human body which is the only ectodermal derivative of the tooth that act as a porcelain-like cap covering the whole of the crown of a primary or permanent tooth. Inorganic components account for 96% in the form of hydroxyapatite crystals and organic components and water accounts for 4% [(2,3)]. Dentin is a complex hydrated biological composite structure which forms the bulk of the tooth, its main function is to protect the pulp. Dentin contains 30% organic matter and water, 70% inorganic matter in the form of hydroxyapatite crystals, and when compared to enamel hardness of dentin less. Hydroxyapatite Crystals adheres to the surface of the organic components and forms nucleates and crystals [(4,5)]. The modulus of elasticity (stiffness) plays a major role of material properties as it is an indication of the amount of deformation that will occur in the dental tissue when a load is applied to it [(6).] The modulus of elasticity for enamel ranges from 74.47±2.85 GPa to 99.94±3.95 GPa and for dentin, the elastic modulus ranges from 18.23±0.81 GPa to 23.97 ±0.72GPa [(7)]. The maximum masticatory load in natural teeth is 200 - 300N while the maximum forces during mastication of complete denture wearers range between 60N and 80N [(8)]. The ultimate compressive strength of a material is the value of uniaxial compressive stress attained when the material breaks entirely. Compressive strength is the ability of a material or structure to bear loads [(9)].Dental caries is defined as"Biofilm mediated, multifactorial, sugar driven, dynamic disease characterized by phasic demineralization and remineralization of dental hard tissues that leads to morphological and physiological changes of enamel and dentin that aid in complete loss of form and function"[(10)]. Tooth destruction that ranges from sub-clinical sub-surface changes at the molecular level to lesions with dentinal involvement, either with an intact surface or obvious cavitation [(11)]. Operative dentistry plays a major role in treating these lesions by mechanical alteration of the tooth followed by restoration that re- establishes a healthy state of the tooth, including esthetic corrections where indicated and with normal form and function[(12)]. The ideal requirement for a restorative material is to reinforce the tooth with adequate physical and mechanical properties that includes color, stability, compressive strength, shear strength, tensile strength, flexural strength, biocompatibility and so on. Direct filling gold, one of the old ancient restorative material which are indicated for small cavities where esthetics concern is limited. Gold foil is one of the rarely used restorative material in dentistry, and contrary to popular belief, it is still being used in many dental practices. The disadvantage of DFG demands cleanliness, exactness, precision, concentration, patience, and perseverance [13]. To overcome the disadvantage of Direct Filling Gold, Amalgam dental fillings has been an accepted part of restorative dentistry for over a century with little change to the powder. Due to the potential health risks associated with exposure to mercury, the use of dental amalgam fillings remains a source of controversy [14]. With the advancement of Calcium Silicate based cements, Glass Ionomer Cements has been widely used in restorative dentistry and has capacity to bond chemically to polar materials such as bone, enamel and dentin. These materials have a high surface energy, but are not able to react with the noble metals and porcelain. One of the advantages of GIC, it bonds chemically to the tooth surface without any bonding agent and has various applications such as lining, bonding, sealing, luting or restoring a tooth. Fluoride release is considered one of the important advantages of Glass-Ionomer Cements [15,16,17]. Glass-Ionomers have certain advantages over composites as fissure sealants, specifically that they are hydrophilic and dimensionally stable [18]. The significant properties of the Glass-Ionomers are anticariogenic, chemical adhesion and biocompatible material which has a refractive index similar to that of enamel and dentin [19]. The introduction of resin-modified glass-ionomer cements (RMGICs) was an attempt to address issues with the traditional GIC, such as its low mechanical qualities and susceptibility to moisture. The use of other modifications, like Polyacid-modified Composite Resin (Compomer), is limited to low stress-bearing areas due to its poor mechanical properties, such as low compressive strength, low abrasion resistance, and low fracture resistance. Its lack of translucency and moisture sensitivity during setting also make it unsightly [20,21]. To enhance the compressive strength of Conventional GIC, Type IX GIC and Hybrid GIC was introduced with certain modifications in powder component.

CESP (Chicken Egg Shell Powder) is a natural, low-cost, readily available waste product of the food industry, making it a cost-effective option and previous studies have investigated the integration of CESP to enhance the mechanical properties of restorative dental materials. Positive effects have been observed when CESP is used as a filler in Glass Ionomer Cement (GIC) [22]. The use of chicken eggshell powder in dentistry has drawn interest recently due to its potential therapeutic properties and applications. It also exhibits antibacterial effects against common oral infections [23].

Incorporation of chicken egg shell powder to hybrid GIC may increase the compressive strength of the material and this research was done to evaluate the compressive strength of chicken egg shell powder incorporated Hybrid GIC as permanent restorative material in Class II cavities and null hypothesis was rejected.

Materials and Method: This in vitro study was conducted in SATHYABAMA DENTAL COLLEGE AND HOSPITAL after getting clearance from SATHYABAMA Institutional Review Board on 15-03-2024 with approval ID:392/IRB-IBSEC/SIST.

Eggshell powder preparation: Twenty eggshells was taken and cleaned with distilled water. These egg shells were then kept in hot water bath at 100 deg Celsius for 10 minutes followed by removing the membrane and the eggshells was then crushed using a sterile motor and pestle to reduce the size of raw eggshell to a particle size sufficient for the intended use of the eggshell. The crushed particles were then heated at 1200 deg celsius in a muffled furnace and then cooling of eggshell particles were done and powdered to small particles and then stored in an air tight container. Normally, CESP contains 95% of calcium carbonate, which converts to basic calcium oxide on calcinations (calcination is a process performed to obtain pure powder free of pathogens and to increase its alkalinity) [24,25]

Tooth Preparation: A sample of 70 intact tooth were collected and conservative class II cavity was prepared with a width of 1/4 th of the intercuspal distance (1mm) and depth of 1/8 th into the dentin (2mm). Dentin conditioner was applied using applicator tip and rinsed after 2 mins. The cavity was then restored with the materials according to two groups. (Figure :1)

Hybrid GIC was mixed according to manufacturer's instruction, with 1:1 (powder: liquid) ratio, and CESP was added to the powder component with proportion of 2% by weight (Figure:2) and the specimens were categorized into two groups:

GROUP I: Hybrid GIC without CESP (n=35).

GROUP II: Hybrid GIC with 2% wt. CESP added to the powder component (n=35).

Specimens were then stored in 100% relative humidity for 24 hours in an incubator at 37 deg celsius after that, these specimens were subjected to universal testing machine (INSTRON 350K) at WHITE LAB, Saveetha Dental College and Hospital to calculate the maximum load (600 - 1000N) until fracture (Figure:3,4) and thus compressive strength was calculated, using formula,

$F = P/A$,

where: F: The compressive strength in MPa

P: The maximum load (or load until failure) to the material in N

A: The cross section of the area of the material resisting the load in mm^(2) (square).

Data analysis

The data obtained was analysed using IBM SPSS version 21 (SPSS version 21.0; IBM corporation, Armonk, NY, USA) statistical software. Statistical significance was set at 0.05 levels. Test of normality distribution resulted in p-value>0.05. Hence, parametric test were used for analysis. Intergroup comparison was analysed using Independent t test.

Results

The test resulted in statistically significant difference between the compressive strength of the two materials with t statistics (-8.914) with degree of freedom (68) p-value of 0.001* (table 2).

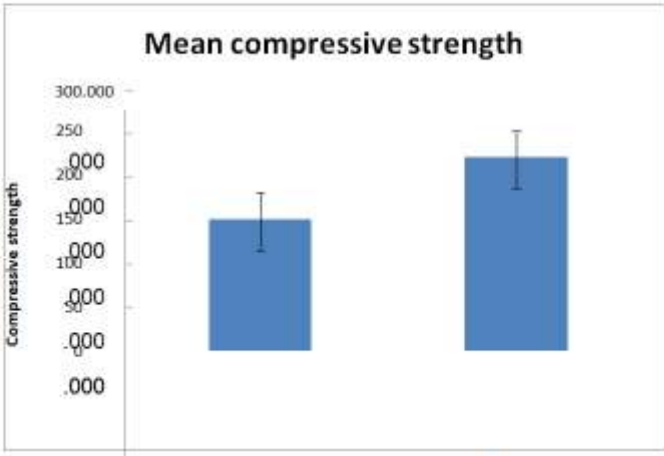
The mean compressive strength of egg shell incorporated hybrid GIC (222.806) is higher than the conventional hybrid GIC (151.346) as shown in table 1

Table 1: Descriptive statistics of compressive strength of the material

Compressive strength	N	Mean	Std. Deviation	Std. ErrorMean
Conventional hybrid GIC	35	151.346	30.839	5.213
Egg shell incorporated hybrid GIC	35	222.806	36.028	6.090

Table 2: Independent t test of compressive strength of two materials

Variable	t-test for Equality of Means						
	T	Df	p-value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Compressive strength	-8.914	68	.001*	-71.4600	8.016	- 55.4638	- 87.4561



	Conventional hybrid Gic	Egg shell incorporated hybrid GIC
Mean	151.34 6	222.806

Graph 1: Mean compressive strength

Discussion

Glass-ionomer cements are prepared from polyacrylic acid or related polymers. The advantage conferred by their adhesion to the tooth surface and were highly recommended for the repair of cervical erosion lesions and as pit and fissure sealants. The physical properties of glass-ionomer cements are influenced by how the cement is prepared, including its powder: liquid ratio, the concentration of the poly acid, glass powder particle size and age of the specimens.

Fluoride release is considered as one of the important advantage of Glass-Ionomer cements [26]. As a filling material, glass-ionomer cement mimics the tooth colour but not as good as composites and also shows faster surface loss by wear. As it is less technique demanding, it may serve in many more ways successfully than resin-based composites [27].

The mechanical properties of the GIC limit its applications because it is composed of carboxylic acid groups that make the resin easily interact with water and results in brittleness of the material. Various modifications such as Metal modified GIC, Resin modified GIC, Compomers, Condensable/Self-hardening GIC, Low viscosity/flowable GIC, Fiber-reinforced GIC, Chlorhexidine-impregnated GIC, Proline-containing GIC, Nano-bioceramic-modified GIC, and Calcium aluminate GIC has been made to enhance the mechanical properties of the cements. Although there is limitations in the application of GIC as permanent restoration in class II cavities as it lowers compressive and tensile strength [28,29,30,31,32].

Eggshell is a three-layered structure, with cuticle on the outer surface, a calcareous spongy layer in the middle surface and inner mammillary lamellar layer (Tullett, 1987, Stadelman, 2000). The calcium carbonate crystal bound to the matrix(calcite)is composed of protein fibers that are formed by spongy and mammillary layers of chicken egg shell, and it's chemical composition (by weight)are as follows: calcium carbonate (94%), magnesium carbonate (1%), calcium phosphate (1%) and organic matter (4%) (Stadelman, 2000) [33]. Eggshell calcium is probably considered the best natural source of calcium and trace elements of collagen, magnesium and phosphorus are also found that are essential for the formation and healing of dentin. Eggshell powder also has the capacity to promote tissue regeneration when used as a scaffold in regenerative procedures [34,35].

Glass hybrid technology is the combination of two types of Fluoro-Alumino-Silicate (FAS) glass and also two types of polyacrylic acid, that are distributed in small particle size with increased mechanical strength and durability of the material [36].

The presence of calcium carbonate in silicate cements produce calciumcarboaluminate that accelerate the cement hydration and provides the nucleation site for the hydration product to precipitate and also lead to low capillary porosity and might also increase early strength and decreases the setting time [37]. Chicken egg shell powder which is rich in calcium carbonate is used as filler in hybrid GIC to increase the compressive strength of the material. In the previous study conducted by Gehan Allam et al concluded that the mechanical properties of conventional GIC was enhanced by the addition of CESP and the calcium release was potentiated at 5% CESP [concentration], which can enhance the remineralizing ability of GIC without altering the fluoride release (38).

In the present study, Class II cavity which was restored with Modified Hybrid GIC (CESP)was able to withstand the maximum masticatory load without fracture (600 - 1000N) thus, increases the compressive strength of the material modified with CESP and has statistically significant difference present with that of conventional Hybrid GIC.

Conclusion

Within the limitation of the study, incorporation of chicken egg shell powder to conventional Hybrid GIC has enhanced its compressive strength of the material and there is a stastically significant difference when compared to that of Conventional Hybrid GIC and we also concluded that it can withstand a maximum masticatory load without fracture. Thus CESP modified Hybrid GIC can be used an alternative restorative material for permanent restoration of Class II cavities.

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Legend Figures

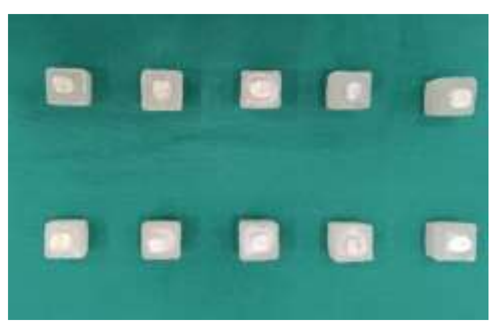

Figure 1:

Figure 2:

Figure 3:

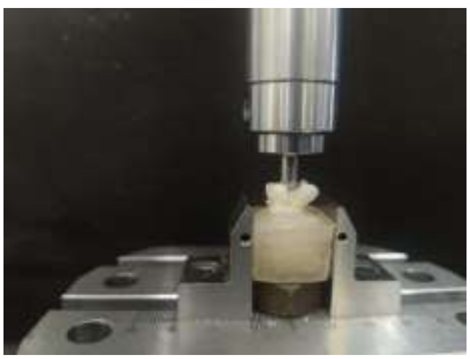

Figure 4: