Comparative evaluation of flexural strength of type II type VII and nano based glass ionomer cement - In vitro

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ABSTRACT:-

Introduction:- The capacity of a material to withstand bending forces applied perpendicular to its longitudinal axis is known as flexural strength. It is a phrase that is frequently used in dentistry. Megapascals, or MPa, are the metric units used to describe it. Glass ionomer cements (GICs) are aesthetically pleasing dental products with special qualities that make them effective as luting and restorative materials. GIC cements come in a total of 9 varieties.
Aim:- The aim of this study is to compare and evaluate the flexural strength of type 2 and type 7 glass ionomer cement.
Materials and methods:- Ten samples in total were collected, five of which belonged to type II glass ionomer cement and five of which belonged to type VII glass ionomer cement. A stainless steel mould was used to prepare the samples. The formula, σ = 3FL / 2BH2 was used to determine the flexural strength.
Result:- Type 2 GIC has a mean flexural strength of 26.5 MPa. Type 7 GIC has a mean flexural strength of 6.31 MPa. The flexural strength of dip coated type 2 GIC was 26.6 MPa. The flexural strength of dip coated type 7 GIC was 25.8 MPa.
Conclusion:- Titanium dip coated type 2 GIC showed superior results compared to the other GIC samples.

Keywords:- Flexural strength; Type 2 GIC; Type 7 GIC; Titanium; Dip coating.

1.INTRODUCTION:-

In the field of dentistry, the phrase "flexural strength" is commonly employed. Megapascals, or MPa, are the metric units used to describe it. The intensity of pressure or force per unit area that a material can withstand before breaking is measured in megapascals. Every dental material producer provides MPa values that represent flexural strength. With this reason, flexural strength is a crucial factor in determining how durable a dental material will be. With the emergence of tooth-colored materials over the past 10 to 20 years, there have been noticeable changes in the way dental restorative materials are employed as aesthetic considerations have grown in importance.These substances include composite resins, resin-modified glass ionomer cements, glass ionomer cements changed by resin, polyacid-modified composite resins (compomers), and more recently, giomers.[1] Not all tooth-colored dental restorative materials, such as those used in Class I, Class II, and Class IV restorations, can be advised for stress-bearing areas. A repair can only withstand a certain amount of applied force before it fractures.[1,2] For brittle materials, particularly resin-based filler materials, strength values like tensile, shear, compressive, and flexural strength are typically utilised as indications of structural performances.[1–3]

We chose the flexural strength for this investigation because it is a therapeutically relevant metric for characterising a filling material's resistance to occlusal force. The most frequent reason for dental repair failure has been recurrent caries. To address this drawback, fluoride-releasing restorative materials were developed.[4] Glass-ionomer cement (GIC) has the highest fluoride release of all the commercially available fluoride-releasing materials. Flexural strength, as defined by science, is a material's resistance to breaking or fracture. Flexural strength reveals the amount of force needed to fracture a test sample with a certain measurement diameter. When this threshold is crossed, the test specimen cracks.[5] The material can endure more impacting forces the higher the value. However, the measurement technique and sample surface preparation, such as whether a material is polished or ground, have a significant impact on the flexural strength discovered during a test. GIC has some inherent qualities that make it suited for a wide range of clinical applications, including anti-cariogenicity, biocompatibility, adherence to enamel, dentin, and composite, as well as a low coefficient of thermal expansion that is comparable to that of tooth structure.[5,6] Despite these benefits, GIC has certain disadvantages, including brittleness and porosity, which have a negative impact on its mechanical properties and cause it to have low wear resistance and fracture toughness. As a result, it is not always possible to draw firm conclusions from comparisons of different materials, and values obtained through various measurement techniques are not comparable. The values must be obtained using the same measuring technique in order for them to be comparable. An industry standard is being pushed for by current research, but it has not yet been reached. The integration of a wide range of biologically active elements has been tested in the composition of GIC. [7] Although the mechanical qualities of various modified GIC formulations have improved, bacterial adhesion on its surface is still a problem because it puts the tooth restoration interface's microenvironment at risk for secondary caries. High flexural strength materials have a number of benefits. A restoration might contain more units depending upon the strength of the material. The material should be as extensive as the extent of strength of the restoration. [8] When it comes to stress-bearing restorations like posterior crowns, high flexural strength is crucial. Flexural strength dictates which material should be selected when a material or restoration is subjected to significant strain or stress, particularly in bruxism patients.[5,8] Minimally invasive treatment options are necessary in the case of thin wall thicknesses. The thickness of the repair walls benefits from high flexural strength as well. A material with excellent strength enables a thin wall. As a result, a material that has great flexural strength and strong fracture resistance can generate very thin restorations and is suitable for minimally invasive procedures. [2,5,8] Our team has extensive knowledge and research experience that has translated into high quality publications.

Therefore the aim of this study is to compare and evaluate the flexural strength of type 2 and type 7 glass ionomer cement.

2.MATERIALS AND METHODS:-

2.1SAMPLE PREPARATION:-

The base of the mould was applied with vaseline to the mould's base in order to make it easier to remove the specimens, and a cellulose strip was placed over it to provide isolation. The test materials were painstakingly inserted into the mould without any voids, and then the top surface of the mould was once more covered with a cellulose strip. Excess material was extruded by gently applying pressure on a glass slide on top of the mould. The samples were then taken out of the mould. A total of 16 samples were taken, out of which five samples belonged to type II glass ionomer cement, five samples of Type VII Glass Ionomer Cement. Ten bar-shaped specimens were prepared in stainless steel mould measuring (25mm X 2mm X 2mm in length, width and thickness respectively). Three samples in each group were subjected to dip coating with titanium oxide.

2.2DIP COATING:-

Samples were dip coated using a Holmarc Dip coating unit with Infrared heater Model: HO-TH-02BT. Dip duration was set for 15 mins,travel speed 10 mm for dipping. This depends on the height of the substrate and the liquid level in the beaker, Dry duration was set for 10 mins.

2.3FLEXURAL STRENGTH TEST (THREE POINT BEND STRENGTH):-

The INSTRON E3000 universal testing machine with a crosshead speed of 1 mm/minute was used to execute the flexural strength test in accordance with the ISO standard. Using the following formula, **σ = 3FL / 2BH2** the flexural strength was determined, where, F is the maximum load applied to the specimen in newtons; L is the space between the supports in millimetres; B is the specimen's width in millimetres measured before testing; and H is the specimen's height in millimetres measured prior testing.

3.RESULT:-

The results are depicted in **Table 1** below.

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Type2GIC	6.889	2	.020	26.53333	9.9614	43.1052
Type7GIC	3.427	2	.076	6.31667	-1.6135	14.2468
Type2GICnano	58.909	2	.000	27.33667	25.3400	29.3333
Type7GICnano	32.764	2	.001	24.49667	21.2797	27.7136

Table 1:- Flexural strength parameter analysis of type 2 GIC, type 7 GIC and nanoparticle dip coated type 2 and 7 GIC.

The flexural strength between the class 2 (P-value:- 0.20) and class 7 (P-value:- 0.76) groups studied showed significant statistical variation ($P<0.01$). The statistical value of the titanium dip coated samples of type 2 and type 7 GIC was insignificant ($P<0.01$) were insignificant.

The flexural strength of class 2 GIC samples when infused with nanoparticle titanium oxide was found to be 27.3 MPa at a maximum force of 5.68N. The average flexural strength at its maximum, of class 7 GIC samples when infused with nanoparticle titanium oxide was found to be 24.4 MPa at a force of 5.52 N. The flexural strength of class 2 GIC samples was found to be at an average of 26.5 MPa at an average maximum force of 5.67N. The flexural strength displacement of class 7 GIC samples at an average was found to be 6.31 MPa at a maximum force of 2.00 N.

The highest mean value of flexural strength (MPa) was exhibited by titanium nanoparticle coated type 2 GIC (27.3 MPa) followed by type 2 GIC (26.5 MPa) , dip coated type 7 GIC (24.4 MPa) and type 7 GIC (6.31 MPa).

4.DISCUSSION:-

Glass ionomer cements integrate the chemistry and technology of zinc polycarboxylate and silicate materials to embrace the advantageous aspects of each. The limited flexural strength of GIC, despite the fact that it is a versatile restorative material in paediatric dentistry, means that it can only be used in places that bear little stress.[5] It is a straightforward full volume bulk replacement material that is made to be used quickly and easily. It is designed to fill Class I, II, or V cavities in permanent teeth as well as deciduous teeth. the inclusion of 78.4% weight of a proprietary alkaline inorganic filler, which has a higher flexural strength and adds enough strength to withstand oral cavity forces.[2] Flexure is where dental materials generally fail. This is as a result of the numerous strains that the mouth cavity places it under. Since flexural strength tests are more likely to detect minute changes in the substructure than compressive strength tests, they are frequently used to analyse the mechanical properties of dental materials. [9]Smith's research suggests that it is possible to predict the long-term wear of any material by measuring the flexural strength since there is a high explanatory power between flexural strength and long-term wear. Additionally, the flexural strength generates an accurate estimation of the material's tensile strength, simulating a clinical setting. In situations where they are subjected to strong stress, such as in class II cavities, materials with high flexural strength are preferred because they give restorations reduced susceptibility to fracture at the borders or in bulk.[10] [11] The ISO specifications for sample dimensions was 25 mm × 2 mm × 2 mm, for flexural strength testing. This dimension was used in our study as well. According to Queirozet al. [1] the specimen dimensions had no impact on the flexural strength. The way dental materials are stored may affect their varied mechanical qualities. Conflicting findings were found in the earlier in-vitro investigations when GIC's flexural strength was compared while stored in various storage media.[1,5] Some people have utilised artificial saliva, stimulated saliva, distilled water, deionized water, saline, petroleum jelly, and distilled water. In the current investigation, steps were made to ensure that testing parameters, including handling, specimen dimensions, storage media, temperature, time intervals, and testing techniques, were nearly equivalent to the intraoral environment.[6] In the present study the mean flexural strength of GIC specimens of class 2 GIC was 26.5 MPa at a maximum force of 5.67 N and for class 7 GIC was 6.31 MPa at a maximum force of 2.00 N. So, it has been observed that this material is having a statistically significant displacement in flexural strength.[8] Similar results were observed in other studies by Beyabenaki et al as well when he tested out glass ionomer cement.[12]

Choukimath et al. [12,13] used 0.9% saline as a storage medium while examining the fluctuation in flexural strength over time and found no change in the strength between 24 hours and one week (33.1 Mpa). Yao et al. [14] showed that storage in deionized water increased flexural strength from 33 MPa after 24 hours to 37 MPa after 1 week. The completion of the first two stages of the setting reaction (dissolution and gelation) and the maturation of the cement matrix as a result of more cross-linking were credited with the improvement in strength. But in contrast to earlier research by Rodrigues et al,[15] Up to week 4, there was a rise in flexural strength, and at week 4, there was a reported decrease in flexural strength (36.5 Mpa), which was not statistically significant.

In this research the flexural strength of class 2 GIC samples when infused with nanoparticle titanium oxide was found to be 26.6 MPa at a maximum force of 5.68 N. The flexural strength of the class 7 GIC samples when infused with nanoparticle titanium oxide was found to be 25.8 MPa at a maximum force of 5.52 N. This increase in strength, according to Rigobello et al. [16] was brought on by the continuing synthesis of aluminium salt, which was in charge of the cement's ultimate hardening. According to a more recent, critically examined theory, the maturation of GIC is the result of ongoing poly salt complex synthesis that involves other ionic species in addition to aluminium ions.[16,17] Opposing the above studies, [16–18] while stored in distilled water, flexural strength values increased from 24 hours (29.8 Mpa) to one week (44.1 Mpa) and decreased at the end of four weeks (31.8 Mpa). Wang et al. [16–19] found similar findings, stating that storage in artificial saliva increased flexural strength values from 24 hours (23.1 Mpa) to one week (24.4 Mpa), and further decreased them at the end of four weeks (14.5 Mpa). It was mentioned that using water to store GIC is not recommended because it can result in lower physical qualities due to the cement absorbing water molecules and the cement's vulnerability to chemical erosion brought on by hydrolysis when kept in distilled water. [8]

Enhancing the binding between GIC and the composites has been suggested as a way to improve the overall clinical success of the final repair. These involve using various intermediary materials and following surface treatment techniques.[4,8] GIC has historically been the material of choice, whether it is chemically cured or uncured. In order to get a suitable composite and GIC bonding, it is necessary to etch the surface of the GIC or use an intermediary bonding agent, or both. Studies conducted in the past employing an adhesive bonding and acid etching combination revealed that acid etching did not enhance sandwich restorations' capacity to seal. The binding strength significantly improved when bonding chemicals were used alone.[4,6,8] Thus, the flexural strength of the GIC itself, which depends on handling and the powder to liquid ratio, the viscosity of the bonding agent, which determines its wettability and flow, the volumetric change caused by the polymerization of the composite resin, and the technique to pack the GIC and composite without the incorporation of voids are all factors that affect the bond strength of a sandwich restoration with an intermediary adhesive liner. [7] An benefit of a relatively new hybrid dental restorative material is that it has the same strength as composite resins and the ability to release and recharge fluoride. It also has superb aesthetics and is simple to polish. In cervical restorations, it might thus take the place of traditional glass ionomer cement or composite. Dental restorative materials should, in theory, have characteristics that are strikingly similar to the tooth tissue they are replacing in every way. Indicators of structural performance for brittle dental materials, particularly resin-based restorative materials, are typically referred to as physical characteristics.[12] Clinically, anterior and posterior regions of composite restorations may be subjected to unfavourable flexural forces.[20] For this reason, material scientists and dental professionals alike must characterise flexural strength. High flexural strength is necessary in stress-bearing areas (Class I, Class II, and IV restorations) in order to endure forces and loads during biting without breakage.

5.CONCLUSION:-

When extrapolating the findings of this investigation to the therapeutic performance of the tested materials, care must be used. This is due to the possibility that the relative flexural strength of dental materials in actual clinical settings will vary greatly from what can be inferred from their mechanical properties when tested in a test tube.When comparisons were done within the constraints of this investigation, dip coated type 2 GIC outperformed other GIC samples in terms of flexural strength, although the difference was statistically insignificant.

1. Queiroz J, Fernandes L, Dovigo LN, Fonseca RG. Effect of Successive In-office Bleaching Sessions on the Surface Properties, Substance Loss, Biaxial Flexural Strength, and Reliability of CAD-CAM Monolithic Materials. Oper Dent [Internet]. 2022 Nov 28; Available from: http://dx.doi.org/10.2341/21-145-L

2. Darkoue YA, Burgess JO, Lawson N, McLaren E, Lemons JE, Morris GP, et al. Effects of

Particle Abrasion Media and Pressure on Flexural Strength and Bond Strength of Zirconia. Oper Dent [Internet]. 2022 Nov 28; Available from: http://dx.doi.org/10.2341/20-168-L

3. May MM, Machry RV, Fraga S, de Andrade GS, Bottino MA, Valandro LF, et al. Resin cement coating reverts the machining damage on the flexural fatigue strength of lithium disilicate glass-ceramic. J Biomed Mater Res B Appl Biomater [Internet]. 2022 Nov 26; Available from: http://dx.doi.org/10.1002/jbm.b.35206

4. Yılmaz Atalı P, Doğu Kaya B, Manav Özen A, Tarçın B, Şenol AA, Tüter Bayraktar E, et al. Assessment of Micro-Hardness, Degree of Conversion, and Flexural Strength for Single-Shade Universal Resin Composites. Polymers [Internet]. 2022 Nov 17;14(22). Available from: http://dx.doi.org/10.3390/polym14224987

5. Battula MS, Kaushik M, Mehra N, Raj V. A comparative evaluation of fracture toughness, flexural strength, and acid buffer capability of a bulk-fill alkasite with high-strength glass-ionomer cement: An study. Dent Res J . 2022 Oct 20;19:90.

6. Guimarães TGFA, Feitosa VP, Rifane TO, Sfalcin RA, Guimarães BM, Correr AB. Effects of Alternative Solvents in Experimental Enamel Infiltrants on Bond Strength and Selected Properties. Biomed Res Int. 2022 Nov 14;2022:4293975.

7. Souza MA, Ricci R, Bischoff KF, Reuter E, Ferreira ER, Dallepiane FG, et al. Effectiveness of ultrasonic activation over glycolic acid on microhardness, cohesive strength, flexural strength, and fracture resistance of the root dentin. Clin Oral Investig [Internet]. 2022 Nov 21; Available from: http://dx.doi.org/10.1007/s00784-022-04792-4

8. Cengiz S, Bagis B, Külünk Ş, Velioğlu N, Sağlam G. Comparison of fiber reinforcing methods of composite resin: A flexural strength and stereo microscopy study. Microsc Res Tech [Internet]. 2022 Nov 21; Available from: http://dx.doi.org/10.1002/jemt.24266

9. Chopra A, Lakhanpal M. Glass Ionomer Cement: GIC- A Tooth Colored Restorative Material. LAP Lambert Academic Publishing; 2013. 172 p.

10. Smith L, Ali M, Agrissais M, Mulligan S, Koh L, Martin N. A comparative life cycle assessment of dental restorative materials. Dent Mater [Internet]. 2022 Nov 22; Available from: http://dx.doi.org/10.1016/j.dental.2022.11.007

11. Manas A, Kumar A, Sorte Gawali K, Ismail PMS, Goutam M, Das I. Analysis of Fracture Resistance of Endodontically Treated Teeth with Different Restorative Materials: An Study. J Pharm Bioallied Sci. 2022 Jul;14(Suppl 1):S977–9.

12. Beyabanaki E, Ashtiani RE, Moradi M, Namdari M, Mostafavi D, Zandinejad A. Biaxial flexural strength and Weibull characteristics of a resin ceramic material after thermal-cycling. J Prosthodont [Internet]. 2022 Nov 19; Available from: http://dx.doi.org/10.1111/jopr.13622

13. Choukimath MC, Banapurmath NR, Riaz F, Patil AY, Jalawadi AR, Mujtaba MA, et al. Experimental and Computational Study of Mechanical and Thermal Characteristics of h-BN and GNP Infused Polymer Composites for Elevated Temperature Applications. Materials [Internet]. 2022 Aug 5;15(15). Available from: http://dx.doi.org/10.3390/ma15155397

14. Yao DX, Dong-Xu YAO, Zeng YP. High Flexural Strength Porous Silicon Nitride Prepared via Nitridation of Silicon Powdernitridation; porous silicon nitride; flexural strength; porosity [Internet]. Vol. 26, Journal of Inorganic Materials. 2011. p. 422–6. Available from: http://dx.doi.org/10.3724/sp.j.1077.2011.00422

15. Rodrigues Pais Alves MF, Figueira Vaz Fernandes MH, Macário Barboza Daguano JK, Dorión Rodas AC, Vasconcelos Amarante JE, Santos CD. Effect of the surface finish on the mechanical properties and cellular adhesion in (Ce,Y)-TZP/AlO ceramic composites for denture implants. J Mech Behav Biomed Mater. 2022 Oct;134:105363.

16. Rigobello A, Colmo C, Ayres P. Effect of Composition Strategies on Mycelium-Based Composites Flexural Behaviour. Biomimetics [Internet]. 2022 Apr 25;7(2). Available from: http://dx.doi.org/10.3390/biomimetics7020053

17. Lim JH, Lee SY, Gu H, Jin G, Kim JE. Evaluating oxygen shielding effect using glycerin or vacuum with varying temperature on 3D printed photopolymer in post-polymerization. J Mech Behav Biomed Mater. 2022 Jun;130:105170.

18. Sarcinella A, Aguiar JLB de, Frigione M. Physical Properties of an Eco-Sustainable, Form-Stable Phase Change Material Included in Aerial-Lime-Based Mortar Intended for Different Climates. Materials [Internet]. 2022 Feb 4;15(3). Available from: http://dx.doi.org/10.3390/ma15031192

19. Wang X, Hu X, Ji X, Chen B, Chen H. Development of Water Retentive and Thermal Resistant Cement Concrete and Cooling Effects Evaluation. Materials [Internet]. 2021 Oct 16;14(20). Available from: http://dx.doi.org/10.3390/ma14206141

20. Xiong BG, Chai Y, Yuan SP, Niu GL. Effects of plasma-induced grafting modification on the adhesive strength and mechanical properties of fiber posts. Eur Rev Med Pharmacol Sci. 2022 Nov;26(21):7840–9.