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COMPARATIVE EVALUATION OF COMPRESSIVE STRENGTH OF GLASS IONOMER CEMENT REINFORCED WITH SILVER NANOPARTICLES AND POWDERED CHICKEN EGG SHELL WITH TRADITIONAL GLASS IONOMER CEMENT: AN IN-VITRO STUDY.

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ABSTRACT **Introduction-** This in vitro study investigated the compressive strength of glass ionomer cement reinforced with silver nanoparticles and powdered chicken eggshells. **Methodology-** Following the manufacturer's directions, GIC was combined in a 1:1 (powder: liquid) ratio, and 3% of CESP and 10% of AgNp by weight was added to the powder component of GIC. Three groups comprised the specimens. Group1-GIC,Group 2-GIC+3%CESP and Group3-GIC+3%CESP+10%AgNp. **Results-**Group 3 showed the highest compressive strength followed by group 2 and the least was shown by group 1. Pairwise comparison showed a significant difference among all the groups with $p<0.001$. **Conclusion-**Within the limitations of this study, Glass ionomer cement reinforced with Silver nanoparticles and powdered CESP showed the highest compressive strength.

KEYWORDS : Chicken eggshell, Silver nanoparticles, glass ionomer cement, compressive strength, Universal testing machine.

INTRODUCTION

Glass-ionomer cement (GIC) has been one of the most ideal restorative material among clinicians since its introduction in 1972 because of its special properties, which include chemical adherence to mineralized tissues, moisture insensitivity, and a low coefficient of thermal expansion comparable to that of dental structures.[1] GIC's anti-cariogenic properties are further enhanced by its exceptional fluoride release, rechargeability, and biocompatibility.[2] Despite all of these benefits, GIC's low mechanical strength compromises its longevity in regions subjected to stress. [2]

Several methods, including the addition of resin and the incorporation of alumina, carbon, glass, hydroxyapatite, and fluorapatite nanoparticles, have been tried to enhance the mechanical properties of conventional GIC without compromising the material's capacity to release fluoride.[3]

About 94%–98.2% calcium carbonate (CaCO3), 0.9–1% calcium phosphate, 4% organic content, and 0.9–1% magnesium carbonate are found in chicken eggshells.[4]

Numerous clinical studies have successfully investigated the use of this abundant calcium source in the treatment of osteoporosis, bone replacement, and, more recently, the remineralization of early enamel abnormalities.[5]

As a rich source of calcium carbonate, chicken eggshell powder (CESP) has also been utilized to mechanically reinforce polyethylene/polypropylene composites used in a range of industrial applications.[4]

Because CESP is easily available, inexpensive, and naturally renewable, it can be used as a filler material to improve the mechanical qualities of GIC.[6] Because of this, the current study sought to determinehow adding CESP to glass ionomer powder affected its mechanical characteristics as well as the release of calcium and fluoride. Silver is a naturally occurring metallic element known for its wide-ranging and highly effective antibacterial properties against numerous types of bacteria. [7]

It exhibits low levels of drug resistance, making it suitable for use in various fields, including cosmetics, textiles, water purification systems, and coatings.[8]

Nanosilver is a type of one-dimensional fibre developed through nanotechnology, with a diameter of less than 100 nanometers. Nanosilver retains the same advantages as conventional silver, such as prolonged antibacterial effectiveness, minimal drug resistance, high thermal stability, and low volatility. Furthermore, owing to its larger surface-to-volume ratio and small particle size, nanosilver can boost antimicrobial effectiveness without compromising mechanical properties.[9]

The inclusion of CESP in conjunction with silver nanoparticles (AgNp) to reinforce glass ionomer cement has not yet been the subject of any research.

Few studies have examined and contrasted the use of silver nanoparticles and powdered chicken eggshell in glass ionomer cement with that of regular glass ionomer cement.

MATERIALS AND METHODS

Three groups have been formed for this invitro study.

Group 1 Samples: GIC was mixed in a 1:1 (Powder: Liquid) ratio as directed by the manufacturer.

Group 2 Sample: GIC was mixed in accordance with the manufacturer'sinstructions using a 1:1 (Powder:Liquid) ratio after CESP was added to the powder component of GIC in a proportion of 3% by weight.

Group 3 Sample: 3% and 10% by weight of CESP and AgNP were added to the powder component, respectively. GIC was combined using a 1:1 (Powder: Liquid) ratio as directed by the manufacturer.

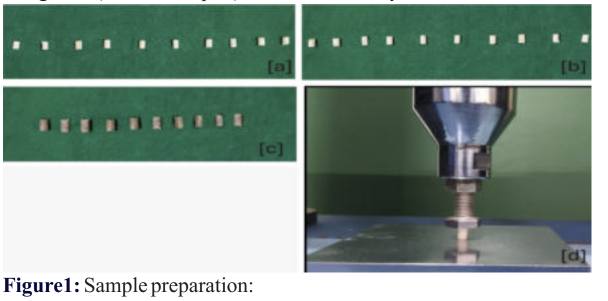

Figure1: Sample preparation:

(a)Group1GIC,(b)Group2GIC+3%CESP(c)Group3-GIC+3%CESP+10%AgNps and(d)Compressive strength testing of samples

30 samples in all, 10 in each of the three groups, were created. Plastic cylinder molds measuring 4 mm in diameter and 10 mm in height were used to create cylindrical samples for a compressive strength test. To get rid of entrapped air from the set cement paste, the molds were covered with glass slides.

To standardize the pressure applied during the material's initial setting, a 200g weight was positioned on top of the set.

After 30 minutes of setting, the samples were removed from the molds.

Statistical Analysis

The One-way ANOVA test was used to compare quantitative data, and a P value of less than five was chosen as the significance level. Version 23.0 of the IBM SPSS Statistics for Windows program was used for all data analysis. (IBM Corp., Armonk, NY).

RESULTS

1. Increasing Mean Compressive Strength:
o GIC: 62.18 MPa
o GIC+3%CESP: 67.42 MPa (Higher than GIC)
o GIC+3%CESP+AgNps: 74.60 MPa (Highest)
This suggests that adding 3% CESP improves compressive strength, and further adding Ag enhances it even more.

2. Low Standard Deviation (SD):
o The SD values are relatively small (1.36–1.69), indicating that the data points within each group are closely clustered around the mean.
3. Significant Difference (P-value < 0.001):

Table No.1 Representing Comparison Of The Compressive Strength Among Three Groups

Group	Mean	SD	Minimum	Maximum	F value	P value
GIC	62.18	1.63	59.80	64.90	158.44	<0.001
GIC+3%CESP	67.42	1.36	65.50	69.40		
GIC+3%CESP+AgNp	74.60	1.69	72.10	77.90		

o The one-way ANOVA test shows a **highly significant difference (F = 158.44, P < 0.001)**, indicating strong statistical evidence that at least one group differs significantly.

Interpretation:

- Adding CESP and Ag significantly increases compressive strength.
- The differences between groups are statistically significant, meaning the enhancements are not due to random variation.
- Further comparisons (like post-hoc tests) may help pinpoint exactly which groups differ significantly from each other.

PAIRWISE COMPARISON

The increase in compressive strength follows this order: GIC < GIC+3%CESP < GIC+3%CESP+AgNp.

The biggest improvement occurs when AgNp is added to GIC+3%CESP, showing that AgNp has a strong reinforcing effect.

The Tukey test confirms that all differences are statistically significant, meaning the improvements are real and not due to random variation.

Table No.2 Representing The Pairwise Comparison Among 3 Groups

Group	Mean difference	p-value
GIC vs GIC+3%CESP	-5.24	<0.001*
GIC vs GIC+3%CESP+AgNp	-12.42	<0.001*
GIC+3%CESP vs GIC+3%CESP+AgNp	-7.18	<0.001*

DISCUSSION

The present in vitro study evaluated the effect of incorporating silver nanoparticles (AgNp) and powdered chicken eggshell (CESP) into glass ionomer cement (GIC) on its compressive strength. The results revealed that the modified GIC formulations exhibited significantly higher compressive strength compared to conventional GIC, with the highest strength observed in the group reinforced with both CESP and AgNp.

The improvement in compressive strength can be attributed to the synergistic effects of CESP and AgNp. **Chicken eggshell powder** is primarily composed of calcium carbonate ($CaCO_3$), which enhances the mechanical properties of GIC by providing additional mineral reinforcement and promoting better ionic bonding with the cement matrix. [10] The presence of $CaCO_3$ may contribute to an increase in the density and hardness of the cement, reducing porosity and improving its mechanical stability. Various material's mechanical and biological qualities have been enhanced with the application of CESP.[4]

Silver nanoparticles, on the other hand, are known for their antimicrobial properties and their ability to enhance the mechanical characteristics of dental materials. Their small particle size allows for better dispersion within the GIC matrix, leading to improved interparticle bonding and reduced microstructural defects. The existence of voids in the cement matrix is the most frequent cause of GIC restorations breaking. Nanoparticles included onto GIC typically cover these gaps[11]. This explains why the combination of both reinforcements (CESP and AgNp) resulted in the highest compressive strength among the tested groups.

The findings of this study are in agreement with previous research that demonstrated the positive effects of **mineral-based and nanomaterial reinforcements** on GIC.[12] The significant increase in compressive strength observed in Group 3 suggests that incorporating both additives into GIC may provide a viable strategy for improving the performance of this restorative material.

However, some **limitations** must be considered. This study was conducted under controlled laboratory conditions, and the behavior of the modified GIC in a clinical setting remains to be explored. Factors such as oral pH fluctuations, saliva exposure, and long-term wear resistance were not evaluated in this study. Additionally, further research is needed to assess other mechanical properties, such as flexural strength, surface hardness, and bond strength, to determine the overall performance of the modified GIC.

Clinical Implications

The incorporation of CESP and AgNp into GIC could be beneficial for restorative dentistry, particularly in pediatric and geriatric patients where GIC is commonly used. The **enhanced mechanical properties** may contribute to increased durability and longevity of restorations, reducing the need for frequent replacements. Moreover, the antimicrobial properties of silver nanoparticles could help in preventing secondary caries, thereby improving the overall success of restorative treatments.

CONCLUSION

Within the limitations of this study, it can be concluded that GIC reinforced with silver nanoparticles and powdered chicken eggshell exhibits superior compressive strength compared to conventional GIC. This modified formulation holds promise for improving the durability and clinical performance of GIC-based restorations. Future studies involving **long-term in vivo assessments** and evaluation of additional properties will be essential to further validate these findings.

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