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Comparative evaluation of compressive strength of conventional GIC and nano curcumin incorporated GIC

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Abstract
Aim: Aim of this *in vitro* study was to compare and evaluate the compressive strength of Conventional GIC and two different concentrations of Nanocurcumin incorporated GIC.
Materials & Method: A total of 45 specimen blocks (3x6mm) was prepared for this study.
The specimen were divided into 3 groups consisting of 15 samples each. Group A consisting of (n=15) samples of Conventional GIC (Control group), Group B consisting of 15 samples of 80/20% of Nanocurcumin incorporated GIC & Group C consisting of 70/30% of Nanocurcumin incorporated GIC. The specimen were immersed in water for 24hrs at 37ºC to mimic the oral environment. The samples were then tested for compressive strength using Universal Testing Machine.
Compressive load was applied along the long axis of the specimen, at a cross-head speed of (0.75 ± 0.30) mm min^{-1}, using a Universal testing machine with load cell of 1000 N.
Results: Group C (70/30% wt Nanocurmin incorporated GIC) had the highest compressive strength followed by Group B (80/20% wt Nanocurcumin incorporated GIC) and Group A (control group) had the least compressive strength.
Conclusion: On comparing and evaluating the compressive strength of Conventional GIC and different concentrations of Nanocurcumin-incorporated GIC can offer both improved mechanical properties and potential therapeutic benefits.

Keywords: Nanocurcumin, glass ionomer, nanoparticles

Introduction

Glass ionomer cement (GIC) is a biomaterial with an acid-base composition, comprising fluoro-aluminosilicate glass powder that degrades in acid, a polymeric acid dissolved in water, and tartaric acid [1].
These cements exhibit distinct characteristics that render them valuable for restorative and adhesive purposes. These include the ability to adhere to moist tooth structure and base metals, anticariogenic properties stemming from fluoride release, thermal compatibility with tooth enamel due to a low coefficient of thermal expansion comparable to that of tooth structure, as well as biocompatibility and low cytotoxicity [2].
Despite being commonly used as a restorative material, GIC has certain limitations that pose significant challenges in clinical applications. One such drawback is its low mechanical properties, including a diminished fracture strength, making it susceptible to cracks and ultimately leading to the failure of restorations [3].
Since the introduction of glass-ionomer cement (GIC) by Wilson and Kent in the early 1970s, numerous modifications to the original formulation have been implemented to enhance its clinical applications [4].
Recent studies have highlighted that nanomaterials offer innovative preventive and therapeutic approaches for dental caries. This is particularly evident in their potential to reduce and manage dental plaque biofilms, enhance the antibacterial properties of dental materials, and contribute to the remineralization of early dental caries lesions [5].
The utilization of nanoparticles containing safe and biocompatible degradable compounds have significant benefit. This is particularly crucial due to the persistent concerns in the medical field regarding the biosafety and accumulation of non-biodegradable nanoparticles in various body organs. In this regard, the application of nanoparticles with safe and biocompatible degradable compounds proves advantageous [6].
Curcumin, a polyphenolic compound and a significant constituent of Curcuma longa, is recognized for its diverse biological effects, including anti-inflammatory, antioxidant, and antibacterial properties. Despite its robust biological activity, curcumin suffers low solubility, limited bioavailability, poor absorption, and rapid metabolism within the human body. These factors collectively constrain its clinical application [7]. To combat these problems, nanosized curcumin particles have been used in this study.
The aim of this study was to compare and evaluate the compressive strength of Conventional GIC and two different concentrations of Nanocurcumin incorporated GIC.

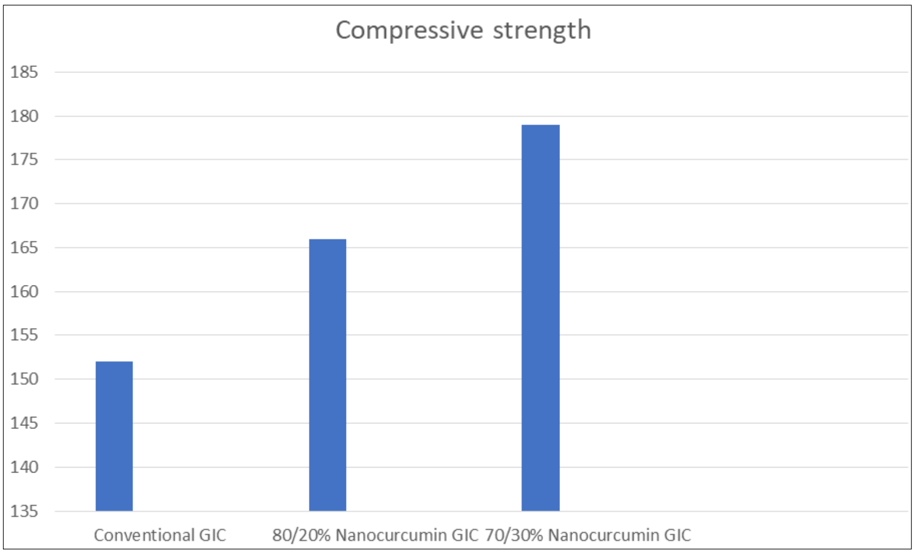
Materials & methods

Sample preparation

GC Fuji II (GC Corporation/Itabashi-CHO, Tokyo, Japan) was manually mixed with curcumin nanocrystals powder with weight percentages of 80 to 20 and 70 to 30. For standard mixing of cement powder and nanoparticle powder, each of them was weighed accurately with a digital balance and then the specified weight percentages of them were mixed.
First, a thin and transparent layer of glass was placed on the metal molds (15 mm in diameter and 1 mm in height). The curcumin cement powder was prepared by mixing nanocurcumin, GIC (with weight percentages of 80 to 20 and 70 to 30) with cement liquid based on the manufacturer’s instructions. Mixed cements were put into metal molds and covered with a second transparent layer on

the samples and were allowed to set. They were then placed in light-proof boxes for one hour. Samples were taken out and carefully removed from molds. Excess cement was removed from the margins of the samples and the samples were polished to remove irregularities and additions of cement. The specimen were immersed in water for 24hrs at 37ºC to mimic the oral environment.

The samples were then tested for compressive strength using Universal Testing Machine. Compressive load was applied along the long axis of the specimen, at a cross-head speed of (0.75 ± 0.30) mm min^{-1}, using a Universal testing machine with load cell of 1000 N.



Results

Group C (70/30% wt Nanocurmin incorporated GIC) had the highest compressive strength followed by Group B (80/20% wt Nanocurcumin incorporated GIC) and Group A (control group) had the least compressive strength. (P value <0.05)

Discussion

Restorative materials- especially those that are tooth-colored have seen a significant transformation in recent years. Nanotechnologies have been used in the production of glass-ionomer cements (nano-ionomers), endodontic sealants, dental composites, and tooth regeneration.8 Through the addition of various products and the usage of various types of nanomaterials, several modifications have been made to improve the mechanical, physical, and antibacterial properties of GICs [6].

The majority of the masticatory forces that occur in the oral environment are compressive. The precise critical values for compressive tests are yet unclear.9 A more reliable test for assessing brittle materials is the CS test. According to reports, primary and permanent teeth must have a minimum CS of 100 MPa for posterior teeth and 125 MPa for anterior teeth in order to survive the forces of mastication.10 The mean CS of the nanoparticles blended GICs in this study ranged from 166–179 MPa.

Our study is in agreement with a similar study by Moghaddam & Ali Torab et al which showed that the set structure of Nanocurcumin incorporated type I GIC had a stable structure, better antibacterial and physical properties [7].

In the present study Nanocurcumin incorporated GIC's improved physicomechanical characteristics could indicate that the tested nanoparticles reinforce GIC by filling up the empty or vacant spaces between the larger glass particles and acting as additional sites for polyacrylic acid binding [11].

Set GIC pores and voids serve as stress-raising points where fracture is possible. These voids become trapped in the Cement after the material hardens, where they become a cause of stress concentration and mechanical weakness [12, 13].

Al-Hamdan et al. evaluated the shear bond strength (SBS) of CAD cemented to a dental glass ionomer cement following chlorhexidine and curcumin/O3 disinfection. Improved cement SBS was demonstrated by Curcumin/O3. Bond integrity decreased and low microleakage scores were shown by Chlorhexidine [14].

The impact of turmeric inclusion on the fluoride release, antibacterial effectiveness, and physical features of GICs was evaluated by Prabhakar et al. Turmeric was added at a concentration of 1%, which showed that it improved the fluoride release and antibacterial activity of GICs without affecting its physical properties, shear bond strength, micro leakage, or setting time [15].

In a recent Turmeric-modified GICs were used to restore a cavity, and the results shown that they could lower the S. mutans levels when compared to traditional GICs [16].

This study had a few drawbacks that must be noted. Firstly, only one mechanical property i,e compressive strength of the experimental material was tested. Second, this material has not been tested for its ability to cause discoloration of the teeth since curcumin has a possibility to do so.

Further studies may explore these aspects of nanocurcumin incorporated GIC to validate its clinical feasibility.

Conclusion

The findings in this study suggest that the introduction of Nanocurcumin into GIC formulations has the potential to enhance the mechanical properties of the material. The observed increase in compressive strength indicates improved resistance to forces encountered in the oral environment, which is a critical factor for dental restorative materials. Further studies are warranted for better clinical applications of this restorative material.

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