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Original Article

Comparative Evaluation of Compressive Strength and Diametral Tensile Strength of New Ceramic Reinforced GIC, Alkasite Restorative Material, Conventional GIC in Simulated Saliva – An *In vitro* Study

R Batty Sharan[1], M S Keerthivasan[2], C J Venkatakrishnan[3], B Tamizhesai[4]

[1]CRRI, Department of Prosthodontics and Crown and Bridge, Tagore Dental College and Hospital, Chennai, Tamil Nadu, India, [2]Senior Lecturer, Department of Prosthodontics and Crown and Bridge, Tagore Dental College and Hospital, Chennai, Tamil Nadu, India, [3]Principal, Professor and Head, Department of Prosthodontics and Crown and Bridge, Tagore Dental College and Hospital, Chennai, Tamil Nadu, India, [4]Reader, Department of Prosthodontics and Crown and Bridge, Tagore Dental College and Hospital, Chennai, Tamil Nadu, India

Abstract

Background: Dental restorative materials play a vital role in maintaining form and function of the tooth structure after restoration. The compressive strength (CS) and diametral tensile strength play a significant role in materials strength. Glass cement has been widely used for their properties such as biocompatibility, fluoride release, and their chemical adhesion to tooth structure. Although glass ionomer cement (GIC) is put upon most, they have certain drawbacks such as moisture sensitivity, low strength, and low wear resistance. Newer materials such as, Amalgomer CR, Cention N were introduced to overcome the drawbacks of GIC. These materials are claimed to have greater properties than conventional GIC.

Aim: The aim of this study is, "comparative evaluation of compressive and diametral tensile strength of new ceramic reinforced GIC, alkasite restorative material, Type II GIC in simulated saliva."

Objectives: The present study is to evaluate and compare the compressive and diametral tensile strength of new ceramic reinforced GIC, alkasite restorative material, type II GIC in simulated saliva for 1st day and 7th day.

Methods: This *in vitro* evaluation of compressive and diametral tensile strength of following materials is done in 1st day and 7th day of storing it in simulated saliva. Study contains total of 3 groups with 3 samples each separately for 1st and 7th day using universal testing machine. Group A - GIC type II, Group B - Cention N, Group C - Amalgomer CR.

Results: The values were recorded and subjected to statistical analysis for comparison of CS (MPa) and tensile strength between the three materials using SPSS software.

Conclusion: Cention N showed highest CS and diametral tensile strength for 1st day and after 7 days followed by Amalgomer CR and least strength by conventional GIC.

Key words: Amalgomer CR, Cention N, Compressive strength, Diametral tensile strength, Glass ionomer cement

INTRODUCTION

Human teeth possess a limited ability to regenerate, so when they lost, replacements are required. The form and functionality of the tooth are profoundly reliant upon the materials used for restorations.[1] For these materials to be effective, they must adhere firmly to the dentinal surface to resist a variety of dislodging forces.[2]

Over time, numerous kinds of restorative materials have been developed, although basic materials have built-in drawbacks such as poor flexural strength, low wear resistance, metallic sensitivity, and bonding failure.[3] New materials have been developed to conquer these shortcomings; one such material, glass ionomer, has been successfully applied in dental restorations since

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Corresponding Author: Dr. Keerthivasan, Senior Lecturer, Tagore Dental College and Hospital, Chennai, Tamil Nadu, India.

its debut in 1972.[4] Glass ionomers, however, are only useful for minimally loaded anterior tooth restorations due to their shortcomings, which include moisture sensitivity, low strength, poor wear resistance, and brittleness.

Cention N is a dimethacrylate alkasite restorative material that was recently added to the direct bulk restoration field. It has a tendency to self-cure and light cure. It has benefits such fluoride ion release, bulk placement with or without adhesives, dual curing durability, and esthetic appeal. It uses alkaline fillers and releases acid-neutralizing ions. Manufacturers claim that Cention N is a unique substance with excellent mechanical qualities. One of its special qualities is that it releases calcium and fluoride, which helps to remineralize early enamel lesions.[5] Cention N presents a strong alternative in the field of restorative dentistry, positioning itself as a rival to known and tried-and-true esthetic adhesive solutions.

Another novel invention is Amalgomer CR, ceramic-reinforced glass ionomer cement (GIC) which brings together the advantages of glass ionomer and amalgam's durability and esthetic appeal. The company suggests this tooth-colored alternative to standard glass ionomer because it is esthetically pleasant and boosts wear resistance, radiopacity, and overall strength of the cement.[6] Despite the addition of ceramic fillers, it still has a good working time and the capacity to chemically attach to tooth structure.[7]

Important characteristics of restorative materials are their tensile and compressive strengths (CSs), which show how well they connect. In particular, tensile strength will evaluate the material's capacity to withstand stress before the onset of cracks. The *in vitro* performance of these more recent materials has not been compared in many researches. Thus, the objective of this study is to assess and contrast the compressive and diametral tensile strengths of Cention N, Amalgomer CR, and GIC Type II.

MATERIALS AND METHODS

In this *in vitro* study, the compressive and diametral tensile strength of three different materials was evaluated on the 1st and 7th days after being stored in simulated saliva. The study comprised three groups, each with three samples, separately assessed for both time points [Table 1]:

- Group A: GIC Type II [Figure 1a]
- Group B: Cention [Figure 1b]
- Group C: Amalgomer CR [Figure 1c].

For the compressive and diametral tensile strength assessment, samples were prepared in the form of cylinders, each measuring 2 mm in length, 2 mm in width [Figure 2]. Three samples were prepared for each group. Subsequently, these samples were stored in simulated saliva for a period of 24 h and 7 days before undergoing tensile strength testing.

Statistical Analysis

The CS and diametral tensile strength of Cention, Amalgomer CR, and GIC were measured after 24 h and 7 days. Test was carried out on Instron, universal testing machine, with cross-head speed of 5 mm/min [Figure 3]. The formula used to calculate CS was UCS = F/b2, here F is maximum applied load in Newton and b is the size of the

Figuere 1: (a) Type II glass ionomer cement. (b) Cention N. (c) Amalgomer CR

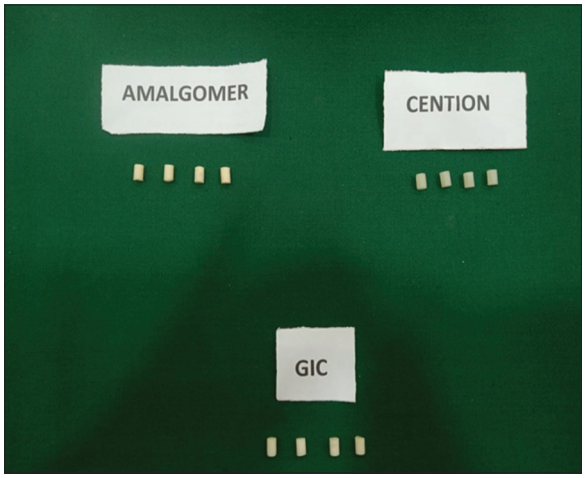

Figure 2: Prepared sample

square specimen in mm. The data were represented using the descriptive statistics; mean ± standard deviation (SD), minimum and maximum values for each group. To compare the statistical significance between the three groups, one-way analysis of variance was used to compare means between groups. All statistical analysis was performed using SPSS version 20.0

RESULTS

The results are showed in Table 2 and Figure 4 is related to the CS after 24 h according to the groups. The highest values of CS after 24 h were shown by Cention with a mean ± SD: 60.965 ± 0.947, followed by Amalgomer with mean and SD of 30.713 ± 0.579 and then by GIC with a mean ± SD: 11.999 ± 0.440.

After 7 days, the trend remained the same with highest values of CS after 24 h were shown by Cention with a mean ± SD: 72.18 ± 1.734, followed by Amalgomer with mean and SD of 31.551 ± 1.076 and then by GIC with a mean ± SD: 18.277 ± 0946. This is presented in Table 3 and Figure 5.

The results are showed in Table 4 and Figure 6 is related to the diametral tensile strength after 24 h according to the groups. The highest values of diametric tensile strength (DTS) after 24 h were shown by Cention with a mean ± SD: 38.687 ± 3.268, followed by Amalgomer with mean and SD of 29.657 ± 0.579 and then by GIC with a mean ± SD: 13.644 ± 0.796 after 7 days, the trend remained the same with highest values of DTS after 24 h were shown by Cention with a mean ± SD: 95.48 ± 25.429, followed by Amalgomer with mean and SD of 16.56 ± 4.820 and then by GIC with a mean ± SD: 10.58 ± 2.481. This is presented in Table 5 and Figure 7.

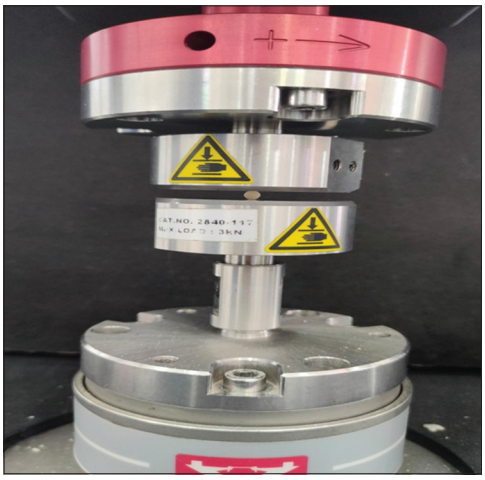

Figure 3: Universal Instron machine

There was statistically significant difference ($P < 0.001$) between the three groups showing the quiet a large significant difference between Cention, Amalgomer, and GIC material.

The same can be observed in the box plots presented.

For the measured traits, the three materials were tested with regard to the Kruskal–Wallis test, which was statistically significant regardless of the size of the groups.

DISCUSSION

In the realm of *in vitro* studies, the assessment of CS and diametral tensile strength takes precedence, as these measurements serve as crucial indicators in simulating the forces encountered by restorative materials during mastication. CS is a key to success of materials because materials with high CS can withstand masticatory and parafunctional forces. The Instron Universal Testing Machine was chosen to test compressive and diametral tensile strength as it is simple, accurate, and effective in analyzing these parameters. Artificial saliva is used to replicate the environment of oral cavity;[8] dynamic oral environment cannot be replicated so, thermocycling procedure is done to stimulate the oral cavity environment since the materials are subjected to various food materials at different temperature.[9]

Despite advantages of GIC, it also has various drawbacks such as, brittleness, moisture sensitivity, and low wear resistance. Various modifiers were introduced to overcome those drawbacks of GIC. Cention N and Amalgomer CR were among them.

Table 1: Total number of sample used in each group to measure compressive and diametral tensile strength after 24 h and on 7th day

Parameters	Group A		Group B		Group C		Total no. of sample
	After 24 h	After 7 days	After 24 h	After 7 days	After 24 h	After 7 days	
Compressive strength	3	3	3	3	3	3	18
Diametral tensile strength	3	3	3	3	3	3	18

Total number of sample tested is 36

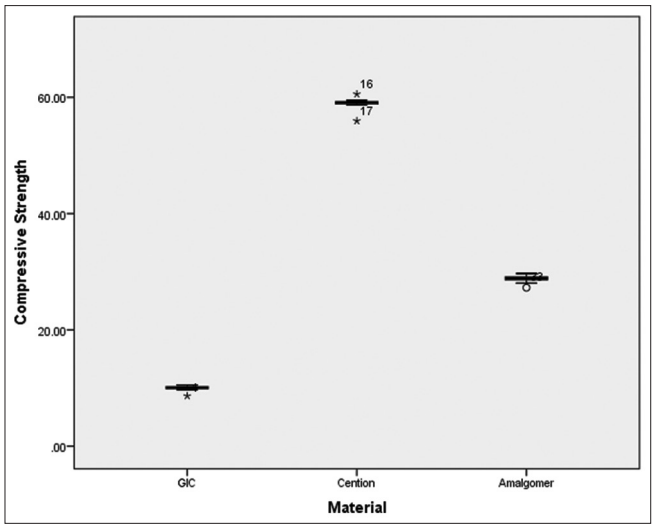

Figure 4: Box plot of the compressive strength after 24 h according to the groups. Comparing the mean compressive strength of glass ionomer cement (GIC), cention, Amalgomer CR, cention shows the highest value followed by Amalgomer CR and GIC after 24

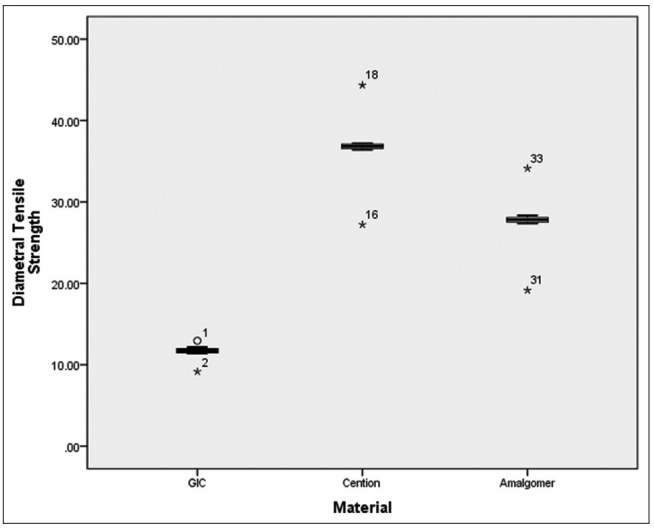

Figure 6: Box plot of the diametral tensile strength after 24 h according to the groups. Comparing the mean diametral tensile strength of glass ionomer cement (GIC), cention, Amalgomer CR, cention shows the highest value followed by Amalgomer CR, and GIC after 24 h

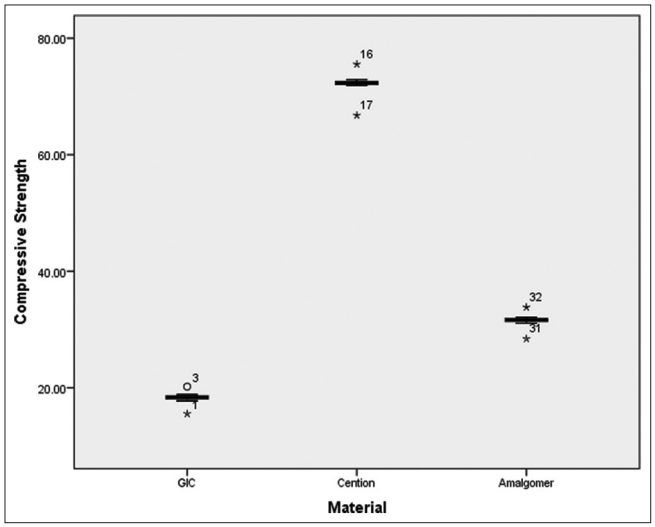

Figure 5: Box plot of the compressive strength after 7 days according to the groups. Comparing the mean compressive strength of glass ionomer cement (GIC), cention, Amalgomer CR, cention shows the highest value followed by Amalgomer CR and GIC after 7 days

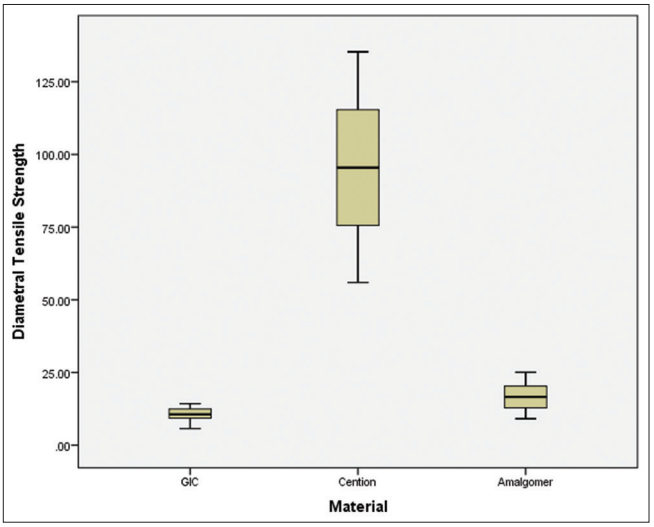

Figure 7: Box plot of the of diametral tensile strength after 7 days according to the groups. Comparing the mean diametral tensile strength of glass ionomer cement (GIC), cention, Amalgomer CR, cention shows the highest value followed by Amalgomer CR and GIC after 7 days

Cention N is an alkasite material that demonstrates remarkable mechanical properties. The key to its enhanced mechanical properties is because of the composition of its organic monomer. The dimethacrylate present in the monomer is urethane dimethacrylate (UDMA), DCP, and polyethylene glycol 400 dynamic mechanical analysis, which tends interconnect as they undergo polymerization. UDMA plays a crucial role in formation of matrix composition. A study conducted by Sadananda *et al.* revealed that Cention exhibits significantly higher flexural and CSs when compared to other materials such as zirconomer and GIC.[10] This suggests that Cention N may be a preferred choice in dental applications or other areas where high flexural and CSs are essential.

Table 2: Descriptive statistics of compressive strength after 24 h according to the groups

Group	Mean	Std. deviation	Minimum	Maximum
GIC	11.999	0.440	10.63	12.48
Cention	60.965	0.947	57.94	62.56
Amalgomer	30.713	0.579	29.26	31.69

Mean and standard deviation of Compressive strength after 24 h of three groups. $P<0.001$ is statistically significant. GIC: Glass ionomer cement

Table 3: Test statistic with significance for groups

Source of variation	Sum of squares	Df	Mean square	F value	Sig.
Between groups	18309.589	2	9154.794	19245.053	0.000
Within groups	19.979	42	0.476		
Total	18329.568	44			

Table 4: Descriptive statistics of compressive strength after 7 days according to the groups

Group	Mean	Std. Deviation	Minimum	Maximum
GIC	18.277	0.946	15.52	20.20
Cention	72.184	1.734	66.76	75.53
Amalgomer	31.551	1.076	28.40	33.81

Mean and standard deviation of compressive strength after 7 days of three groups. *P*<0.001 is statistically significant. GIC: Glass ionomer cement

Table 5: Test statistic with significance for groups

Source of variation	Sum of squares	Df	Mean square	F value	Sig.
Between groups	23665.889	2	11832.945	7011.558	0.000
Within groups	70.881	42	1.688		
Total	23736.770	44			

Table 6: Descriptive statistics of diametral tensile strength after 24 h according to the groups

Group	Mean	Std. deviation	Minimum	Maximum
GIC	13.6446	0.796	11.16	14.94
Cention	38.6879	3.268	29.21	46.35
Amalgomer	29.6579	2.875	21.14	36.13

Mean and standard deviation of diametral tensile strength after 24 h of three groups. *P*<0.001 is statistically significant

Table 7: Test statistic with significance for groups

Source of variation	Sum of squares	Df	Mean Square	F value	Sig.
Between groups	4825.681	2	2412.841	369.549	0.000
Within groups	274.225	42	6.529		
Total	5099.906	44			

Table 8: Descriptive statistics of diametral tensile strength after 7 days according to the groups A B C

Group	Mean	Std. Deviation	Minimum	Maximum
GIC	10.58	2.481	5.69	14.26
Cention	95.48	25.429	55.93	135.29
Amalgomer	16.56	4.820	9.08	25.09

Mean and standard deviation of diametral tensile strength after 7 days of three groups. *P*<0.001 is statistically significant. GIC: Glass ionomer cement

Amalgomer CR is a type of ceramic-reinforced GIC with international GIC standards and amalgams. The incorporation of ceramic reinforcement brings additional benefits to the material, including excellent wear and erosion resistance, enhanced radiopacity, and overall

Table 9: Test statistic with significance for groups

Source of variation	Sum of squares	Df	Mean square	F value	Sig.
Between groups	67369.174	2	33684.587	149.455	0.000
Within groups	9466.066	42	225.383		
Total	76835.240	44			

increased strength of the cement. The setting mechanism of Amalgomer CR is similar to conventional acid-base reaction characteristic of GICs.[11]

However, a study by Dawood *et al.* observed a significant decrease in the CS of Amalgomer CR after 6 months of aging in deionized water.[7] In a separate study, Ayad *et al.* evaluated various mechanical properties of Amalgomer CR, such as CS, DTS, surface hardness, and surface roughness, in comparison to high-copper dental amalgam.[12]

The study concluded that Amalgomer CR shows superior physico-mechanical properties to amalgam.

This study reveals that on the 1st day, Cention N exhibits the highest compressive and tensile strength, followed by Amalgomer CR and GIC. These rankings persist on the 7th day. Notably, GIC demonstrates a significant increase in values after 7 days, whereas for Cention N and Amalgomer CR, the values remain constant. This shows superior properties of Cention N over other materials.

In this current study, comparing newer materials with conventional GIC shows that advanced materials have highest mechanical properties than the conventional material.

Cention N and Amalgomer CR are tooth-colored materials same as GIC but, they have greater mechanical properties than GIC.[13,14] In prosthodontics, these high strength esthetic materials can be used for post and core build up.

CONCLUSION

Cention showed the highest CS and DTS in comparison to Amalgomer CR and conventional GIC on the 1st and 7th day after storing it in artificial saliva. It can be concluded that Cention N may be a better choice of restorative materials in comparison with Amalgomer CR and GIC.

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