A Comparative Evaluation of the Mechanical Properties of Cention–N with Contemporary Restorative Material under the Influence of Thermocycling: An In-Vitro Study

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Abstract:-
Aim: To comparatively evaluate the compressive strength and microhardness of Alkasite restorative material with Light cure-composite, RMGIC, Dual-cure composite resin under thermocycling conditions.

Materials& methods: Metal cylindrical mold of dimension 6±1mm (Height) ×4±1mm (diameter) was used to fabricate 20 samples of Alkasite, Light-cure composite resin, Resin modified GIC and Dual-cure composite resin each. Samples were tested using Vicker hardness tester and universal testing machine.
Statistical Analysis Used: Data were analyzed statistically using the ANOVA, Tukey's HSD test)

Results: The statistical difference between the hardness values of different groups was found to be statistically significant. There was no statistically significant difference in the values ofcompressive strength between the groups.

Conclusions: Within the limitations of the study, it can be concluded that: RMGIC had highest microhardness with and without thermocycling and Cention-N had highest compressive strength after thermocycling. Cention -N can be used as a best material for core-build-up.

Keywords:- *Light-cure Composite resin, Resin modified GIC, Cention-N, Dual-cure composite resin, Compressive strength, microhardness, Universal testing Machine, Vicker hardness tester.*

I. INTRODUCTION

Restoring a decayed / fractured tooth with the best available restorative material to enhance its longevity is one of the major aspects of treatment planning. The selection of a restorative material becomes confusing due to the plethora of materials available in the market; with each one of them being claimed to be superior to others by the manufacturers.

The tooth in the oral environment is subjected to varying temperature due to intake of food and fluids. An ideal restorative material would not undergo degradation under such changing conditions; but there is no such ideal material. Besides properties like water absorption, modulus of elasticity, fracture toughness; the strength greatly influences the selection of core build-up material because these materials withstand masticatory load[1]. Several direct filling materials are available to the dental practice – from amalgams to composites resin.

Amalgam has been core of direct filling material since many years, it is technique –insensitive and provides good strength but use of amalgam has been decreasing over the years because of its toxicity and high demand of esthetic values[2].

GIC cements are substantially accepted as an alternative core build-up material because of certain modifications that are superior to those of light-cure composite, dental amalgam and dual-cure composite. These characteristics include chemical adhesion to mineralized dental tissues and incorporation of fillers and resins to conventional GIC made this material with mechanical strength approximating that of amalgam.

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However, the problems related to conventional glass-ionomer cements include lower mechanical strengths, moisture sensitivity and susceptibility to fracture and dehydration, thereby limiting the applicability of conventional glass- ionomer cements for posterior restoration.

A lot of research in direct filling materials has been made with dental composites due to higher esthetic and long–lasting demand but despite having good esthetic and strength the main disadvantage is polymerization shrinkage[3].

An alternative for posterior direct filling restorations materials is a cost-effective, fluoride releasing material i.e. Cention-N was introduced a couple of years back[4].

Keeping all the above discussed factors in mind, this study wasdone in the Department of Prosthodontics and Crown and Bridge, Babu Banarasi Das College of Dental Sciences, Lucknow to evaluate the microhardness and compressive strengths of commonly used direct core build up materials-resin modified Glass ionomer, dual cure composite resin, light cured composite resin and Alkasite containing material before and after thermocycling[5].

II. MATERIALS AND METHODS

Fig. 1: Material and equipment used for preparing samples

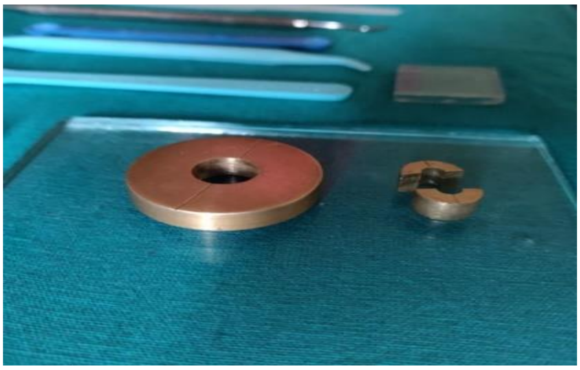

Fig. 2: Metal mold

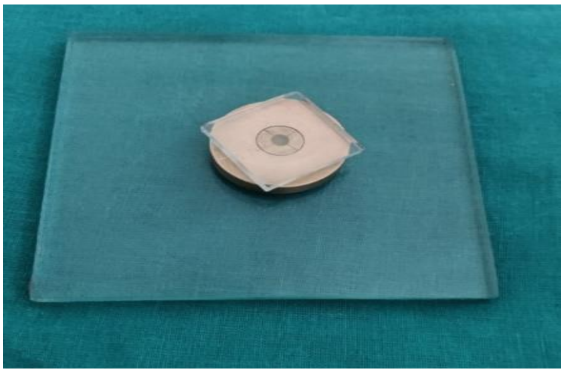

Fig. 3: Metal mold with sample and glass slab

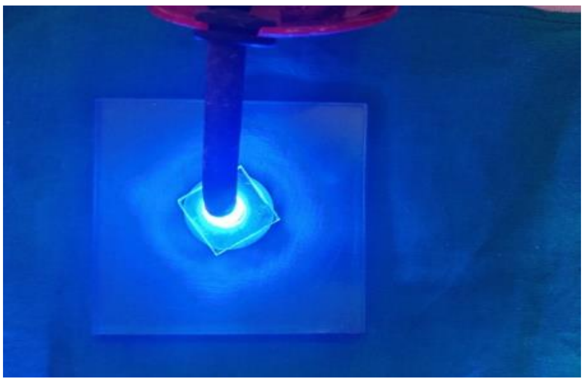

Fig. 4: Curing of sample with LED light

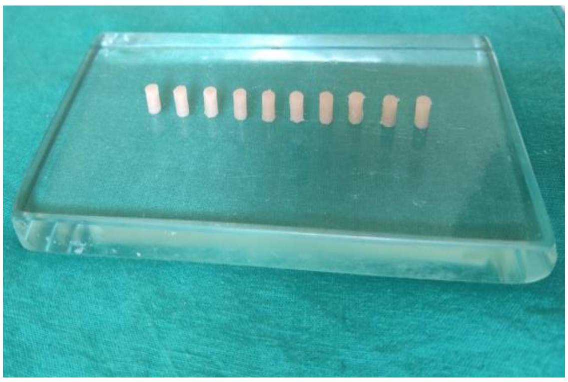

Fig. 5: Cylindrical samples

Cylindrical Gun metal mold of customized dimension 6±1mm (Height) ×4±1mm (diameter) was used to fabricate 20 samples of each of Alkasite, Light –cure composite resin, Resin modified GIC and Dual-cure composite resin.

Table 1: Distribution of sample in Groups

Group	Brand/ Generic composition	Company Name	No. of samples	Compressive strength		Hardness	
				Without thermocycling	With thermocycling	Without thermocycling	With thermocycling
A	Swisstec Composite/Light–cure composite resin	Coltene	20	5 (CO-WT)	5 (CO-AT)	5 (CO-WT)	5 (CO-AT)
B	Hy-bond resiglass/Resin modified GIC	Shofu	20	5 (RM-WT)	5 (RM-AT)	5 (RM-WT)	5 (RM-AT)
C	Paracore/Dual-cure composite resin	Coltene	20	5 (PA-WT)	5 (PA-AT)	5 (PA-WT)	5 (PA-AT)
D	Cention –N/Alkasite	Ivoclar vivadent	20	5 (CN-WT)	5 (CN-AT)	5 (CN-WT)	5 (CN-AT)

Table 2: Compositions of testing groups[6]

MATERIAL	COMPOSITION	FILLER CONCENTRATION	SETTING REACTION
Composite (control group)	Polymeric matrix Filler particles, Silane coupling agent that links the matrix to the fillers Initiators and coupling agents	78% wt.%	Composites sets by LED light
Resin Modified GIC	Powder-fluoro alumino silicate glass particles Initiators, Liquid - H_2O Polyacrylic acid or polyacrylicacid modified with Methacrylate and hydroxyl methacrylate(HEMA) (20-40% wt. %)	20-40wt%	RMGIC sets by acid-base reaction and chemical-free radical polymerization
Paracore	**A**-Para Post Paracore contains:- Methacrylate, 68wt% Fluoride, Barium Glass, Amorphous Silica **B**- Para Bond None rinse conditioner contains: 0.1μmWater,Acrylamidosulphonic acid, Methacrylate Para Bond Adhesive A-Methacrylate, Maleic Acid, Benzoyl peroxide Para Bond Adhesive B-Ethanol, Water, Initiators	68wt%	Paracore sets chemical and light curing
Cention –N	**Matrix** • UDMA • DCP •Aromatic aliphatic UDMA • PEG-400 DMA **Fillers** •Barium aluminium silicate glass •Ytterbium trifluoride • Isofiller •Calcium barium aluminium fluorosilicate glass • Calcium fluorosilicate glass	78.4wt.%, 57.6 vol.%	Sets by chemical reaction between powder and liquid

After sample preparation, it was send to Praj Metallurgical Lab, Pune for subsequent experiment. Half samples of each group i.e. were subjected to a homogenous thermocycling regime. Thermocycling machine contains two baths filled with distilled water and temperature controlled at 55̊C for the hot bath and 5̊C for the cold bath using a thermostat. The samples were subjected to 500 cycles of thermocycling. Each sample was placed in the respective baths for 20 seconds and transfer time between the baths will be 3 seconds. (Figure 6)

The samples with or without thermocycling were subjected to hardness and compressive strength test subsequently.(Figure 7,8)

Fig. 6: Thermocycling procedure


Fig. 7: Microhardness test


Fig. 8: Compressive strength test with Universal testing machine

III. RESULTS

Table 3: Inter group comparison of mean and standard deviation values (Mean±SD) for microhardness and compressive strength with and without thermocycling

	Microhardness in HV		Compression Strength (MPa)	
Group	Mean	StDev	Mean	StDev
CN-AT	69.68	3.64	305.5	42.6
CN-WT	82.03	3.59	231.7	36.3
CO-AT	78.65	3.94	258.9	53.3
CO-WT	88.99	2.58	295.7	48.3
PA-AT	73.16	2.098	235.5	65.8
PA-WT	51.64	4.5	219.7	48
RM-AT	89.86	1.508	219.1	40.3
RM-WT	103.3	3	237.52	21

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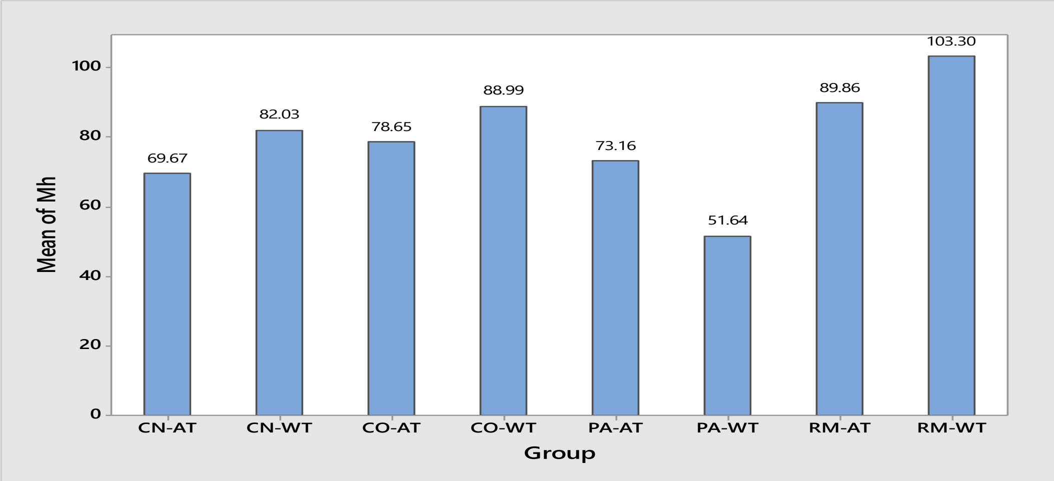
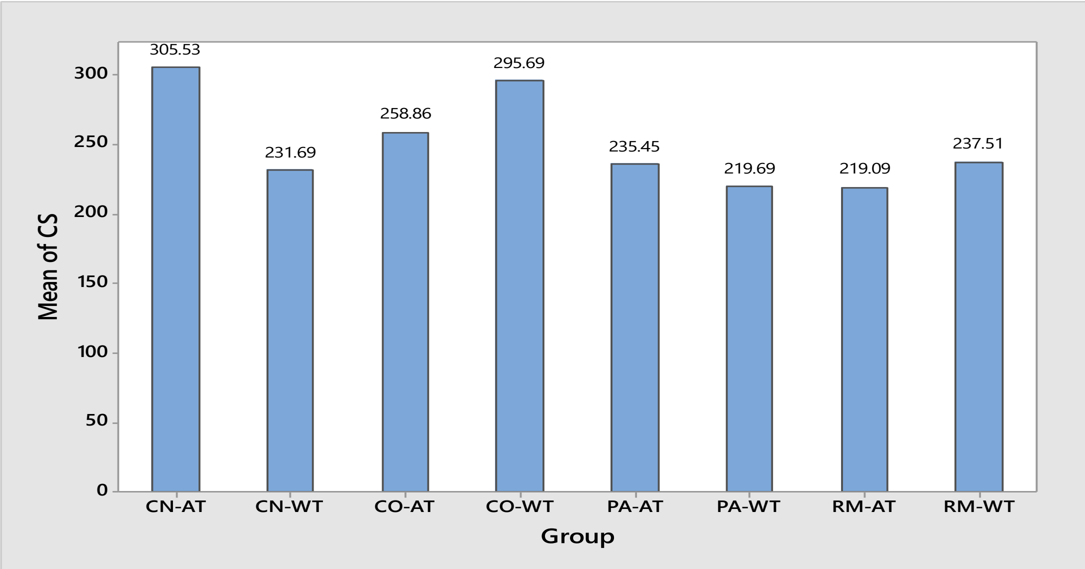


Graph 1: Mean value for compressive microhardness of testing group with and without thermocycling



Graph 2: Mean value for compressive strength of testing group with and without thermocycling

- Microhardness without thermocycling: RMGIC showed highest microhardness followed by light-cure composite, Alkasite and dual-cure composite.(Table3,Graph1)
- Microhardness with thermocycling: RMGIC showed highest microhardness followed by light-cure composite, dual-cure composite and Alkasite. (Table3, Graph1)
- Compressive strength without thermocycling: Light-cure composite showed highest compressive strength followed by RMGIC, Alkasite and dual-cure composite.(Table3, Graph 2)
- Compressive strength with thermocycling: Alkasite showed highest compressive strength followed by light-cure composite, dual-cure composite and RMGIC.(Table3, Graph 2)

Difference between the compressive strengths with or without thermocycling was not statistically significant.

IV. DISCUSSION

The ultimate goal of restorative / core build up material is to withstand the masticatory load properties factors that enhance longevity of material are fracture toughness, hardness, and flexural strength; shear strength, tensile strength and compressive strength.[37]

The study measures hardness and compressive strength of all the four core build up material as a stronger material resist deformation and fracture thus provide greater stability and strength for clinical success. Compressive strength is considered to be a critical indicator of success because a high compressive strength is necessary to resist masticatory and para-functional forces.[39]

Compressive strength is defined as the capacity of a material or structure to withstand loads.

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Hardness is the mechanical property of material which resists indentations under constant load. There is standard test like Brinnel, Rockwell, Vickers and Knoop, Shore A and Barcol for evaluating the hardness and roughness of the material[32, 40.]

The indenter of Vickers tester is shaped like a pyramid to make indentation. In contrast, diamond indenting tool used in Knoop hardness which is narrower and elongated.

The various experimental variables of specimen size, shape, testing configuration, fabrication procedure, temperature, and set time were all standardized in this study. All specimens were treated identically throughout this study, which was based on American Dental Association (ADA) Specification No. 27 so as to compare materials uniformly.

Without thermocycling, RMGIC showed highest hardness, followed by light-cure composite resin, Alkasite and dual-cure composite resin. (Table3, Graph1) with statistically significant difference between RMGIC and CO.

With thermocycling RMGIC showed highest microhardness followed by light-cure composite, dual-cure composite and Alkasite. (Table3, Graph1).

RMGIC hardness values were highest amongst all the material before and after thermocycling. This could be because they set in part by an acid-base reaction and in part by photochemical polymerization resulting in optimal physical properties[15].

Though, the micro hardness values after thermo cycling decreased which could be due to dissolution of chemicals which had set by acid base reaction.[47]

In resin based materials, a decrease in surface hardness could be expected after thermocycling due to water absorption. The action of the water molecules inside the polymeric structure has a plasticizing effect and the decrease in hardness would be associated with the reduction in the inter-chain interactions for all the resin based materials like Cention -N, Composite, and RMGIC.[17]

It has been reported that there is an increase in the roughness of the composite resin after thermocycling; may be attributed to the hydrolysis of silane coupling agents as well as the stress at the filler-matrix interface.[41]

The difference between the hardness values of different groups after thermocycling was found to be statistically significant. Micro hardness values were higher for RMGIC and light-cure composites resin than Alkasite.

The resin based materials like paracore and composite resin exhibited lesser hardness than RMGIC, this could be due to the air inhibited polymerization of outer layer of rest of the resin containing materials.[25]

The microhardness values of Cention-N before and after thermocycling were lesser than that of RMGIC and Composite and there is no plausible explanation for this as a multitude of factors responsible for final value. Cention-N exhibited least hardness after thermocycling. A study has reported inferior surface characteristics of Cention-N samples when compared to composite.[28] Unfortunately, the minimal number of thermocycles necessary for plasticization is not known due to a multitude of reasons.

From the table 3, it was observed that microhardness of paracore increased after thermocycling but decreased for Composite, Cention-N and RMGIC; this finding could be attributed to the presence of unidirectional fibres in paracore which could have strengthened the matrix post thermocycling[18]

The values of Microhardness and compressive strength of RMGIC was higher than other comparative studies[10].

Without thermocycling, Light-cure composite showed highest compressive strength followed by RMGIC, Alkasite and dual-cure composite[17, 29]. (Table3, Graph 2)

With thermocycling Alkasite showed highest compressive strength followed by light-cure composite, dual-cure composite and RMGIC. (Table3, Graph 2)

There was no statistically significant difference in the values between the groups

Compressive strength depends upon the amount of filler load and particle size present in the inorganic phase and the reasons mentioned are the particle size of materials, degree of polymerization, the effect of composition, finishing influence the surface quality of material[48].

Composite resin exhibited maximum compressive strength without thermocycling amongst all groups (table 1).This could be due to the higher filler content i.e.78% by weight and 59% by volume of inorganic fillers of composite resin. Though the difference between the compressive strengths with or without thermocycling was not statistically significant.

It was observed from table 3 that the strength of Cention-N and Paracore increased after thermocycling with Cention-N exhibiting highest compressive strength. This could be due to higher filler content [2, 4]. It has been mentioned that UDMA, DCP, aromatic aliphatic UDMA and PEG-400 DMA, cross-linking during polymerization, help confer mechanical strength and good long-term stability of Cention-N. This material does not contain Bis-GMA, HEMA or TEGDMA and UDMA are the main component of the organic matrix. In addition to presenting moderate viscosity, it does not have hydroxyl side groups, giving hydrophobic characteristics to the material, and low water absorption[49].

All of these accounted for the higher values of Cention-N whereas the dual curing mechanism i.e. light curing and self-curing mechanism of paracore contributed to the rise in compressive strength as compared to the decreased values of composite resin and RMGIC after thermocycling.[50]

Paracore has thorough and even distribution of nanoparticles throughout the resin matrix, with the addition of Zirconium Oxide, the compressive strength has been enhanced. Presence of macroscopic size of the unidirectional fiber bundles used in fiber reinforces the resins (Bis-GMA, TEGMA and UDMA) and improves its mechanical properties. The presence of fibers affects the fracture process that results in interrupting crack growth progression and thus enhances the fracture toughness of the fiber reinforced composite material. Also it is a dual cure material which ensures complete cure, thereby improving the strength of the material.[37]

The contradictory results of literature mentioning that Cention-N with highest microhardness followed by silver amalgam, nanohybrid composite resin and type II glass ionomer cement.[2]

Compressive strength of composite and Alkasite in present study was higher than others .[29]

V. LIMITATIONS OF THIS STUDY

The sample size was limited and the study was conducted in vitro, due to which the effect of bonding to tooth structure to the compressive strength could not be ascertained.

The light cure polymerization was done with only one type of technique and for limited duration. The sample shape was cylindrical and this doesn't simulate the different results that would be obtained in various cavity shapes and sizes.

Some materials, such as resin modified glass ionomers, continue to mature for extended periods while resins continue to polymerize indefinitely. Though the effects of increased curing over time are small in comparison to the large differences among materials, and established specifications recommend 24-h test times. This parameter could not be addressed in the study as the samples had to be sent to Pune for experiments.

It is advisable to measure the microhardness ratio of the top and bottom surface of the sample to get the average value of hardness.

VI. CONCLUSIONS

Within the limitations of the present study it can be concluded that:

- Without thermocycling, RMGIC showed highest hardness, followed by light-cure composite resin, Alkasite and dual-cure composite resin.
- With thermocycling RMGIC showed highest microhardness followed by light-cure composite, dual-cure composite and Alkasite.
- Without thermocycling, Light-cure composite showed highest compressive strength followed by RMGIC, Alkasite and dual-cure composite.
- With thermocycling Alkasite showed highest compressive strength followed by light-cure composite, dual-cure composite and RMGIC.
- Microhardness of Dual-cure composite resin increased after thermocycling but decreased for Light-cure composite resin, Alkasite and RMGIC

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