"A COMPARATIVE EVALUATION OF THE MECHANICAL PROPERTIES OF CENTION–N WITH CONTEMPORARY RESTORATIVE MATERIAL UNDER THE INFLUENCE OF THERMOCYCLING: AN IN VITRO STUDY"

Dissertation

Submitted to

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In the partial fulfilment of the requirements for the degree

of

MASTER OF DENTAL SURGERY

In

PROSTHODONTICS, CROWN & BRIDGE AND IMPLANTOLOGY

By

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BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW

(Faculty of Babu Banarasi Das University)

YEAR OF SUBMISSION: 2022 **BATCH: 2019-2022**

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"A COMPARATIVE EVALUATION OF THE MECHANICAL PROPERTIES OF CENTION–N WITH CONTEMPORARY RESTORATIVE MATERIAL UNDER THE INFLUENCE OF THERMOCYCLING : AN IN VITRO STUDY"** is a bonafide and genuine research work carried out by me under the guidance of ***Dr. Swati Gupta,*** Professor & Head, Department of Prosthodontics, Crown & Bridge and Implantology, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

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Dedicated to

My Parents

Acknowledgement

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"The single greatest cause of happiness is gratitude"

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Dr. Rehana Bano

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LIST OF ABBREVIATION

S. NO.	ABBREVIATIONS	FULL FORM
1.	RM-AT	RMGIC-After thermocycling
2.	RM-WT	RMGIC-Without Thermocycling
3.	CN-AT	Cention-N -After Thermocycling
4.	CN-WT	Cention-N-Without Thermocycling
5.	PA-AT	Paracore -After Thermocycling
6.	PA-WT	Paracore -Without Thermocycling
7.	CO-AT	Composite -After Thermocycling
8.	CO-WT	Composite -Without Thermocycling
9.	Mh	Microhardness in HV or VHN
10.	ML	Maximum Load (N)
11.	CS	Compression Strength (MPa)
12.	HV	Vicker hardness
13.	MPa	Mega Pascal
14.	UTM	Universal testing machine
15.	VHT	Vicker hardness tester

Abstract

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&METHODOLOGY

Metal cylindrical mold of 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. Samples were tested using Vicker hardness tester and universal testing machine. Data were analyzed statistically using the ANOVA, Tukey's HSD test).

RESULTS:

The difference between the hardness values of different groups after thermocycling was found to be statistically significant. There was no statistically significant difference in the values between the groups Compressive strength.

CONCLUSION:

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. 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

Introduction

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.

Direct filling restorative materials such as Amalgam and Glass ionomer cements are being used since many years and are economical and easy to manipulate .

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.

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.

For successful restoration of posterior tooth, the main goal is to sustain the masticatory force without failure. Since majority of masticatory forces in posterior teeth are compressive so higher compressive strength of material is needed.

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].

Alternative to all described posterior direct filling restorative materials, a cost-effective, fluoride releasing product (Cention-N) that offers both strength and good esthetics was introduced a couple of years back[4].

Keeping all the above discussed factors in mind, this study was performed 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].

Aim & Objectives

AIM & OBJECTIVES OF THE STUDY:

AIM

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

OBJECTIVES

1. To evaluate the compressive strength and abrasion resistance of Alkasite restorative material before and after under thermocycling.
2. To evaluate the compressive strength and abrasion resistance of bulk fill composite before and after under thermocycling.
3. To evaluate the compressive strength and abrasion resistance of ionomer based cement (GIC) before and after under thermocycling.
4. To evaluate the compressive strength and abrasion resistance of Para core before and after under thermocycling.
5. To compare the properties of above mentioned 4 groups with each other.

Review of Literature

REVIEW OF LITERATURE

Lloyd et al (1978)[6] noted a similarity in enamel crack lengths in teeth in vivo after several years' service and newly erupted extracted teeth after several thousand thermal cycles in vitro. He therefore suggested that several thousand thermal cycles might occur in vivo in several years. But this conclusion must be confounded by mechanical stresses both during service and extraction.

Longman, C.M Pearson, G.J. (1987)[7] measured the change of temperature at different site in the oral cavity and mentioned that the variations in temperature were noted in different areas of the mouth. This may be associated with the position of the tongue during swallowing and the effect of the tissues of the oral cavity as heat absorbers. The range of temperatures noted at the tooth surface and the duration of the temperature changes were at variance with those utilized in many thermocycling studies. It is suggested that closer alignment with the clinical situation is desirable. The results indicate that temperatures noted at the tooth surface, within the mouth, during fluid intake were less than the temperatures of the fluid imbibed.

Jack L Ferracane et al (1987)[8] evaluated the fracture toughness of a variety of dental composites using notched bending specimens, with and without pre-cracks. The pre-crack simulates more accurately a sharp, natural flaw in a material than does a notch, and is standard procedure in fracture-toughness evaluation. The fracture toughness was related to the filler composition and degree of conversion in the composite resins. In general, fracture toughness was highest in the more heavily filled resins, independent of degree of conversion in the matrix. The results also show that producing a pre-crack in certain composites reduced the value of their fracture toughness compared with notched-only specimens.

Spierings et al. (1987)[9]used two separate thermocouples on the upper first molar and first premolar, and even when so close together there were notable differences. Secondly, the volume of fluid taken into the mouth has a large effect on the temperature change, as well as its duration. Even within the same person in the same

location with the same liquid type (30ML), great variation was noted, with differences between occasions of as much as 23℃.

Thomas Attin (1996)[10] evaluated the physical properties of four resin-modified glass-ionomer cements (Fuji II LC, ionosit Fil, Vitremer, and Photac-Fil) and polyacid-modified resin composite materials (Dyract and Variglass VLC)). The compressive strength and surface microhardness of the hybrid resin composite was superior to those to resin-modified glass-ionomer materials due to presence of filler concentration.

M.S. Gale et al (1997)[11] determined the temperature range, no. of cycles and dwell time of thermocycling process .The standard cyclic regimen defined is: 35℃ (28 s), 15℃ (2 s), 35℃ (28 s), 45℃ (2 s). No evidence of the number of cycles likely to be experienced in vivo was found and this requires investigation, but a provisional estimate of approximately 10,000 cycles per year is suggested. Thermal stressing of restoration interfaces is only of value when the initial bond is already known to be reliable.

S. Gladys et al (1997)[12] determined several physical and mechanical properties of eight such materials in comparison with two conventional glass ionomers, one micro-filled, and one ultrafine compact-filled resin composite. The micro-hardness values varied substantially among all eight hybrid restorative materials. In general, hybrid restorative materials showed values comparable with those of resin composites and conventional glass ionomer because they set in part by an acid-base reaction and in part by photochemical polymerization.

Esteban D. Bonilla (2000)[13] five core build-up materials were tested: (1) glass ionomer, (2) resin modified glass ionomer, (3) titanium-reinforced composite, (4) composite resin with fluoride, and (5) amalgam. Fracture toughness may be directly related to the content of resin in the material and inversely related to ionomer content and amount of particulate metal. Composite materials showed higher fracture toughness than RMGIC because of resin concentration.

Phillips 'Science of Dental Materials (2004)[14]

The Vickers hardness test employed for determining the hardness of metals. A square-based pyramid is used as an indenter. Although the impression is square, the method for calculating the Vickers hardness number (usually abbreviated as HV or VHN that the load is divided by the projected area of indentation. The lengths of the diagonals of the indentation are measured and averaged. The Vickers test is employed in the standard testing of dental casting gold alloys. The test is suitable for determining the hardness of brittle materials; therefore, it has also been used for measuring the hardness of other cast dental alloys as well as of tooth Structure.

André Mallmann (2007)[15]evaluated the compressive strength of two glass-ionomer cements, a conventional one and a resin-modified, using two test specimen dimensions: One with 6 mm in height and 4 mm in diameter and the other with 12 mm in height and 6 mm in diameter. The resin-modified glass ionomer cement obtained the best results, irrespective of specimen dimensions. For both glass ionomer materials, the 12 mm x 6 mm matrix led to higher compressive strength results than the 6 mm x 4 mm matrix. The resin-modified glass ionomer cement presented higher strength values than the conventional material, irrespective of the matrix dimensions employed for specimen fabrication. Probably, this is due to the inclusion of resinous polymers that present higher mechanical strength.

Rodrigo O. A. Souza, DDS (2010)[16] evaluated the degree of conversion (DC) of four indirect resin composites (IRCs) with various compositions processed in different polymerization units and investigated the effect of thermal aging on the flexural strength and Vicker's micro hardness. In the case of Sinfony (Group 2 IRC), flexural strength decreased after thermocycling in almost 50% of specimens, which could be due to the differences in monomer types of the IRCs. While Sinfony contains HEMA at 10% to 30% (octahydro-4, 7-methano-1Hindenediyl) bis (methylene) acrylate, the other three IRCs contain some UDMA in their composition.

Jerusa Cleci de Oliveira (2010)[17] evaluated the effect of storage in water and thermocycling on hardness and roughness of resin materials for temporary restorations. Three acrylic resins were selected and one composite resin was used as a parameter for comparison. Thermocycling (3000 cycles; 5-55 °C, 30 seconds dwell time). Thermocycling increased the roughness in most tested materials without affecting hardness, while storage in water had no significant effect in the evaluated properties.

Taiseer A. Suleiman (2017)[18] conducted a study to evaluate the fracture toughness (FT), compressive strength (CS) and diametral tensile strength (DTS) of resin-based cements. After thermocycling (n=7/subgroup) for 20000, the specimens were mounted and loaded at a crosshead rate of 1 mm/min (0.5 mm/min for FT) with a universal testing machine until failure occurred. Auto-mixed resin –based cements was better than that of their hand –mixed counterpart.

Dr. Mohammad Iqbal (2017)[19] compared the compressive strength of four different core build up materials Paracore, Luxacore Z Dual, Fluorocore and Multicore. Para core showed the highest compressive strength than the rest of the group. It was concluded that Paracore is the best suited material for core build up.

Dr.Debolina Chowdhury (2018)[20] evaluated the fracture resistance and compressive strength of nanofill composite resin and Cention-N restorative material in a class II cavity with routinely used silver amalgam material. Cention-N exhibited highest compressive strength followed by composite then amalgam because of filler contents.

Dr. Jagvinder Singh Mann (2018)[21] in a review article stated that Cention N resin-based filling material is easy to use clinically and does not require any special products or learning additional skills. Proximal contact tightness of Cention-N same as that of a composite material . Cention-N significantly strengthens teeth after Class II cavity preparation and restoration. As there is demand in tooth colored restorations, this material of choice can be a cost-effective way to deliver a high-quality, predictable restoration, and consume less time. It can be considered as a suitable material for posterior restoration.

Mishra Abhishek et al January (2018)[22] compared the compressive strength and flexural strength of Cention-N with Amalgam, Glass ionomer cement and hybrid composite resin on tooth samples. The sample was tested using a universal Instron testing machine (UTM). The Compressive strength in composite was higher than Cention-N and GIC due to micromechanical bonding to tooth structure .Flexural strength in Cention-N was higher than GIC and Amalgam due to higher filler concentration.

Mazumdar Paromita et al March (2018)[2] evaluated the hardness of nanohybrid composite resin, Cention -N, silver amalgam and type II GIC. Cention-N showed highest microhardness value in comparison to nanohybrid composite resin, silver amalgam and type II GIC. Fillers were responsible for imparting restorative materials with the adequate strength to withstand the stresses and strains of the oral cavity and to achieve acceptable clinical longevity.

Daniel Pieniak (2019)[23] discussed a quantitative fatigue evaluation based on mechanical strength, elastic modulus and strain work to fracture for composites for dental restorations. The specimens intended for the strength test underwent 104 hydro-thermal fatigue cycles. This procedure of thermocycling was preceded by aging, which meant immersing the specimens in artificial saliva at 37℃ for 30 days. The elastic modulus of the composite material significantly increased after thermocycling which could mean that the maximum temperature of the thermal cycle, set as 55℃, could cause phase transitions leading to increased stiffness.

Dr.Kaur Manpreet et al (2019)[24] did comparative study of compressive strength of Cention–N and Glass ionomer cement. Cylindrical mold of customized dimension 6±1 mm (Height) ×4±1mm (diameter) were used to fabricate 10 samples of each of Cention-N and Glass ionomer cement (GIC ix high strength posterior restoration). Then samples were tested by using universal testing machine (UTM) and load were applies to the sample at crosshead speed of 0.75±0.25mm per 1 minute till the samples fractured. Cention-N showed higher compressive strength than GIC because of its inorganic fillers.

Kumar S.Arun, Ajitha P. (2019)[25]compared and evaluated the compressive strength of Cention N and high copper amalgam using a universal Instron testing machine. Cylindrical sample of dimension 6 (±1) mm × 4 (±1) mm was fabricated using straw and glass slab, a total of 20 samples, amalgam (n = 20) and Cention N (n = 20) were tested for compressive strength using a universal Instron testing machine of a crosshead speed of 0.75 ± 0.25 mm per one minute till the samples fractured. Compressive strength of Cention-N is significantly equal that of high copper amalgam due to fillers or UDMA composition that provides mechanical strength to the cement and it can be used in stress-bearing posterior region.

Kelvin I. Afrashtehf (2019)[26] performed a study of new bioactive alternative to amalgam and bulk fill composites by illustrations of the step by step application, from the removal of decay to the final polishing of the Alkasite material on a posterior tooth. The alkaline filler that is contained in its inorganic part increases the release of hydroxide ions to regulate the pH value during the attacks with acid. As a result, the demineralization can be prevented. In addition, the release of large amounts of fluoride ions and calcium forms a solid basis for the remineralization of tooth enamel. The Alkasite is an optimal restorative material in the field of operative dentistry due to its bioactive properties, bulk fill characteristics, aesthetics and time saving application.

Ahad Fahd Al Qahtani (2019)[27] conducted a study to compare the compressive & tensile strength of four different core build up materials- Paracore, Luxacore Z Dual, Fluorocore and Multicore. Paracore showed the highest compressive strength and tensile strength than the rest of the materials. Para Core showed excellent strength because the macroscopic size of the unidirectional fiber bundles used in fiber reinforces the resins and improves its mechanical properties.

Parth V Dodiya (2019)[28] compared clinical effectiveness of Cention–N and Nanohybrid composite resin as a restoration of non-carious cervical lesion for gross fracture, marginal integrity & surface texture. Cention–N was as effective as Tetric-N-Ceram for gross fracture and marginal integrity till 6 months BUT had an inferior

surface characteristics than Tetric N Ceram after 1 week. This could be due to factors like type of mixing and particle size of materials, the effect of composition, degree of conversion, finishing, and polishing procedures.

Nahid Iftikhar (2019)[29] compared the mechanical properties (compressive strength (CS) and diametral tensile strength (DTS)) of four different restorative materials: conventional glass ionomer (Fuji IX), ClearFil AP-X, Filtex Z350-XT, and Cention N. Clear Fil AP-X exhibits the highest mechanical properties (CS and DTS) and the properties of Z350-XT and Cention N were almost similar and least values were obtained by the Fuji IX. Strength is one of the most important criteria for the selection of a restorative material. Stronger materials better resist deformation and fracture, presenting more equitable stress distribution, greater probability, and greater stability of clinical success.

Shilpa Shah (2020)[30] performed the study to evaluate the fracture resistance of mandibular molars restored with Cention N, Giomer and Amalgam in Class 2 cavity preparation. All groups were stored in saline at 37℃ for 24 hours and thermocycled. Cention-N showed highest fracture resistance when compared to other restorative material due to sole use of cross-linking methacrylate monomers in combination with self –cure initiator.

Priyanka Yadav (2020)[31] evaluated and compared the compressive strength of three different bulk filled composite restorative materials: Beautifil II LS, Cention- N and Filtek Z250. Beautifil II LS, a giomer showed highest compressive strength due to highest filler contents (83 wt. %)

Killi N Kumar (2020)[32] evaluated the temperature changes in the pulp chamber that occur during the polymerization of bulk-fill, flowable bulk-fill, and dual-cure resin restorative materials influenced by various light-curing devices at different curing tip distances. Teflon molds were restored with 2 mm Spectrum (universal micro hybrid composite DENTSPLY), Tetric N flow (Bulk Fill Ivoclar-Vivadent), and Cention N (self-curing resin based with light-curing option Ivoclar-Vivadent), respectively, the remaining difference in the length of the Teflon mold depicts the curing tip distance

for the light-curing units. Significant differences were observed in the temperature rise among bulk-fill, flowable bulk-fill, and dual-cure resin. Halogen curing unit exhibited significantly higher temperature rise than LED.

Girish Kumar(2021)[33] This study was conducted to evaluate certain mechanical properties of commonly used materials for direct core build-up, including visible light cured composite, poly-acid modified composite, resin modified glass ionomer, high copper amalgam, and silver cermet cement. Considerable differences in compressive strength, diametral tensile strength, and flexural strength were observed. The compressive strength of composite (122.25 Mpa) was higher than that of RMGIC (109.13Mpa). It is mentioned that minimum compressive strength required for a core build up is not known.

Kharys ,Fabíola, Azevedo de Oliveira (2021)[34]published a case report and mentioned that Cention-N, this material is intended for direct restorations in posterior teeth, has similar colors to teeth, and promises to be able to release calcium ions (ca2+), fluorine (F-) and hydroxyl (OH-) in the face of an acid challenge. It is a material with a dual cure reaction, of optional association to the use of adhesive systems, which has good performance in laboratory tests, but still has few reported clinical evaluations.

Vishakha Verma et al (2021)[35] conducted a study to evaluate compressive strength, shear bond strength and micro hardness of glass ionomer cement (GIC) Type IX and Cention N. It has been mentioned that compressive strength, shear strength and microhardness were significantly higher for Cention N as compared to GIC Type IX. The strong mechanical properties and good long-term stability can be attributed to the combination of UDMA, DCP, an aromatic aliphatic-UDMA and PEG-400 DMA, which interconnects (cross-links) during polymerization. Along with the high strength, other properties such as the dual-cured mechanism, fluoride ion release, calcium and hydroxide ion release, low polymerization shrinkage, and the capacity to remineralize make Cention-N as a preferred restorative material in pediatric dentistry.

N Sathyajith Naik (2021)[36] evaluated and inter-compared the fracture resistance of resin composite, fiber-reinforced composite and dual-curing restorative material (Cention-N) with conventional amalgam. After restoration, the samples were thermocycled for 500 times at 5°C and 55°C with each cycle corresponding to a 15 s bath at each temperature. Fracture resistance was tested. Fracture resistance of Cention N was found to be higher than amalgam and conventional composite. This may be attributed to the fact that the highly cross-linked polymer structure is responsible for higher mechanical properties.

Materials and Methodology

MATERIALS AND METHODOLOGY

The study was done in the Department of Prosthodontics and Crown and Bridge, Babu Banarasi Das College of Dental Sciences, Lucknow with the aim to evaluate and compare the hardness and compressive strength of Alkasite with Light-cure composite resin, Resin modified GIC and Dual-cure composite resin before and after thermocycling.

ARMAMENTARIUM FOR THE STUDY:

To conduct the present study, armamentariums used are listed below:

Materials:

Light-cure composite resin (Figure 1)

Resin modified GIC (Figure 2)

Dual –cure composite resin (Figure 3)

Alkasite (Figure 4)

Gun-metal mold (Figure 9)

EQUIPMENTS:

- Thermocycling apparatus (LG Model: 051SA , Mahavir , India) (Figure 5)
- Vickers hardness test machine (Reichert Austria Make (Figure 15)
- Universal testing machine (ACME Engineers, India., Model : UNITEST 10) (Figure 16)
- 2 Glass slab (Figure 8)
- Cement mixing pad (Figure 8)
- Double-ended measuring scoop for Resin modified GIC (Figure 8)
- Measuring scoop, plastic filling instrument for Alkasite (Figure 8)
- Agate spatula(SS White No.142) (figure 8)
- API Germany stainless Plastic filling instrument#3067 (Figure 8)

Figure 1: SWISSTEC composite

Figure 2: Paracore

Figure 3: Resin modified GIC

Figure 4: Cention –N

Figure 5: Thermocycling machine

Figure 6: Microhardness Tester

Figure 7: Universal Testing Machine

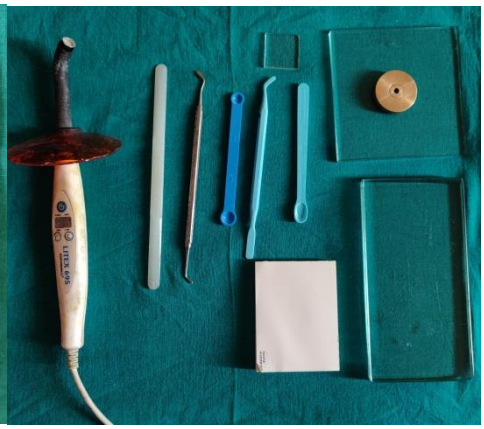


Figure 8: Material and equipment used for preparing samples

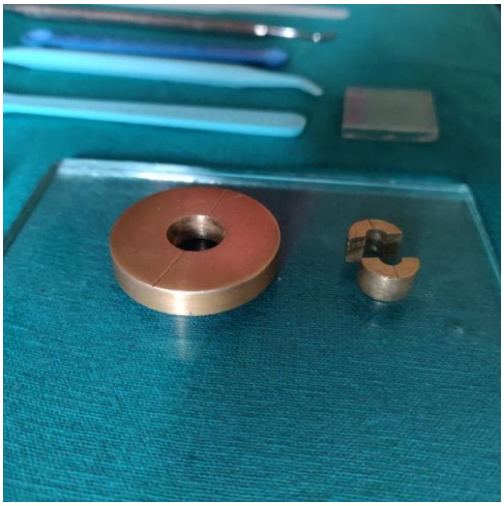


Figure 9: Metal mold

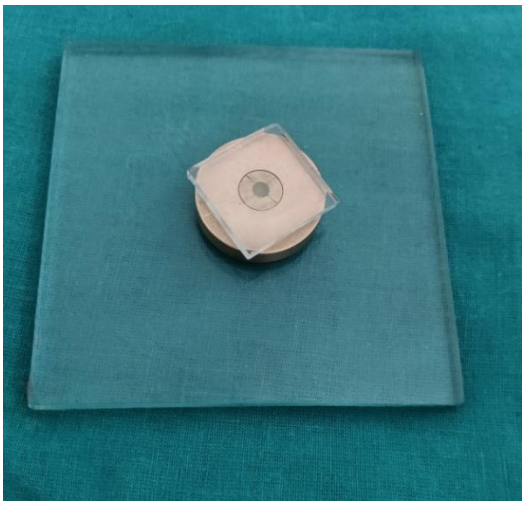


Figure10: Metal mold with sample and glass slab

METHODOLOGY

Preparation of 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.

The grouping of the samples was done as follows:

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 -1: Distribution of sample in Groups

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 polyacrylic acid 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	68wt%	Paracore sets chemical and light curing

	Adhesive B-Ethanol, Water, Initiators		
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

Table: 2 Compositions of testing groups

PROCEDURE FOR PREPARING SAMPLES:

Group A (Light-cure composite resin):

The prefabricated mold was filled with composite resin using composite filling instrument and levelled with flat glass slab (1"×1") placed over the mold to flatten the surface of the cylindrical sample . The curing was done with LED curing-light (30-40sec) as per manufacturer instruction. After curing, the sample was removed from mold for required test.

Group B (Resin modified GIC):

Dispensed one large scoop of powder and 2 drops of liquid as manufacturer instruction in 1.6:1.0 gm. Mixed the powder and liquid in the prescribed ratio on a mixing pad using plastic spatula for 20 seconds, then placed the mixture into the mold and removed excess cement, over which a glass slab was placed to level the cylindrical sample.

Group C (Dual –cure composite resin):

For Dual-cure composite resin, the material was placed into mold using automixing tips and removed excess cement, over which a glass slab was placed to level the sample. After initial setting for 3-4 min cured with LED light.

Group D (Alkasite):

Powder and liquid was dispensed onto mixing pad as per requirement. Powder was separated in 2 equal parts with plastic spatula and one part was mixed with liquid thoroughly and added the remaining powder and mixed it again until the homogeneous consistency was achieved (40-60 seconds). Material was condensed in bulk with cement carrier into mold. The excess was removed and leveled with glass slab (1”×1”) then cured with LED light.

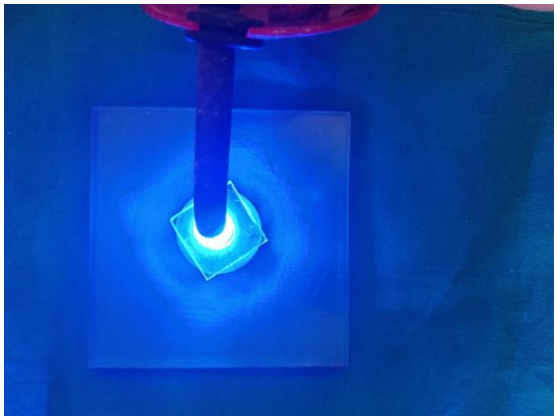


Figure11: Curing of sample with LED light

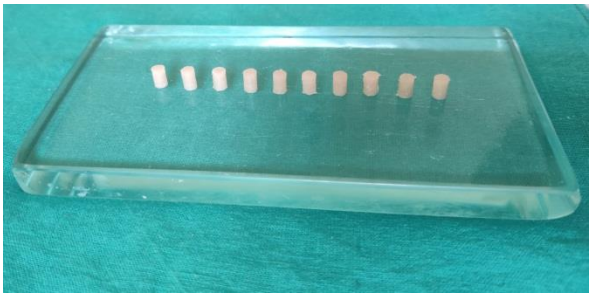


Figure 12: Cylindrical samples

STEPS FOR TESTING THE HARDNESS AND COMPRESSIVE STRENGTH

Thermocycling procedure:

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 55℃ for the hot bath and 5℃ 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 13)

The samples with or without thermocycling were subjected to hardness and compressive strength test subsequently.

Figure 13: Thermocycling procedure

Microhardness test:

Values of microhardness were recorded using Vickers Hardness Tester which have pyramid indenter (Figure14) and load of 100 gm.

For the calculation of Vickers microhardness (VHN), the lengths of the two diagonals of each indentation were measured and averaged. Thus, for a given load, the smaller the indentation, the larger is the number and the harder the material and VHN was calculated using the following formula:

$$\mathbf{VHN = 1.854F/d^2}$$

Where F is the load applied in Newton and d is the mean length of the two diagonals of each indentation

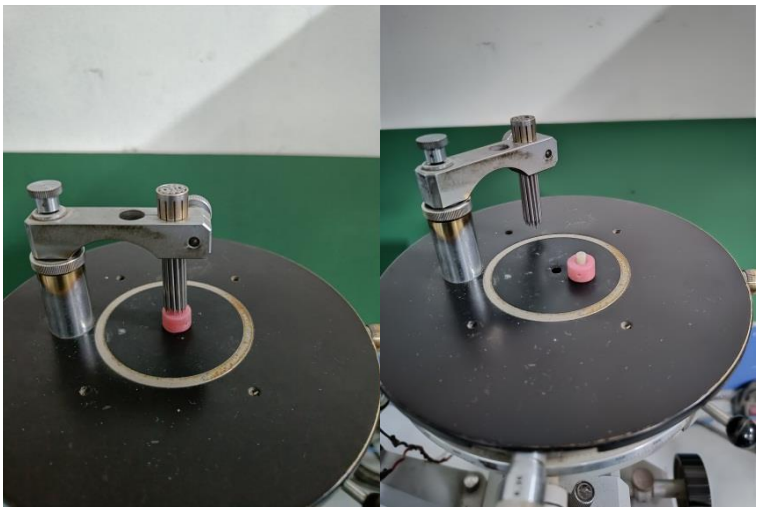


Figure 14: Microhardness test

Compressive strength test:

Compressive strength was tested with a steel ball with a crosshead speed of 1.0 mm/min in Universal Testing Machine and subjected to vertical load till the samples were fractured. (Figure 15)

Compressive strength (UCS) was calculated from the formula:

$UCS=4f/\pi d^2$,

Where F is maximum applied load (N) and D the cylindrical specimen diameter (mm)

Figure 15: Compressive strength test with Universal testing machine

STATISTICAL TOOLS:

Mean: It is the simplest measure of central tendency. It is obtained by adding the individual observations and then divided by the total no. of observations.

Mean is calculated using the formula,

$\boldsymbol{\Sigma}$ **Xi/n**

Where, (Sigma), means the sum of, Xi is the value of each observation in the data, n is the no. of observation in the data.

Standard Deviation:

In statistics, the standard deviation is a measure of the amount of variation or dispersion of a set of values. A low standard deviation indicates that the values tend to be close to the mean (also called the expected value) of the set, while a high standard deviation indicates that the values are spread out over a wider range.

We can write the formula for the standard deviation as

$$s = \sqrt{\frac{\sum (xi - \bar{x})^2}{n-1}}$$

Where

Means "the sum of"

xi represents each value x in the date

$\bar{x}$ is the mean of the xi values

n is the total of xi values

Anova test:

Analysis of variance (ANOVA) is a statistical technique that is used to check if the means of two or more groups are significantly different from each other. ANOVA checks the impact of one or more factors by comparing the means of different samples.

Tukey's multiple comparison tests:

This test is used to determine which means amongst a set of means differ from the rest. Tukey's multiple comparison tests is also called Tukey's honestly significant difference test or Tukey's HSD

When we have more than two groups, it is inappropriate to simply compare each pair using a t-test because of the problem of multiple testing. The correct way to do the analysis is to use a one-way analysis of variance (ANOVA) to evaluate whether there is any evidence that the means of the populations differ.

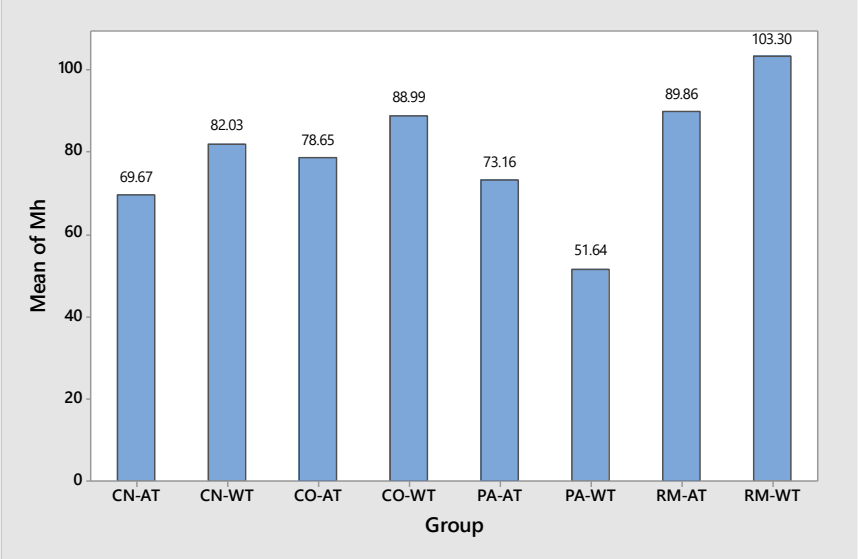
Observations & Results

OBSERVATIONS AND RESULTS

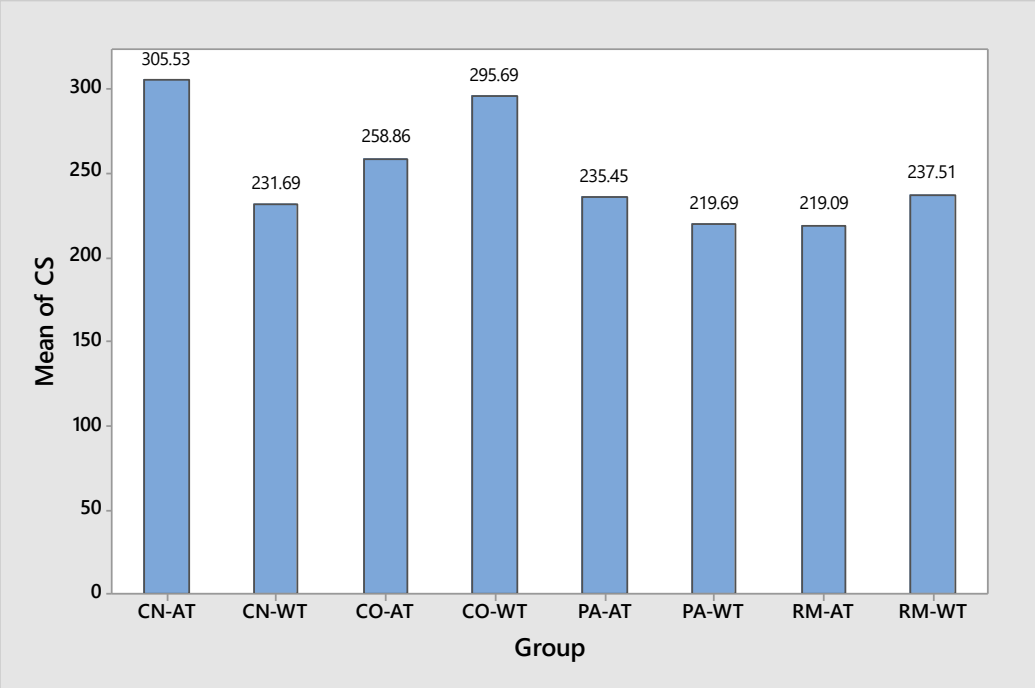
Observations:

	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

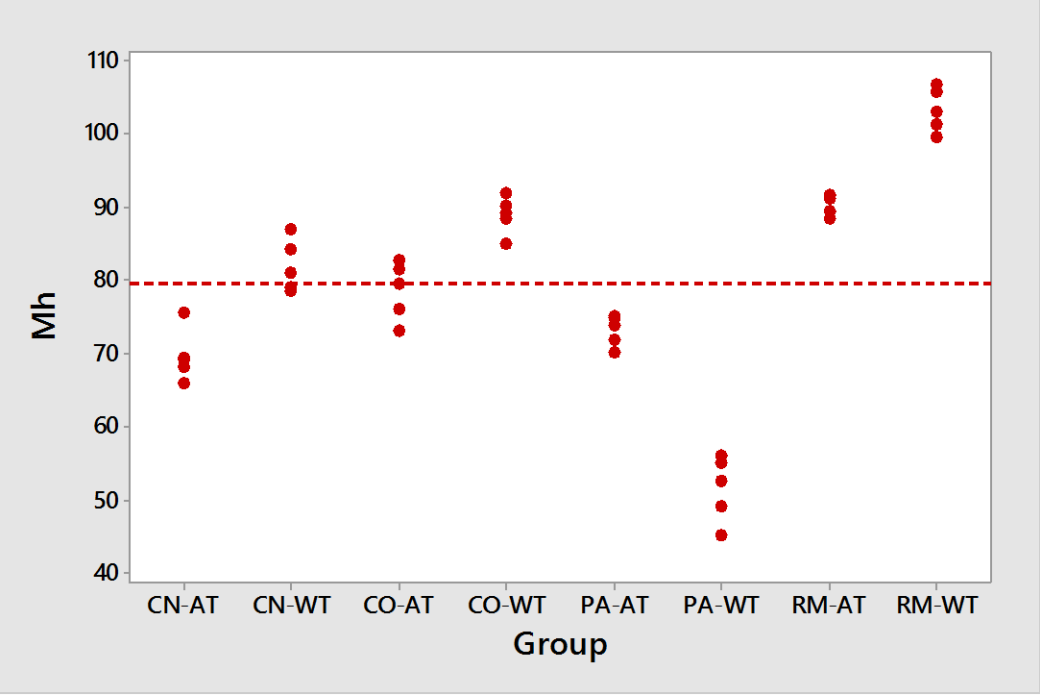
Table 3: Inter group comparison of mean and standard deviation values (Mean±SD) for microhardness and compressive strength with and without thermocycling



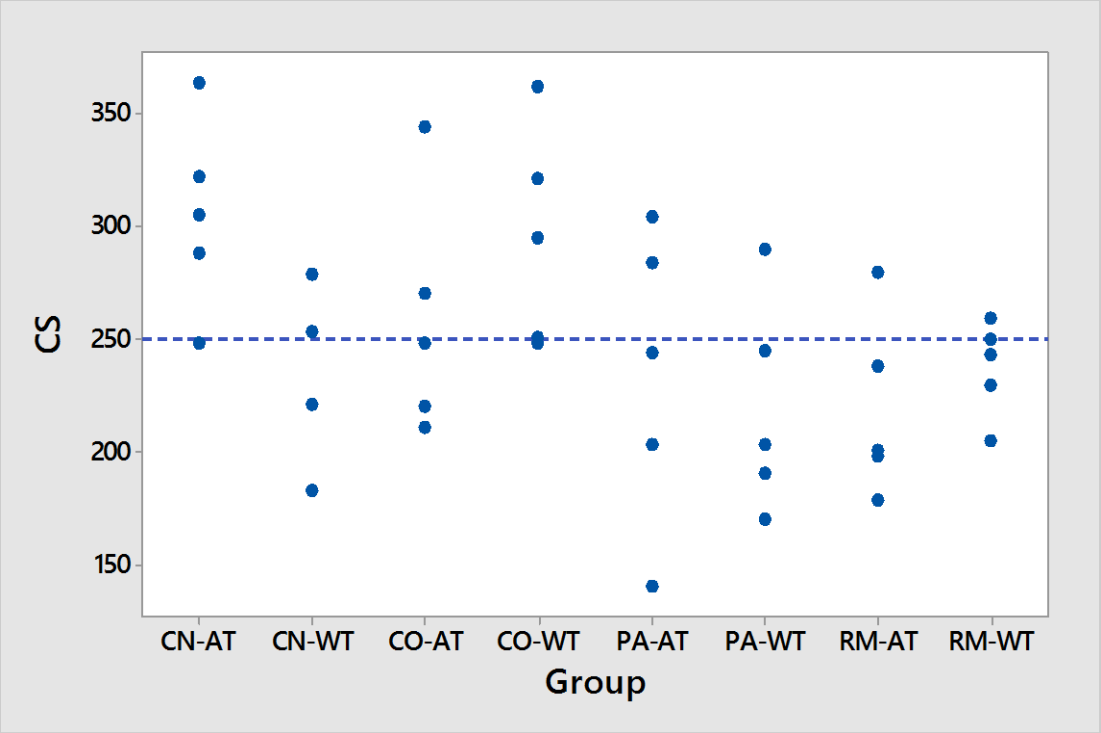
Graph 1: Mean value for compressive microhardness of testing group with and without thermocycling



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



Graph3: Mean value and standard deviation for microhardness of testing group with and without thermocycling



Graph 4: Mean value and standard deviation for compressive strength of testing group with and without thermocycling

Groups	Sample No.	Without thermocycling		With thermocycling	
		Microhardness in HV	Compressive strength (MPa)	Microhardness in HV	Compressive strength (MPa)
(A) Composite (Control group)	1	89.16	321.71	73.16	344.24
	2	90.20	251.16	81.60	270.50
	3	85.00	248.12	82.70	248.75
	4	88.60	295.29	79.60	210.78
	5	92.00	362.17	76.20	220.06
(B) Resin modified GIC	1	105.8	243.29	91.70	178.36
	2	106.7	259.27	89.40	279.77
	3	99.50	250.15	88.50	238.46
	4	101.4	229.49	91.20	200.57
	5	103.1	205.38	88.50	198.31
(C) Paracore	1	45.20	170.19	74.80	304.64
	2	49.20	203.00	75.10	244.54
	3	52.50	190.28	73.90	203.61
	4	55.10	244.62	71.80	140.36
	5	56.20	290.38	70.20	284.14
(D) Cention–N	1	81.16	278.99	75.69	364.03
	2	79.20	221.46	69.10	305.27
	3	84.20	253.58	68.20	287.96
	4	87.10	183.19	69.50	248.36
	5	78.50	221.23	65.90	322.03

Table 4: Compressive strength and Hardness test of all four group material with and without thermocycling

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Group	7	8418.1	1202.59	114.22	0
Error	32	336.9	10.53		
Total	39	8755.1			

Table 5: Inter-group comparison of microhardness assessed by using ANOVA.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Group	7	39122	5589	2.63	0.029
Error	32	68005	2125		
Total	39	107127			

Table 6: Inter-group comparison of compressive strength assessed by using ANOVA.

Difference of Levels	Difference of Means	T-Value	Adjusted P-Value
CN-WT - CN-AT	12.35	6.02	0
CO-AT - CN-AT	8.97	4.37	0.003
CO-WT - CN-AT	19.31	9.41	0
PA-AT - CN-AT	3.48	1.70	0.689
PA-WT - CN-AT	-18.04	-8.79	0
RM-AT - CN-AT	20.18	9.83	0
RM-WT - CN-AT	33.62	16.38	0
CO-AT - CN-WT	-3.38	-1.65	0.719
CO-WT - CN-WT	6.96	3.39	0.035
PA-AT - CN-WT	-8.87	-4.32	0.003
PA-WT - CN-WT	-30.39	-14.81	0
RM-AT - CN-WT	7.83	3.81	0.0120
RM-WT - CN-WT	21.27	10.36	0
CO-WT - CO-AT	10.34	5.04	0
PA-AT - CO-AT	-5.49	-2.68	0.167
PA-WT - CO-AT	-27.01	-13.16	0
RM-AT - CO-AT	11.21	5.46	0

RM-WT - CO-AT	24.65	12.01	0
PA-AT - CO-WT	-15.83	-7.71	0
PA-WT - CO-WT	-37.35	-18.20	0
RM-AT - CO-WT	0.87	0.42	1.000
RM-WT - CO-WT	14.31	6.97	0
PA-WT - PA-AT	-21.52	-10.49	0
RM-AT - PA-AT	16.7	8.14	0
RM-WT - PA-AT	30.14	14.69	0
RM-AT - PA-WT	38.22	18.62	0
RM-WT - PA-WT	51.66	25.17	0
RM-WT - RM-AT	13.44	6.55	0

Table 7: Inter-group comparison of microhardness assessed by using TUKEY HSD

Group	Mean	Grouping					
RM-WT	103.3	A					
RM-AT	89.86		B				
CO-WT	88.99		B				
CN-WT	82.03			C			
CO-AT	78.65			C	D		
PA-AT	73.16				D	E	
CN-AT	69.68					E	
PA-WT	51.64						F

Table 8: Grouping the information using the Tukey HSD method

Difference of Levels	Difference of Means	T-Value	Adjusted P-Value
CN-WT - CN-AT	-73.80	-2.53	0.218
CO-AT - CN-AT	-46.70	-1.60	0.747
CO-WT - CN-AT	-9.80	-0.34	1.000
PA-AT - CN-AT	-70.10	-2.40	0.274
PA-WT - CN-AT	-85.80	-2.94	0.097
RM-AT - CN-AT	-86.40	-2.96	0.093
RM-WT - CN-AT	-68.00	-2.33	0.308
CO-AT - CN-WT	27.20	0.93	0.980
CO-WT - CN-WT	64.00	2.20	0.381
PA-AT - CN-WT	3.80	0.13	1.000
PA-WT - CN-WT	-12.00	-0.41	1.000
RM-AT - CN-WT	-12.60	-0.43	1.000
RM-WT - CN-WT	5.80	0.20	1.000
CO-WT - CO-AT	36.80	1.26	0.906
PA-AT - CO-AT	-23.40	-0.80	0.992
PA-WT - CO-AT	-39.20	-1.34	0.875
RM-AT - CO-AT	-39.80	-1.36	0.866
RM-WT - CO-AT	-21.30	-0.73	0.995
PA-AT - CO-WT	-60.20	-2.07	0.457
PA-WT - CO-WT	-76.00	-2.61	0.191
RM-AT - CO-WT	-76.60	-2.63	0.183
RM-WT - CO-WT	-58.20	-2.00	0.500
PA-WT - PA-AT	-15.80	-0.54	0.999
RM-AT - PA-AT	-16.40	-0.56	0.999
RM-WT - PA-AT	2.10	0.07	1.000
RM-AT - PA-WT	-0.60	-0.02	1.000
RM-WT - PA-WT	17.80	0.61	0.998
RM-WT - RM-AT	18.40	0.63	0.998

Table 9: Inter-group comparison of microhardness assessed by using TUKEY HSD

Results

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

Discussion

DISCUSSION

The in vitro study was done to evaluate and compare the microhardness and compressive strength of Alkasite with light-cure packable composite, resin modified GIC and dual-cure composite resin with and without thermocycling. The newer material Alkasite was compared with the already existing materials so as to evaluate the clinical applicability and to validate the manufacturer's claim.

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; this test has been done with universal test machine, which supplied fundamental data about the material.[25]

Hardness is the mechanical property of material which resists indentations under constant load. There are 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. Both Knoop and Vickers tests employ load less than 9.8N and resulting indentations are small and to a depth of less than 19µm.[14]If the objective is to compare two hardness number, it seems more suitable to consider the true area of

contact, which is higher in Vickers hardness as compare to Knoop .So the preferred test for microhardness in this study is Vickers hardness test.[41]

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.

20 samples each of Alkasite, light-cure composite, resin modified GIC and Dual-cure composite resin) were fabricated in a cylindrical Gun metal mold of Customized dimension 6±1mm (Height) ×4±1mm (diameter) according to International Standards Organization 4049 (ISO, 1992).[25, 42, 43]

Half of the samples were subjected to 500 cycles of thermocycling.[11, 16, 37] so as to simulate the varying temperatures of the mouth and the presence of saliva as the varying temperatures and water absorption affects the mechanical properties of the materials when in mouth.

Though large variations in terms of temperature range, dwell time and cycles exist in the literature and that is due to the factual variations occurring in mouth coupled with variations as per the location of teeth.[11]

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 (Table 7).

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 microhardness values after thermocycling 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 (Table 9)

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 have 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]

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.

Scope of this study:

The future scope of the study includes conducting the study in vivo to perfectly simulate the oral environment as well as to evaluate the bonding of restorative/core build up material to tooth structure.

Clinical implication:

As core build-up materials, Cention -N exhibited highest compressive strength though there was no statistically significant difference amongst the four materials.

Conclusions

CONCLUSIONS

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

1. Without thermocycling, RMGIC showed highest hardness, followed by light-cure composite resin, Alkasite and dual-cure composite resin.

2. With thermocycling RMGIC showed highest microhardness followed by light-cure composite, dual-cure composite and Alkasite.

3. Without thermocycling, Light-cure composite showed highest compressive strength followed by RMGIC, Alkasite and dual-cure composite.

4. With thermocycling Alkasite showed highest compressive strength followed by light-cure composite, dual-cure composite and RMGIC.

5. Microhardness of Dual-cure composite resin increased after thermocycling but decreased for Light-cure composite resin, Alkasite and RMGIC

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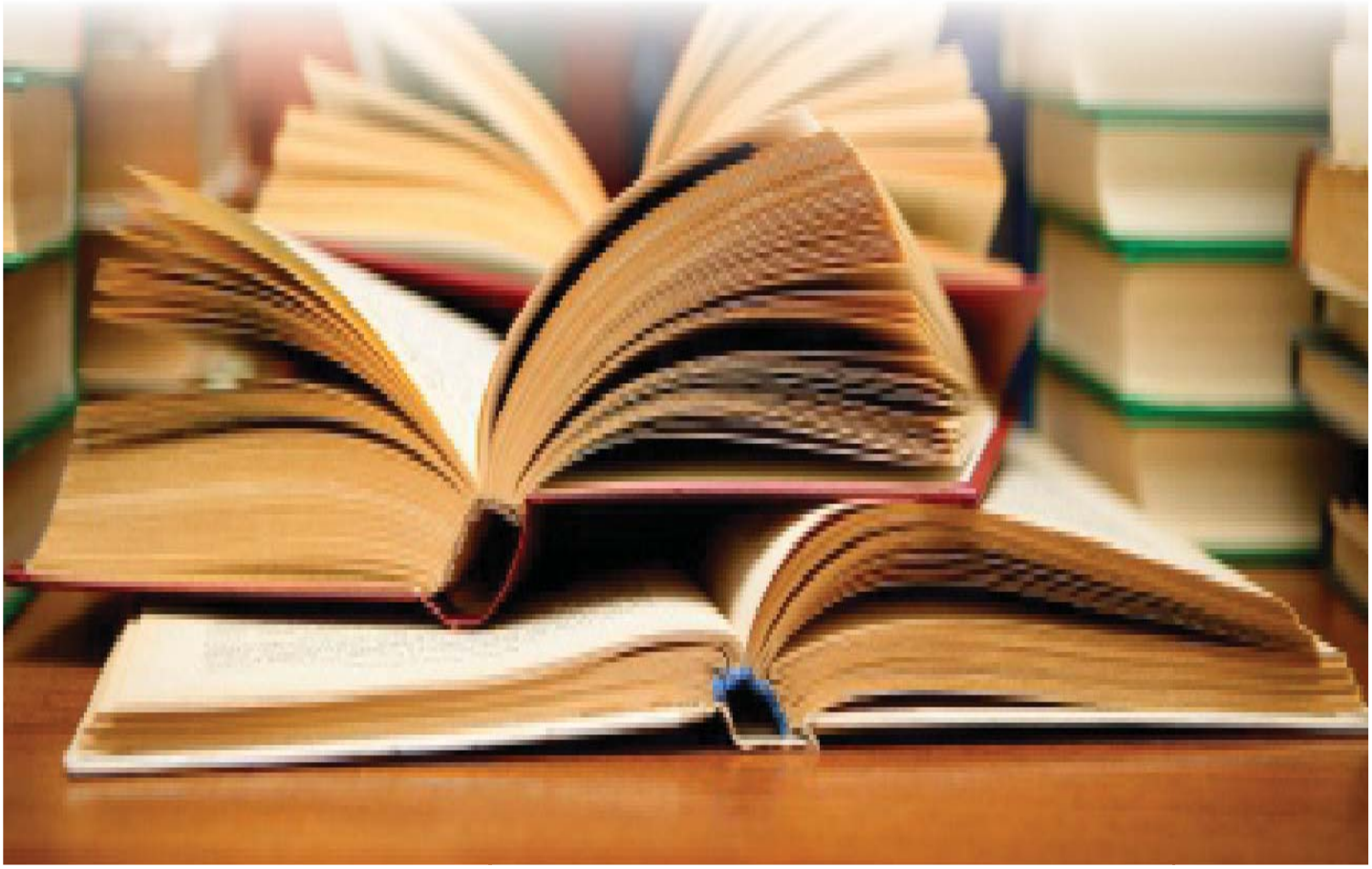

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Annexures

ANNEXURE 1

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES (FACULTY OF BBD UNIVERSITY), LUCKNOW

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"A Comparative Evaluation of the Mechanical Properties of Cention-N with Contemporary Restorative Material under the Influence of Thermocycling: An In Vitro Study"** submitted by **Dr Rehana Bano** Post graduate student from the **Department of Prosthodontics & Crown and Bridge** as part of MDS Curriculum for the academic year 2019-2022 with the accompanying proforma was reviewed by the Institutional Research Committee present on **19th December 2019** at BBDCODS.

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

Prof. Vandana A Pant
Co-Chairperson

Prof. B. Rajkumar
Chairperson

ANNEXURE 2

Babu Banarasi Das University
Babu Banarasi Das College of Dental Sciences,
BBD City, Faizabad Road, Lucknow – 226028 (INDIA)

Dr. Lakshmi Bala
Professor and Head Biochemistry and
Member-Secretary, Institutional Ethics Committee

Communication of the Decision of the VIIIth Institutional Ethics Sub-Committee

IEC Code: 21 **BBDCODS/03/2020**

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

Principal Investigator: Dr. Rehana Bano **Department:** Prosthodontics and Crown & Bridge

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Project Protocol

Dear Dr. Rehana Bano,

The Institutional Ethics Sub-Committee meeting comprising following four members was held on 18th March, 2020.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry, BBDCODS, Lucknow
2.	Dr. Amrit Tandan Member	Prof. & Head, Department of Prosthodontics and Crown & Bridge, BBDCODS, Lucknow
3.	Dr. Sahana S. Member	Reader, Department of Public Health Dentistry, BBDCODS, Lucknow
4.	Dr. Sumalatha M.N. Member	Reader, Department of Oral Medicine & Radiology, BBDCODS, Lucknow

The committee reviewed and discussed your submitted documents of the current MDS Project Protocol in the meeting.

The comments were communicated to PI thereafter it was revised.

Decisions: The committee approved the above protocol from ethics point of view.

Forwarded by:

Lakshmi Bala 18/03/20

(Dr. Lakshmi Bala)
Member-Secretary
IEC

Member-Secretary
Institutional Ethic Committee
BBD College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

(Dr. B. Rajkumar)
Principal
BBDCODS

PRINCIPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

ANNEXURE 3

Ouriginal

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