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Original article

COMPARISON OF COMPRESSIVE STRENGTH OF BULK FILLED COMPOSITE AND NANO HYBRID COMPOSITE- AN IN-VITRO STUDY.

Dr.Sonali Bhuyan[a], Dr. Prasanta Kumar Swain[a,*], Dr. Susant Mohanty[b], Dr. Mrinali Shukla[b], Dr. Sulagna Pradhan[b]

[a] Department of Dentistry, VIMSAR, Burla, Sambalpur, Odisha, India.
[b] Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be University),Bhubaneswar 751003, Odisha, India.

Abstract

Background:

During the past 60 years, the use of composite resin for direct restorations in anterior and posterior teeth has increased significantly, largely due to the esthetic demands of patients and concerns regarding mercury in amalgam fillings. Because composite resins require little to no preparation, minimally invasive procedures can be used to preserve tooth structure and provide natural-looking results. Dental composites typically are composed of three chemical materials: an organic matrix, an inorganic matrix, and a coupling agent. Today's composite resins produce highly esthetic, long-lasting restorations for many indications. Through an understanding of advanced layering techniques, microleakage and fracture rate concerns can be decreased significantly. Hence it is imperative evaluate the compressive strength of bulk filled composite and nano hybrid composite.

Aims & Objectives:

To assess, evaluate and compare the compressive strength of Bulk filled composite and Nano Hybrid composite.

Materials and Methods:

Study method- In-vitro study. **Sample A**-Ivoclar Vivadent Inc. Bulk filled composite & Tetric N-Ceram Bulk Filled Composite (Leichtenstein). **Sample B**-Ivoclar Vivadent Nano filled composite & Tetric N- Ceram Nano Hybrid Composite (Leichtenstein).The cylindrical specimens were transferred on to the Instron testing machine (Model H50KS; Instron,Redhill,Surrey,RH15DZ, UK) individually and subjected to compressive testing at crosshead speed of 1.0 mm/minute.

Results:

Comparison of the compressive strength of the individual groups was done. There was a statistically significant difference between the groups pertaining to compressive strength. The mean score for Group B was more than Group A.

Conclusions:

Within the limitation of the specific materials, testing methods and in-vitro environment in the study, it is concluded that, Nanohybrid composite material have better compressive strength as compared to bulk fill composite.

Recommendations:

Further sfiltudies are needed to determine the optimal curing light intensity to obtain the best results in terms of mechanical properties for newer bulk-fill composite materials.

Keywords: Compressive strength, Filtek bulk-fill, Nanohybrid, Submitted: 2023-06-23 Accepted: 2023-06-28

1. Introduction:

Oral health is one of the most important part of the human health, which is necessary to maintain an optimum functioning of the systemic activity. The ability to process food, to be adequately digested and absorbed, the ability to speak and communicate and the ability to acquire a presentable social appearance, are all essential in the modern day life[1].

Dental material manufacturers have seen great advancement with the growth in the market, thus focusing on and working towards more innovations, new patents and discoveries, together with more demand from patients for more efficient and more esthetic restorations.(HA Sayed, 2017). A wide variety of restorative materials have been developed due to various researches and the innovation of new compositions and techniques[2,3].

The American Dental Association (ADA) prescribed a list of basic criteria for restorative dental materials. These include, the dental material should neither be poisonous or harmful to the body, nor be harmful or irritating to the tissues of the oral cavity. It must resemble the natural dentition and help protect the tooth and tissues of the oral cavity. It must be easily formed and placed in the mouth and should withstand the biting and chewing force in the posterior area of the mouth. Finally, all these criteria should not degrade by time[3,4].

Classification of composites is necessary in order to know its esthetic and therapeutic values easily. The most popular classification which is still valid is that of Lutz and Phillips, which is based on filler particle size5. A more detailed classification by Willems et al is based on a number of parameters such as Young's modulus, the percentage (by volume) of inorganic filler, the size of the main particles, surface roughness and compressive stress[6].

Table 1. Classification of composites (Willems, 1993).

Composite Type	Filler
Densified composites	< 60% by volume
-Midway-filled -Ultrafine Fine -Compact-filled >60% by volume - Ultrafine -Fine	 Particles < 3 µm Particles > 3 µm > 60% by volume Particles < 3 µm Particles > 3 µm
Microfine composites - Homogeneous - Heterogeneous	Average particle size = 0,04 µm
Miscellaneous composites	Blends of densified and microfine Composites
Traditional composites	Equivalent to what are termed macrofill composites in other classifications
Fiber-reinforced composites	Industrial-use composites

1.1. Types of Composites:

Recent modifications to composite resins have improved their physical and mechanical properties. Different types of composites are-Hybrid composites, Nanofilled Composites, Bulk filled composites, Microfilled Composites. In this study we will be evaluating compressive strength between Nanohybrid composite and Bulk filled composite. Nanohybrid composites were recently introduced in order to provide a material which had high initial polishing and superior polish and gloss retention. Nanohybrids use the method of uniting nanomeric and conventional fillers. Bulk-filled Resin Bonded Composites (RBC) materials provide tooth-coloured restorations, that can be more efficient and less technique sensitive to place than conventional RBCs.8

1.2. Aims And Objectives Of This Study:

To assess, evaluate and compare the compressive strength of Bulk filled composite and Nano Hybrid composite.

2. Materials and Methods:

2.1. Place of Study:

Department of Paediatric and preventive dentistry, Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha.

* Corresponding author.
Email address: drprashantkumarswain@gmail.com
(Dr. Prasanta Kumar Swain)

Institute of materials and materials technology (IMMT), Bhubaneswar

The study was approved by the Institutional Ethics Committee, Institute of Medical Sciences and SUM Hospital, Siksha 'O' Anusandhan (Deemed to be University)

2.2. Materials used:

Sample A-Ivoclar Vivadent Inc. Bulk filled composite -Tetric N-Ceram Bulk Fill(Leichtenstein).

Sample B-Ivoclar Vivadent Nano filled composite -Tetric N- Ceram Nano Hybrid (Leichtenstein).

Table 2 (A): Name and product details of the materials used

Materials	Type and composition
Sample A-IvoclarVivadent (Tetric N-Ceram Bulk Fill, Leichtenstein)- Bulk filled Composite	The monomer matrix is composed of dimethacrylates (19–21% weight). The total content of inorganic fillers is 75–77% weight or 53-55% volume. The fillers consist of barium glass, prepolymer, ytterbium trifluoride and mixed oxide. Additives, catalysts, stabilizers and pigments are additional contents (1.0% weight). Photoinitiator – Ivocerin Additives, stabilizers and pigments are additional ingredients (<1.0 wt%). The total content of inorganic fillers is 68.2 wt% / 46.4 vol%.

Table 2 (B): Name and product details of the materials used

Sample B-IvoclarVivadent (Tetric N- Ceram,Leichtenstein) -Nanohybrid composite	Tetric N-Ceram consists of dimethacrylates (19-20 wt.%). The fillers contain barium glass, ytterbium trifluoride, mixed oxide and copolymers (80-81 wt.%). Additives, initiators, stabilizers and pigments are additional contents (< 1 wt.%). The total content of inorganic fillers is 55–57 vol.%. The particle size of inorganic fillers is between 40 nm and 3000 nm.

2.3. Armamentarium Used for the Study:

- Cylindrical moulds
- Light emitting diode (LED D Curing Light unit, Woodpecker,India)
- Glass slab
- Universal Instron machine(Model H50KS;Tinius Oleus,Redhill,Surrey,RH15DZ, UK)
- Ivoclar Vivadent Tetric N Ceram –Bulk Fill Composite IV A (Leichtenstein)
- Ivoclar tetric N Ceram –Nanohybrid composite (Leichtenstein)
- Plastic Filling Instrument [(GDC ,CE,PF-21),India]
- Ball burnisher(GDC, India)
- Composite Finishing Instrument[(GDC, CE,CTB1,LOT:210301),India]
- Mylar Strip

2.4. Collection and preparation of sample

2.4.1. Group A Ivoclar Vivadent (Tetric -N -Ceram Bulk fill)-Bulkfilled composite:

The mould was placed on a glass slide covered with a Mylar strip, and then the composite was filled in bulk for each material. The specimen was polymerized for 20s, keeping the tip of the cordless LED light-curing unit(LED D Curing Light unit, Woodpecker) in contact with the glass slide (1.2-mm thick) to ensure a constant distance from the specimen. After polymerization, each specimen was removed from the mold. The specimens were retrieved and were examined for presence of

Figure 1: Group A – (Ivoclar Vivadent Tetric- N -Ceram Bulkfill composite) Group B – (Ivoclar Vivadent Tetric- N -Ceram Nanohybrid composite

external voids and those with voids were excluded from further testing.

2.4.2. *Group B IvoclarVivadent(Tetric -N-Ceram)-Nanohybrid composite:*

Group B samples were prepared in the same manner as Group A except after complete filling of the mould space, curing of the material was done in three segments. Each segment was cured for 20s according to manufacturer's instructions, to ensure complete polymerisation of the resin with a light curing unit(20 seconds light-emitting diode (LED) light without put 550 mW/cm2)

2.5. *Testing of Sample:*

After completion of the polymerization process, the specimens were conditioned for 48 hours in distilled water at 37°C. The cylindrical specimens were transferred on to the Instron testing machine (Model H50KS; Instron,Redhill,Surrey,RH15DZ, UK) individually and subjected to compressive testing at crosshead speed of 1.0mm/minute.

2.6. *Calculation of compressive strength*

Compressive Strength: It is a material property which is maximum force per unit area before failure occurs.UCS = $4f/\pi d2$

Where f was the load in Newton (N)Is the diameter of the cylindrical specimen in millimeters.

2.7. *Statistical Analysis:*

Descriptive statistics were computed using Mean and Standard deviation. Inferential statistics were computed using one way ANOVA statistics. Intra group comparison over the period of time was done using Friedman's statistics. The software used for statistical analysis is IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY:IBM Corp.

Figure 2: **Armamentarium**

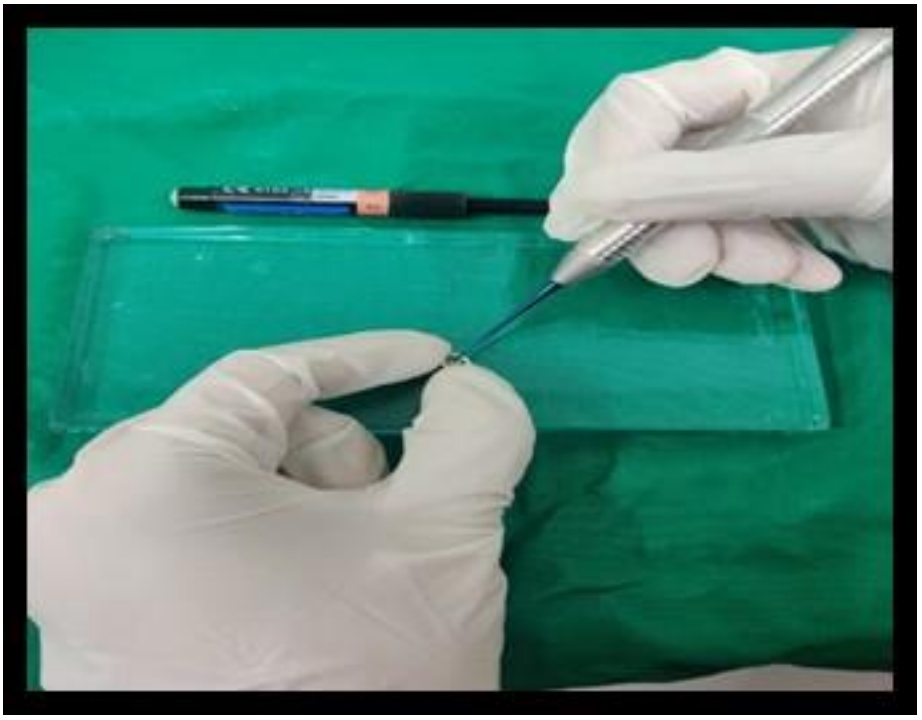

Figure 3: **Placement of material into mould**

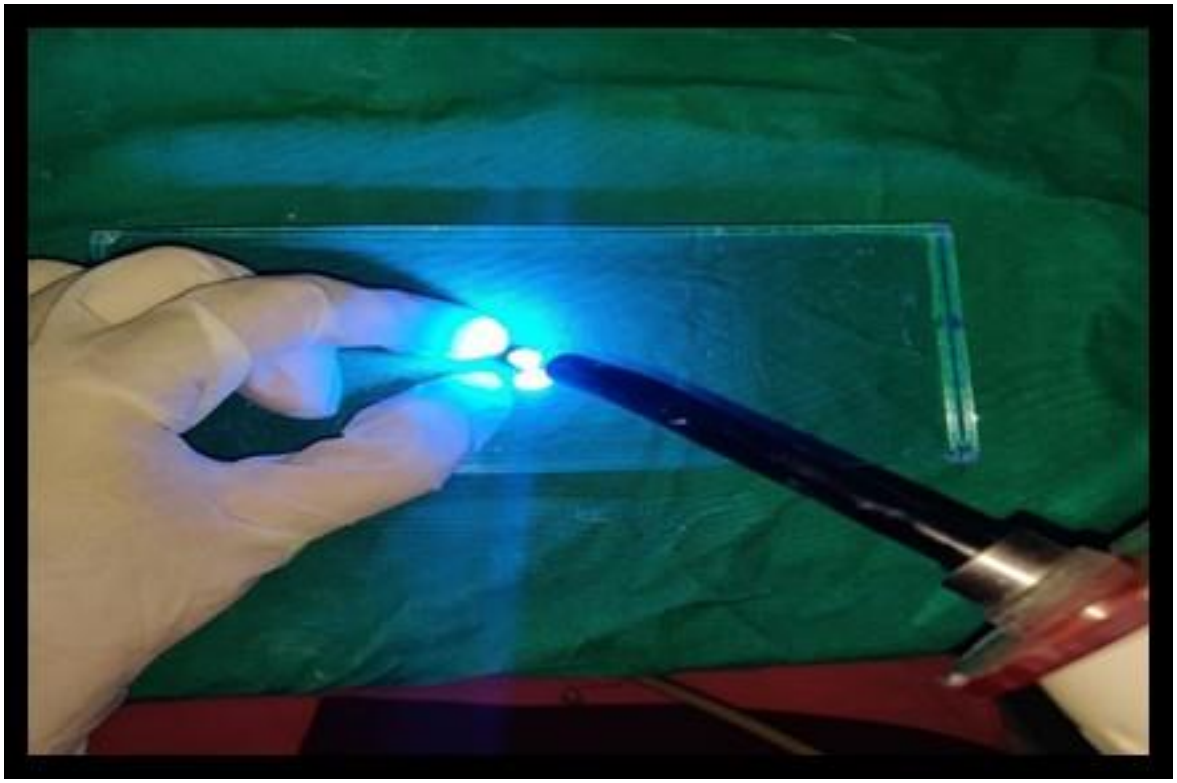

Figure 4: **Curing of the material with light curing device**

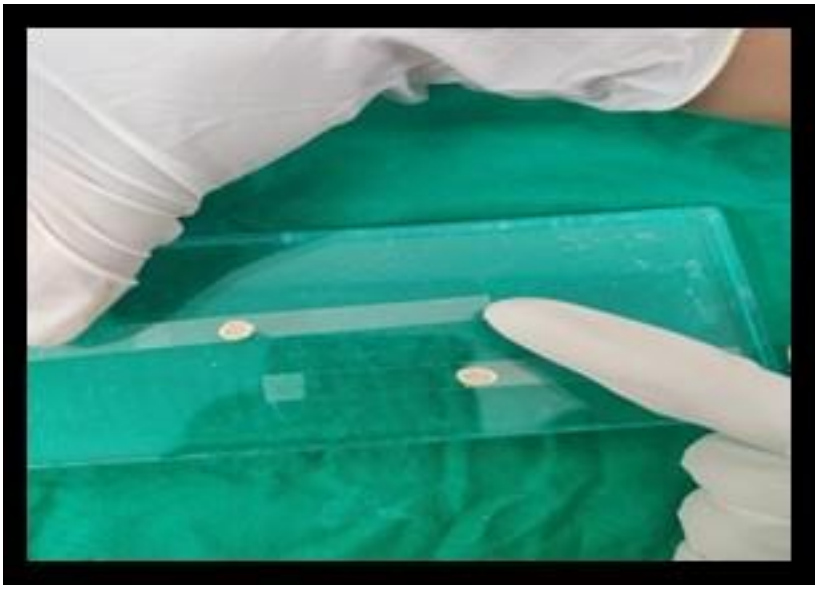

Figure 5: **Polishing with mylar strip**

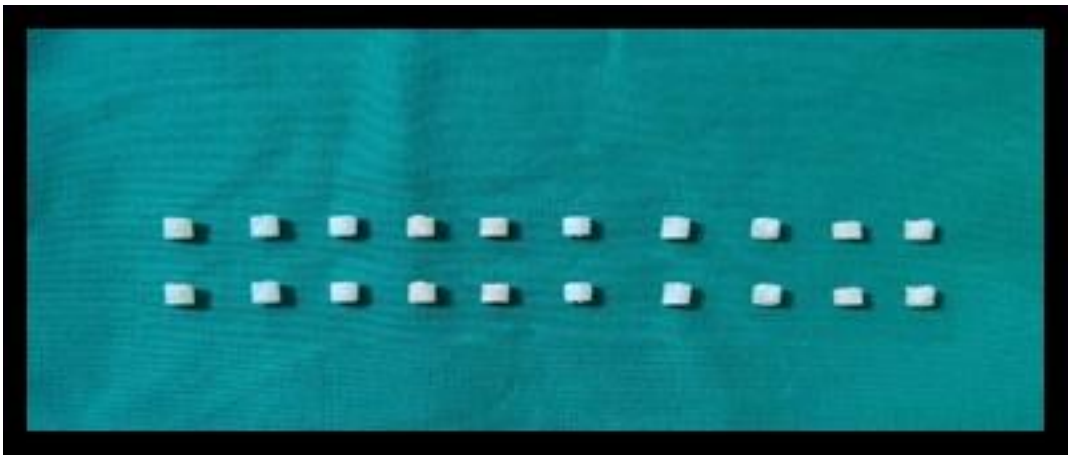

Figure 6: **Retrieval of samples from moulds**

Figure 7: **Instron testing machine** (Model H50KS; Instron,Redhill,Surrey,RH15DZ, UK)

3. Results:

Table 3: Comparison of the Groups as a whole for the Stress variable (Mean±S.D.)

MP	N	Mean	Std. Deviation	95% Confidence Interval for Mean		F Score	P Value
				Lower Bound	Upper Bound		
Group A	20	1074.136	1062.075	577.069	1571.20	3.309	0.017*
Group B	20	1751.279	1282.016	1151.278	2351.28		
Total	40	1412.708	1211.536	1025.239	1800.17		

*Statistically significant, Significance level (p<0.05)

Comparison of the Groups as a whole for the Stress variable is calculated. The mean score for Group B was more than Group A. There was a statistically significant difference between the groups (P Value=0.077). The same have been graphically presented in Figure 8.

Table 4: Comparison of the Groups as a whole for the Strain variable (Mean±S.D.)

Strain	N	Mean	Std. Deviation	95% Confidence Interval for Mean		F Score	P Value
				Lower Bound	Upper Bound		
Group A	20	0.493	0.242	0.3798	0.6065	0.075	0.016
Group B	20	0.715	0.252	0.3966	0.6325		
Total	40	0.504	0.244	0.4258	0.5819		

*Statistically significant. Significance level (p<0.05)

Table 5: Descriptive statistics for the Stress among individual at several time interval (Mean±S.D.)

Time (in sec)	Group A		Group B		F score	P Value
	Mean	Std. Deviation	Mean	Std. Deviation		
0-12	18.61	17.667	263.69	162.195	9.025	0.024*
13-22	182.32	116.831	990.31	631.272	6.336	0.045*
23-32	914.99	366.218	2132.46	1210.300	3.708	0.102
33-42	1711.28	598.594	2762.79	1162.702	2.586	0.159
43-52	2543.45	798.851	2607.13	954.196	0.010	0.922
Chi Square	1569.09		1678.90			
P Value	<0.0001		<0.0001			

*Statistically significant, Significance level (p<0.05)

Table 6: Descriptive statistics for the Strain among individual at several time intervals (Mean±S.D.)

Time (in sec)	Group A		Group B		F Score	P Value
	Mean	Mean	Std. Deviation	Std. Deviation		
0-12	0.1600	0.1675	0.009	0.000	2.455	0.168
13-22	0.3265	0.3325	0.005	0.004	3.042	0.132
23-32	0.4913	0.5375	0.082	0.002	1.265	0.304
33-42	0.6605	0.7053	0.083	0.001	1.160	0.323
43-52	0.8275	0.8300	0.039	0.005	0.016	0.903
Chi Square	20.00		20.00			
P Value	<0.0001*		<0.0001*			

*Statistically significant , Significance level (p<0.05)

Table 7: Comparison of the compressive strength of the individual groups (Mean±S.D.)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		F Score	P Value
					Lower Bound	Upper Bound		
Group A	20	186.6	0.0140	.00313	205.7	150.5	0.075	0.005*
Group B	20	274.5	0.0135	.00301	308.9	250.9		

*Statistically significant, Significance level (p<0.05)

Descriptive statistics for the Stress among individual at several time interval was calculated. A statistically significant difference was noted between the groups at 0 to 12 secs interval (P value <0.001), and also at 13 to 22 secs (P Value = 0.045). Although there were differences in the mean scores between Group A and Group B, no statistically significant difference was seen among the groups at an interval of 23 to 32 secs, 33 to 42 secs and also at 43 to 52 secs.

Descriptive statistics for the Strain among individual at several time interval was calculated. Although there were differences in the mean scores between Group A and Group B, no statistically significant difference was seen among the groups at any of the intervals: 0 to 12 sec, 13 to 22 sec, 23 to 32 secs, 33 to 42 secs and also at 43 to 52 secs.

Comparison of the compressive strength of the individual groups was done. There was statistically significant difference between the groups pertaining to compressive strength.

4. Interpretation:

Statistics using one way ANOVA were used to compare between the two groups for the individual variables. Group B was found to be of superior nature as compared to Group A when comparison was made for the parameters. Recordings were made at several time intervals. Friedman statistics were calculated to compare the values over the period of time. For all the parameters, group wise comparison was made using One way ANOVA.

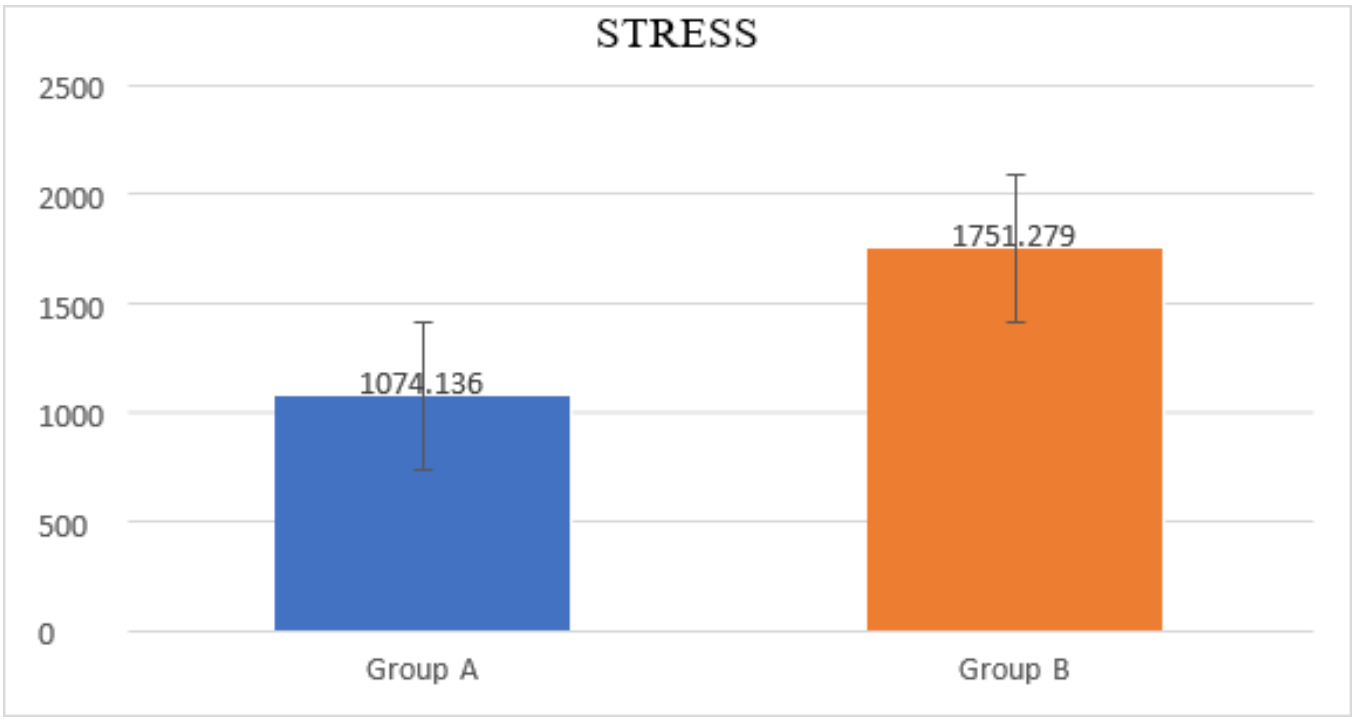

Figure 8: Representation of the Groups as a whole for the Stress variable.

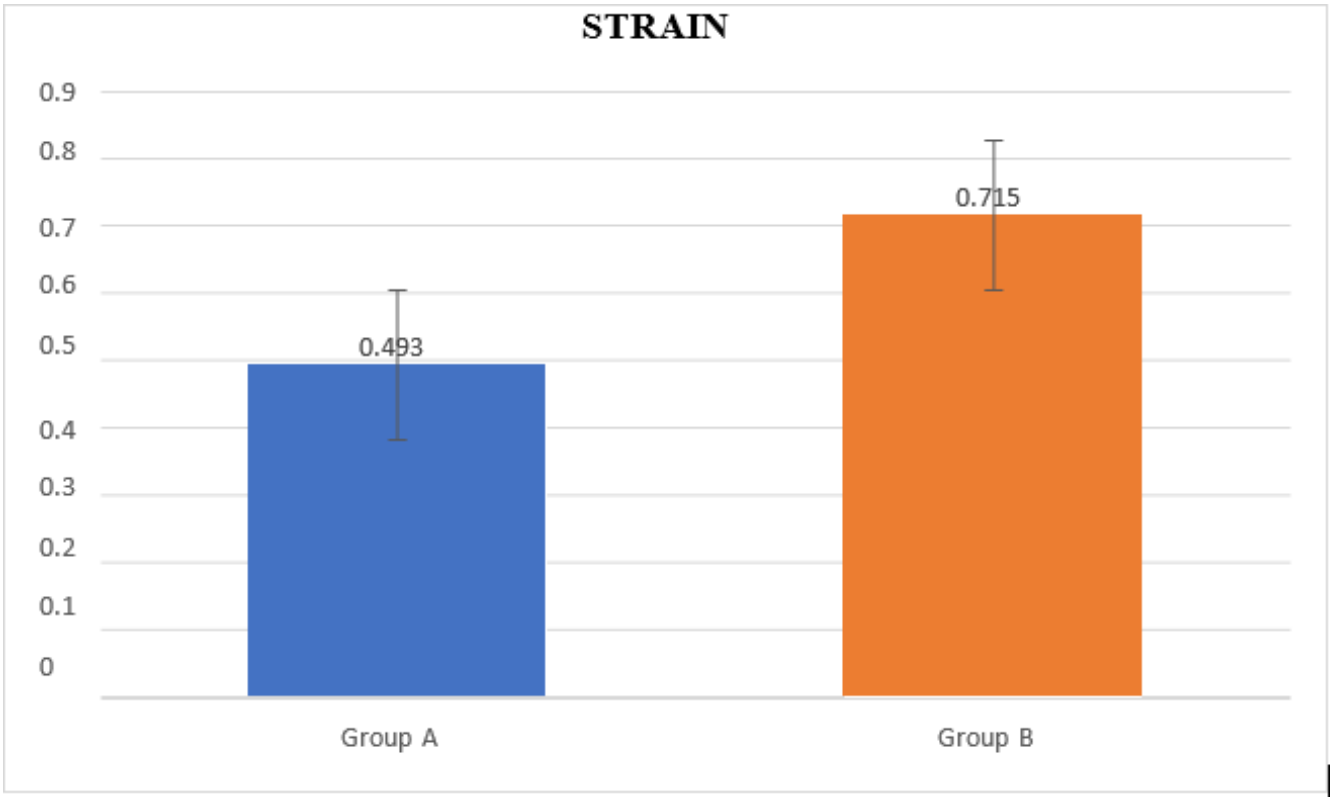

Figure 9: Representation of the Groups as a whole for the Strainvariable

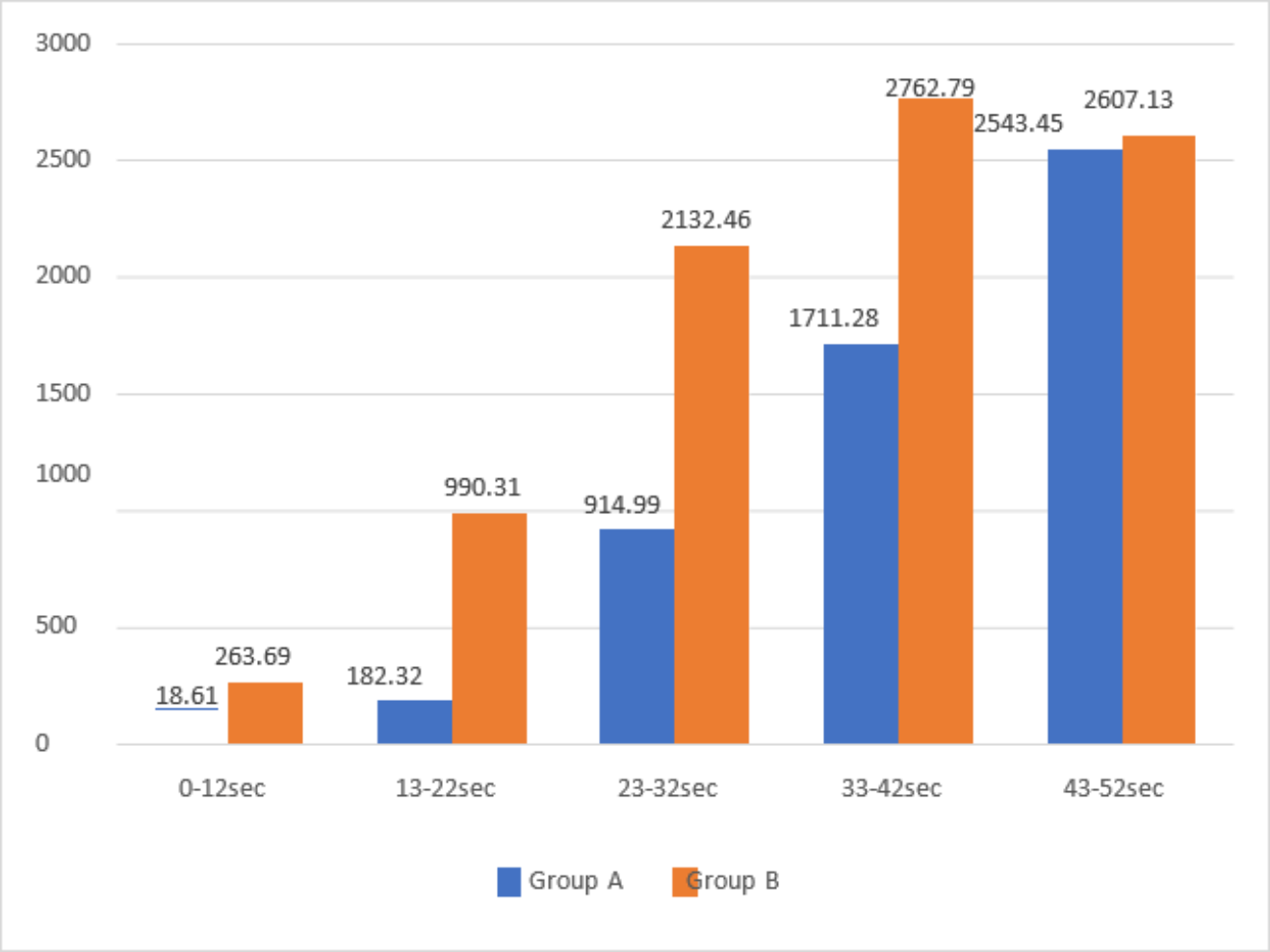

Figure 10: Descriptive statistics for the Stress amongindividual at several time interval

5. Discussion:

Restorations should bear the load of the masticatory forces that occur in the oral cavity for prolonged periods and they must provide enough strength and resistance to fracture[8]. The most important mechanical property is compressive strength of materials because restoratives usually replace a large bulk of tooth structure and they should provide sufficient strength to resist intraoral masticatory forces[9]. The most traditional dental composites for restorative purposes are hybrid and microfill composites[10]

Hybrid composites are comprised of fillers with varying average particle sizes and exhibit better mechanical properties though they are esthetically inferior compared with microfill composites.

Microfill composites were introduced in the market to overcome the problems of poor esthetic properties. Unfortunately, due to lowerfiller loading, the mechanical properties are considered low which is essential for its application in regions of high occlusal force. In order to overcome the demerits of these systems, nano composites have been manufactured and marketed in recent past.

Nano hybrid composites are believed to offer good wear resistance, strength, and ultimate esthetics due to their excellent palatability, polish retention, and lustrous appearance[11]. The emerging heed in nanotechnology and its use in resin composites was based on the desire to use the ability of nano sized particles to alter composite's structure[12].

Recently, Bulk fill composites are being intro-

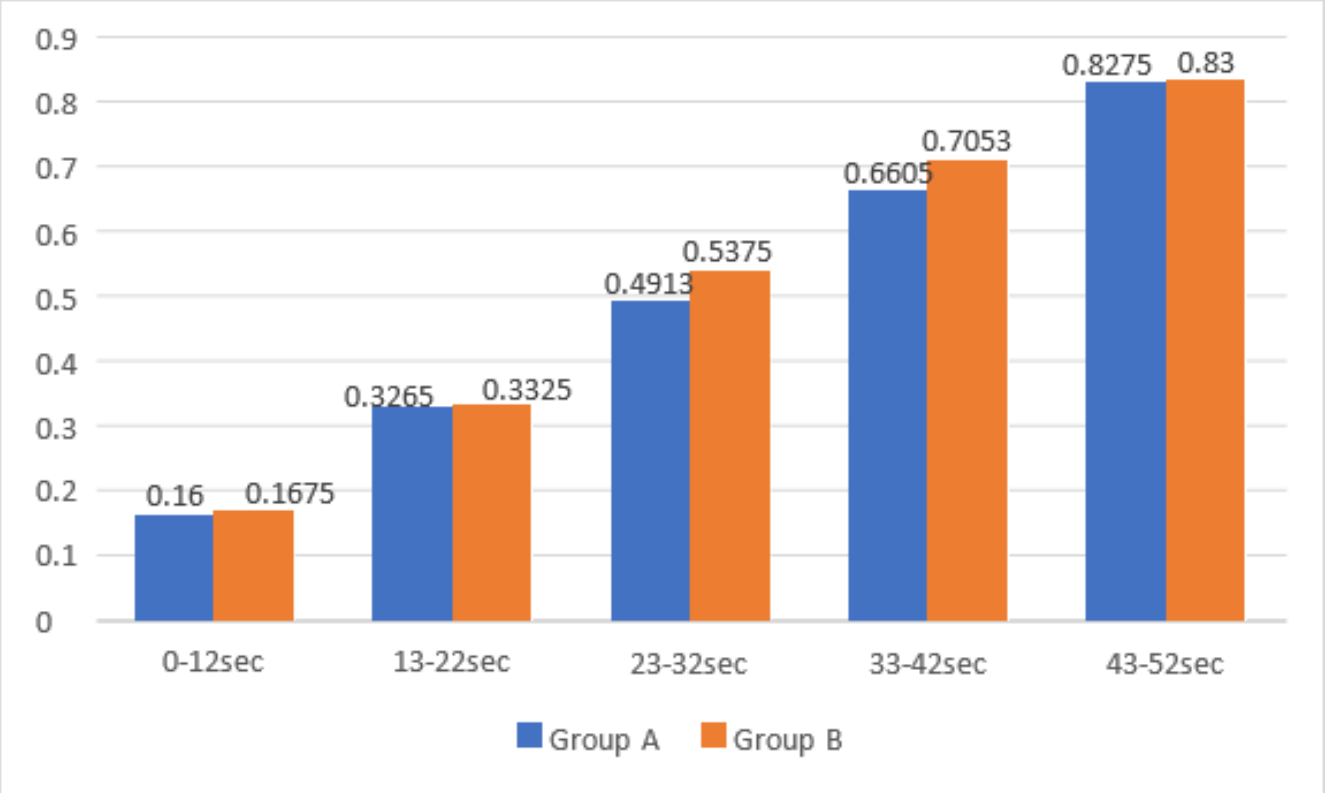

Figure 11: Descriptive statistics for the Strain among individual at several time intervals

duced into the market, with a property of easy handling as it enables restoration to be cured at a depth of 4 to 5 mm. Manufacturers claim that bulk-fill materials have increased curing depth and lower polymerization induced shrinkage stress due to technology like "polymerization modulators," which they say allow a certain amount of flexibility and optimized network structure during polymerization technology like "polymerization modulators," which they say allow a certain amount of flexibility and optimized network structure during polymerization[13].

Compressive strength (CS) is used for evaluation of the mechanical properties of dental restorative materials. Since most of the masticatory forces fall into the category of compressive forces, assessment of the durability of restorative materials in such conditions is of great importance[14]. This in turn may improve mechanical, chemical, and optical properties and develop a resin composite that can perform optimally in all parts of the mouth. Consequently, Mitra and others introduced novel nano fillers and then utilized various methacrylate resins and curing technologies to develop nano composites[15].

With relevance to this background, the present study has been done in order to evaluate the comparative compressive strength of Bulk fill and Nano hybrid composite. The results showed that Nano hybrid composites (Tetric N Ceram) have better compressive strength as compared to bulk filled composite (Tetric N Ceram Bulk fill)

Cilingir A et al reported bulk-fill resin composites demonstrated poorer mechanical properties compared to nano-hybrid composite but similar to that of SF.16 K Pradeep et al reported that SDR and Filtek bulk-fill have greater compressive strength than Filtek Z-250 (Nanohybrid composite) ($p<0.05$). Analysis in their study showed that bulk fill have greater compressive strength than nano hybrid composite.[17]

Nica I et al conducted a study on compressive strength of different composite resins used for direct restorations. The studied materials were:

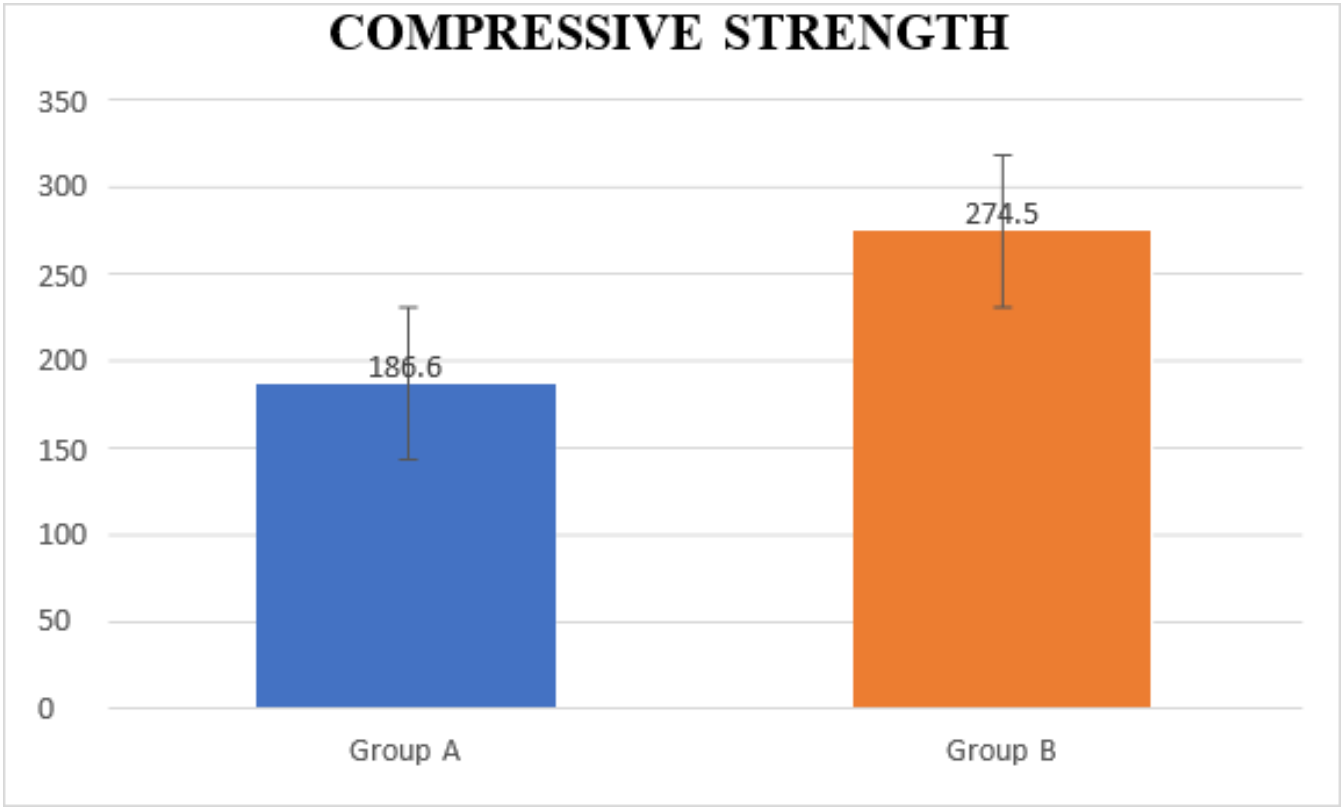

Figure 12: Comparisonof the Compressive strength of the groups

Filtek Z250 Universal Restorative, Filtek Z550 and Filtek Bulk Fill Posterior Restorative. Filtek Z250 (Microhybrid) had the lowest value of Young's modulus for compression and the results were statistically significant($p<0.05$) when compared to Filtek z550 and filtek bulk fill posterior composite18. Mofidi M et al conducted a study on two bulk fill composite resins and one conventional nano hybrid conventional resin and reported that there was no statistically significant difference between the 3 study groups19. Sadananda V et al conducted a study and concluded that the Filtek bulk-fill presented significantly higher flexural and compressive strengths than SDR and Tetric N-Ceram bulk- fill ($p < 0.001$)[20].

According to the Czasch P et al., the low hardness properties were not due to the increase in the amount of filling particles rather, due to a decrease in the total size of the filling particles, which is a key factor in the decrease in hardness22. Alrass B et al conducted a study to compare compressive strength and hardness between bulk-fill composite and conventional composite. The results showed that the compressive strength of the conventional resin is more than the compressive strength of the bulk composite resin and they said, it is due to the higher filler loading and nano-filler dimensions.[24]

In the present study the nanohybrid composites showed superior compressive strength than the bulk fill composite similar to the study of Cilingir A et al in 2020. It is pertinent to mention, that the outcomes of this study are limited with respect to the in-vitro testing environment, compressive strength test and the specific materials used in the investigation. However, in order to assess the clinical behavior of nanohybrid and bulk fill composites further in-vivo and in-vitro studies are recommended.

6. Limitations:

The limitation of the present study might be in-vitro testing environment. The sample size of the study is small, a larger sample size might assure more reliable results. Very few studies have been conducted regarding evaluation of compressive strength between Bulk filled and nanohybrid composites. In order to evaluate the clinical behaviour of Bulk filled and nano hybrid composite further in-vivo and in-vitro studies are recommended.

7. Conclusions:

Within the limitation of the specific materials, testing methods and in-vitro environment in the study, it is concluded that, Nanohybrid composite material have better compressive strength as compared to bulk fill composite. Further in-vivo studies are needed to assess the clinical behaviour of nanohybrid and bulk fill composites.

8. Conflict of Interest:

Nil

9. Funding:

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10. List of abbreviation:

Abbreviations:
LED- Light emitting diode
ADA- American Dental Association

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Author biography

Dr.Sonali Bhuyan Senior Resident, Department of Dentistry, VIMSAR, Burla, Sambalpur, Odisha, India.

Dr. Prasanta Kumar Swain Associate Professor & HOD, Department of Dentistry, VIMSAR, Burla, Sambalpur, Odisha, India.

Dr. Susant Mohanty Professor, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be University),Bhubaneswar 751003, Odisha, India.

Dr. Mrinali Shukla Ex Post Graduate, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be University),Bhubaneswar 751003, Odisha, India.

Dr. Sulagna Pradhan Ex Post Graduate, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be University),Bhubaneswar 751003, Odisha, India.