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A COMPARATIVE EVALUATION OF COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH OF BULK- FILL RESIN- BASED COMPOSITES: AN INVITRO STUDY

Dr. Anindita Saikia	Postgraduate Trainee, Department of Conservative dentistry and Endodontics, Regional Dental College, Guwahati, Assam. Pin 781032.
Dr. Chandana Kalita*	Professor, Department of Conservative dentistry and Endodontics ,GDC,Dibrugarh, Assam. *Corresponding Author
Dr. Anija R	Postgraduate Trainee, Department of Conservative dentistry and Endodontics, Regional Dental College, Guwahati, Assam. Pin 781032.
Dr. Tribisha Kalita	Postgraduate Trainee, Department of Conservative dentistry and Endodontics, Regional Dental College, Guwahati, Assam. Pin 781032.
Dr. A. C.Bhuyan	Head of the Department, Department of Conservative dentistry and Endodontics, Regional Dental College, Guwahati, Assam. Pin -781032.

ABSTRACT **Objectives-** The aim of this study was to evaluate and compare the compressive strength and flexural strength of Filtek bulk fill posterior restorative, Tetric N-Ceram, SDR plus and Filtek bulk fill flowable restorative and to evaluate and compare the compressive strength and flexural strength of flowable and non-flowable resin based bulk fill composites.

Materials and Methods- The study samples consisted of a total of 120 samples of resin based composite materials consisting of 60 cylindrical and 60 cuboidal moulds. The cylindrical specimens were subjected to compressive strength analysis in universal testing machine . The cuboidal specimens were loaded in a three point bending test device for flexural strength analysis. The pair wise comparison of the four groups was done using Tukey's Post Hoc tests at 0.05 significance level.

Results- Compressive strength of Filtek bulk fill posterior restorative was highest whereas SDR plus showed the least compressive strength values. SDR plus showed the highest flexural strength. Packable and flowable bulk fill composites showed comparable compressive and flexural strengths except that of SDR plus which showed lower values of compressive strength.

Conclusion- The compressive strength and flexural strength didn't vary greatly among the bulk fill flowable and packable composites.

KEYWORDS : bulk fill composites, flowable composites, packable composites, compressive strength, flexural strength

INTRODUCTION

An ideal restorative material is expected to substitute the biological, functional as well as aesthetic properties of a sound tooth structure. Especially when it comes to posterior restorative material, the main challenge is to overcome the problem of bulk fracture. Composite resins have been available to the dental profession for over many years. The latest developments in restorative composites have focussed on reducing polymerisation shrinkage which is one of the major disadvantage of composite materials, increasing the aesthetic appearance, polishability, resistance to wear and providing colour compatibility.

There are a number of bulk fill Resin restorative materials in the market. The first bulk-fill material on the market, SureFil SDR flow (or SDR on the European market), as well as Venus Bulk Fill, x-tra base, and Filtek Bulk Fill, require an additional final capping layer made of regular resin based composites (RBCs), while other materials in the same category (SonicFill, Beautifil Bulkfil Restorative, Tetric EvoCeram Bulk Fill, and x-tra fil) can be placed without it. They are claimed to enable the restoration build-up in thick layers, up to 4 mm thereby reducing the interfacial gap formation of incremental technique and improve physical and mechanical properties of composite resin restorations.[1] This new material class includes flowable and higher viscosity paste material types.

The current in-vitro study was prepared with an aim to evaluate the mechanical performance of 4 different bulk fill composites including 2 flowable and 2 packable composites. The following null hypothesis were established : 1) there would be no significant difference in macromechanical (compressive strength and flexural strength) properties among the bulk- fill resin based composites. 2) there would be no significant difference in the above mentioned properties among the material class of flowable and non-flowable RBCs.

The aim of this study was comparative evaluation of compressive strength and flexural strength of different bulk- fill resin based composites.

The objectives were 1) To evaluate and compare the compressive strength and flexural strength of Filtek bulk fill posterior restorative, Tetric N- Ceram, SDR plus and Filtek bulk fill flowable restorative. 2)To evaluate and compare the compressive strength and flexural strength of flowable and non- flowable Resin based bulk fill composites.

MATERIALS AND METHODS

The study samples consisted of a total of 120 samples of resin based composite material which included 60 cylindrical samples and 60 cuboidal samples.

Four different commercially available composite restorative materials were selected and were divided into four groups :

Group I : Filtek Bulk Fill Posterior Restorative (3M/ESPE, Seefeld, Germany)

Group II: Tetric N Ceram Bulk fill (Ivoclare vivadent, Schaan, Liechtenstein)

Group III : SDR plus (Dentsly, Knstanz, Germany)

Group IV : Filtek bulk fill Flowable Restorative (3M/ESPE, Seefeld, Germany)

Sample Preparation For Compressive And Flexural Strength Determination:

For the measurement of compressive strength, cylindrical plastic moulds with an internal diameter of 5 mm and height of 5 mm were used. The composite resins are placed in a cylindrical plastic mould of 5mm height and 5mm diameter for measurement of compressive strength.

For the measurement of flexural strength, cylindrical brass split mold with an internal diameter of 25 mm length, 2 mm breadth and 2 mm height were used. Four screws were incorporated in the design of the mould to approximate the two ends of the mould. The composite resins are placed in a 25x2x2 mm^3 cuboidal plastic moulds for measurement of flexural strength.

All the moulds were then covered with mylar strips. A glass plate is then placed over the composites and pressure is applied to accommodate the material into the mould and to extrude extra material. After removing the glass plate, the composite samples were irradiated from the top and bottom surfaces as per manufacturer's instructions using the LED light curing unit.

The specimens were taken out of the mould and light cured again and were ground with silicon carbide paper to remove the protruding edges and bulges. Then the prepared samples were placed in distilled water at controlled temperature of 37°C for 24 hours in an incubator to ensure complete polymerization.

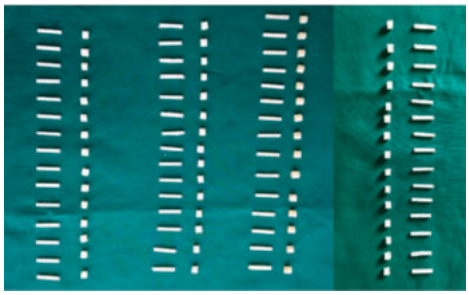


Image 1: Showing prepared cylindrical and cuboidal samples

The cylindrical specimens were then transferred to the universal testing machine individually and subjected to compressive strength analysis. The samples were loaded between the platens of a universal testing machine and the load at break was determined. A cross head speed of 1mm/min was maintained.

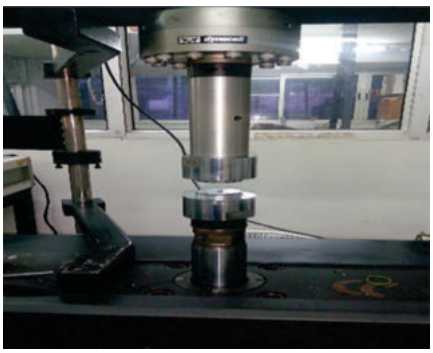


Image 2: Showing fracture of sample under compressive load for the analysis of compressive strength

For flexural strength analysis, the specimens were loaded until failure in a universal testing machine in a three point bending test device. The cross head speed was 0.5 mm/min.

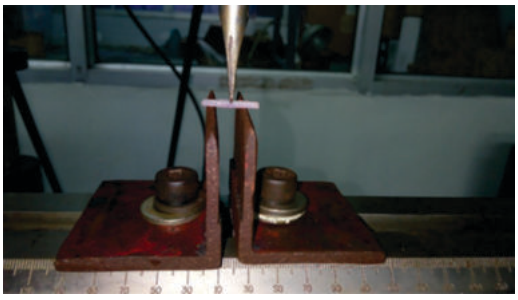


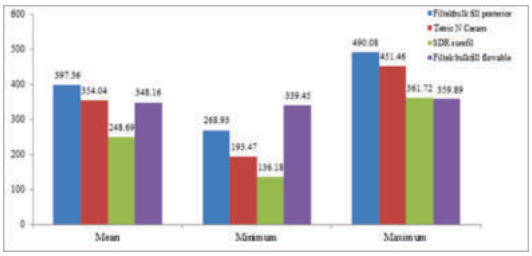
Image 3 : Showing fracture of sample with three point bending test for the analysis of flexural strength

RESULTS

The pairwise comparisons shows that mean compressive strength of SDR plus bulk fill (248.69 ± 63.90) is significantly lower that of Filtek bulk fill posterior (397.36 ± 72.84) ($p < 0.001$), Filtek bulk fill flowable (348.16 ± 5.64) ($p < 0.001$) and Tetric N ceram (354.04 ± 66.67) ($p < 0.001$). No statistically significant difference is found between Filtek bulk fill posterior and Tetric N ceram ($p = 0.195$), between Filtek bulk fill posterior and Filtek bulk fill flowable ($p = 0.113$) and between Filtek bulk fill flowable and Tetric N ceram ($p = 0.993$)

Table 1: Pair wise comparison of the four groups for compressive strength

PAIRS	GROUPS	Mean	Std Dev	Min	Max	Mean Difference	P value
1	Filtek bulk fill posterior	397.36	72.84	268.93	490.08	43.32	0.195, NS
	Tetric N Ceram	354.04	66.67	193.47	451.46		
2	Filtek bulk fill posterior	397.36	72.84	268.93	490.08	49.20	0.113, NS
	Filtek bulk fill flowable	348.16	5.64	339.45	359.89		
3	Filtek bulk fill	397.36	72.84	268.93	490.08	148.67	P < 0.001, HS
	SDR plus	248.69	63.90	136.18	361.72		
4	Tetric N Ceram	354.04	66.67	193.47	451.46	5.88	0.993, NS
	Filtek bulk fill flowable	348.16	5.64	339.45	359.89		
5	Tetric N Ceram	354.04	66.67	193.47	451.46	105.35	P < 0.001, HS
	SDR plus	248.69	63.90	136.18	361.72		
6	Filtek bulk fill flowable	348.16	5.64	339.45	359.89	99.47	P < 0.001, HS
	SDR plus	248.69	63.90	136.18	361.72		



Graph 1 :Bar chart showing the distribution of the raw data values of compressive strength in all the groups

The mean flexural strength of Filtek bulk fill posterior was found to be 176.07 ± 13.90 with a recorded low of 147.91 and a high of 201.79. The mean of Tetric n ceram was found to be 173.06 ± 22.96 with a recorded low of 140.47 and a high of 220.21. The mean of SDR plus was found to be 178.29 ± 21.22 with a recorded low of 126.12 and a high of 208.58. Finally, the mean of Filtek bulk fill flowable was found to be 164.21 ± 42.83 with a recorded low of 102.24 and a high of 251.64. The test shows that the variance amongst the four group means is statistically not significant ($p = 0.519$).

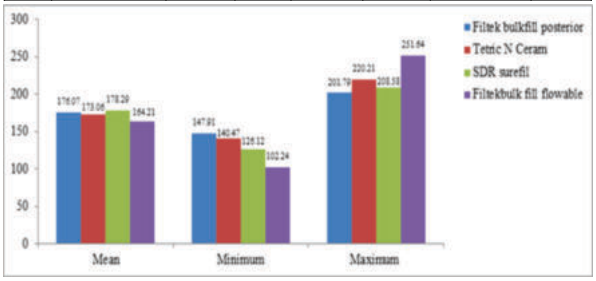
The pair wise comparison of the four groups was done using Tukey's Post Hoc tests at 0.05 significance level. The results are summarized in the following table:

The pairwise comparisons show **no statistically significant difference** between the groups in terms of flexural strength.

Table 2: Pair Wise Comparison Of The Four Groups For Flexural Strength.

PAIRS	GROUPS	Mean	Std Dev	Min	Max	Mean Difference	P value
1	Filtek bulk fill posterior	176.07	13.90	147.91	201.79	3.01	0.990, NS
	Tetric N Ceram	173.06	22.96	140.47	220.21		
2	Filtek bulk fill posterior	176.07	13.90	147.91	201.79	11.86	0.638, NS
	Filtek bulk fill flowable	164.21	42.83	102.24	251.64		
3	Filtek bulk fill posterior	176.07	13.90	147.91	201.79	2.22	0.996, NS
	SDR plus	178.29	21.22	126.12	208.58		
4	Tetric N Ceram	173.06	22.96	140.47	220.21	8.59	0.812, NS
	Filtek bulk fill flowable	164.21	42.83	102.24	251.64		

5	Tetric N Ceram	173.06	22.96	140.47	220.21	5.22	0.953, NS
	SDR plus	178.29	21.22	126.12	208.58		
6	Filtek bulk fill flowable	164.21	42.83	102.24	251.64	14.08	0.500, NS
	SDR plus	178.29	21.22	126.12	208.58		



Graph 2:Bar chart showing the distribution of the raw data values of flexural strength in all the groups

DISCUSSION

Bulk fill composites (BFC) have higher filler volume percentage, monomer technology and occasionally a modified initiator system to ensure better curing in depth and decrease polymerisation shrinkage, as compared with traditional composites, thus ensuring superior physical and mechanical properties to combat higher masticatory forces.[2] Another factor that determines the strength and polymerisation shrinkage is the filler load. The fillers particles are crucial for reducing wear and polymerisation shrinkage as their inclusion enables the reduction of the monomer content.

Literature search shows that there are numerous studies testing the compressive strength and flexural strength of bulk fill resin based composites. However there are very few in vitro studies that have been performed comparing flowable and packable bulk fill composites.

Thus the current study was conducted to compare and evaluate the compressive strength and flexural strength of four commercially available bulk fill resin based composites Filtek bulk fill posterior restorative, Tetric N-Ceram , SDR plus and Filtek bulk fill flowable restorative.

According to the results obtained in the current study, the first null hypothesis was partially rejected as there was a significant difference in compressive strength among the bulk-fill RBCs. Similarly, the second null hypothesis was also partially rejected as there was a significant difference in compressive strength between the flowable and non flowable bulk fill composite resins but no significant difference was seen in flexural strength and compressive strength.

Evaluation of performance of biomaterials is most often evaluated using laboratory tests. The maximal stress required to fracture a structure is called its strength and depending upon the predominant type of stress present, it may be referred to as tensile strength, compressive strength, shear strength or flexural strength. Restorative materials and teeth are generally subjected to both compressive and flexural forces hence these tests are very important to determine the mechanical properties of materials [3,4]

Comparison in the variances within the four mean values showed that the mean compressive strength of Filtek bulk fill posterior was the highest among all and the mean of SDR plus was found to be the lowest compressive strength. Tetric N-Ceram and Filtek bulk fill flowable showed comparable values. This is similar to a study done by Sadananda et al, where they had found that Filtek bulk-fill presented significantly higher compressive strength than SDR and Tetric N-Ceram bulk-fill. [5]

The increased compressive strength of Filtek bulk fill posterior restorative might be due to the combination of a high molecular weight AUDMA and an AFM along with the zirconia fillers which improved the overall mechanical properties of the composite. [6] AUDMA (aromatic dimethacrylate) helps to decreases the number of reactive groups in the resin and helps to moderate the volumetric shrinkage as well as the stiffness of the developing and final polymer matrix—both of which contribute to the development of polymerization stress. AFM (additional fragment monomer)reacts into the developing polymer as with any methacrylate, including the formation of cross-links between adjacent polymer chains. AFM contains a third reactive site that cleaves through a fragmentation process during polymerization and helps in relaxation of the developing network with subsequent stress relief. However the fragments still retain the capability to react with each other or other reactive sites of the developing polymer. [6] This helps in stress relief while maintaining the physical properties of the polymer.

On the other hand SDR plus showed least compressive strength in the present study. This might be because of the reduced filler content and increased amount of low molecular weight monomer. These results are in a trend similar to the study by Zorzin et al [7] and Son et al [8]. Because of its reduced hardness and compressive strength, it is advised by the manufacturer to apply a 2mm of capping layer of packable composite following the application of SDR or SDR plus. A study done by Almozainy M [9] also recommends the same.

Unlike SDR plus, Filtek bulk fill flowable restorative in spite of being a bulk fill flowable composite showed comparable result with Tetric N Ceram. This could be attributed to the zirconia filler loading of the material which provides good compressive strength to the material. A study by Umesh Vishnu Hambire and Vipin Kumar Tripathi [10] has shown that zirconia is a significant contributing factor in the compressive strength of dental composite and with increase in the volume percentage of zirconia the compressive strength increases. This is also supported by another study by Guo G et al [11] which showed that incorporation of ceramic nanofibres in dental composites can significantly improve their mechanical properties and fracture toughness and thus may extend their service life.

Tetric N-Ceram Bulk Fill on the other hand utilises the initiators: camphorquinone plus an acyl phosphine oxide, along with a recently patented initiator Ivocerin. The new light initiator Ivocerin - a dibenzoyl germanium derivative plays an important role here by allowing the application and curing of posterior restorations in larger increments of up to 4 mm, without compromising the optical properties of the composite such as translucency or colour. [12,13] Ivocerin features a high absorption coefficient (higher than camphorquinone) allowing for increased quantum efficiency and contributes to the strength of the material. Tetric N-Ceram also includes prepolymerized fillers in the total filler amount, which acts like stress relievers and increases the modulus of elasticity, helps to reduce the high possible stress within the materials and increases the strength of the material. These findings have been shown in studies by Son SA et al [8] and Moszner N et al. [13]

Pair wise comparison of the groups showed that mean compressive strength of SDR plus is significantly lower that of Filtek bulk fill posterior restorative, Filtek bulk fill flowable restorative and Tetric N ceram. All these values were statistically highly significant with p value less than 0.001. A study done by Pradeep K et al in 2016 [14] showed that SDR and Filtek bulk-fill have greater compressive strength than Filtek Z-250 however there was no statistical difference between compressive strength of SDR and Filtek bulk-fill composites. Flexural strength among the groups were determined similarly. Inter group comparison showed that the mean flexural strength of SDR plus was found to be highest followed by Filtek bulk fill posterior restorative. A study done by J. Manhart et al [15] in 2000 had shown that Surefil SDR revealed a significantly higher flexural modulus and wear than Tetric Ceram and Ariston pHc. However study by Vandana Sadananda and Mithra Nidarsh Hegde in 2017 [16] had found that Filtek bulk-fill presented significantly higher flexural strength than SDR and Tetric N-Ceram bulk-fill. Another study by Didem et al [17] in 2014 showed that SDR presented the lowest strength values for both flexural and compressive tests when compared with Sonicfill system and G-aenial and showed comparable results with Tetric EvoCeram.

In the present study, when the flowable and packable bulk fill composites were compared, it was found that the compressive strength and flexural strength didn't vary greatly among the bulk fill flowable and packable composites except that of SDR plus, which showed comparatively lower compressive strength.

Thus this study provides an insight into the mechanical properties of the bulk fill composites based on which they can be intended to use in different clinical situations. For instance, Filtek bulk fill flowable restorative can be placed in 4mm with adequate depth of cure but bulk

fill flowable composites like SDR plus needs to be placed with a capping layer of conventional composite in order to compensate for its reduced compressive strength and hardness.

CONCLUSION

Based on the study it can be concluded that composition of resin based composite materials significantly affects their macro- mechanical properties. Composites with higher fillers content have shown to exhibit better compressive strength and flexural strength. The bulk fill composites present the ability to place larger increments of the material which reduces time and improves the convenience while maintaining the functional longevity of the restoration. Further in vitro and in vivo studies need to be performed to evaluate the l ong term clinical success of the bulk- fill materials.

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