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Alkasite Restorative Material: Flexural and Compressive Strength Evaluation

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ABSTRACT

This study was performed to compare and evaluate the flexural and compressive strengths of four restorative materials. Ten specimens for materials of each group - Group A (Cention N, Ivoclar Vivadent, Liechtenstein), Group B (Fuji IX, GC Dental India), Group C (Ketac™ Molar, 3M, ESPE) and Group D (Zirconomer, Shofu Inc., Japan) of dimension 25mm length, 2mm width, 2mm height for flexural strength testing and 3mm diameter, 25mm length for compressive strength testing were fabricated. The specimens were subjected to strength testing in a Universal Testing Machine after 24 hours. The data obtained were statistically analyzed by ANOVA and Tukey Post Hoc test. The mean values (MPa) were Group A – 107.21, Group B - 40.80, Group C – 49.80, Group D – 45.61 for flexural strength and 321.92 – Group A, 210.56 – Group B, 261.53 – Group C, 294.96 – Group D were exhibited for compressive strength. Group A – Cention N exhibited higher flexural and compressive strength values.

Keywords: Compressive strength, flexural strength, alkasite

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INTRODUCTION

Restorative materials have evolved exponentially over the years. Glass ionomer cements (GIC) have exhibited many firsts in this evolutionary path. These materials exhibit many beneficial properties such as resistance to recurrent decay, are bioactive materials with the capability to release, recharge or replace fluoride ions in the oral environment and easy to use as a bulk fill material. Various improvements have been incorporated into the original formulation thereby leading to improved properties such as ease in handling, strength, wear resistance and aesthetics. [1-4]

Cention N (Ivoclar, Vivadent, Liechtenstein) a newly introduced restorative alkasite material is resin based with characteristics of both silver amalgam and GIC. The manufacturers claim advantages over the existing materials. It consists of an alkaline filler which release acid neutralizing ions – fluoride, calcium and hydroxide ions. Organic monomer comprises of urethane dimethacrylate (UDMA), tricylodecan-dimethanol dimethacrylate (DCP), tetramethyl-xlylen-diurethane dimethacrylate (aromatic aliphatic-UDMA) and polyethylene glycol 400 dimethacrylate (PEG-400 DMA) which form part of the liquid. Fillers containing barium aluminium silicate glass, ytterbium trifluoride, Isofiller, calcium barium aluminium fluorosilicate glass, calcium fluoro silicate glass are found in the powder. [5]

Zirconomer (Shofu inc., Japan) a newer formulation of GIC was developed as per manufacturer's claims employing a rigorous manufacturing technique to exhibit strength consistent with that of silver amalgam. To achieve optimum particle size and characteristics the glass component of the formulation is subjected to finely controlled micronization. Homogeneous zirconia particles are incorporated which enable further reinforcement of the material for higher occlusal load tolerance and longer durability. [6-9]

The aim of the study was to determine, compare and evaluate the flexural and compressive strengths of the new materials with traditional long existing materials.

MATERIALS AND METHODS

Four restorative materials were tested for flexural and compressive strengths. Ten specimens (N = 10) for materials of each group - Group A (Cention N Ivoclar, Vivadent, Liechtenstein) Group B (Fuji IX, GC Dental India), Group C (Ketac™ Molar, 3M, ESPE) and Group D (Zirconomer, Shofu Inc., Japan) were fabricated. Samples of dimension 25mm length, 2mm width, 2mm height for flexural strength and 3mm diameter, 6mm height for compressive strength testing were fabricated by expressing the materials into custom made stainless steel split moulds and light cured as per manufacturer's instructions. The specimens were stored in distilled water for 24 hours at 37^{o}C to ensure complete polymerization was attained. The flexural strength values were obtained by mounting the specimens on a 3-point bending test device with 20 mm span length and loaded in the Universal Testing Machine (Instron 3366) at a cross head speed of 1mm/min with 2 Kn loading force. Samples fabricated were subjected to compressive strength testing in a Universal Testing Machine at a cross head speed of 0.05 mm/min. The data obtained were statistically analyzed to establish statistical significance using one-way ANOVA and post-hoc comparison was done by Tukey test.

RESULTS

Statistically significant highest flexural strength was exhibited by Group A – Cention N with mean value (MPa) of 107.21±0.81. and highest compressive strength mean value (MPa) of 321.92±1.41. Least flexural and compressive strength value was observed in Group B – Fuji IX with a mean value of 40.80±0.70 and 210.56±0.83. (Table 1)

Highest mean difference in flexural strength value (MPa) was observed between Group A – Cention N and Group B – Fuji IX. Mean difference of 111.36 was observed between Group A – Cention N and Group B – Fuji IX in compressive strength values. A statistically significant p-value of <0.001 was seen between the study groups. (Table 2)

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Table 1: One-way ANOVA comparison of flexural and compressive strengths (MPa) between the study groups

Test	Group	N	Mean	Standard Deviation	Min	Max
Flexural strength	Group A	10	107.21	0.81	105.73	108.33
	Group B	10	40.80	0.70	39.34	41.58
	Group C	10	49.80	0.60	48.78	50.55
	Group D	10	45.61	0.47	44.89	46.15
One-way ANOVA F value – 22407.79, p-value <0.001*						
Compressive strength	Group A	10	321.92	1.41	319.83	323.19
	Group B	10	210.56	0.83	209.46	211.93
	Group C	10	261.53	0.55	260.79	262.22
	Group D	10	294.96	0.71	293.95	296.02
One-way ANOVA F value 26519.20, p-value <0.001*						

*p<0.05 statistically significant,

Table 2: Pairwise comparison of flexural and compressive strengths between the study groups based on Tukey post-hoc

Test	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p-value
Flexural strength	Group A	Group B	66.41	0.29	<0.001*
		Group C	57.40	0.29	<0.001*
		Group D	61.60	0.29	<0.001*
	Group B	Group C	-9.00	0.29	<0.001*
		Group D	-4.81	0.29	<0.001*
	Group C	Group D	4.20	0.29	<0.001*
Compressive strength	Group A	Group B	111.36	0.42	<0.001*
		Group C	60.39	0.42	<0.001*
		Group D	26.96	0.42	<0.001*
	Group B	Group C	-50.97	0.42	<0.001*
		Group D	-84.40	0.42	<0.001*
	Group C	Group D	-33.43	0.42	<0.001*

*p<0.05 statistically significant

DISCUSSION

The role of the restorative material is to simulate the functional, biological and aesthetic harmony of the lost tooth structure. Researchers and manufacturers have aimed at offering better delivery of treatment. Dental restorative materials are evolving rapidly hence it is imperative to evaluate the properties based on tests put forth by regulatory bodies and ascertain whether they are more suitable for clinical purposes

Compressive and flexural strength of a material plays an important role in masticatory process. It determines its ability to exhibit resistance to occlusal forces produced both in function and parafunction.

Cention N an alkasite material which exhibited highest flexural and compressive strengths contains organic monomer in the liquid consisting of four different dimethacrylates a combination of UDMA, DCP and PEG-400 DMA which interconnect during polymerization reaction. UDMA is the major component of the monomer matrix. The stronger mechanical properties may be attributed to its higher viscosity and lack of hydroxyl side groups which are hydrophobic in nature hence exhibit lower water absorption. DCP has a cyclic aliphatic structure which facilitates enhancement of strength. Cention N higher strength values may be due to

the dense polymer network and degree of polymerization. The fillers are found in the powder of the material comprising of barium aluminium silicate glass filler, ytterbium trifluoride, Isofiller (Tetric N-Ceram technology), calcium barium aluminium fluorosilicate glass filler and calcium fluorosilicate an alkaline glass filler. The particle sizes of these fillers range between 0.1 m and 35 m. These fillers are responsible for imparting adequate strength. The Isofiller which is a patented filler functionalized by silanes is bonded to other filler particles. This enhances the bond between the organic monomer matrix and the inorganic filler. Photoinitiators, Ivocerin – a dibenzoyl germanium derivative and acyl phosphine oxide absorb photons during curing leading to cleavage of chemical bond within the initiators leading to formation of two radicals which react with the organic monomers to produce a strong polymer network. [9-11]

Any material if to be used in high stress bearing areas need to fulfil flexural strength values of over 80MPa which has been stipulated by International Standards Organization standard 4049 for resin based restorative materials. Flexural strength is the ability of a material to resist fracture. In the present only Group A – Cention N exhibited value of over 80 MPa of 107.21 MPa. [12]

Group D – Zirconomer exhibited significant high compressive strength of 294.96 after Group A – Cention with value of 321.92 MPa. This increase in strength in comparison to conventional GIC may be due to finely controlled micronization of the glass component which is achieved during manufacturing. Zirconia which are homogenously incorporated to glass components also facilitate reinforcement of the material leading to higher strength. [7]

CONCLUSION

In this study the highest flexural and compressive strengths was exhibited by Cention N. Further analysis of the material in clinical scenarios is essential to ascertain its choice over other materials

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