doi:10.5368/aedj.2012.4.2.1.2

COMPARATIVE EVALUATION OF COMPRESSIVE STRENGTH, VICKERS HARDNESS AND MODULUS OF ELASTICITY OF HYBRID AND PACKABLE (CONDENSABLE) POSTERIOR COMPOSITES – AN *IN-VITRO* STUDY

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ABSTRACT

Background. The authors evaluated the compressive strength, Vicker`s hardness and modulus of elasticity of two hybrid composites, comparing them to two packable resin composites in order to determine differences that occur with respect to specific restorative materials. **Methods.** The authors studied the following resin-based restorative materials: two hybrid composites (Z-100, CHARISMA) and two packable resin composites (SUREFIL, SOLITAIRE- 2) The objective of the present study was to test compressive strength, Vicker`s hardness and modulus of elasticity. Specific sized moulds were prepared for each restorative material, which were then photopolymerized. Following this, the moulds were stored in physiologic saline. Compressive strength was evaluated using universal testing machine and Vicker's hardness was determined using Vicker`s indenter. The test for modulus of elasticity was conducted using a three point bending technique and universal testing machine.**Results.** Results calculated by one-way ANOVA and Tukey`s test indicated that the hybrid composite (Z-100) was superior in all the three physical properties evaluated, followed by SUREFIL, SOLITAIRE- 2, and CHARISMA.**Conclusion**. The hybrid composite Z-100 is the material of choice for restoration in high stress bearing areas, but further clinical research is still needed in order to substantiate these results. **Clinical Implications.** Packable composites may be easier for clinicians to handle than conventional resin-based composites; however, their physical properties were not superior to those of the conventional hybrid resin-based composite.

KEYWORDS: Compressive Strength,Vickers Hardness Number, Hybrid, Packable Composite

INTRODUCTION

Restoration is defined as a material so placed in the prepared cavity of a tooth that its physiological and mechanical functions, anatomic forms, occlusion, contact point and esthetic appearance are properly restored (or) preserved and the tooth in the area of the restoration is protected, as far as possible, from recurrence of dental caries. (Mc GEHEE). [1]Amalgam and cast restorations have been the restoration of choice for posterior teeth. However, the disadvantages of these materials are becoming a matter of great discussion. Particularly amalgam has been the subject of intense criticism because of concerns about the effect of mercury release from amalgam restorations.[2, 3]

Advancement in material technology and demand for esthetics has shifted the focus to the resin composites, a new class of materials.[4, 5] Components of dental resin composites are Matrix: a plastic resin material that forms a continuous phase and binds the filler particles (BisGMA, UDMA, TEGDMA), Fillers: reinforcing particles and (or) fibers that are dispersed in the matrix (silica, fused silica). Coupling agent: bonding agent that promotes adhesion between filler and resin matrix i.e γ -methacryloxy propyl trimethoxy silane. Variations in this basic chemistry can produce a range of composites with distinct properties and different handling characteristics.[6]

Since the development of resin composite restorative material by R. Bowen in 1960, it has been proved to be a restorative material. However the large filler content created significant disadvantages like poor wear

resistance, difficulty in polishing and a tendency to stain and discolour.[2, 7]

In order to overcome such disadvantages, Ivoclar N.A introduced microfill composite resin in 1970,consisting of silica particles of 0.04-0.4 μm in size and 35-67% by weight. However, the composite showed a high co-efficient of thermal expansion because of high resin content. This gave rise to the newer hybrid composite resins.[5, 8]

Hybrid composites are a combination of macro filler and small particle composites having a filler range of 0.4 to 1 microns. The different sizes of filler particles allow high filler loading of 75-80% by weight. Its co-efficient of thermal expansion is close to that of tooth structure and it offers superior physical properties. However these composites did not fulfill the requirements for posterior restorations such as building of contacts and polymerization shrinkage.[6, 9] Hence the search began for a better, more reliable posterior composite. These efforts included numerous modalities. Firstly, an attempt was made to improve on the existing hybrids by incorporating more fillers and using different resin matrices. These hybrid composites were sticky, lacked condensability and did not allow build up of ideal contacts and contours. Then came the concept of packable (condensable) composites.[4] The demand for a condensable composite came so as to simulate the feel of condensing amalgam and building of better contacts. However, the term condensable was not proper because they could not be truly condensed. They were rather packed together. Therefore they were termed as Packable composite. Packable composites frutified as a result of advances in filler technology, filler packing and bonding the resin matrices to the filler.[4, 10,11] These composites consist of ceramic fiber resin incorporated into the filler network. The particle size of filler ranges from 0.6 to 0.4□m, with the filler loading of 65-81% by weight. The advantages of these composites are improved wear resistance, lesser shrinkage, better strength and excellent handling characteristics.[4, 6,7,10]

Materials used for posterior restoration should have high strength, hardness, and modulus of elasticity that is high stiffness so as to resist functional loads. The co-relation of these properties in posterior situations may determine the suitability of hybrid and packable composites in such instances. Hence, this study was designed to compare the compressive strength, Vickers hardness and modulus of elasticity of hybrid and packable posterior composites in an *in vitro* set up.

Materials and methods

This *in vitro* study was done to evaluate the compressive strength, modulus of elasticity and Vickers hardness of two conventional hybrid resin composites, compared to that of two packable resin composites. This study was carried out in the Department of Conservative Dentistry and Endodontics, SDM College of Dental Sciences, Dharwad.

Details of materials used

1. Z100 - (3M ESPE). [5,12,15]

- Universal microhybrid composite with filler silane treated zirconia/silica filler
- Average particle size-0.01-3.5 μm
- Filler weight-84.5 %
- Filler volume-71%
- Filler morphology -Round particles.
- Resin contains: Bisphenol A diglycidyl ether dimethacrylatetriethylene glycol dimethacrylate.

2. Charisma - (Heraeus Kulzer). [5,12,16]

- Universal sub micron hybrid composite with barium,aluminum-boron fluoride silicate glass 70%, pyrogenic silicon dioxide 5%
- Average particle size- 0.7 –2.0 μm.
- Filler weight- 75%
- Filler volume- 60%
- Filler morphology - Irregular-shaped particles.
- Resin contains: Bisphenol A diglycidyl ether dimethacrylate triethylene glycol dimethacrylate.

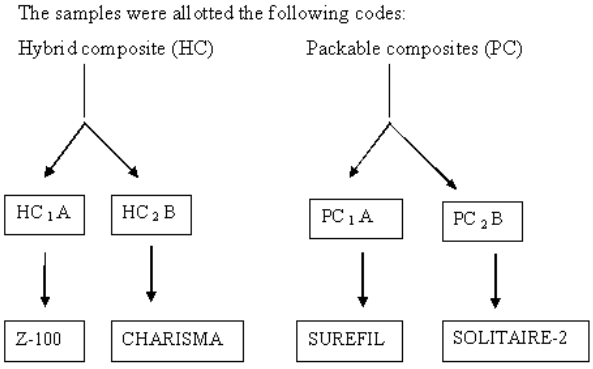
3. **Surefil- (Dentsply / Caulk).** [5,12,17]

- Posterior hybrid composite with filler type Ba-B- F- glass, SiO_2 plus nanofillers.
- Average particle size - 0.08 μm
- Filler weight - 77-82%
- Filler volume - 58-66%
- Filler morphology-Irregular-shaped particles.
- Resin Matrix as Urethane-modified Bisphenol – A glycidyl methacrylate (U-Bis GMA).

4. Solitaire-2- (Heraeus Kulzer). [5,12,18]

- Posterior hybrid composite with Ba-Al-F silicate glass filler.
- Average filler size-0.7 – 20 μm
- Filler weight-75%
- Filler volume-78%
- Filler morphology- Porous particles.
- Resin matrix -Vitroid polyglass monomer, an indirect high heat and pressure-cured polycarbonate vitroid glass ceramic material.

Method of collection of data



A. ***Compressive Strength***

To determine the compressive strength, 10 specimens of each material were prepared in cylindrical stainless steel moulds with an internal diameter of 3mm and depth of 6mm. The specimens were polymerized in the moulds using conventional visible light for 40 seconds for each of the 2mm increments of composite. The specimens were cured for additional 40 seconds on two sides, the total exposure time being 200 seconds. They were removed from the moulds and finished with fine sand paper. They were then stored in physiologic saline solution and transferred to an incubator at 37°C for 24 hours to simulate clinical conditions. After 24 hours the specimens were loaded on the universal testing machine at a crosshead speed of 1 mm/min, at 24°C and humidity of 56%, until fracture occurred. The compressive strength was calculated in Megapascals (Mpa). Changes in dimensions were recorded using a Digimatic Caliper. [19]

Formula:

$CS = load / \pi r^2$
Where, CS = compressive strength,
Load is expressed in newtons
π = 3.14
r = half the diameter of the mould.

B. Vickers Hardness

To determine the Vickers hardness, 6 specimens of each material were prepared in cylindrical aluminium moulds with an internal diameter of 6 mm and depth of 3 mm. The surface of each specimen was covered with a transparent plastic matrix strip before light curing with conventional visible light for 40 sec. This was done to avoid formation of oxygen inhibited superficial layer, which has lower hardness. Curing was completed in two increments with total exposure time of 80 sec per side. The specimens were then removed from the moulds and finished with a fine sand paper. They were then stored in physiologic saline solution and transferred to an incubator at 37°C for 24 hours to simulate clinical conditions. After 24 hours, the micro hardness measurement of each specimen was recorded using a Vickers indenter, with a load of 200 grams for 40 sec (HV 0.2/40). Changes in dimensions were recorded using a Digimatic Caliper. [20]

Formula:

$HV = 1854.4\ p_1 / d_1^2$
Where, HV = Vickers hardness
p_1 = load in gram force
d_1 = mean diagonal of indentation in μm.

C. Modulus of elasticity

The test to determine modulus of elasticity was conducted according to ISO specification number 4049, a three point bending method. Resins were placed into rectangular brass molds measuring 20mm in length, 2mm in width and 2 mm in depth. Each specimen was polymerized with conventional visible light source, directing the beam for 40 secs from each of the four overlapping positions along the length of the mould, i.e. a total exposure time of 160 secs for one side. This was accomplished for both the top and bottom of each specimen. The specimens were removed from the molds and finished with fine sand paper. They were then stored in physiologic saline solution and transferred to an incubator at 37°C for 24 hours to simulate clinical conditions. After 24 hours, the specimens were loaded on the universal testing machine at a crosshead speed of 0.5 mm/min, at 24°C temperature and humidity of 55%, until fracture occurred. The modulus of elasticity was determined from the slope of stress-strain curve obtained from the three-point bending test. The modulus of elasticity was calculated in Megapascals (Mpa). Changes in dimensions were recorded using a Digimatic Caliper. [20,21.]

Formula:

$E = fl^3 / 4bh^3d$
Where, E = modulus of elasticity
f = load in Newtons
d = deflection (displacement) in mm
l = length
h = depth or (height)
b = width in mm.

Results

The results obtained were tabulated separately for compressive strength, Vickers Hardness Number and modulus of velocity for all the four materials. **(Table.I, Table.IV. Table.VII).** Anova test is carried out to find out whether there are statistically significant differences both between and within the groups for all the above three properties **(Table.II, Table.V. Table.VIII).** . Tukey pairwise comparison of means for groups is done for compressive strength**(Table.III),** Vickers Hardness Number **(Table.VI),** and Modulus of elasticity **(Table.IX).**

Discussion

The replacement of lost teeth is desired for two primary reasons: restoration of function (partial /complete) and esthetics. The main function of these restorative materials is to withstand the forces during mastication.[13] There are numerous restorative materials available to the dentist such as gold, amalgam, cements and recently composites.

Among them gold and amalgam have a long history as posterior restorative materials. There are certain disadvantages of gold as a posterior restorative material such as its manipulation, need for isolation and cost.[1] Amalgam on the other hand, is quite popular as a posterior restorative material because of its easy manipulation and cost, but has some disadvantages such as color and mercury toxicity. [2,3,4]

However, the increasing demand for aesthetics and concerns regarding the potential toxicity of mercury resulted in an increased use of aesthetic filling materials. [2,4,12]

Silicate cement was one of the first aesthetic filling materials in 1930's. This material was highly irritating to the pulp because of its high phosphoric acid content (70%); hence silicate cement is no longer used as an aesthetic filling material.[22]PMMA (Poly methyl methacrylate) resin was developed in 1940's. This material was easier to handle, gave smooth finished surfaces and had colour close to the natural tooth, but its polymerization shrinkage was more and the coefficient of thermal expansion was different from that of natural tooth with the result that the problem of microleakage was extensive causing discoloration and secondary caries. Furthermore, the free monomers acted as pulpal irritants.[22]

Bowen developed BIS-GMA composite resin in 1960s. Resin composite is defined as a compound of two or more distinctly different materials with properties that are superior or intermediate to those of the individual constituents.[6]

This material consisted of 70% glass fillers, which resulted in better mechanical properties, the polymerization shrinkage was less than that of PMMA resin, and the coefficient of thermal expansion was comparable to that of the tooth structure, minimizing the microleakage. In spite of such advantageous properties, the larger filler content created some disadvantages like difficulty in surface polishing and tendency to stain and discolor. [9,22] In order to overcome such disadvantages, microfill composite resin was developed. This material consisted of silica particles of about 0.04-0.4µm in size and 35-67% by weight, which resulted in smoother finished surfaces. This microfill composite resin however showed a relatively high coefficient of thermal expansion because of its high resin content. Initially this resin composite was limited to anterior teeth because of its aesthetic properties.[5, 8, 9]

The mechanical properties of this composite improved gradually due to the combination of various filler particles such as quartz, colloidal silica, silica glass containing barium, strontium and others. The filler particles increase the strength, modulus of elasticity and reduce the polymerization shrinkage and coefficient of thermal expansion. Hence, they can be used as a posterior restorative material where patient's aesthetic demands are high. They are termed as Hybrid composites.[23]

Table.1.Values of compressive strength for the four different materials (MPa)

	HC_1A	HC_2B	PC_1A	PC_2B
	(Z-100)	**(CHARISMA)**	**(SUREFIL)**	**(SOLITAIRE-2)**
1	310.6	288.2	304.3	309.1
2	291.2	281.3	281.4	270.8
3	289.6	250.5	279.9	297.4
4	326.2	258.5	296.2	300.7
5	319.6	282.5	329.1	291.79
6	335.4	285.4	305.8	280.9
7	328.8	299.2	318.4	301.8
8	329.3	288.1	319.5	310.6
9	330.1	298.3	310.6	299.15
10	325.9	296.6	302.2	290.12

Table.2.One-way ANOVA for compressive strength of Z-100, CHARISMA, SUREFIL and SOLITAIRE-2

Source	df	Ss	Ms	F	P-Value	Remark
Between	3	6869	2289.6	9.77	0.0001*	S
Within	36	8437	234.4			
Total		15306				

**Statistically significant*

Table.3.Tukey pairwise comparison of means for compressive strength of Z-100, CHARISMA, SUREFIL and SOLITAIRE-2

Variables		Mean	S.D	Homogeneous Groups
HC_1A	(Z-100)	318.7	16.33	I
PC_1A	(SUREFIL)	304.7	15.9	I I
PC_2B	(SOLITAIRE-2)	295.2	12.3	.. I I
HC_2B	(CHARISMA)	282.9	11.1	 I

Critical Q Value - 3.81
Critical Value for comparison - 18.443
Standard error for comparison - 6.8464

Table.4. Values of Vickers Hardness Number (VHN) for the four different materials

	HC_1A	HC_2B	PC_1A	PC_2B
	(Z-100)	**(CHARISMA)**	**(SUREFIL)**	**(SOLITAIRE-2)**
1	115.	72.7	79.7	77.4
2	113.	71.7	80.1	76.5
3	112.	68.3	74.4	76.0
4	118.	72.8	76.0	75.4
5	115.	72.7	77.8	74.8
6	117.	71.9	78.2	74.4

Table.5. One-way ANOVA for Vickers Hardness Number of Z-100, CHARISMA, SUREFIL and SOLITAIRE-2

Source	df	Ss	ms	F	P-Value	Remark
Between	3	7297.0	2432	687.08	0.0001*	S
Within	20	70.8	3.54			
Total	23	7367.8				

**Statistically significant*

Table . 6. Tukey pairwise comparison of means for Vickers Hardness Number (VHN) of Z-100, CHARISMA, SUREFIL and SOLITAIRE-2

Variables		Mean	S.D	Homogeneous Groups
HC_1A	(Z-100)	115.0	2.280	I
PC_1A	(SUREFIL)	77.70	2.182	.. I
PC_2B	(SOLITAIRE-2)	75.75	1.113	.. I
HC_2B	(CHARISMA)	71.68	1.721	 I

Critical Q Value - 3.959
Critical Value for comparison - 3.0412
Standard error for comparison - 1.0863

Table.7. Values of modulus of elasticity for the four different materials (in MPa)

	HC_1A	HC_2B	PC_1A	PC_2B
	(Z-100)	(CHARISMA)	(SUREFIL)	(SOLITAIRE-2)
1	15950.	8784.	11424.	8692.
2	19130.	8621.	12743.	9505.
3	14840.	8896.	11885.	9072.
4	19300.	8025.	10500.	8429.
5	14170.	8334	12132.	9170
6	13760.	8896.	11924.	8224.
7	12621.	7896.	11325.	9242.
8	11246.	8286.	12123.	8426.
9	13262.	9936.	11214.	8125.
10	11876.	8224.	12243.	9862.

Table.8. One-way ANOVA for modulus of elasticity of Z-100, CHARISMA, SUREFIL and SOLITAIRE -2.

Source	df	Ss	Ms	F	P-Value	Remark
Between	3	2.388E+08	7.959E+07	35.96	0.0001*	S
Within	36	7.969E+07	2.214E+06			
Total	39	3.185E+8.				

**Statistically significant*

Table.9. Tukey pairwise comparison of means for modulus of elasticity of Z-100, CHARISMA, SUREFIL and SOLITAIRE-2

Variables		Mean	S.D	Homogeneous groups
HC_1A	(Z-100)	14620	2784.	I
PC_1A	(SUREFIL)	11700	645.6	.. I
PC_2B	(SOLITAIRE-2)	8875	582.3	 I
HC_2B	(CHARISMA)	8590	589.8	 I

Critical Q Value - 3.810
Critical value for comparison - 1792.4
Standard error for comparison - 665.37

"Hybrid composites", as the name implies, contain two kinds of filler particles, (the optimum physical properties of the glass "macro" filler particles and the outstanding polishing properties of the pyrogenic silicic acid "micro" filler particles, enabling the advantages of both groups to be combined) and constituting approximately 75 to 80% by wt of the composite. The glasses have an average particle size of 0.4 to 1.0 μm, in a typical size distribution: 75% of the ground particles are smaller than 1.0 μm. Colloidal silica represents 20 wt% of total filler content. [6,9,24,25] They are formulated to provide better strength, wear resistance and polishability, which are a combination of macro and micro filled composites. They are widely used for restoration of posterior teeth.[4, 9,11,23] However, hybrid composites have certain drawbacks like high polymerization shrinkage, low wear resistance and difficulty in establishing proper contact point.[4, 10]

Packable composites were introduced in the market as an alternative to amalgam. They had an advantage of easy condensability and did not stick to instruments. These composites could be condensed like amalgam; hence they were named as "condensable composites". However in case of condensable composites we do not condense the composite in the cavity rather we pack the material in the cavity, thus a more appropriate term to describe this group would be"packable composites". [10,11,23] The improved

handling property of packable composites was achieved by altering the filler size, shape and distribution in the resin matrix to provide high viscosity

The packable composites have higher filler content and more matrix viscosity using various types of monomers. Packable composites consist of elongated, fibrous, filler particles of about 100μm in length. This increases its stiffness and moldability in cavity during condensation. Rough surfaces and blend of fibers and fillers produce a packable consistency and enable other properties to be optimized for clinical performance. Based on filler load these materials were superior in physical and mechanical properties and had better handling qualities.[4, 7,10,11,26,27]

The physical properties of restorative materials include strength, hardness and elasticity. These properties are important while selecting a posterior restorative material.In our study we compared compressive strength, Vickers hardness and modulus of elasticity of two hybrid (Z-100, CHARISMA) and two packable (SUREFIL, SOLITAIRE-2) posterior composites.

Compressive strength is defined as the compressive stress within compression at the point of fracture. Compressive strength is an important property of restorative dental materials. This is particularly important in the process of mastication because many of the forces of mastication are compressive in nature. The compressive strength is most useful for comparing the materials that are brittle and weak in tension. Compressive strength is therefore a useful parameter for the comparison of resin composites.[6,12,13,14]

The next property analyzed is Vickers hardness, which is the resistance of a material to undergo plastic deformation, typically measured under an indentation load. The tests most frequently used in determining the hardness of dental materials are known by the names of Barcol, Brinell, Rockwell, Vickers and Knoop. The material being tested should determine the selection of the test. The principle of this test is based on resistance to indentation. Vickers hardness test employs a square pyramid shaped diamond indenter and is especially suited for brittle materials such as resin composites. The hardness number is based on the depth of penetration of the indenter point into the material. The relative importance of a Vickers hardness test lies in the fact that it throws light on the mechanical properties of the materials investigated. This is true because of the relation that exists between hardness and the other physical properties, such as abrasion resistance.[6,12,13,14]

The third property analyzed is the modulus of elasticity. The relative stiffness of a material. It is the ratio of elastic stress to elastic strain. A material having a higher modulus is more rigid; conversely, a material with a lower modulus is more flexible[28]. The modulus of elasticity is an very important parameter for evaluating composites. The modulus of elasticity is interrelated to many properties such as hardness, fracture toughness and fatigue behaviour.[6, 12,13,14,29]

Due to the plethora of available materials and a dearth of available literature on comparative physical properties, this study was devised to compare and evaluate the compressive strength, Vickers hardness and modulus of elasticity of two hybrid (Z-100, CHARISMA) and two packable (SUREFIL, SOLITAIRE-2) posterior composites, so as to select the material best suited for posterior applications.

In this study, samples of the four composites to be tested were prepared according to the specified dimensions. All the experimental procedures were carried out in accordance with ISO 4049 standardization. The results of this study after being subjected to statistical analysis elucidated various observations.

Compressive strength

The test for compressive strength **(Table-I**) revealed that the hybrid composite Z-100 exhibited the highest compressive strength followed by the packable SUREFIL, then SOLITAIRE-2 and lastly CHARISMA. Z-100 and SUREFIL composites were significantly better than SOLITAIRE-2 and CHARISMA. This finding is similar to that reported by Cobb et al (2000), [19] who found SUREFIL to have higher compressive strength than SOLITAIRE-2, and Willems et.al(1993),[12] who reported the highest values for Z- 100, compared to CHARISMA. This can be explained by the higher filler weight percentage i.e. nearly 85% for (Z100 - 3M ESPE) [15] followed by 77-82% for (SUREFIL - Dentsply/Caulk)[17],75%for(SOLITAIRE–2-HeraeusKulzer)[18],and(CHARISMA - HeraeusKulzer)[16]. The higher filler content probably strengthens the matrix so as to enable the material to withstand high compressive stresses. The one-way ANOVA analysis shows that there are statistically significant differences both between and within the groups compared **(Table-II).** Turkey Pair wise comparison showed that there are three groups in which the means are not significantly different from one another **(Table-III).** This analysis reveals that the compressive strength of Z-100 and SUREFIL is significantly higher than SOLITAIRE-2 and CHARISMA, with no significant difference between Z-100 and SUREFIL, with no significant difference between SUREFIL and SOLITAIRE-2, and also there is no significant difference between SOLITAIRE-2 and CHARISMA.

Vickers hardness

The results of the test for Vickers hardness**(Table-IV)** revealed that Z-100 had the highest hardness values followed by SUREFIL, SOLITAIRE-2 and CHARISMA. Statistics show-ed that the Z-100 composite was significantly better than all the other three composites. This is in agreement with the review by Willems et.al

(1993).[12] This result could be attributed to the higher filler content and smaller filler particle size distribution (Liy.et al 1985, Kerby et al 1999). [20] The one-way ANOVA analysis shows that there are statistically significant differences both between and within the groups compared**.(Table-V)**

Turkey pairwise analysis **(Table-VI)** revealed that Z-100 had the highest VHN value, significantly higher than the other three materials. Also no significant difference was found between SUREFIL and SOLITAIRE –2, but SOLITAIRE-2 was found to be significantly better than CHARISMA. There are three groups in which the means are not significantly different from one another

Modulus of elasticity

The experiment for modulus of elasticity (**Table-VII)** revealed, Z-100 composite had the highest modulus of elasticity followed by SUREFIL, SOLITAIRE-2, and lastly CHARISMA**.** The one-way ANOVA analysis shows that there are statistically significant differences both between and within the groups compared**.(Table-VIII).** There are three groups in which the means are not significantly different from one another. In Turkey pairwise analysis, the Z-100 composite had a significantly higher modulus of elasticity than the other three materials. SUREFIL had significantly higher value than SOLITAIRE-2 and CHARISMA, and there was no significant difference between the latter two. Z-100 was significantly better than all the other three groups and SUREFIL group significantly better than SOLITAIRE-2 and CHARISMA. This is in agreement with findings reported by Subbagh et al (2002) [30] who reported Z-100 to have higher elastic modulus followed by SUREFIL. Y.Abe et al (2001) [31] also reported highest values for Z-100 followed by SUREFIL and then SOLITAIRE-2. Choi et al (2000) [32] reported Z-100 to have higher elastic modulus followed by SUREFIL and then SOLITAIRE-2. This can be explained by the higher filler content of the Z-100 composite. A material with a low elastic modulus will deform more under masticatory stresses, particularly in posterior regions, resulting in catastrophic failures (Albers et al 1985 Willems et al 1993).[12]

SUMMARY AND CONCLUSION

Restorative dentistry cannot exist without material science. The advent of numerous materials has given the astute clinician a wide array of choices. Among these classes of materials are the resin composites. However, any material must satisfy the basic physical and mechanical criteria so as to withstand the rigours of the oral cavity, especially in posterior restorations. Resin composites must similarly have favorable properties like strength, hardness and modulus of elasticity to be suitable for demanding restorations.

Thus, in our study the Z-100 composite has proved to be a material with better physical properties. It demonstrated highest compressive strength, the highest Vickers hardness and the highest modulus of elasticity, significantly better than all other groups. These superior properties can be attributed to its high filler loading of about 85%. Taking this into consideration it would seem that Z-100 would be more suitable for posterior restorative purposes than the other classes of materials.

However, there are certain limitations in this study and the results of *in-vitro* laboratory testing cannot be extrapolated into live clinical settings. Hence there is a need for continuous *in-vitro* and *in-vivo* research so as to substantiate these results and characterize the better material for posterior restorations.

Acknowledgement

My sincere and warm gratitude to Dr Biju, Dr. Kalliyana Krishnan and Dr Lizymol, Scientist-in-charge, Sri Chitra Tirunal institute of Biomedical Technology, Thiruvananthapuram. I thank them for giving me an opportunity to conduct the study and for their encouragement, constructive criticism, and timely help and for ensuring that this work saw the light of day in time.

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