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Comparative Evaluation Of Polymerisation Shrinkage,Flexural Strength And Elastic Modulus Of Silorane,Ormocer And Dimethacrylate Based Composites- An In-Vitro Study

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Abstract: *Composites are widely used materials in restorative dentistry. But like other materials they do have their disadvantages for example polymerization shrinkage which gradually leads to, stress at the tooth-restoration margins causing marginal discoloration, post- operative sensitivity and recurrent caries. The composite restorations are also subject to masticatory forces and flexural stresses. So, the analysis of volumetric shrinkage, elastic modulus and flexural strength, is crucial in predicting the clinical success of composites.Some new materials have been introduced nowadays, which claim to overcome such shortcomings, eg silorane-based composite and ormocer-based composites.The purpose of this study is to compare the volumetric shrinkage,elastic modulus and flexural strength of silorane and ormocer based composites to the conventional dimethacrylate based composites,and to judge the clinical worth of these materials.*

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I. Introduction

Throughout the history of the dental profession many materials have been used as restorative materials to replace lost tooth structure due to dental disease. [1]

Among the numerous triumphs of present day biomaterials, composite resins are the best choice to restore the appearance and function of teeth. Most posterior restorations are done using composite resins. In spite of the advancements,many modifications are still required in the composite resins, chiefly properties like mechanical properties, polymerization shrinkage and stress,abrasion and wear resistance and marginal leakage .These shortcomings are the driving force for improvement in dental composites to improve their longevity. [2]

Polymerization shrinkage happens during the polymerization reaction of composite resins. When it comes to chemically cured composites, the shrinkage is seen in the center of the restoration. However, it is seen in light cured materials that contraction occurs in the outer surface of the restoration. This is the area of initial hardening. Both types of contraction contribute to a shearing stress that can cause a marginal gap between the cavity wall and restoration. Adhesion of the setting material to the cavity wall results in internal stresses, probably causing microcracks and premature failure of the composite resin restoration. [3]

Various properties of dental material viz. hardness fatigue resistance, compressive strength, elastic modulus, and diametral tensile strength are interrelated on each other.[4]

Flexural strength is a significant property for brittle materials as it portrays structural reliability of the material. [5]

Modulus of elasticity is also an important mechanical property provided by the flexural test characterizing the rigidity of the material. Resin-based restorative materials with various moduli of elasticity are applicable in various clinical situations. For example a low modulus restorative material is compatible with a class V restoration. [5]

Although composites are widely used materials in restorative dentistry. But they do have their disadvantages for example polymerization shrinkage as mentioned above.

Shrinkage stress which is caused by polymerization shrinkage causes marginal gap formation, stress at the tooth-restoration margins leading to marginal discoloration, post- operative sensitivity and recurrent caries.

The composite restorations are also subject to masticatory forces and flexural stresses.

So, the analysis of volumetric shrinkage, elastic modulus and flexural strength, is crucial in predicting the clinical success of composites.

Some new materials have been introduced nowadays, which claim to overcome such inadequacies for examples the Silorane – based composite. It shows low polymerization shrinkage owing to the ring-opening oxirane monomer component and increased hydrophobicity due to the existence of the siloxane component,.

Ormocer-based composite is another composite, which has a three dimensionally cross-linked copolymers. Even before to light curing is done,the ormocer is a polymer. The composition of ormocer is ceramic polysiloxane, which claims very low polymerization shrinkage.

The volumetric shrinkage evaluation of the composite resins in this study presented silorane with the statistical lower values, followed by ormocer, which was statistically different from the methacrylate composite.

Polymerization shrinkage causes separation between a composite resin mass and adjacent tooth structure. Various factors like polymerization shrinkage,bond between restorative material and the tooth surface, co efficient of thermal expansion of the material affect the marginal adaptation of the composite restoration.[6]

To reduce shrinkage, the main approaches adopted so far are to change the monomer structure or chemistry, respective to change the filler amount, shape or surface treatment. To date, versatile methods to modify the monomer matrix have been developed, starting with typical dimethacrylate monomers being replaced by methacrylates with reduced reactive group. Other approaches proposed for reducing polymerization shrinkage include the development of liquid crystal monomers or ring-opening systems so as to develop non- or minimally-shrinking dental composites that contain spiroorthocarbonates as additives to dimethacrylate or epoxy-based resins.[7]

One of the fresh improvements in the restorative composite resins have concentrated on the use of ring-opening systems like visible light cured oxirane-based resins. Oxirane resins display many suitable characteristics like improved depth of cure, lower polymerization shrinkage and higher strength when compared with conventional resins. [7]

The reaction of oxirane and siloxane molecules produces the new silorane monomer system. This new resin claims to show low polymerization shrinkage due to the ring-opening oxirane monomer and also increased hydrophobicity owing to the presence of the siloxane species[7]. All the strategic features boost the prospective of silorane monomers to be used a restorative resin.

The purpose of this study is to compare the volumetric shrinkage, elastic modulus and flexural strength of silorane and ormocer based composites to the conventional dimethacrylate based composites, and to judge the clinical worth of these materials.

II. Material And Methods

This was an in-vitro study which was conducted in the department of Conservative Dentistry and Endodontics of School of Dental Sciences, Sharda University, Greater Noida,Uttar Pradesh. The volumetric shrinkage analysis was conducted at Spectro Analytical Lab, Okhla, New Delhi. The elastic modulus and flexural strength determination was conducted at ITS Engineering College, Greater Noida,Uttar Pradesh.

Study Design: Invitro comparative evaluation

Study Location: Department of Conservative Dentistry and Endodontics of School of Dental Sciences, Sharda University, Greater Noida, Uttar Pradesh,India.

Sample size: Polymerization shrinkage, flexural strength and elastic modulus were determined and compared for the following composite resins:

1.Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)

2.Ormocer based composite – Admira, Light-curing Ormocer® based restorative material (VOCO GmbH,Germany)

3.Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)

1. Sample preparation for volumetric shrinkage evaluation:

(a) 6 cured and 6 uncured cylindrical samples of 6 mm diameter and 5 mm height of Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)

(b) 6 cured and 6 uncured cylindrical samples of 6 mm diameter and 5 mm height of Ormocer based composite – Admira,Light-curing Ormocer® based restorative material(VOCO GmbH,Germany)

(c) 6 cured and 6 uncured cylindrical samples of 6 mm diameter and 5 mm height of Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)

2. Sample preparation for evaluation of young's modulus:

(a) 10 cured cylindrical samples of 6 mm diameter and 5 mm height of Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)

(b) 10 cured cylindrical samples of 6 mm diameter and 5 mm height of Ormocer based composite – Admira, Light-curing Ormocer® based restorative material (VOCO GmbH,Germany)

(c) 10 cured cylindrical samples of 6 mm diameter and 5 mm height of Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)

3. Sample preparation for evaluation of flexural strength:

(a) 10 cured bar - shaped samples of dimension 12*6*5 mm of Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)
(b) 10 cured bar - shaped samples of dimension 12*6*5 mm of Ormocer based composite – Admira, Light-curing Ormocer® based restorative material (VOCO GmbH,Germany
(c) 10 cured bar - shaped samples of dimension 12*6*5 mm of Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)

Armamentarium and materials: The following armamentarium and materials were used –

III. Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)
IV. Ormocer based composite – Admira, Light-curing Ormocer® based restorative material (VOCO GmbH,Germany)
V. Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)
VI. Mylar strips (Sony Dent, India)
VII. Composite instrument kit (GDC, India)
VIII. Stainless steel split mould (Manufactured at ITS Engineering College, Greater Noida)
IX. Light cure unit (Dentsply Sirona USA)
X. Analytical balance (Spectro Analytical Lab, Okhla, New Delhi)
XI. Universal testing machine (Banbros Computerized UTM, WDW-5, India)

Inclusion criteria:
1. Precise sample dimension
2. Finished samples

Exclusion criteria:
1. Dimensionally deformed specimens

Procedure methodology:

<u>1. Evaluating volumetric shrinkage</u>

The volumetric polymerization shrinkage was calculated by measuring the difference in specific gravities of uncured and cured samples using the ASTM D-792 method of "Specific gravity and density of plastics by water displacement".

The samples were divided in 3 groups:

XII. Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)
XIII. Ormocer based composite – Admira, Light-curing Ormocer® based restorative material (VOCO GmbH,Germany)
XIV. Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)

6 uncured and 6 cured samples of each material were taken. Samples were prepared in a stainless steel mould of 6mm diameter and 5 mm height.The uncured samples were weighed in air and wate in an analytical balance (Fig.14) and the respective readings were noted. The specific gravity was calculated. The cured samples were weighed in air and water and the respective readings were noted. The specific gravity was calculated.

Specific gravity was calculated as follows:-

$$\text{Specific gravity} = \frac{\text{Weight of the sample in air}}{\text{Weight of the sample in air-Weight of the sample in water}}$$

The percentage volumetric shrinkage was calculated as follows:

$$\text{Percentage shrinkage} = 1 - \frac{\text{Specific gravity (uncured)}}{\text{Specific gravity (cured)}} \times 100$$

<u>2. Evaluating young's modulus</u>

For evaluation of young's modulus, the samples were divided in 3 groups of 10 each.

XV. Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)
XVI. Ormocer based composite – Admira, Light-curing Ormocer® based restorative material (VOCO GmbH,Germany)
XVII. Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)

Cylindrical specimens 5 mm thickness and 6 mm diameter were made by injecting the resin-composite in a stainless steel mouldcovered by mylar strips from both sides and light activating for 60 seconds at 550 mw/cm 2 . Bench curing was performed as soon as the samples were removed from the mould. Samples were stored dry at room temperature and loaded after 24 h. A universal testing machine (Banbros Computerised UTM, WDW-5) was used to load the specimens. For young's modulus measurement, non-constricted specimens were submitted to gradual loading up to 1000 N with a crosshead speed set at 1 mm/min,and young's modulus was obtained

3. Evaluating flexural strength

For evaluation of flexural strength, the samples were divided in 3 groups of 10 each.

XVIII. Silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA)

XIX. Ormocer based composite – Admira, Light-curing Ormocer® based restorative material (VOCO GmbH,Germany)

XX. Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA)

For each experimental group, bar-shaped specimens (12*6*5 mm, n = 10) were built using a stainless-steel split mould. The composite confined by the mould was sandwiched between mylar strips, with pressure applied to ensure consistent thickness in all specimens.Light curing was done.The specimens were submitted to three-point bend testing in a universal testing machine at a crosshead speed of 0.5 mm / min.. The distance between the supports was kept 10 mm. The load at fracture and the specimen dimensions were used to calculated the FS.

The following formula was used:

$$FS = \frac{3*L*D}{2*w*h2}$$

Where L is the load at fracture (N), D is the distance between the supports, w is the width, and h is the height of the specimen, all in mm.

Statistical analysis

In the present in vitro study, polymerization shrinkage, flexural strength and elastic modulus were determined and compared for the following composite resins - silorane based composite - Filtek Low Shrink Posterior Restorative - Silorane (3M/ESPE, St.Paul, MN, USA) Ormocer based composite – Admira,Light-curing Ormocer® based restorative material (VOCO GmbH,Germany),Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative (3M/ESPE, St.Paul, MN, USA) using cylindrical and rectangular specimens made with the help of a stainless steel split mould. The values for volumetric shrinkage, elastic modulus and flexural strength were determined. The data collected in the present study was analysed statistically by SPSS (Statistical Package for the Social Sciences version 22.0.0.0) by computing the descriptive statistics namely means and standard deviation. Data was analysed by one-way ANOVA test to determine differences between group means. For the statistical test, a 'p'value <0.05 was taken to indicate a significant difference.

III. Result

(I) VOLUMETRIC SHRINKAGE:

The following table depicts the values in percentage of volumetric shrinkage for all the three groups and the means of values of each individual group.

VOLUMETRIC SHRINKAGE (IN PERCENT)			
SAMPLE NO.	SILORANE-BASED COMPOSITE	ORMOCER-BASED COMPOSITE	DIMETHACRYLATE-BASED COMPOSITE
1	1.23%	1.62%	3.92%
2	1.48%	1.81%	2.89%
3	1.50%	1.79%	1.98%
4	1.62%	1.99%	2.30%
5	1.31%	1.68%	1.90%
6	1.46%	2.21%	3.12%
Average	1.43%	1.85%	2.69%

Table 1: Values for volumetric shrinkage for individual samples according to groups and their average values

The results depicted that the highest average volumetric shrinkage was seen in the dimethacrylate based composite, followed by ormocer – based composite and least volumetric shrinkage was seen in silorane-based composite.

Table 2: Volumetric shrinkage values across samples

Volumetric shrinkage across individual samples was observed to be highest in dimethacrylate-based composite group followed by ormocer-based composite group. The least volumetric shrinkage was seen in silorane-based composite group.

Table 3: Variation in average volumetric shrinkage

These results also reflected on the average values for the same material where the highest average value was found to be that of dimethacrylate-based composite at 2.69% followed by ormocer-based composite at 1.85% and the lowest volumetric shrinkage was found to be 1.43%, that of the silorane based composite.

Summary of Data					
	1	**2**	**3**		**Total**
N	6	6	6		18
∑X	8.6	11.1	16.11		35.81
Mean	1.4333	1.85	2.685		1.9894
∑X2	12.4254	20.7712	46.2733		79.4699
Std.Dev.	0.1405	0.2173	0.7769		0.6957

Table 4: Summary of data for volumetric shrinkage values

Table 3 shows summary of data for volumetric shrinkage values where N = total sample number, ∑X = Summation of all values of the particular group, ∑X2 = Summation of squares of all values of the particular group, Std.Dev = Standard Deviation.

Result Details				
Source	***SS***	***df***	***MS***	
Between-groups	4.875	2	2.4375	*F* = 10.90482
Within-groups	3.3529	15	0.2235	P<.05
Total	8.2279	17		

Table 5: Results details for volumetric shrinkage values, where SS = Sum of Squares, df = degree of freedom, MS = mean square , F = f-ratio, P = p-value/probability value

The statistical analysis was done using a One-Way ANOVA test, the results were found to be statistically significant with a p value of .001191, (significant at p<.05).This result implies that there is a statistically significant difference between the volumetric shrinkage between the samples tested.

(II) ELASTIC MODULUS:

The following table depicts the values in megapascals for elastic modulus for all the three groups and the means of values of each individual group.

ELASTIC MODULUS (IN MPA)					
SAMPLE NO.	**SILORANE-BASED COMPOSITE**		**ORMOCER-BASED COMPOSITE**		**DIMETHACRYLATE-BASED COMPOSITE**
1	322.5		545.23		533.66
2	298.59		485.6		784.23
3	300.65		410.23		855.11
4	287.5		510.6		755.9
5	330.6		531.2		548.02
6	345.8		401.5		585.6
7	284.23		479.4		691.75
8	315.5		432.5		682.45
9	305.6		500.36		710.25
10	310.2		402.5		725.1
Average	**310.11**		**469.91**		**687.2**

Table 6: Values for elastic modulus for individual samples according to groups and their average values

Table 7: Elastic modulus across individual samples in all three groups

Elastic modulus across individual samples was observed to be highest in dimethacrylate-based composite group followed by ormocer-based composite group. The lowest value for elastic modulus was seen in silorane-based composite group.

Table 8: Variation in elastic modulus across average values of groups

These results also reflected on the average values for the same material where the highest average value was found to be that of dimethacrylate-based composite at 687.2 MPa followed by ormocer-based composite at 469.91 MPa and the lowest volumetric shrinkage was found to be 310.11 MPa, that of the silorane based composite.

Summary of Data				
	1	2	3	Total
N	10	10	10	30
∑X	3101.17	4699.12	6872.07	14672.36
Mean	310.117	469.912	687.207	489.0787
∑X2	965025.3	2234707	4820142	8019874
Std.Dev.	19.1477	54.2975	104.1406	170.5908

Table 9: Summary of data for elastic modulus values

Table 7 shows summary of data for elastic modulus values where N = total sample number, ∑X = Summation of all values of the particular group, ∑X2 = Summation of squares of all values of the particular group, Std.Dev = Standard Deviation.

Result Details				
Source	SS	df	MS	
Between-groups	716494.8	2	358247.4	F = 75.89923
Within-groups	127441.1	27	4720.039	P<.05
Total	843935.8	29		

Table 10: Result details for elastic modulus values , where SS = Sum of Squares, df = degree of freedom, MS = mean square , F = f-ratio, P = p-value/probability value

The statistical analysis was done using a One-Way ANOVA test, the results were found to be statistically significant with a p value .00001, (significant at $p<.05$). The f-ratio value is 75.89923. This result implies that there is a statistically significant difference between the elastic modulus between the samples tested.

(III)FLEXURAL STRENGTH:

The following table depicts the values in megapascals for flexural strength for all the three groups and the means of values of each individual group

FLEXURAL STRENGTH (IN MPA)			
SAMPLE NO.	**SILORANE-BASED COMPOSITE**	**ORMOCER-BASED COMPOSITE**	**DIMETHACRYLATE-BASED COMPOSITE**
1	201.4	231.6	365.2
2	232.1	394.2	335.6
3	254.7	254.7	300.5
4	289.6	365.2	299.5
5	256.32	322.4	280.6
6	298.5	387	301.4
7	257.6	368.7	290.8
8	258.12	289	340.2
9	154.3	398.9	501.2
10	157.2	297.5	478.5
Average	**235.98**	**330.92**	**349.35**

able 11: Values for flexural strength for individual samples according to groups and their average values

The average values for flexural strength are reflected in the table above. The highest average value was found to be that of dimethacrylate-based composite followed by ormocer-based composite . The lowest values for flexural strength was found in silorane-based composite.

Table 12: Flexural strength across individual samples in all three groups

Flexural strength across individual samples was observed to be highest in dimethacrylate-based composite group followed by ormocer-based composite group. The lowest value for elastic modulus was seen in silorane-based composite group.

Table 13: Variation in flexural strength across average values of groups

These results also reflected on the average values for the same material where the highest average value was found to be that of dimethacrylate-based composite at 349.35 MPa followed by ormocer-based composite at 330.92 MPa and the lowest volumetric shrinkage was found to be 235.98 MPa, that of the silorane based composite.

Summary of Data				
	1	2	3	Total
N	10	10	10	30
∑X	2359.84	3309.2	3493.5	9162.54
Mean	235.984	330.92	349.35	305.418
∑X2	579478.8	1128074	1276042	2983595
Std.Dev.	50.1047	60.5473	78.5899	79.9116

Table 14: Summary of data for flexural strength values

Table 12 shows summary of data for flexural strength values where N = total sample number, ∑X = Summation of all values of the particular group, ∑X2 = Summation of squares of all values of the particular group, Std.Dev = Standard Deviation.

Result Details				
Source	SS	df	MS	
Between-groups	74014.53	2	37007.26	F = 8.98756
Within-groups	111175.5	27	4117.611	p<.05
Total	185190	29		

Table 15: Result details for flexural strength values, where SS = Sum of Squares, df = degree of freedom, MS = mean square , F = f-ratio, P = p-value/probability value

The statistical analysis was done using a One-Way ANOVA test, the results were found to be statistically significant with a p value .001019, (significant at $p<.05$). The f-ratio value is 8.98756. This result implies that there is a statistically significant difference between the flexural strength between the samples tested.

Summary of results:
The average highest volumetric shrinkage was seen in dimethacrylate based composite (2.69%). The lowest volumetric shrinkage was in the silorane- based group (1.43%), followed by ormocer –based group (1.85%).
The average highest elastic modulus was seen in dimethacrylate-based composite group (687.2 MPa) followed by ormocer based group (469.91 MPa). The lowest elastic modulus was seen that of the silorane – based group (310.11 MPa).
The average highest flexural strength was seen in dimethacrylate-based composite group (349.35 MPa) followed by ormocer-based composite (330.92 MPa). The lowest values for flexural strength was found in silorane-based composite (235.98 MPa).

IV. Discussion

The volumetric shrinkage evaluation of the composite resins in this study showed silorane with the statistical lower values, followed by ormocer, which was statistically different from the methacrylate composite. Visible light cured composites resins have been the primary choice for restorations. However during photo-polymerization they contract causing gap formation, which is termed polymerization shrinkage. .[8]

Various methods have been employed in evolving composite resin materials to decrease the polymerization shrinkage for example by changing the monomer formation or chemistry, changing the filler amount or shape among many others. Useful methods to alter the chemistry of monomer have been established, where reduced reactive group are being used instead of dimethacrylate monomers.[6]

Some modern developments in dental composite research have demonstrated the use of ring-opening systems like visible light cured oxirane-based resins cured.They show many advantageous properties such as reduced polymerization shrinkage, enhanced depth of cure, superior strength and hardness compared to the conventional bis-GMA-based dental resins. [6]

Silorane is a new system which has been acquired from the reaction of oxirane and siloxane molecules. The new resin has combined the two rewards of the individual constituents: low polymerization shrinkage due to oxirane component and its ring-opening mechanism and siloxane component providing improved hydrophobicity. [6]

Eick et al. showed in his study that siloranes were stable and insoluble in biological fluids.[6,8]

All the advantages of siloranes make them a promising restorative resin.

Because it comprises of ceramic polysiloxane,it shows lesser polymerization shrinkage compared to the dimethacrylate based composite resins.[7]

Incorporation of filler particles decreases volumetric shrinkage from 2–8% when it has no fillers to 1–3% when fillers are incorporated. The filler particles are 1–1.5 μm in size. This material presents 77–78 wt% of filler loading and 61% filler volume.[7]

Various methods have been projected for calculating the shrinkage of dental materials during polymerization. Most methods are based on measuring volumetric changes by using dilatometry or through measurement of linear dimensional changes.[9]

The present study illustrates a straight procedure to evaluate volumetric polymerization shrinkage of light cured composite resins by using a modified version of ASTM method D792 "Specific Gravity and Density of Plastics by Displacement" as suggested by Puckett and Smith in 1992. [9]

The method described provides a precise measure of polymerization shrinkage without the need of advanced equipment. The equipment required is an analytical balance capable of measuring to the nearest 0.1 mg. The values measured agree well with the range of values previously reported.[9]

Polymerisation shrinkage promotes a distortion in the composite which eventually results in stress generation.[10]The stress escalates and ultimately becomes higher than the bond strength resulting in gap formation.[11,12] The gap can lead to sensitivity, marginal leakage and secondary caries. All the clinical concerns enlighten the reason why polymerization shrinkage is the drawback of these materials and also why the replacement or modification of conventional resins is needed.[11, 13]

The volumetric polymerization shrinkage, elastic modulus, visco-elastic behavior, adaptation of the composite material to the tooth surface and the c-factor of the restoration are several aspects that influence the production of stress .[10]

The stiffness or rigidity of a material is known as the material's elastic modulus. It runs a direct association with the inorganic filler content. It is determined via slope of the elastic region of the stress × strain graph and has a vital impact on the stress created during shrinkage of the polymerization of resin composites. Hooke's law states that the strain of these resins produces stress. [13]

The aim of the present study was to evaluate the polymerization shrinkage, flexural strength and elastic modulus resulting from composites formulated by silorane-based composite, ormocers-based composite, dimethacrylate-based composite and to compare the resulting polymerization shrinkage, flexural strength and elastic modulus.

The new silorane monomer was made with a prime goal of overpowering a few downsides concerning the polymerization of methacrylate-based composites, like radical oxygen inhibition, polymerization shrinkage, polymerization stress, and water sorption. So,the new silorane-based composite resin has the capacity to counterbalance shrinkage by opening the oxirane ring during polymerization reaction — a photoinitiated cationic polymerization which is insensitive to oxygen, as well as increased hydrophobicity — due to the presence of siloxane species. The cationic polymerization initiation system consists of three components: camphorquinone, an iodonium salt, and an electron donor. [14]

The highest values for elastic modulus were seen in the dimethacrylate based composite group followed by ormocer based composite group. The lowest elastic modulus was seen in the silorane based composite group. The results demonstrate a progressive association between modulus and filler content.

A correlation of higher elastic modulus with increased shrinkage seems to be valid in the present study for the methacrylate-based composites, as silorane-based composite attained lower volumetric shrinkage than dimethacrylate-based composite.

The highest values for flexural strength were seen in the dimethacrylate based composite group followed by ormocer based composite group. The lowest flexural strength was seen in the silorane based composite group.

Properties of fillers like the size, content and distribution significantly impact the physical and mechanical properties of composite resin restorative material. The filler volume fraction and filler load level of composites is associated with the fracture toughness,material strength and flexural modulus.[15]

Properties of restorative resins like fracture resistance, elasticity, and marginal strength of materials under stress have been calculated by the determination of considerations like flexural strength, flexural modulus and fracture toughness.[15]

Kim *et al.* observed a significant influence of the filler rate and morphology on the flexural strength and modulus, microhardness and fracture toughness of the composites evaluated.[16]

Flexural strength is a measure of resistance of a material to withstand occlusal force and is related to the fracture strength of a material. [15] Composite restorations can be exposed to substantial flexural strains in both anterior and posterior teeth. The physical properties of a restorative material show that how the material will function under stress in the oral environment, indirectly determining the resistance to fracture in the areas of great masticatory effort.

The considerations for evaluating the flexural strength are followed according the ISO specification 4049 - (International Organization for Standardization – ISO, 2000). However, in resin composite evaluations, the difficulty of polymerizing large specimens (25 mm) is recommended.[17]

For this reason, the option was to use specimens with dimensions of 12 mm * 6 mm * 5 mm in this study. The use of smaller test specimens has no influence on the flexural strength results and decreases the amount of time and material used to perform the test, as well as being closer to clinical reality.

Depending on the intended use, composites with different mechanical properties may be required; in some situations the materials must be hard and strong, while in other situations the flexibility of the material is more important and strength is not an important factor; in contrast, stiffness or resilience may be the properties of interest.[18]

V. Conclusion

On the basis of the findings presented herein and within the limitations of this study,it may be concluded that Silorane based composite - Filtek Low Shrink Posterior Restorative had the lowest polymerization shrinkage,followed by Ormocer based composite – Admira-Light-curing Ormocer. The highest polymerization shrinkage was seen in Dimethacrylate based composite - Filtek™ Z250 XT Nano Hybrid Universal Restorative. The lowest polymerization was seen in the silorane-based composite owing to the cationic ring opening process during polymerization.

The highest values for elastic modulus were seen in the dimethacrylate based composite group followed by ormocer based composite group. The lowest elastic modulus was seen in the silorane based composite group. The highest values for elastic modulus were seen in the dimethacrylate based composite mainly due to the increased filler content compared to the other two groups.

The highest values for flexural strength were seen in the dimethacrylate based composite group, followed by ormocer based composite group. The lowest flexural strength was seen in the silorane based composite group.

As in most in vitro studies, a degree of caution must be exercised in interpreting the finding of the present study and extrapolating the same clinically.

Further investigations are needed to test these materials for their widespread use, influencing the long term success of restorative resins.

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