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Comparative Evaluation of Two Packable Bulk Fill Dental Resin Composite for Depth of Cure -An in Vitro Study

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"COMPARATIVE EVALUATION OF TWO PACKABLE BULK FILL DENTAL RESIN COMPOSITE FOR DEPTH OF CURE -AN IN VITRO STUDY"

Conservative Dentistry and Endodontics

Work done by Dr. Chandni Bhatia

Sharad Pawar Dental College and Hospital,
Datta Meghe Institute Of Medical Sciences

Guided By Dr. Manoj Chandak

DMIMS NAGPUR

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Name of the Guide:

Dr. Manoj Chandak

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Chandni Bhatia (Adwani)

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The Perfection of Art is to Conceal Art.

Esthetic restorations are in vogue today and their demand is increasing day by day. Composites represent two major advances in restorative dentistry. Composite resins have been classified in different ways, depending on their composition, to make it easier for dentists to identify and use them for therapeutic purposes. A very popular classification which is still valid is that of Lutz and Phillips, which is based on filler particle size. These authors divided composite resins into macro filler composites (particles from 0.1 to 100 μ), micro filler composites (0.04 μ particles) and hybrid composites (fillers of different sizes).

HYBRID COMPOSITE RESINS

These composites are made up of polymer groups (organic phase) reinforced by an inorganic phase, comprising 60% or more of the total content, composed of glasses of different compositions and sizes, with particle sizes ranging from 0.6 to 1 micrometers, and containing 0.04 micrometer sized colloidal silica. They make up a large majority of the composites currently used in dentistry.

FLOWABLE COMPOSITES

These are low-viscosity composite resins, making them more fluid than conventional composite resins. The percentage of inorganic filler is lower and some substances or rheological modifiers which are mainly intended to improve handling properties have been removed from their composition. Their main advantages are: high wettability of the tooth surface, ensuring penetration into every irregularity; ability to form layers of minimum thickness, so improving or eliminating air inclusion or entrapment; high flexibility, so less likely to be displaced in stress concentration areas (cervical wear processes and cavitated dentine areas); radio-opaqueness and availability in different colours.

CONDENSABLE COMPOSITES

Condensable composites are composite resins with a high percentage of filler. The advantages are: condensability (like silver amalgam), greater ease in achieving a good contact point and better reproduction of occlusal anatomy. Their physical and mechanical behaviour is similar to that of silver amalgam, bettering that of hybrid composites. Their main indication is Class II cavity restoration in order to achieve a better contact point thanks to the condensation technique.

One alternative is the new Packable composites, developed to overcome some of the difficulties with placement of posterior composite restorations, a number of manufacturers have developed 'condensable' or 'packable' resin based composites for which amalgam-like packability is claimed and as a result of this, there is the potential to achieve tighter contact points more easily. 'Packable' has been considered to be a more appropriate term than condensable: these materials cannot be condensed (as amalgams can) but they can be compacted. Examples of packable composite are Venus, Solitaire, Tetric Evoceram, Alert, Surefil , Filtek P-60, Pordigy condensable, Pyramid.

Packable composites generally have larger than average filler particles, and the resin matrix is modified chemically to allow a slight increase in filler amount. Some of these materials also claim that they may be cured in bulk. Recent studies have indicated that some of the packable composites claiming bulk fill to 5 mm depth fall short of these claims.

In 1980 to 1985, early packable composite formulations were formulated. Later, in 1990 packable composites were used in clinical trials. In mid of 1990 to 1995, first PRIMM admixed composites developed. In mid of 1995 to 2000 many of the packable composite were developed like Solitaire, Alert, Surefil, etc.

In the study two packable composites are used of different companies that is 3M ESPE, KERR, IVOCLAR-VIVADENT. Filtelk™ Bulk Fill, 3M ESPE, GERMANY can be placed in the thickness of 4-5mm and its matrix contain Bis-GMA, BisEMA, and UDMA. Filler% (wt) is 64.5. SonicFill™ Sonic-activated bulk fill, KERR CORP, USA can be cured in the depth of 4-5mm and matrix is composed of Bis- GMA, TEGDMA, BisEMA, SIMA. Filler% (wt) is 83.5. Tetric EvoCeram Bulk Fill, IVOCLAR-VIVADENT, SCHAAN can be placed in the depth of 4-5mm and it contains Dimethacrylate co-monomer. Filler% (wt) is 80.

The Vickers Hardness Tester was used to measure the Microharness of the three packable composite materials. The Vickers hardness test was developed in 1921 by Robert L. Smith and George E. Sandland at Vickers Ltd as an alternative to the Brinell method to measure the hardness of materials.

The Vickers test is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness. The basic principle, as with all common measures of hardness, is to observe the questioned material's ability to resist plastic deformation from a standard source.

The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as theVickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). The hardness number can be converted into units of pascals, but should not be confused with pressure, which also has units of pascals.

The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force, and is therefore not pressure. It was decided that the indenter shape should be capable of producing geometrically similar impressions, irrespective of size; the impression should have well-defined points of measurement; and the indenter should have high resistance to self-deformation.

Therefore, the present study was carried out with the aim of evaluation of microhardness of two packable bulk fill dental resin composite for depth of cure.

AIM & OBJECTIVES

AIM

"To compare microhardness of two packable bulk fill dental resin composite containing different filler loading for depth of cure using Vickers hardness profiles (VHN) -An In vitro".

OBJECTIVES:

1. To evaluate microhardness of two packable bulk fill composite containing filler loading of "80% (wt)" using Vickers hardness profiles (VHN).

2. To evaluate microhardness of two packable bulk fill composite containing filler loading of "83.5% (wt)" using Vickers hardness profiles (VHN).

3. To compare Microhardness of two packable bulk fill dental resin composites containing different filler contain using Vickers hardness profiles.

Review of Literature

D.C. Watts, V. McNaughton, A.A. Grant in 1986 studied the development of surface hardness in visible light-cured posterior composites. For study four posterior composite were used. Specimens were prepared specimen by four posterior composite and specimens were photopolymerized 40sec and half specimens were stored in water and half dry at room temperature at 37^0 C and 27^0 C respectively. The surface microhardness of four visible light-cured posterior composite materials was measured at a series of time intervals up to 1 month, commencing from the end of the light irradation period. Authors found that the microhardness steadily increased with time and tended towards a maximum, usually reached after 1 week. In all cases the rate of increase was substantial over the first hour and was greater for samples stored at 37°C as compared with 20°C. Therefore the authors concluded that the progressive cross-linking reaction in the resin phase of the materials continues after photoactivation because the surfaces of samples stored in water were softened compared to dry samples and differences between materials may be attributed to compositional differences and extent of cure.

Yap AU in 2000 evaluated the impact of variation of cavity depth and light- source exposure time upon the effectiveness of polymerization of two "bulk placement" composite restoratives were assessed indirectly using hardness testing. For study microhardness tester was used to evaluate hardness gradient between top and bottom surfaces of composite specimens of various depths after different light-exposure inies. Authors found that the effectiveness of polymerization decreased significantly with increased cavity depth regardless of exposure time. From this study it was concluded that the composite restoratives should not be placed in increments greater than 2 mm in order to obtain uniform and maximum polymerization.

Sharkey S, Ray N, Burke F, Ziada H, Hannigan A in 2001 evaluated microhardness values of top and bottom surfaces of 3 commercially available resin composites. For study 3 commercially available resin composites were compared and cured using

both traditional halogen source and a plasma arc lamp. Surface microhardness measurements were carried out using a Vickers indenter on both top and bottom surfaces. From the results of this study, authors concluded that commercially available light activated resin composite exhibited significantly greater surface hardness values with halogen lamp, plasma arc lamps results in low values because of reduced exposure time, which may result in increased early termination of polymer chains in the pre-gel polymerization period.

Poskus LT, Placido E, **Cardoso PE in 2004** analyzed the influence of two placement techniques on Knoop and Vickers hardness of class II cavities restored using packable (A.L.E.R.T., Solitaire 2, SureFil) and conventional microfilled and hybrid (Filtek A1 10 and Z250, respectively) resin composites. Foe study fifty standardized class II cavities (5 x 3 x 1.5 mm^3) were prepared in human premolars. They were divided into ten groups and restored according to each resin composite material. 24 hours later Knoop and Vickers hardness measurements were performed using sixteen indentations for each restoration, eight on the occlusal and eight on the cervical surfaces. Results showed that all materials presented lower hardness values at the cervical surfaces when the bulk placement technique was employed, when compared to the occlusal surfaces whereas the same did not occur with the incremental technique. Pearson's correlation test demonstrated a positive correlation between Vickers and Knoop hardness numbers. Authors concluded that bulk placement technique resulted inlower hardness and incremental placement technique promoted a more uniformpolymerization. Also there is a good correlation between Knoop and Vickers hardness due to their similar indentation methods.

Hubbezoğlu I, Bolayir G, Doğan OM, Doğan A, Ozer A, Bek B. **in 2007** studied microhardness evaluation of resin composites polymerized by three different light sources. For study ten specimens of 2 mm thickness and 4 mm diameter of each resin composite were polymerized using a halogen light, a blue light-emitted diode, and a plasma arc unit. Microhardness evaluation was performed at top and bottom surfaces for each specimen using a Vickers microhardness tester. Furthermore, morphologies of the polished top surfaces of composites cured with blue light-emitted diode were observed using scanning electron microscopy. Authors results indicated that composites cured with halogen or blue light-emitted diode light yielded higher microhardness values, although it also appeared to depend on the type of composite cured. Authors concluded that the Plasma arc curing according to manufacturer's instructions yielded the lowest microhardness values for all the materials because among the materials tested, the nanofilled resin composite displayed the highest microhardness values for each curing regime due to its filler loading and smaller particles size.

Mohame d El-Nawawy , Lubna Koraitim, Oss ama Aboue latta, Hanan Hegaz in 2012 studied depth of Cure and Microhardness of Nanofilled, Packable and Hybrid Dental Composite Resin. For study a total of sixty human mandibular first molars were used. The teeth were divided into three main groups (20 teeth each) according to the composite resins that were used. In group I, Surefil (packable composite) was used as the restorative material. In group II, Esthet-X-improved (nanofilled composite) was used, while in group III Glacier (hybrid composite) was used. Each group was subdivided into four subgroups (five teeth each) according to the storage intervals (24 hours, one week, two weeks, and three weeks). In each group, occlusomesial cavities were prepared with diamond burs and restored with the composite, according to manufacturer's instructions. In all specimens, composite was applied to the cavity using incremental technique. All the restored teeth were subjected to in vitro thermal cycling and mechanical loading simulating a total of six months in vivo function. Depth of cure was evaluated using penetrometer and microhardness was measured using Vicker's microhardness tester. Authors concluded that their was significant difference in depth of cure and microhardness were found between the three composites used, the depth of cure and microhardness of the packable composite was better than the other two composites used because of increase in filler size and contain and also the process of conversion of the monomer to the polymer stage which accelerates the polymerization reaction was found to be more in packable composite which improved depth of cure of packable composite.

Affan Ahmad, Syed Yawar Ali Abidi, Zubair Ahmed Abbasi, Aqeel Ahmed Shaikh, Ashraf Ali Meo 2014 evaluated the effect of different chlorhexidine based Mouthwashes on hardness of resin based dental composites.an in vitro study. For study a total of 90 disc shaped specimens were fabricated from Ceram- X (Dentsply) and Filtek Z-350 (3-M ESPE) composite restorative materials. After initial hardness testing (Baseline), samples of each type of composite were randomly divided into three groups (n= 30). The specimens were then stored in Mouthwash – 1, Mouthwash – 2 and Distilled water (DW). All specimens were stored in an incubator at 37oC and were tested for hardness at baseline, after one week and then after 4 weeks of storage span. Surface hardness measurements were done using a WOLPERT Micro Vickers tester 402-MVD (Hylec Controls, Australia). Three indentations were made with 300 g force for 30 seconds, indentations was taken as Vickers Hardness Number (VHN). Authors found that the VHN values of Composite – 1 and composite -2 specimens were significantly decreased upon storage in Mouthwash-1 and Mouthwash- 2 when compared at baseline (57.36 ± 0.80) to one week (54.18 ± 1.57) and four weeks (53.91 ± 1.57) of storage. (p-value < 0.001). Therefore, Authors concluded that both the restorative materials exhibited decrease in hardness upon immersion in chlorhexidine based mouthwashes of different concentrations because mouthwash may changed the polymeric matrixes of the composite by catalysis of ester groups from dimethacrylate monomer present in its composition.

Kapoor N, Bahuguna N, Anand S in 2016 studied influence of composite insertion technique on gap formation. For study Class I cavities were prepared in 60 intact molars, with a shallow depression in the center of the pulpal floor. The samples were divided into four groups (n = 15), according to the material used; smart dentine replacement (SDR), SonicFill, Ever X Flow and Z350 XT, restored to a depth of 4 mm. Following thermocycling, samples were sectioned buccolingually and examined under a stereomicroscope. Seven samples from each group were coated with nail varnish except for approximately 1 mm around the tooth restoration junction. These samples were examined under stereomicroscope after staining with 2% buffered methylene blue dye. The remaining samples were examined under a scanning electron microscope for gap formation. Authors found thatSDR showed the significantly best adaptability as compared to both SonicFill and Ever X Flow (comparable). However, significantly least adaptive capacity was seen in the incrementally filled group (Z350 XT). Authors concluded that Bulk-fill composites performed better than incremental composites, demonstrating better adaptability and less gap formation at the pulpal floor because of fillers particles are closely packed in SDR.

Aysin Dumani, Sehnaz Yilmaz, Gorkem Ozbilen, Cihan Cem Gurbuz, Oguz Yoldas in 2016 studied comparative evaluation of Push-Out Bond Strength of Bulk-Fill versus Dual-Cure Resin Composites in Root Canals .For study forty four extracted single-rooted teeth were removed 12 mm from the apex and a root canal treatment was performed. The post spaces were prepared to a depth of 8 mm using a Cytec Blanco pilot bur. Then, the roots were randomly divided into four groups according to the restoration protocols: Fiber post + Panavia F, Clearfil DC Bond + Bulkfill composite (SonicFill), Clearfil DC Bond + Bulkfill composite (Clearfil PhotoCore), and Clearfil DC Bond + Dualcure composite (Clearfil DC CorePlus). For the push-out test, the roots were embedded in acrylic and sectioned using a watercooled diamond coated saw. Three slices (coronal, middle, and apical) were obtained from each root. Authors found that the SonicFill group had the lowest push-out bond strength values, while the Fiber post

Sr. no	Armamentarium used	Manufacture
1	Glass slab	Samit products, Jhandewalan, delhi, India
2	Composite instruments	GDC, India.
3	Protective eyewere	Foshan Tanton Trade Co., Limited
4	Custom-made stainless steel mold	Maxwell industries Pvt. Ltd. Nagpur, India.
5	Mylar Matrix strips	RM Ltd, UK
6	LED Light curing Unit	QTH curing light.
7	Sonicfill handpiece	Kerr Corporation, USA.
8	Profilometer	Vicker's hardness tester, DHV-3000, Croma

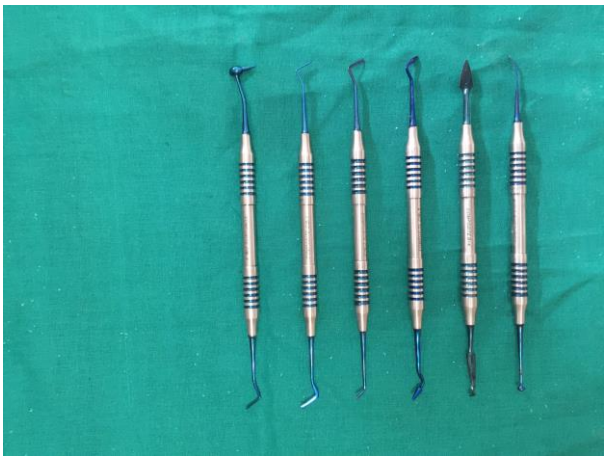
Panavia F group had the highest median MPa levels for the coronal, middle, and apical levels ($p<0.001$).In all groups, the apical third section had a lower push-out bond strength compared with the middle and coronal levels. Authors concluded that the bond strength of a sonic activated bulk-fill composite in root canals is lower than that of other conventional methods because the filler loading in sonic activated composite is dispersly placed and size of filler particle is small so of matrix contain is more so the strength is reduced.

TABLE 2 : List of Materials

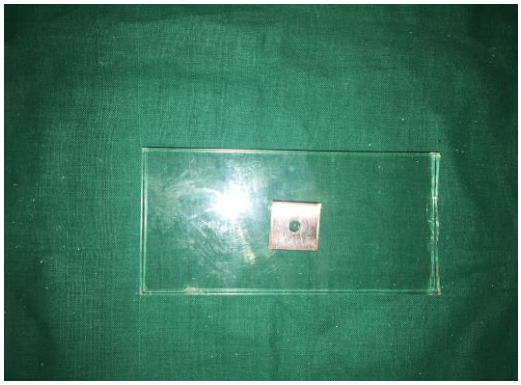
Sr. No.	Material	Code	Type	Manufacture increment thickness (mm)	Matrix	Filler % (wt)	Manufacture
1.	Tetric EvoCeram Bulk Fill	TBF	Bulk Fill	4mm-5mm	Dimethacrylate co-monomer	80% (wt)	IVOCLAR VIVADENT, SCHAAN
2.	SonicFill™	SF	Sonic-activated bulk fill	4mm-5mm	Bis-GMA, TEGDMA, BisEMA, SIMA	83.5% (wt)	KERR CORP, USA

PICTURES

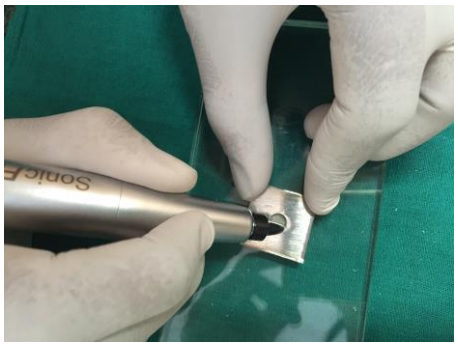
1) Intruments



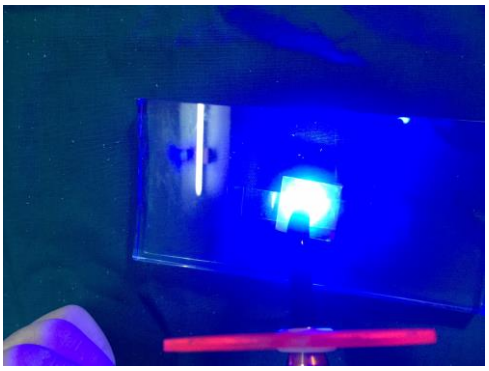
2)Mold



3) filling Sonic handpiece



4) Curing



Step 1: Fabrication of Mold

A customized metal mold made up of stainless steel was prepared (Maxwell industries Pvt. Ltd. Nagpur, India). the mold consist of specific dimensions of 5mm X 5mm in length and width respectively.

Step2: Grouping of specimens :

The specimens were divided according to the filler loading of packable bulkfill dental resin composite. **(Fig.4)**

Table No. 3: Grouping of specimens

Sr. No.	Group	Filler loading	MANUFACTURE	Number of samples
1	Group-I	"80% (wt)"	IVOCLAR VIVADENT, SCHAAN	20
2	Group-II	"83.5% wt)"	KERR CORP, USA	20

This table depicted that data there were two groups with two different Packable bulk fill composite materials containing different filler loading. Each group were consisted by 20 subjects.

Step 3: Preparation of Specimens

40 specimens of packable bulkfill dental composite resin were prepared. 20 specimens of each were made that is packable bulk fill composite containing filler loading of "80% wt"(Tetric EvoCeram Ivoclar Vivadent, Schaan) and packable bulk fill composite containing filler loading of "83.5% wt" (SonicFill™ :KERR CORP, USA), To prepared each specimen, the customized stainless steel mold was rested on the flat glass slab. The packable bulkfill dental composite resins material was gently packedinside the mold with the teflon coated composite manipulation instruments (GDC, India) for Filtelk™ Bulk Fill and Tetric EvoCeram Bulk Fill. For compacting SonicFill™ composite Sonic-activated handpiece was used according to manufacturer's instruction. After that Mylar strip was placed on top of materials and subsequently pressed into position to provide smooth glossy surface. Each specimen was photo-polymerized for 40 sec using visible light cure unit, under the standard curing mode.

Step 4: Storage of samples

After preparation of specimens, all samples were stored dry at room temperature in light proof containers for 24hour.

Step 5: Testing of samples

After the completion of all above procedures, the specimens were subjected for testing. The mylar strip was removed and all the specimen were examined for microhardness with instrument VHN (Vickers Hardness Number) with the fixed load of 300g and at the centre of specimen indentation was made as microharness of that tested sample and it was repeated for all other specimens

and a constant fixed load of 300g was applied for 15sec. Observational data (microhardness of each specimens) was obtained. Data was subjected for statistical analysis.

Table No. : Micro-hardness of two Packable bulk fill composite materials containing different Filler Loading (master chart)

Sr No.	Group I (80 % wt)	Group II (83.5 % wt)
1	74.96	97.72
2	72.39	103.07
3	75.85	102.7
4	75.48	103.41
5	75.12	101.08
6	82.86	102.07
7	92.86	104.06
8	78.91	98.8
9	77.72	111.8
10	91.19	98.72
11	88.16	98.78
12	75.48	103.16
13	76.39	101.71
14	72.49	96.18
15	77.62	99.72
16	82.18	96.98
17	81.91	102.12
18	86.94	103.78
19	78.18	97.13
20	77.16	101.8

This table depicted that data there were two groups with two different Packable bulk fill composite materials containing different filler loading. Micro hardness is displayed in two different groups.

The Mean

For a data set, the mean is the sum of the observations divided by the number of observations. It identifies the central location of the data, sometimes referred to in English as the average. The mean is calculated using the following formula.

$$M = \frac{\Sigma(X)}{N}$$

Where Σ = Sum of X = Individual data points

N = Sample size (number of data points)

The Standard Deviation

The standard deviation is the most common measure of variability, measuring the spread of the data set and the relationship of the mean to the rest of the data. If the data points are close to the mean, indicating that the responses are fairly uniform, then the standard deviation will be small. Conversely, if many data points are far from the mean, indicating that there is a wide variance in the responses, then the standard deviation will be large. If all the data values are equal, then the standard deviation will be

$$S^2 = \frac{\Sigma(X-M)^2}{n-1}$$

zero. The standard deviation is calculated using the following formula.

Where Σ = Sum of X = Individual score

M = Mean of all scores N = Sample size (number of scores)

One way ANOVA

A One-Way Analysis of Variance is a way to test the equality of three or more means at one time by using variances.

Assumptions

- The populations from which the samples were obtained must be normally or approximately normally distributed.
- The samples must be independent.
- The variances of the populations must be equal. **Hypotheses** The null hypothesis will be that all population means are equal; the alternative hypothesis is that at least one mean is different. In the following, lower case letters apply to the individual samples and capital letters apply to the entire set collectively. That is, n is one of many sample sizes, but N is the total sample size. **Grand Mean** The grand mean of a set of samples is the total of all the data values divided by the total sample size. This requires all of the sample data, which is usually the case, but not always. It turns out that all that is necessary to find perform a one-way analysis of variance are the number of samples, the sample means, the sample variances, and the sample sizes.

$$\bar{X}_{GM} = \frac{\sum x}{N}$$

Another way to find the grand mean is to find the weighted average of the sample means. The weight applied is the sample size.

Total Variation

The total variation (not variance) is comprised the sum of the squares of the differences of each mean with the grand mean.

There is the between group variation and the within group variation. The whole idea behind the analysis of variance is to compare the ratio of between group variance to within group variance. If the variance caused by the interaction between the samples is much larger when compared to the variance that appears within each group, then it is because the means aren't the same.

Between Group Variation

The variation due to the interaction between the samples is denoted SS (B) for Sum of Squares Between groups. If the sample means are close to each other (and therefore the Grand Mean) this will be small. There are k samples involved with one data value for each sample (the sample mean), so there are k-1 degrees of freedom.

The variance due to the interaction between the samples is denoted MS (B) for Mean Square Between groups. This is the between group variation divided by its

degrees of freedom. It is also denoted by s_b^2.

$$\bar{X}_{GM} = \frac{\sum n\bar{x}}{\sum n} \quad SS(T) = \sum (x - \bar{X}_{GM})^2 \quad SS(B) = \sum n(\bar{x} - \bar{X}_{GM})^2$$

Within Group Variation

The variation due to differences within individual samples, denoted SS (W) for Sum of Squares

Within groups each sample is considered independently, no interaction between samples is involved. The degrees of freedom are equal to the sum of the individual degrees of freedom for each sample. Since each sample has degrees of freedom equal to one less than their sample sizes, and there are k samples, the total degrees of freedom is k less than the total sample size: df = N - k.

The variance due to the differences within individual samples is denoted MS (W) for Mean Square Within groups. This is the within group variation divided by its

degrees of freedom. It is also denoted by s_w^2. It is the weighted average of the variances (weighted with the degrees of freedom).

F test statistic

Recall that a F variable is the ratio of two independent chi-square variables divided by their respective degrees of freedom. Also recall that the F test statistic is the ratio of two sample variances. The F test statistic is found by dividing the between group variance by the within group variance. The degrees of freedom for the numerator are the degrees of freedom for the between group (k-1) and the degrees of freedom for the denominator are the degrees of freedom for the within group (N-k).

$$F = \frac{s_b^2}{s_w^2}$$

$$SS(W) = \sum df \cdot s^2$$

Decision Rule

The decision will be to reject the null hypothesis if the test statistic from the table is greater than the F critical value with k-1 numerator and N-k denominator degrees of freedom.

If the decision is to reject the null hypothesis, then at least one of the means is different. However, the ANOVA does not tell you where the difference lies. For this, Tukey test should be used for equal number of varience.

Tukey's HSD test

Tukey's test was developed in reaction to the LSD test and studies have shown the procedure accurately maintains alpha levels at their intended values as long as statistical model assumptions are met (i.e., normality, homogeneity, independence). Tukey's HSD was designed for a situation with equal sample sizes per group, but can be adapted to unequal sample sizes as well (the simplest adaptation uses the harmonic mean of n-sizes as n*). The formula for Tukey's HSD is:

Tukey's HSD = q √MSE / n*

Where q = the relevant critical value of the studentized range statistic and n* is the number of scores used in calculating the group means of interest.

Levene's test

Levene (1960) presents a test of homogeneity (equal variance). The test does not assume that all populations are normally distributed and is recommended when the normality assumption is not viable. Suppose g groups each have a normal distribution

with possibly different means and standard deviations σ1, σ2, ..., σg. Let n1, n2, ..., ng denote the number of subjects in each group, Yki denote response values, and N denote the total sample size of all groups. The test assumes that the data are obtained by taking a simple random sample from each of the g populations. The formula for the calculation of Levene's test is

where,

$$Z_{ki} = |Y_{ki} - \bar{Y}_k|$$

$$\bar{Z}_k = \frac{1}{n_k}\sum_{i=1}^{n_k} Z_{ki}$$

$$\bar{\bar{Z}} = \frac{1}{N}\sum_{k=1}^{g}\sum_{i=1}^{n_k} Z_{ki}$$

$$\bar{Y}_k = \frac{1}{n_k}\sum_{i=1}^{n_k} Y_{ki}$$

If the assumptions are met, the distribution of this test statistic follows the F distribution with degrees of freedom g - 1 and N - g.

Regression analysis

The idea behind regression is that when there is significant linear correlation, to estimate the value of the dependent variable for certain values of the independent variable. The regression equation should only used

- When there is significant linear correlation.
- The value of the independent variable being used in the estimation is close to the original values.

$$W = \frac{(N-g)\sum_{k=1}^{g} n_k (Z_k - \bar{\bar{Z}})^2}{(g-1)\{\sum_{k=1}^{g}\sum_{i=1}^{n_k}(Z_{ki} - \bar{Z}_k)^2\}}$$

- The regression equation should not be used with different populations.
- The regression equation shouldn't be used to forecast values not from that time frame.
- Here, regression equation had used because there was significant linear correlation between the two variables, the equation becomes: y' = ax + b or y' = a + bx.

$$a = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

- a is the slope of the regression line:

$$b = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2}$$

b is the y-intercept of the regression line:

- The regression line is sometimes called the "line of best fit" or the "best fit line". Since it "best fits" the data, it makes sense that the line passes through the means.

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. This table depicts that in all three types of materials the means of homogeneity is not statistically significant (p = 1.000). The mean of Group I is 66.5460, Group II 79.6925 and Group III is 101.2395.

Table

: Comparison between mean and median among Packable bulk fill composite materials containing different Filler Loading

. ***Observation & Results***

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	Group I	Group II
Mean	79.6925	101.2395
Median	77.6700	101.7550

. This table shows that in the case of each material difference between micro-hardness of mean and median is very less. This stands that every set of data were homogeneous and equally distributed.

Table No. Comparison of Packable bulk fill composite materials containing different Filler Loading
Oneway ANOVA

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	F	Sig.
					Lower Bound	Upper Bound				
Group I	20	79.6925	5.97409	1.33585	76.8965	82.4885	72.39	92.86		
Group II	20	101.2395	3.52074	0.78726	99.5917	102.8873	96.18	111.80		

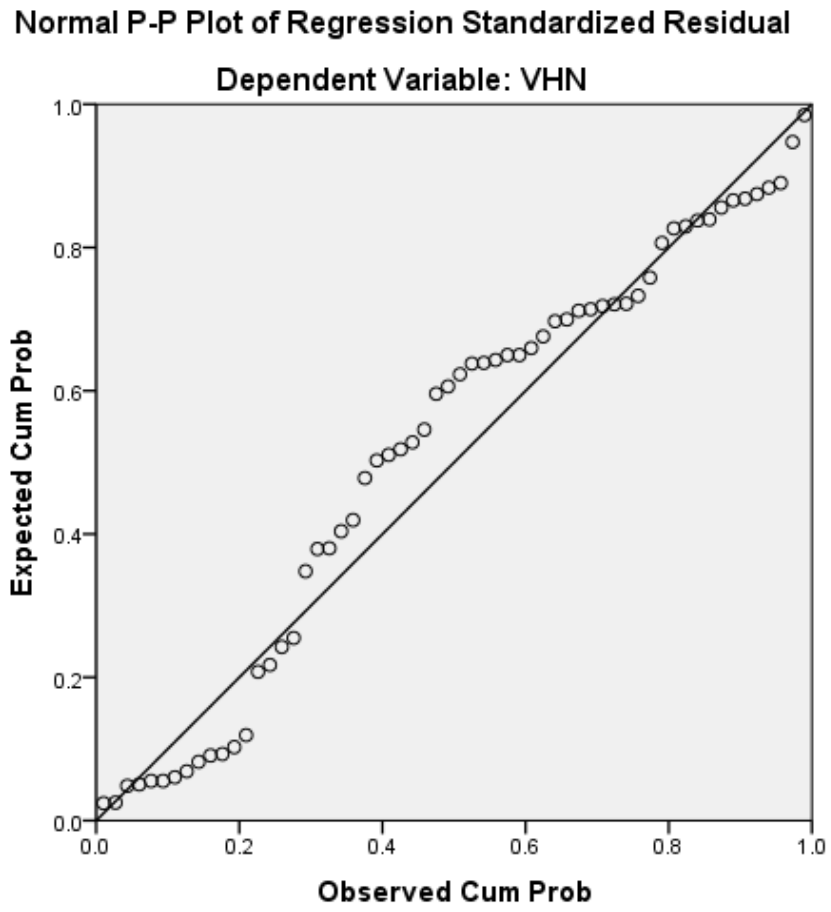
This table depicts the descriptive statistics of mean VHN micro-hardness for each group. The mean micro-hardness is minimum in Group I (79.6925±5.97409) and maximum in Group II (101.2395±3.52074). This stands for statistically significant difference among three means. ($p<0.000$).

Table : Descriptive statistics of micro-hardness and filler of Packable bulk fill composite materials containing different filler Loading

	Mean	Std. Deviation	N	Pearson Correlation	Sig. (1- tailed)
VHN	82.4927	15.12469	60	1.000	0.000*
filler	76.0000	8.32599	60	0.842	

This table shows that mean (± standard deviation) of micro-hardness and filler. Here, pearson correlation (R) is found statistically significant ($p<0.000$). This means that micro-hardness and fillers are positively correlated.

Graph : Normal P-P plot of regression



This normal P-P plot shows that all data are lies more or less approximated toward 45o angulations. This means that micro-hardness and fillers are positively correlated among TWO Packable bulk fill composite materials containing different filler loading.

DISCUSSION

A new bulk fill types of composite introduced with depth of cure which can be placed one layer, advantages of this “New Class” of materials saves time, easier better adaptation to tooth, reduce chance for air entrapment, better conformity to cavity walls, better marginal integrity, less shrinkage stress, greater depth of cure 4-5 mm , and better degree of conversion.The introduction of Bulk fill composite developed superior properties when compared to other conventional composites and restorative materials. Hence, the study was conducted with an aim to evaluate microhardness of three packable bulk fill dental resin composite containing different filler loading using Vickers hardness profiles (VHN).

In the present study three packable bulk fill dental resin composite were used that is packable bulk fill composite containing filler loading of "80% wt (IVOCLAR VIVADENT, SCHAAN) , and packable bulk fill composite containing filler loading of "83.5% wt” (KERR CORP, USA).

Bulk fill materials are available in sculptable and flowable form. The flowable composites are mainly used to replace dentin. In contrast, sculptable bulk fill composites can be applied in one layer.

Packable resin composites possess the advantages over silver amalgam like low thermal conductivity, the ability to be bonded to tooth structure, absence of galvanic currents, and esthetics. The bulk placement of packable composites demonstrated decrease polymerization shrinkage due to increased filler loading.

The fracture toughness for packable composites is specific, since Packable resin composite materials have demonstrated fracture toughness greater than hybrid composites and others significantly lower. Resistance to crack propagation can be related to fracture strength and micro-hardness and is important in resisting catastrophic failure of the composite over time. The increase in filler particle load in packable composites demonstrated a weak correlation to the resistance to microfractures. The packable resin composites are stronger and better able to withstand occlusal forces of mastication because of the increase in filler particle load in packable composites.Therefore, packable bulk fill composite material were selected as material of choice for study.

In the present study customized metal mold made up of Stainless steel used with specific dimension of 5mm inner diameter and 5mm thickness respectively. Stainless steel mold was selected which was round in shape because mold should hold material tightly in position and no fingerprint mark or disturbance to specimen should occur throughout procedure. Total 40 molds were used to prepare the 40 specimens. Samples were prepared by placing mold on flat glass slab, so that specimen should be easily removed. The resin composite material was gently packed inside the mold with Teflon coated instruments (G.D.C., India) so that material should not stick to instruments and can be easily placed, over that mylar srtip was placed and compressed carefully with low pressure on the top of the mold to remove excess of material and to provide smooth, glossy and flat surface.

In the present study sonic activated device was used to fill sonicfill composite which contain filler loading of "83.5% (wt)" which provide sonic energy through a special handpice to increase the flowablity and ease of packing of composite.

In the present study Quartz Tungsten Halogen (QTH) curing light was used to polymerize the composite materials . Its broad emission spectrum allows the QTH curing light to predictably initiate polymerization of all known photo-activated resin- based dental materials. However, the principal output from these lamps is infrared energy, with the generation of high heat. Filters are used to reduce the emitted heat energy and provide further restriction of visible light to correlate better with the narrower absorbance spectrum of photo-initiators. Frederick A in 2000 investigated the Polymerization Depths of Contemporary Light-Curing Units Using microhardness found that Conventional QTH lights provided similar hardness profiles. High-intensity QTH lights provided similar hardness at 2-mm depth in 10 seconds to that of the to those achieved with conventional QTH technique when used according to manufacturer's recommendations.

In the present study 40 seconds of curing time was taken for polymerization with light curing unit. Polymerization depends on exposure time depth, diameter of tip, as well as position of composite resin. Rueggeberg FA et al in 2000 evaluated Polymerization depths of contemporary light-curing units using microhardness and found that Conventional QTH lights provided similar hardness profiles. High-intensity QTH lights provided similar hardness at 2-mm depth in 10 seconds to that of the standard 40-second exposure due to consideration of high-intensity curing units, composite increments should still be no greater than 2 mm to provide homogeneous hardness.

In the present study 4mm-5mm thickness of composite samples were fabricated in agreement with study by Eun-Ha Kim et al in 2015. Eun-Ha Kim et al in 2015 evaluated the effects of the resin thickness on the microhardness and optical properties of bulk-fill resin composites and author concluded that bulk-fill resin composites used can be placed and cured properly in the 4 mm bulk because the microhardness decreased with increasing resin thickness. The bulk-fill resin composites showed a bottom/top hardness ratio of almost 80% or more in 4 mm thick specimens due to higher filler loading.

In the present study after completion of sample preparation the samples were stored in dark lightproof box condition for 24 hours. Light- cured composites polymerize both during and after visible light- activation. These two curing reaction are known as "light" and "dark" reactions.

The light reaction occurs while light from the curing unit penetrates the composite. The dark reaction, also called post-irriadiation polymerization, begins immediately after the curing light goes off and continues for up to 24 hours. In all composites maximum hardness is achieved within 24 hours.

In the present study Vickers hardness test method was used, which is also referred as a micro hardness test method, is mostly used for small parts, thin sections, or case depth work. The Vickers method is based on an optical measurement system. The Micro hardness test procedure, specifies a range of light loads using a diamond indenter to make an indentation which is measured and converted to a hardness value. The Microhardness methods are used to test on metals, ceramics, composites Therefore, Vickers hardness profile was used for microhardness of bulkfill composite in the study.

The results of the present were obtained by subjecting the observations of the study for statistical analysis using different test that is:

One way ANOVA, Tukey's HSD test, Levene's test and

Regression analysis.

With the background of review of literature, the results obtained in this study were interpreted and discussed as;

In this study the micro hardness of three packable bulk fill resin composites were measured by the determination of their depth profiles with the help of vickers hardness profile.

When Group I was compared with Group II, statistically significant difference was obtainedbetweengroupII&III($p<0.000$),Themeanmicrohardnessofgroup III wasgreaterthan GroupII.Thisresultsareinaccordancewith **VipinSudheer(2011),MohamedEl-Nawawyet al (2012), Kraig S. and Vandewalle et al (2013).**

Vipin Sudheer (2011) concluded that a linear regression was observed positive correlation in the study between the VHN and the filler loading due to increased filler loading which reduces the volume of resin matrix for polymerization and intrinsically increase hardness of the composite materials.

Mohame d El-Nawawy, Lubna Koraitim, Oss ama Aboue latta, Hanan Hegaz in (2012) found that, the depth of cure and microhardness of the packable composite was better than the other two composites used because of increase in filler size and contain and also then process of conversion of the monomertothepolymerstagewhich acceleratesthepolymerization reaction was found to be more in packable composite which improved depth of cure of packable composite.

Kraig S. Vandewalle, Sara A. Dixon, Jeffery Casey, Wen Lien, Emily T. Ibarra (2013) stated that, SonicFill showed low shrinkage, moderate fracture toughness and flexural modulus, and high flexural strength because sonic energy is applied to the hand piece with five different levels of flowability, the modifier causes the viscosity to drop (up to 87%), increasing the flowability of the composite with helps in proper adptation to cavity wall.When the sonic energy is stopped, the composite returns to a more viscous, non-slumping state for carving and contouring, all this result in increasehaedness.

The results of the present study are contradictory to the study done by **Choi, K.K et al (2000).** These authors found that the microhardness of packable composite resins (Filtek p60) showed a significantly higher microhardness than packable composite (Surefil) in all light activation systems in all depth intervals because of inter- locking particle technology. This technology uses a precisely engineered mixture of different-sized filler particles. When these large fluoride-infused glass particles are packed together, the larger particles mechanically interlock with the smaller particles which lead to improvement of the depth of cure and microhardness of packable composite resins (Filtek p60).

The result of the present study are contradictory to the study done by **Albers HF (2002)** the author found that Filtek p60 (in all subgroups) exhibited a statistical higher VHN than Surefil. This is due to the optical properties of resins (optical

transmission coefficient), which vary with the material composition (particle type, contents, morphology and size). The Filtek p60 particle type the contain zirconium which is harder, it diffuse light as it penetrate and increases the strength and microhardness of material. In our study, Group II packable bulk fill composite containing filler loading of "83.5% (wt)" showed increased microhardness.

The result of the present study are not in agreement with the study done by **Arikawa H et al (2007)**. Authors concluded that packable composite resins Filtek p60 (containg filler size 0.19-3.5μm average: 0.6 μm) showed a significantly higher microhardness than packable composite Surefil (containg filler size 0.04-10 μm average: 0.8 μm) since, microhardness depends on the depth of cure which is related to the size of the incorporated fillers. The filler particles in the resin-based composites scatter light, materials with smaller filler particle size showed sharper angular distribution of diffuse light, indicating that less light was scattered within the material and light scattering is increased with increase in filler particle diameter, the larger scattering caused by larger fillers resulted in higher transmittance loss in comparison with materials containing smaller filler particles**.**

The result of the present study are not in agreement with the finding of **Filho JDN et al (2008).** The authors stated that the microhardness of different packable composite resins and the VHN values of Filtek p60 was more than Surefil. The organic matrix composition, the polymerization level varies according to the amount of the monomers and oligomonomers present in the composite resins, in Filtek p60 the majority of the TEGDMA has been replaced with UDMA which is an aliphatic high-

molecular weight monomer that gives the polymer chain great mobility and the crosslink density of the polymeric matrix, therefore, microhardness**.**

The present in vitro study suggested that amongst all the groups tested, the mean micro-hardness was maximum in Group II packable bulk fill composite containing filler loading of "83.5% (wt)", followed by Group I packable bulk fill composite containing filler loading of "80% (wt)"

LIMITATIONS

- This is an in vitro study therefore it is possible that the inferences from the study might not co-relate completely with
- The microhardness was assessed using the vickers microhardness test , which is an indirect method, so direct methods are required to assess the degree of conversions.
- Measurements were recorded at the centre of specimen, and peripherally measurements were not recorded. So, measurements may vary at centre and at periphery of specimen.
- The microhardness was recorded after 24 Hrs but long term evaluation need to be analysed, because further change in the microhardness value of specimen can occur which was not recorded.
- Even though critical care was taken at every step, human error cannot be ruled out from the final result.

CONCLUSION

When comparing all the three groups it was found that Group II packable bulk fill composite containing higher filler loading (83.5% wt.) has the greatest micro hardness followed by Group I packable bulk fill composite containing filler loading (80% wt.).

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