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Research Paper

Comparitive Evaluation of Wear Resistance of Novel Posterior Composites-An in Vitro SEM Study

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ABSTRACT : *Wear resistance of composite restorative materials has been a major concern especially when used as a posterior restorative material. The purpose of this study was to evaluate and compare the wear resistance of novel composites materials by three body wear simulation method. The four posterior composites evaluated in the study were categorized as, group 1filtekz 350, group 2 - tetricevoceram group-3 filtek z250, group 4 surefil. The wear instrumentation used was a Dry abrasion tester, customized with stainless steel wheel, and distilled water was used as lubricant. The initial weight of each specimen was measured in milligrams using a highly sensitive physical balance. Material wear was measured by the loss of material at every 5000 cycles from 5000 cycles till 30000cycles. The wear pattern was analyzed with scanning electron microscope. One-Way ANOVA followed by TUCKEYS post hoc test was used for statistical analysis at the 0.05 significance level The mean weight loss values at the end of 30000 cycle was found to be highest in group 3 and weight loss values was found to be lowest in group1 and these findings were confirmed by scanning electron microscope findings*
Keywords: *Wear, Scanning Electron Microscope, Weight Loss, Composites, Physical Balance*

I. INTRODUCTION

The ultimate goal of dental restoration is to replace the biological, functional, and esthetic properties of healthy tooth structure. [1]. As an alternative to amalgam, the early attempts to place composites in posterior teeth had only limited success, because of insufficient material properties. The most important factor that limits the usage of composites in posterior area is that they do not have enough resistance to wear and mastication strength. [2]

Wear of dental composites include diverse phenomena can be related to either material or clinical factors. Material factors includes filler particle size, content, shape, hardness, inter particle spacing, silane coupling agent, and the nature of matrix.[3] The clinical factors includes etching ,bonding, degree of cure, intensity, type, and placement of the material.[4] Wear resistance of restorative materials is important for clinical longevity, aesthetics, and resistance to dental plaque.[5] To improve wear resistance of posterior resin composites, various modifications have been made in the filler technology and resin chemistry, for minimizing filler exfoliation during wear.[6]

Developments in the filler technology have led to significant reduction in filler size, and improvements in filler packing, reducing the wear and degradation associated with polymer matrix.[7] Microhybrid composites combines the strength of traditional composites and esthetics of micro fine fillers.[8] Nanocompositess are relatively new generation of composites that has a combination of nanofillers and nanoclusters.[9] ,exhibit higher surface quality as well as increased wear resistance.[10]Matrix composition is a significant factor in abrasive wear. Several innovative changes have been made in the resin matrix chemistry, since the advent of traditional resin composites.

The aim of the present in vitro study was to evaluate and compare the wear resistance of four posterior resin composite materials using three body wear simulation method. [11]

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1.1 Objective

The objective of the present in vitro study was to evaluate and compare the wear resistance of four posterior resin composite materials namely a nano hybrid composite (*z350*) nano hybrid composite tetric evoceram , micro hybrid composite (z250) and Packable composite –*sure fill*

1. By measuring the weight loss using a highly sensitive physical balance at various number of cycles from 5000-30,000 cycles.
2. To characterize wear surface by scanning electron microscope, at the end of 30,000 cycles

II. MATERIALS AND METHODS

The four posterior composites evaluated in the study were categorized as Group 1 Filtekz 350 Xt, Group 2 -Tetric Evoceram, Group 3 Filtekz 250, Group 4 - Surefil. [Fig-1] A custom jig was made with a square metal block of following dimensions- 25mm length, 25mm width and 4mm depth. **[Fig-1]** The resin composite material was placed incrementally in 2mm depth using a custom made teflon instrument and polymerized according to the manufacturer's instruction. **[Fig-2]**After the placement of second increment, the mold spaces were covered with acetate strips, the composites restoratives were then light polymerized according to manufacturer's instructions.

After light polymerization, the acetate strips were discarded. To avoid, discrepancies associated with rotary finishing and Polishing procedures, acetate strips was used for finishing composites. **[Fig-3, 4]** The samples were then stored in distilled water for 7 days. The specimens were subjected to three body wear test. The wear instrumentation used was a Dry abrasion tester, (DUCOM TR 50 BANGALORE) customized with stainless steel wheel, and distilled water was used as lubricant. Test instrument was designed such that a flat test sample is pressed radially against a wheel with a force of 20N. Abrasive media was introduced into the contact area between the sample under test and the wheel such that the wheel carries the abrasive media between the sample and the wheel creating a three body wear. The abraded material was collected in a chamber, positioned below the abrading wheel.[**Fig-5,6]**

The initial weight of each specimen was measured in milligrams using a highly sensitive physical balance. (METTLER DEVICES) Material wear was measured by the loss of material at every 5000 cycles from 5000 cycles till 30000cycles.The mean weight loss was calculated from initial weight from 5000-30,000 cycles at an interval of every 5000 cycles and tabulated. The mean weight loss was calculated from previous weight and tabulated and subjected to statistical analysis. The wear surface was analyzed with Scanning electron microscope (HITACHI) to characterize the swear pattern

Fig-1

Fig-2

Fig-3

Fig-4

Fig-5

Fig-6

III. RESULTS

Wear was estimated by calculating the weight loss in milligrams from each sample with n (6) after 5000 cycles till 30,000 cycles at an interval of 5000 cycles. Data's were tabulated in (TABLE 1)

Mean and standard deviations were estimated from the samples with n (6) for each study group. The results of the present study were subjected to statistical analysis to interpret the significant differences in weight loss between 5000-30000 cycles, within each group and also between the groups**.** One-Way ANOVA followed by Post Hoc Tuckey's test was used for statistical analysis in the present study. All statistical analysis was done at the 0.05 significance level. SPSS version 16.0 was used to perform all statistical analysis.

The inter group analysis showed The mean weight loss values at the end of 30000 cycle was found to be highest in GROUP4 and weight loss values was found to be lowest in GROUP 1 With significance level of 1%.The intra group analysis showed The mean weight loss values was found to be highest in all the groups at the end of 30000 cycles and the mean weight loss values was found to be lowest in all the groups at the end of at 5000 cycles with significance level of 1%.

Scanning Eletron Microscope Image For Group1

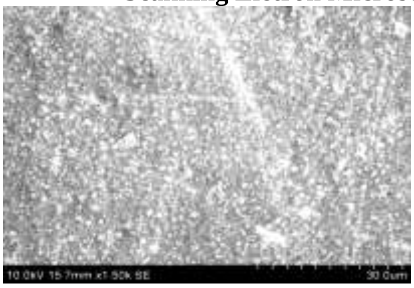
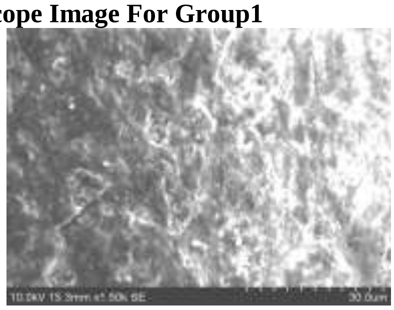

Image Before Wear Test- (Un Worn Area   At The End Of 30,000 Cycles (Worn Area)

Scanning Eletron Microscope Image For Group2

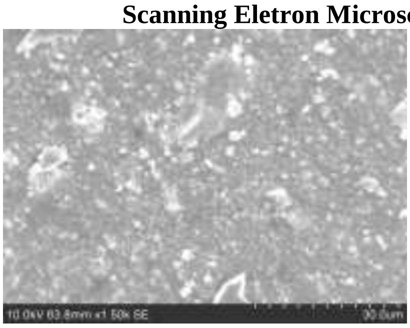
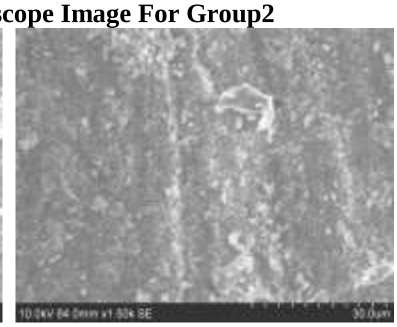

Image before Wear Test- (UN Worn Area   at the End of 30,000 Cycles (Worn Area)

Scanning Eletron Microscope Image For Group3

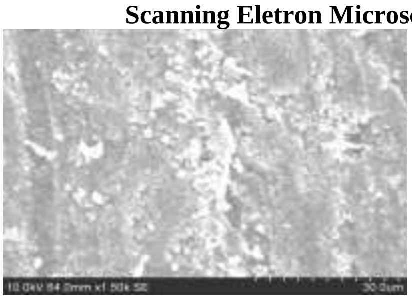
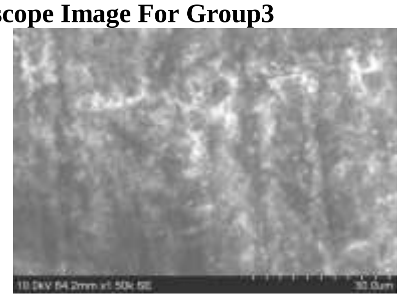

Image before Wear Test- (UN Worn Area   at the End of 30,000 Cycles (Worn Area)

Scanning Eletron Microscope Image For Group4


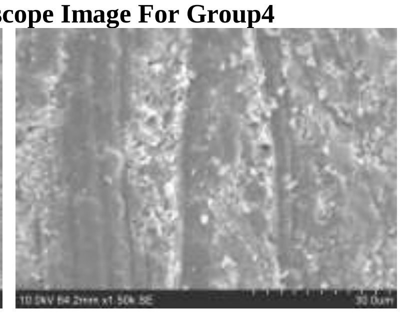

Image before Wear Test- (UN Worn Area   at the End of 30,000 Cycles (Worn Area)

Table 1; Mean Weight Loss In Milligrams From Intial Weight At Various Cycles

MATERIALS		NUMBER OF CYCLES					
		5000	10000	15000	20000	25000	30000
GROUP-1 FILTEKZ350	MEAN	27.83	54.67	82.5	109.5	139.17	166.67
	SD	±3.312	±5.428	±8.270	±11.274	±13.13	±16.170
GROUP-2 TETRICEVOCERAM	MEAN	58.5	114.17	171	226.83	281.67	340
	SD	±4.370	±8.134	±11.165	±14.770	±18.73	±22.724
GROUP-3 FILTEKZ250	MEAN	64.1	127.1	188	247.67	310.83	376.17
	SD	±4.875	±6.812	±6.892	±7.886	±8.329	±10.852
GROUP-4 SUREFIL	MEAN	78.67	156.I2	230	307	381	462.83
	SD	±4.457	±8.989	±14.851	±19.708	±23.723	±23.121
P VALUE	0.000 **	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

IV. Discussion

Wear resistance of composites as a posterior restoration is essential, for the longevity of restorations [12] the aim of the present study was to evaluate the three body abrasive wear resistance of four different posterior resins composite, which have been recently introduced into the market, using Dry abrasion tester. A three body abrasion test was done in this study because; ranking of composite restoration with three body abrasion tests simulated the clinical environment better than the two body abrasion tests. [13]

In the present study, the wear instrumentation used was a Dry abrasion tester, (DUCOM TR 50 BANGALORE) customized with stainless steel wheel, and distilled water was used as lubricant. Test instrument was designed such that a flat test sample is pressed racially against a wheel with a force of 20N. Abrasive media was introduced into the contact area between the sample under test and the wheel such that the wheel carries the abrasive media between the sample and the wheel creating a three body wear. [4].The sample was cleaned with acetone and then dried. Its initial weight was determined with a high precision digital balance (0.1mg accuracy) before it was mounted in the sample holder. The abrasives were introduced between the test specimens and rotating abrasive wheel composed of stainless steel wheel.

In this study ***standardization*** of material was made such that all materials used were of shade A and the specimens were made with a square shaped jig having internal dimension of 25 mm length, 25mm width, 4mm depth ***according*** *to ASTMG 65* guidelines for abrasion testing.[15] In accordance to the study by **Yap et al** to avoid discrepancies associated with rotary finishing and polishing procedures cellulose acetate strips were used to cover the specimens and glass slide was placed over the molds, to get a smooth finish.[16]

Based on the recommendations made by ***Yap*** **et al**, the composites were light polymerized according to manufacturers instruction, using a spectrum curing light .The mean intensity of the curing light was set in the unit as 450~ 10 mw/cm.[2] Distilled water was chosen as the storage medium, one week period of storage time was recommended by **Yap et al** for post curing to occur and for the dissolution of all leachable filler components from the cured materials.[17]

In the present study, according to the recommendation made by Condon and Ferracane in 1997, the specimens were subjected to a maximum period of 30,000 cycles, an amount which procedures roughly the same amount of wear which occurs during six months of in vivo service.[10] The other parameters in the present study was designed based on the reports of *Yap et al* a contact stress of 20 N was used as counter body for performing the abrasive wear test.[18] A stainless steel wheel was used, because enamel and enamel like antagonists tend to polish composite surfaces, producing little wear. Softer counter body materials like stainless steel are abraded by the inorganic fillers, producing a rough contact surface, which wears the composite matrix. Distilled water was used as lubricant, since it has been shown to produce greatest wear for most composite materials. [5]

According to Yap, abrasive forces causes loss of material from the surface, so difference in weight was considered as the parameter to assess wear. *According to the American Standard for Abrasion testing* the amount of wear is determined by weighing the specimens before and after testing [19]. he filler particle size for Group-1 FILTEK Z 350 was 20 nm GROUP 2 tetric evoceram was 0.47 (nm), GROUP -3 (FILTEK Z 250) was0.7 (μm) ,GROUP 4 (SUREFIL) was 0.8 (μm) .

The weight loss obtained as a measure of wear resistance for the four composites at the end of 30,000 cycles were follows. *GROUP 1 (FILTEK Z 350) < GROUP 2 TETRIC EVOCERAM) < GROUP -3 (FILTEK Z 250)) < GROUP 4 (SUREFIL)*The results of this study showed, that decrease in filler particle size leads to decreased weight loss, which was also seen in a study by *Lim et al*.According to that study, dental composite containing larger filler particles have good resistance to attrional wear, but have high abrasive wear rates, resulting in loss of anatomical form.[20]

According to Nagarjan et al filler particle size has a major role on wear properties of dental composites. Previous studies showed that filler size plays an influencing factor in wear resistance of material.[21] High wear rates are related to larger fillers in composite materials. Similar results were seen in the present study even with micro and nano sized filler particles. The results of the present study was in agreement with study by Cleland et al. in which they said that decreasing the particle size and increasing the percentage of filler volume, reduces the composite wear [22] Group 1 (filtekz350) < Group 2 < Group 3) < Group 4 (Surefil)

Lamberechts et al showed that filler particles situated very closely protect the softer resin matrix from abrasive thus reduces wear [4]Ferracane et al showed that abrasion takes place through gradual removal of the resin matrix this eventually leaves the filler particles unsupported and susceptible to exfoliation.[23]The results of the present study, has shown that Group -1 FILTEKZ350 had lower loss of material than other groups evaluated in this study, which was also seen in a study by Jorgenson's that composites "with small particles resist abrasion by protection mechanism in which thin expanses of resin are protected from abrasive forces by the presence of more closely spaced filler particles.[24] Nano composites due to modified filler technology have lesser material removal from the surface than from conventional hybrid composites.[25] .The Overall comparison between groups for weight loss revealed group1 (filtek z 350) showed the least weight loss followed by group2 group-3 and group4 At the end of 30,000 wear cycles, with a gradual increase in weight loss for all the groups from 5000- to 30,000 cycles

At All Intervals Group -1 Filtek Z350 Had The Least Weight Loss And Group-4 Surefil Had The Maximum Weight Loss

According to sarkar wear, as a micromechanical surface interaction, cannot be observed directly. Wear has to be deducted from indirect evidence, such as wear rates, micro structural changes or wear debris type. Deductions were made in this study from the wear measurements and the micro structural features of the worn composite specimens using scanning electron microscope.[26]

The wear performance of composites can be partially be explained by their microstructure of wear track area. In Group-1 the simultaneous loss of both phases, caused less changes, maintained a relatively smooth surface and lesser filler exfoliation due to their unique filler arrangement. protected the matrix from the wear which was evident from their micro structure, than the other Groups. Large voids were observed, especially with Group -4 Surefil, and this can be associated with the exfoliation of the large barium fluoro alumino borosilicate glass particles that have a mean diameter of 5.2 μm. Filler displacement and micro cracking were more obvious around the large fillers in Group-4 than other groups. The aim of the present study was to assess the loss of material in weight, which showed a relation to the filler particle size, the results indicated a decrease in wear resistance with an increase in filler particle size and increase in filler volume.

V. CONCLUSION

From the results of the present study it can be concluded that**,** Particle size plays a major role on the wear resistance of dental composites.FILTEKZ-350 a nano hybrid composite with a filler particle size of 5-20nm revealed least weight loss at the end of 30000 cycles when compared with other newer posterior resin composites namely silorane, ormocers and packable composites used in this study

The scanning electron microscope findings of the wear surface at the end of 30,000 cycles for FILTEKZ350 revealed a relatively, less filler exfoliation and changes in the matrix than the other materials and maintained a smooth surface. Within the limitations of the present study, by correlating the values of mean weight loss, mean surface roughness, along with scanning electron microscope findings it can be concluded that. FILTEKZ 350 a nano hybrid composite material showed better wear resistance when compared with the other posterior resin composites evaluated in this study

From this investigative study it can be summarized that the clinical performance and longevity of a posterior resin composite could be enhanced by a scientific decision making in selection of the materials based on compositional factors such as filler particle size ,filler loading, color stability, wear resistance and polymerization shrinkage.

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