The effect of different finishing and polishing systems on surface roughness of new low polymerized composite materials (An in vitro study)

Mustafa R. Abdurazaq, B.D.S. [1]
Ali H. Al-Khafaji, B.D.S., M.Sc.D. [2]

ABSTRACT

Background: Adequate finishing and polishing of resin composites is a prerequisite for high-quality esthetics and enhanced longevity of resin-based restorations. Finishing and polishing of resin composites are important procedures in restorative dentistry. Finishing refers to gross contouring of a restoration to obtain the desired contour. However, polishing refers to smoothness as well as to reduction of the scratches created by the finishing instruments.

Materials and methods: Four types of composite materials where used in this study, FiltekP90 (3M ESPE, St.paul, U.S.A), Tetric Evoceram (Vivadent, Schaan, Liechtenstein), FiltekZ250 (3M ESPE, St.paul, U.S.A), FiltekP60 (3M ESPE, St.paul, U.S.A), also two polishing systems which are: Optrapol (Ivoclar Vivadent) and Enhance (Dentsply) and one Silicone carbide finishing paper. A total number of 160 disc shaped specimens were produced in a circular steel molds with a circular hole in its center , with a diameter of (10×3mm), specimens where divided into four groups of 40 specimens each (10 samples from each composite type) according to the finishing/ polishing protocol used as follows Group A: control without finishing and polishing. Group B: polishing using optrapol polishing system. Group C: polishing with Enhance polishing system. Group D: finishing only with silicone carbide finishing paper(600 grit). Except for the control group Specimens first are finished using silicone carbide paper 600 grit for obtaining a baseline surface roughness before the application of polishing systems, the At the completion of the finishing and polishing instrumentation, the specimens were ultrasonically cleaned in an ultrasonic unit with distilled water for two minute. The surface roughness was measured by using a portable surface roughness tester (SRT 6210).

Results: The result showed that all the composite materials under control group that cured using mylar strip exhibited the least surface roughness values (best smoothness). All the composite materials produced smoother surface when polished with optrapol system than with Enhance system. For the silicone carbide finishing paper we found that all the materials produced high surface roughness values than with other finishing and polishing systems and there was no significant difference between the composite materials.

Conclusion: FiltekP90 exhibited the smoothest surface finish compared to the other composite materials used in this study while FiltekP60 exhibited the roughest surface finish compared to the other composite materials used in this study.

Key words: Finishing and/or polishing of composite, Surface roughness, Roughness tester, diamond polishers. (J Bagh Coll Dentistry 2013; 25(2):24-30).

INTRODUCTION

Finishing and polishing of resin composites are important procedures in restorative dentistry. Finishing refers to gross contouring of a restoration to obtain the desired contour. However, polishing refers to smoothness as well as to reduction of the scratches created by the finishing instruments [1].

Survival of bacteria in the oral cavity is dependent upon adhesion to hard surfaces, such as those of teeth, filling materials, dental implants, or prostheses [2].

It is widely accepted that the surface roughness of intraoral hard surfaces has a major impact on the initial adhesion and the retention of oral microorganisms: in detail rougher surfaces (crowns, implant abutments, and denture bases) retain more plaque than smoother ones [3].

Roughness has also a major impact on the aesthetic appearance and discoloration of restorations [4], Secondary caries, gingival irritation and wear of opposing and adjacent teeth [5].

In patients with less than adequate oral hygiene, variations in surface roughness of provisional restorations may be associated with onset of subclinical or even clinical inflammation [6]. On the other hand, a smoother surface of intraoral structures ensures patient comfort and facilitates oral hygiene [5].

Adequate finishing and polishing of resin composites is a prerequisite for high-quality esthetics and enhanced longevity of resin-based restorations.

A survey of published studies indicated that smooth, highly polished restorations present a host of advantages ranging from esthetics to survival: more esthetically appealing and easier to maintain than restorations with a more roughened surface [7], less susceptible to plaque accumulation and extrinsic discoloration and

(1) M.Sc. student, Department of Conservative Dentistry, College of Dentistry, University of Baghdad.
(2) Professor, Department of Conservative Dentistry, College of Dentistry, University of Baghdad.

improved mechanical propertie [8]. For resin composite restorations polymerized under a matrix strip, they tend to exhibit the smoothest surface; none the less, the marginal areas would still require finishing and polishing. On the latter procedure, several investigations have shown that removal of the polymer-rich, outermost resin layer is essential to achieving a stain-resistant, more esthetically stable surface [9].

On the other hand, Park et al, [10] found no differences in surface discoloration between celluloid strip-finished and the polished surfaces of microhybrid composites. Finishing and polishing requires sequential use of at least two—but generally more—instruments with gradually smaller abrasive particles. Apart from polyurethane-based finishing and polishing disks, fine diamond burs, rubberized resin- or silicon-impregnated abrasives, and polishing pastes are the most frequently used abrasives to obtain the desired glossy and smooth surface [11].The final polishing result depends on the filler size, shape, and loading in the resin composite. The larger the filler particles, the rougher the surface would be after polishing [12].

MATERIALS AND METHODS

A total number of 160 disc shaped specimens were produced in circular steel molds with a circular hole in its center, with a diameter of (10×3mm).The composite resin was loaded by injecting it directly from the tube in to the hole in order to reduce air voids**.** The material was condensed into the mold by Ash no.6 until it become intentionally overfilled.

The surface of the material was covered with a Matrix strip and covered with a glass slide. The molds were bulk-filled to slight excess, in order to produce a flat smooth surface and to prevent the formation of oxygen-inhibited layer on the surface of the samples [13].

A (200 gm) pressure has been applied for 1min. to expel excess material from the mold and to reduce void [14], each specimen was thoroughly light-cured through the application of the emitting tip of light curing unit directly on the top of the glass slide at a distance of about 1.2mm, which is the thickness of the glass slide and celluloid strip.

The resin composites were exposed by using an Astralis light-curing unit (Ivoclar Vivadent, AG, Schaan, Liechtenstein) at 560 mW/cm2 for 40 seconds. The polymerization of the disk was carried out on the top and bottom sides against the strip and glass plate and then for another similar amount of exposure but without the glass plates [13].

The hardened specimens were then removed from the mold and lightly finished manually at the periphery carefully using a steel cutter after 24 hours from the preparation [13].

Finishing/Polishing protocols and group organization

The composite specimens where divided into four groups of 40 specimens each (10 samples from each composite type) according to the finishing/ polishing protocol used as follows:

Group A: Control without finishing and/or polishing. In this group the samples where prepared and cured under transparent matrix strip only then stored for one week in ionized distilled water before surface roughness measurement.

Group B Finishing using Optrapol polishing system (IvoclarVivadent) (figure 1)**.** This system consist of diamond impregnated polishers (cups, discs and flames) , the polishing procedure should be performed wet under running water from a disposable syringe intermittently for 20 seconds to avoid heat generation .

The polishing is done using the polishing discs attached to a straight hand –piece at a speed of 10000 rpm, according to the manufacturer instructions.

Figure 1: Optrapol polishing system.

The hand-piece was attached to a surveyor for standardization and the sample was placed inside an acrylic mold for stabilization which is attached to an electronic balance plate by using super glue for standardization of pressure applied by the hand-piece on the sample, the polishing disk was brought into touch with the sample till it records a pressure range of (190-210) gm ,and the polishing was done under water spray from air triple syringe of dental unit, the polishing was made for 5 seconds with two second rest, then repeating the procedure to obtain a total of 20 seconds polishing time. The specimens were

thoroughly cleaned with distal water for 5 seconds then placed in an ultrasonic cleaner for two minutes removing detritus formed by polishing before measurement. [13].

Group C: Polishing with Enhance polishing system (Dentsply) (figure 2). This system is a three steps polishing system which involves a finishing foam wheel impregnated UDMA (Urethane dimethacrylate) with two polishing paste systems (Aluminum oxide—silicone dioxide finishing wheel-impregnated UDMA (40 µm), Prisma gloss polishing paste (fine and x-fine)). According to the manufacturer instruction no water spray was used, and every one of the three steps should be done intermittently for 20 second. The first step is polishing with the disc only without using of polishing paste, the next polishing step involved the placement of polishing paste of prisma gloss (fine) on the surface of the sample and proceeding with the same polishing time as mentioned above.

Figure 2: Enhance polishing system

The third step involved the placement of x-fine polishing paste according to the manufacturer instructions. We used glass ionomer cement spoon with one spoon volume for each application for standardization of paste volume.

After each step the sample was thoroughly rinsed with distilled water for 5 seconds and dried with air for 5 seconds before proceeding to the next polishing step [13].

Surface roughness of specimens ground on 600-grit SiC paper, specimens surfaces were manually ground for 10 seconds on wet 600-grit SiC paper under slight pressure with range of (190-210 gm) and in varying directions. After rinsing for 5 seconds and air-drying for 5 seconds using air jet. The samples are ready for surface roughness measurement [15].

Group D: Finishing with Silicone carbide finishing paper

The silicone paper is attached to an electronic balance to standardize pressure on the specimen. The pressure range was between 190 -210 gram.

Storage of the specimens

Each ten samples of each group were stored in a dark plastic container containing distilled water at room temperature for one week. The samples were covered by the water before starting the surface roughness measurement procedures [13].

Experimental Surface Roughness Measurement Procedures

At the completion of the finishing and polishing instrumentation, the specimens were ultrasonically cleaned in an ultrasonic unit with distilled water for two minutes.

The surface roughness was measured by using a portable surface roughness tester (SRT 6210) figure 3. The stylus traversed the surface of the specimen at a constant speed of 0.5 mm/second with a force of 4 mN and automatic return. Each specimen was traced in four line locations across the center of the finished and/or polished surface with an evaluation length of 4 mm.

All preparation of specimens and finishing/polishing procedures were performed by only one operator to minimize the bias. A calibration block was used periodically to check the performance of the profilometer.

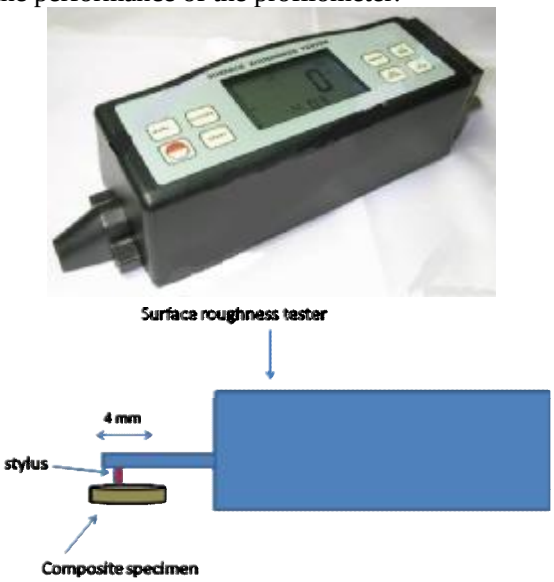

Figure 3: Portable surface roughness tester.

The surface roughness parameter values were monitored on a computer. The overall roughness of the surface, which is called roughness avarage (Ra), was measured. It is defined as the arithmetical average height surface component irregularities (the absolute distance of the roughness profile) from the mean line within the measuring length and the a critical roughness value is 0.2 µm [13].

RESULTS

The descriptive statistics which represent the mean, standard deviation (±SD) with the maximum (Max) and minimum (Min) values of the surface roughness of unpolished and polished samples (Ra) in micrometer (µm) are shown in Table 1.

The comparison between the four groups of control and polishing systems in surface roughness measurement.

One-way ANOVA test showed that there was a highly significant difference among all groups of control and finishing and/or polishing systems ($P < 0.01$). By performing the least significant difference (LSD) test, was performed for all the subgroups and the result showed that there was high significant difference of the control group and both the polishing systems groups and there was no significant difference among subgroups of the silicone carbide finishing group.

Table 1: The descriptive statistics (Means, standard deviations (SD) of roughness values in µm for all groups

Subgroups	N	Mean	±SD
A1	10	.2098	.06617
A2	10	.2792	.06137
A3	10	.2718	.07312
A4	10	.3291	.11558
B1	10	.2726	.06292
B2	10	.3549	.09261
B3	10	.3968	.08243
B4	10	.4792	.09176
C1	10	.5910	.05109
C2	10	.6374	.06308
C3	10	.7349	.07000
C4	10	.7538	.05271
D1	10	.8686	.12933
D2	10	.8315	.10188
D3	10	.8323	.07222
D4	10	.8328	.08668

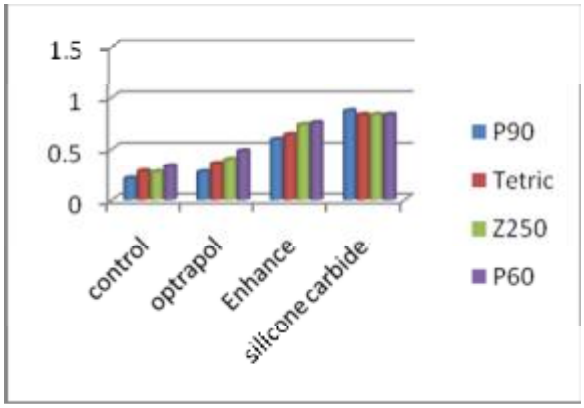

Figure 4: Bar chart showing mean values of surface roughness Ra of all subgroups.

DISCUSSION

Finishing and polishing of resin composite

Finishing and polishing of resin composite restorations are steps critical to enhance the esthetics and longevity of restored teeth [16].

As for the surface quality of resin composite restorations, it has been established that it is closely related to both the polishing procedure and inherent material characteristics such as size, hardness, amount of filler particles, and structure of the resin matrix [17].

The four types of composites used in this study:

Filtek p90; Filtek p60; Filtek Z250 and Tetric EvoCeram, were selected because they have different filler and resin matrix compositions as well as superior properties, as claimed by manufacturers, to be used as low-shrinking posterior restoratives.

They mainly differ in their inorganic component, the type of inorganic filler, the size of the particles and the extent of the filler loading vary widely among these materials in addition to difference in the resin matrix. These factors influence their polish-ability [18, 19].

Two different types of polishing systems were used in this study; Optrapol polishing system and Enhance polishing system.

They were selected because they differ in their abrasives; the first one has an aluminum oxide-silicone oxide abrasives, and the second one has diamond abrasives, so as to compare between the two components.

Purified distilled water was used as a storage medium because it simulates the wet oral environment provided by saliva and water. Saliva is a diluted fluid comprising of 99% water and the concentration of dissolved solids (organic and inorganic) are characterized by wide variations, both between individuals and within a

single individual. Due to these variations, water was used as the storage medium [20]

One week water aging was performed in the present study, because the dimensional changes in composite resins were the result of the shrinkage of the resin monomer during polymerization in the first week.

In the present study, pretreatment of resin composite surfaces was either as cured under a Mylar strip or "finished" with wet, 600-grit SiC paper. Finishing cured specimens with SiC paper of 600-grit (average particle size: 30 μm) was a reasonable procedure, since dental finishing instruments are often loaded with abrasive particles of this size or a similar grain size. Further, grinding on wet SiC paper bore the additional advantage of a finishing process that was easier to standardize than with rotating instruments [15].

Surface roughness of the control group (without finishing and polishing)

According to the study in comparison between the four main groups we found that all the composite materials under control group that cured using mylar strip exhibited the least surface roughness values (best smoothness). The surface roughness of polished composites was higher than unpolished controls, suggesting that polishing determines by itself as a surface damage factor. This may be due to the surface finish that was obtained by the mylar strip is a resin –polymer rich layer containing less fillers giving more smooth surface. This finding is in agreement with [13,15, 21, 22]**.** On the other hand this finding is in disagreement with [23]**.**This could be due to the difference in the type of method and polishing system used in the study.

Surface roughness of Finishing and polishing groups of composite

For the polishing systems there was a high significant difference between them for all the materials used, various surface defects can appear in materials, such as micro-cracks and irregularities, because of the removal of some of the surface particles during polishing, increasing the surface roughness of the restoration, composite surface roughness is basically dictated by the size, hardness, and amount of filler which influences the mechanical properties of the resin composites [19].

All the composite materials produced smoother surface when polished with **optrapol** system than with **Enhance** system. This system has diamond abrasives whereas **Enhance** utilizes aluminum oxide- silicone dioxide as abrasive particles. Diamond is always harder than alumina so it cuts evenly both the matrix and the filler parts of the composite giving less irregularities and more smooth surface, thereby, in this study, **optrapol** produces the smoothest surface on most of the materials . This could be attributed to the fact that diamond discs are less flexible as compared to the extremely flexible aluminum oxide discs. Another reason for the diamond discs giving better surface smoothness in the study over Aluminum oxide-silicone dioxide could be due to the non displacement of part of the composite fillers particles by Enhance. The diamond discs performed better because the fillers in composite are so their malleability promotes a homogeneous abrasion of the fillers and the resin matrix [24].Study by **Mitra et al** [25] also supported the concept of homogeneous abrasion. This finding is in disagreement with others because of different methods and materials used. [26]

Surface roughness after finishing with silicone carbide finishing paper

For the silicone carbide finishing paper we found that all the materials produced high surface roughness values than with other finishing and polishing systems and there was no significant difference between the composite materials. This may be due to the size of the abrasives (average particle size: 30 μm), so it cut the composite surface unevenly producing high irregularities and roughness, this finding is in agreement with [15].

Differences in surface roughness values of the different composite materials

According to this study, for the composite filling materials there was a high significant difference in (Ra) values this may be attributed to the differences in composition among the materials.

The occurrence of *in vitro* surface abrasion (wear and wear resistance) of resin based composites has been identified to be influenced by the filler size, morphology and distribution [27].Following the loss of the resin matrix at the surface of resin based composite restorations, protruding filler particles remain. Subsequently, the rate of wear was initially slow as the protruding filler acts as a 'protective shoulder' to the remaining resin matrix, whilst continued loss of the resin causes filler 'plucking' and surface void formation [28].The presence of larger fillers, such as those in traditional RBCs exhibit stress-induced 'tilting' and subsequent removal of protruding particles, resulting in increased surface roughness due to large pores and defects.

According to the findings of this study, for all the four main groups, **Filtek P90** yielded the lowest Ra values among all composite materials

except D1 after the finishing/polishing procedures. The lower surface roughness of these materials may be attributed to its composition. Among the materials investigated, this composites comprises low filler content by weight (76–77%), also it is characterized by a special resin matrix made up of silorane, which is polymerized cationically by a ring-opening expansion mechanism [29].This expanded network is based on oxirane and siloxane backbones. Siloxane exhibits a more stable chemical structure, as it is conjugated with a silicone atom Furthermore, it has a relatively smaller filler particle size (0.47 μm) that may also contribute to the low surface roughness value [29].

The posterior packable hybrid composite (**Filtek P60**), expressed the highest surface roughness among the materials examined. This material exhibited an average particle size of 0.6 μm with a range of 1 to 3.5 μm and a filler loading of 83% wt. It has been noted that the largest particles present in the composites contribute more to the surface roughness than do the average particle size [12].Additionally, it comprises UDMA and high molecular weight Bis-EMA (Ethoxylated bisphenol A glycol dimethacrylate) that form fewer double bonds resulting in a slightly softer matrix [12].

Another possible explanation could be related to the deficiency of coherence between the matrix and the fillers yielded from non-silanization of the latter. This may cause exfoliation of some filler particles as the weak resin matrix is worn away during finishing and polishing procedures. Dislodgment of larger filler particles is usually associated with preferential loss of the resin, which is unable to adequately stabilize these particles, causing detectable surface irregularities thereby increasing the Ra value [13].This was in agreement with others [30].

The **Filtek Z250** and **Tetri Evoceram** have intermediate roughness values: for **TetricEvoCeram** which is a Nano-hybrid RBCs, showed lower post-polishing (Ra) mean value than Filtekp60. This may be attributed to that, it contain a mixture of colloidal silica particles with a size distribution of 0.01-0.07μm in addition to micron-sized filler particles of 0.1-2.5μm, such as borosilicate, admixed with a methacrylate-based resin matrix [31].The inclusion of smaller filler particles as nano-size in the final formulation of the composites results in reduction of composite's shrinkage and improving their total mechanical properties [32].Additionally, materials reinforced with nano-sized filler particles and agglomerations exhibit distinct properties compared with conventional filler types [33].

The **Filtek Z250** which is microhybrid has almost the same composition of the Filtek p60 but it differs in that it has a silinated filler with less filler loading this lead to less (Ra) mean value than p60 .

REFERENCES

1. Lutz F, Setcos JC, Phillips RW. New finishing instruments for composite resins. J Am Dent Assoc 1983;107: 575–80
2. Sen D, Göller G, Isever H. The effect of two polishing pastes on the surface roughness of bis-acryl composite and methacrylatebased resins. J Prosthet Dent 2002; 88: 527-32.
3. Borchers L, Tavassol F, Tschernitschek H. Surface quality achieved by polishing and by varnishing of temporary crown and fixed partial denture resins. J Prosthet Dent 1999; 82: 550-6.
4. Cavalcante LM, Masouras K, Watts DC, Pimenta LA, Silikas N. Effect of nanofillers' size on surface properties after toothbrush abrasion. Am J Dent 2009; 22: 60-4.
5. Jefferies SR. Abrasive finishing and polishing in restorative dentistry:a state-of-the-art review. Dent Clin North Am 2007; 51: 379-97.
6. Janus J, Fauxpoint G, Arntz Y, Pelletier H, Etienne O. Surface roughness and morphology of three nanocomposites after two different polishing treatments by a multi-technique approach. J Dent Mater 2010; 360–8.
7. Yap AUJ, Wu SS, Chelvan S, Tan ESF. Effect of hygiene maintenance procedures on surface roughness of composite restoratives. Oper Dent 2005; 30: 99-104.
8. Lu H, Roeder LB, Lei L, Powers JM. Effect of surface roughness on stain resistance of dental resin composites. J Esthet Restor Dent 2005; 17: 102-9.
9. Ergücü Z, Türkün LS, Aladag A. Color stability of nanocomposites polished with one-step systems. Oper Dent 2008; 33: 413-20.
10. Park SH, Noh BD, Ahn HJ, Kim HK. Celluloid strip finished versus polished composite surface: difference in surface discoloration in microhybrid composites. J Oral Rehabil 2004; 31: 62-6.
11. Senawongse P, Pongprueksa P. Surface roughness of nanofill and nanohybrid resin composites after polishing and brushing. J Esthet Restor Dent 2007; 19: 265-75.
12. Ryba TM, Dunn WJ, Murchison DF. Surface roughness of various packable composites. Oper Dent 2002; 27: 243-7.
13. Marghalani Y. M. Effect of Finishing/Polishing Systems on the Surface Roughness of Novel Posterior Composites . J Esthet Restor Dent 2010; 22:127–38.
14. Cristina J, Christine M B W, Palma R. Micro-hardness of posterior composite resin at varying post irradiation time. J Oral Sci 2007; 15: 4.
15. Endo T, Werner J. Finger, Kanehira M, Utterodt A and Komatsu M. Surface texture and roughness of polished nanofill and nanohybrid resin Composites. Dent Mater J 2010; 29(2): 213–23.

16. Jefferies SR. The art and science of abrasive finishing and polishing in restorative dentistry. Dent Clin North Am 1998;42: 613-27.
17. Chung KH. Effects of finishing and polishing procedures on the surface texture of resin composites. Dent Mater 1994; 10: 325-30.
18. Turkun LS, Turkun M. The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. Oper Dent 2004; 29(2):203–11.
19. Choi MS, Lee YK, Lim BS, Rhee SH, Yang HC. Changes in surface characteristics of dental resin composites after polishing. Mater Sci Mater Med 2005;16(4):347–53
20. Huang C, Cheung G. Hygroscopic expansion of compomer and a composite on artificial gap reduction. J Dent 2002; 30: 11-9.
21. Giacomelli L, Derchi G, Frustaci A, Bruno O, Covani U, Barone A, Santis DD and Chiappelli F. Surface Roughness of Commercial Composites after Different Polishing Protocols: An Analysis with Atomic Force Microscopy. The Open Dentistry J 2010; 4, 191-4.
22. Borges AB, Marsilio A, Gani V, Rodrigues JR. Surface Roughness of Packable Composite Resins Polished with Various Systems. J Esthet Restor Dent 2004; 16:42-8.
23. Lohbauer U, Frank A Muller, Anselm Petschelt. Influence of surface roughness on mechanical strength of resin composite versus glass ceramic materials. Dental Mater 2008;24: 250–6.
24. Yap AU, Lye KW, Sau CW: Surface characteristics of tooth colored restoratives polished utilizing different polishing systems. Oper Dent 1997; 22(6): 260-5.
25. Mitra SB, WU D, Holmes BN: An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003; 134(10): 1382-90.
26. Gulati GS and Hegde RS. Comparative Evaluation of two Polishing Systems on the Surface Texture of an aesthetic material (nano-composite): A Profilometric Study. People's J Scientific Res 2010; 3(2): 17-20.
27. Schwartz JI and Söderholm KJM. Effects of filler size, water and alcohol on hardness and laboratory wear of dental composites. Acta Odontol Scand 2004; 62: 102-6.
28. Hu X, Shortall AC and Marquis PM. Wear of three dental composites under different testing conditions. J Oral Rehab 2002; 29: 756-64.
29. Eick JD, Kotha SP, Chappelow CC, Kilway KV, Giese GJ, Glaros AG, Pinzino CS. Properties of silorane-based dental resins and composites containing a stress-reducing monomer. Dent Mater 2007; 23: 1011-7.
30. Condon JR, Ferracane JL. Evaluation of composite wear with a new multi-mode oral wear simulator. Dent Mater 1996; 12(4):218–26.
31. Ivoclar Vivadent products (Grandio, Product Specification, 2006; Tetric EvoCeram, Scientific Documentation, 2006).
32. Condon JR and Ferracane JL. Reduced polymerization stress through non-bonded nanofiller particles. Biomaterials 2002; 23(18):3807-15.
33. Curtis AR, Shortall AC, Marquis PM, Palin WM. Water uptake characteristics of a nano-filled resin-based composite. J Dent 2008; 36:186–93.