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ESEM results

INFLUENCE OF STORAGE MEDIA AND POWER-TOOTHBRUSHING ON CONTEMPORARY RESTORATIVES SURFACE-ROUGHNESS

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ABSTRACT

Purpose: This study evaluated the surface-roughness of three resin-based restoratives after storage in different media and tooth-brushing. **Methods:** Fifteen discs were fabricated for each material: FiltekSupreme-Plus, nano-hybrid; KetacN100, nano-ionomer; and Filtek-LS, silorane-based. Discs were divided into three subgroups according to storage media: deionised water (control); lactic acid; and sodium-hydroxide, then stored for one week at 37°C and subjected to power-tooth-brushing abrasion for 100,000 strokes (representing 4.2yr clinical use). Ra values were determined by stereo- microscope 40X (Olympus DP10, SZ-PT, Japan) with software: Image J1.4.1 (NIH, USA). Representative ESEM images were also obtained. **Results:** storage media and toothbrushing abrasion significantly increased surface-roughness of all tested materials. However, there was no significant difference between mean Ra of Filtek-Supreme-Plus and Ketac-Nano which had highest mean Ra compared to Filtek-LS which showed significantly low-est mean Ra values. **Conclusions:** both the storage media and tooth brushing affected the surface roughness of all tested materials. Silorane-based restorative material exhibited more acid and abrasion resistance than methacrylate-based restorative materials.

INTRODUCTION

Marked improvements in restorative materials have occurred during the past decade. Recently, the public fascination in esthetic dentistry has dramatically increased and the importance of direct placement of esthetic tooth-colored restoratives is also increasing. Despite their success in this

respect, resin-based restorative materials still face some clinical problems and their longevity can be compromised, especially in adverse conditions of the oral environment^[1]. One of the problems that could affect the clinical performance of these materials is wear which could occur as a result of occlusion, chewing, tooth brushing or parafunctional activities like grinding and clenching

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as well as hostile chemical, thermal and biological components involved^[2]. Previous studies have reported that acidic challenge has detrimental effects on wear, surface and physical properties of glass ionomer cements and composite resins^[3-5]. Such erosive attack can induce, at least to some extent, the degradation of the matrix and fillers of restorative materials^[6, 7]. Thus the performance of a dental composite resin depends on filler type and amount, resin composition, filler-matrix bonding, and polymerization conditions. Filler levels, filler treatments, and degree of polymerization have been shown to influence wear. Fine fillers have been used to reduce inter-particle spacing to improve wear resistance. Moreover, the continuing action of tooth brushing could result in surface alterations of restorative materials making it more prone to plaque accumulation and soft tissue inflammation^[8]. As the tooth brush abrasion and erosion could have a synergistic effect on surface roughness of resin-based materials, therefore, the aim of this article is to investigate the effect of storage media and simulated tooth-brushing on surface roughness of some contemporary resin based dental restorations.

MATERIALS AND METHODS

Composite materials and storage media

Three direct filling aesthetic restorative materials were selected for this study; Filtek Supreme Plus (nanofill composite; Ketac N100 (resin-modified nanoionomer; and Filtek LS (Silorane based composite). Shade A2 was selected for all materials. The details of the restorative materials used are shown in table (1). The storage media used were deionized water (control), acidic medium (2ml lactic acid solution, at concentration of 0.02mol^{-1} at pH 2.7)^[4,9], and alkaline medium (20 mL of 0.1 N, NaOH at pH 13)

Specimen preparation

Fifteen discs (n=15) from each material were fabricated according to the manufacturer instructions. The restorative material was packed as one increment and pressed into a Teflon mould of dimensions; (3 mm diameter, 2 mm depth) using an appropriate instrument. Each mould was slightly over filled then covered with a glass microscope slide to achieve a smooth flat surface and extrude the excess material, then light cured for 40 seconds

TABLE (1) Materials used in the study

Material	Type	Composition	Fillers /Vol.	Manufacturer
Filtek Supreme Plus	Nanofilled resin composite	Bis-GMA, Bis-EMA, UDMA, TEGDMA	Nano silica and zirconia/silica nano-clusters (Particle size = 20–75 nm Cluster size = $0.6\text{--}1.4\mu\text{m}$, 59.5 vol %)	3M ESPE, Seefeld-Germany
Ketac N100	Resin-modified nanoionomer	Fluoro-alumino silicate glass(FAS), copolymer, a methacrylate modified polyalkenoic acid, HEMA, Deionized water	Two types of surface treated FAS nano-fillers (5-25nm) and nano-clusters (1.0-1.6) μm 69 % wt	3M ESPE, Seefeld-Germany
Filtek LS	Microhybrid resin composite	Silorane-based hydrophobic resin matrix Bis-3,4-Epoxy cyclohexylethyl-Phenyl-Methylsilane 3,4-Epoxy cyclohexyl cyclopolymethyl-siloxane, stabilizers and pigments	Silanized, fine Quartz filler, Yttrium fluoride ($0.1\text{--}2\mu\text{m}$, 55 vol %)	3m ESPE Seefeld-Germany

from both sides using LED light curing unit (blue phase, Ivoclar, Vivadent). The curing light was placed perpendicular to the specimen's surface at contact with the glass slide to ensure curing efficacy. Curing light intensity was measured at 620 mW/cm² and monitored with a light meter. The fifteen specimens of each restorative material were randomly distributed amongst three groups (n=5) according to the storage medium; deionized water, lactic acid and sodium hydroxide, then stored for one week at 37°C.

Power-toothbrushing apparatus[fig1]

Simulated tooth-brushing apparatus was used to perform tooth-brushing abrasion [10]. The apparatus consisted of a power toothbrush (Braun Oral-B CrossAction power Max 7500DLX, Braun GmbH Frankfurter Stabe 145 61476 Kronberg/Germany) which has a pulsating action added to an oscillating/rotational motion in order to realistically imitate real brushing of the restorative materials. A vertical load of 200g was fixed on the head of the toothbrush. Samples were fixed in a wax rim filled glass dish and were totally immersed in abrasive slurry containing 50 g of toothpaste and 100 ml of deionized water. Colgate Fluoriguard, Colgate Oral

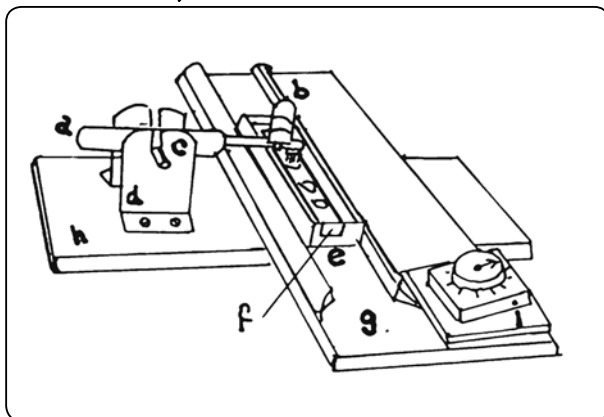


FIG. (1) Simulated power tooth brushing apparatus (a-power tooth brush, b-head load, c- tooth brush holder, d- metal ligature, e- glass dish, f- wax rim, g- movable wooden base, h- fixed wooden base, i- stop watch)

Care, Sydney, Australia). The power toothbrush was fixed in the toothbrush holder of the apparatus so that all the bristles are in contact with the specimen, and was moved in rotating action on the specimen at a frequency of approximately 374 strokes per minute at room temperature. Each experiment was allowed to run for 100000 strokes, representing 4.2 yr of clinical use (Wang et al; 2004) [11]. A new toothbrush and fresh slurry was used for each group. Following the test, the specimens were removed and rinsed with deionized water for ten minutes and then air-dried.

Surface roughness analysis

Ra is the universally recognized and most used international parameter of surface roughness. It is the arithmetic average of the peaks and valleys of a surface from the mean line. All specimens were subjected to surface roughness measurements using photomicrographs obtained by Stereo-microscope image analysis (Olympus DP10, SZ-PT, Japan, and software: Image J1.4.1 (NIH, USA) at 40X before and after storage and after tooth-brushing abrasion. Two samples from each group were randomly selected for environmental scanning electron microscope (ESEM) (Quanta 2000, FEI, Netherland with measuring program XT document). The ESEM offers three-dimensional images (height image). Representative images were obtained and compared.

Statistical analysis

Statistical analyses were performed using SPSS 16.0® (Statistical Package for Scientific Studies) for Windows (SPSS Inc, Chicago, IL, USA). Data were presented as means, standard deviation (SD) values. Repeated measures ANOVA was used to study the effect of material, storage media and brushing on mean surface roughness. The significance level was set at $P \leq 0.05$. One-way ANOVA was used to compare between percentages of change in surface roughness of different groups.

RESULTS

Surface roughness (Ra)

The mean, standard deviation (SD) values of Ra of the three materials are presented in table 2. ANOVA test showed that all variables and their interactions had a statistically significant effect on the mean Ra values.

TABLE (2) The mean, standard deviation (SD) values and results of comparison between the three materials with different storage media

Brushing	Material Storage media	F		N		S		P-value
		Mean	SD	Mean	SD	Mean	SD	
Before	De-ionized water	131.2	1.1	132.6	2.6	132.4	1.8	0.655
	Lactic acid	133.2 ^a	1.3	132.4 ^a	3.8	130.0 ^b	1.8	0.004*
	Na OH	133.9 ^a	2.3	132.0 ^b	1.0	131.8 ^b	1.5	0.026*
After	De-ionized water	134.8	0.7	134.3	0.3	133.6	0.8	0.152
	Lactic acid	138.2 ^a	1.6	138.2 ^a	2.0	131.8 ^b	1.2	<0.001*
	Na OH	138.3 ^a	1	138.8 ^a	1.5	135.1 ^b	1.2	<0.001*

*: Significant at $P \leq 0.05$, Mean with different letters is statistically significantly different according to Tukey's test results

Filtek LS (S) showed significantly lowest mean Ra values. No statistically significant difference was found between the mean Ra of Filtek Supreme (F) and Ketac Nano(N). (fig2).

As for storage media, the results showed that there was no statistically significant difference between mean Ra of Lactic acid and Na OH, which showed the statistically significantly highest Ra values. De-ionized water showed the statistically

significantly lowest mean Ra values (fig 3).

Regarding the effect of tooth brushing, in general, there was a statistically significant increase in mean Ra roughness after brushing (fig 4).

However, de-ionized water group, there was no significant difference between the three materials before and after brushing. In lactic acid, before and after brushing there was no statistically significant difference between Filtek supreme and KetacN;

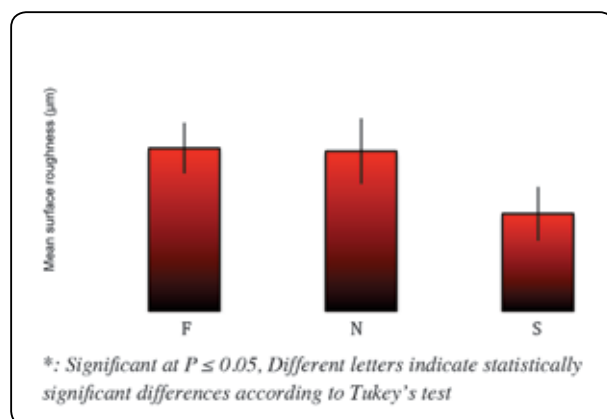


FIG. (2) Comparison between the mean Ra values of all restorative materials in different storage media

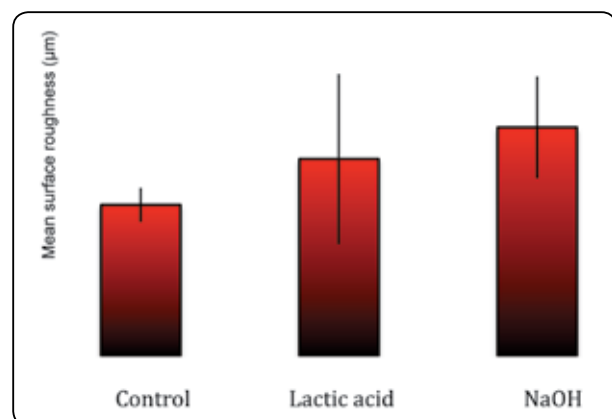


FIG. (3) Comparison between the mean Ra values of different restorative materials

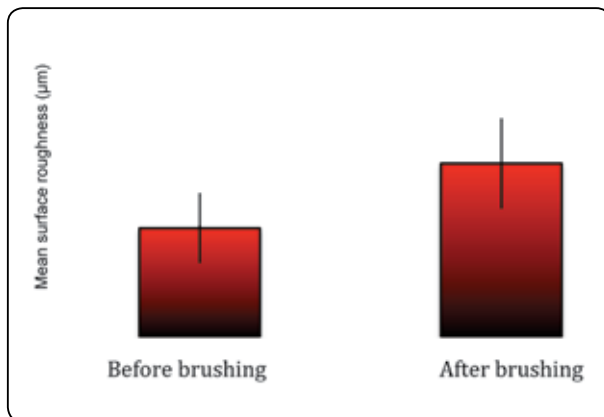


FIG. (4) Comparison between the mean Ra values of all restorative materials before and after brushing

both showed statistically significant highest mean roughness while Filtek LS showed significantly lowest mean roughness. On the other hand, in NaOH before brushing, Filtek Supreme exhibited the significantly highest mean roughness where no statistically significant difference was found between KetacN and FitekLS, which showed the

statistically significant lowest mean roughness (Table 2).

ESEM results

Samples of all materials immersed in de-ionized water exhibited a relatively smooth surface. Samples of Filtek Supreme immersed in lactic acid (fig 8) showed exposed filler particles and matrix degradation as well as irregularities and relatively rough surface when immersed in NaOH (fig 11). These irregularities together with voids were more pronounced after tooth brushing (fig 5a, 5b).

Ketac N samples immersed in lactic acid (fig 6) and NaOH displayed changes in surface morphology associated with voids and cracks which appear more aggressive after tooth brushing (fig 16, 17).

FilteK LS (Silorane-based composite) undergone mild surface changes when immersed in lactic acid and in NaOH. These surface changes were more apparent after tooth brushing (fig 7).

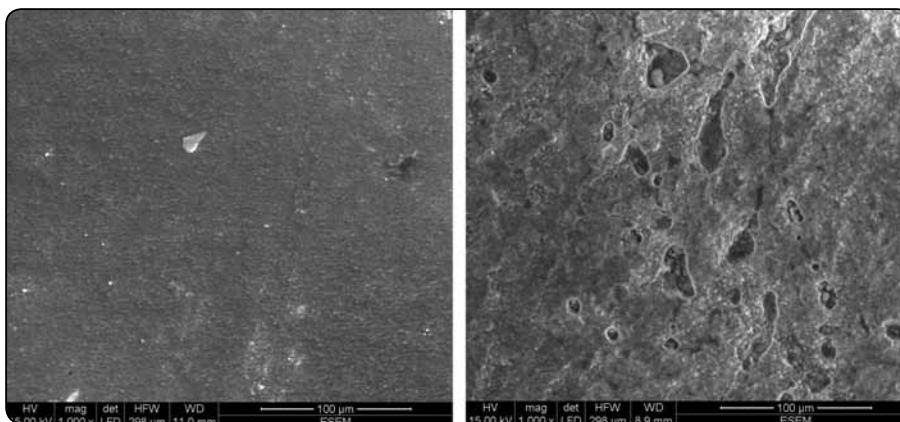


FIG. (5)

Filtek supreme (a. lactic acid, b. lactic acid + brushing)

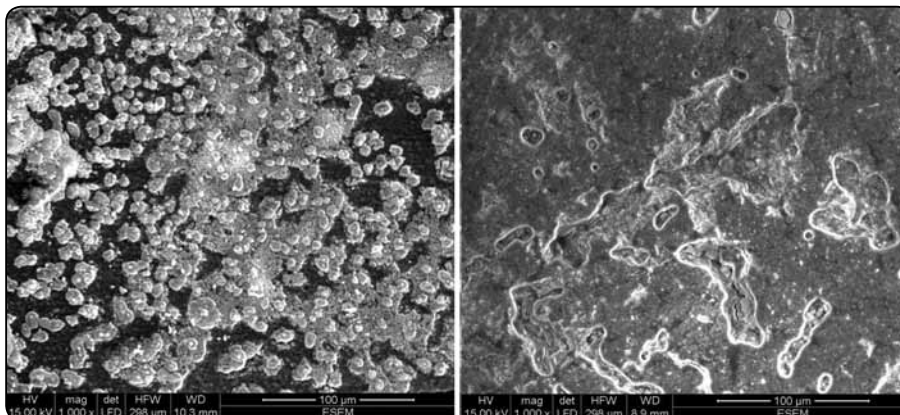


FIG. (6)

Ketaknano 2D, 3D (control-deionized water)

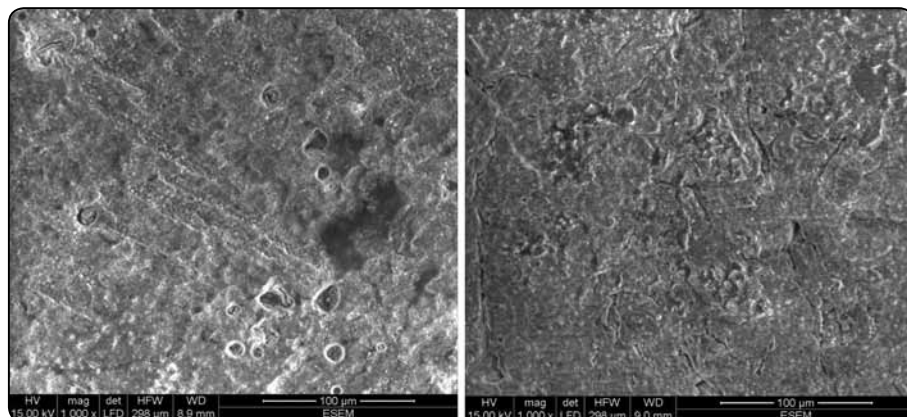


FIG. (7)

Filtek LS (deionized water, lactic. NaOH, brushing)

DISCUSSION

In the oral cavity, corrosive wear results from the chemical reactions taking place between the wear couple and the environment. This type of wear can be due to chemicals from drinks, food, microorganisms and saliva. In fact, on exposure to plaque acids, food simulating constituents and enzymes, resin composites undergo softening^[12,13], and roughening^[14]. Such circumstances may create continuous exposure of these materials to the chemical agents absorbed by adherent debris such as calculus and food particles. Consequently, lactic acid was used in this study being a basic constituent in the plaque encountered in active carious lesions^[15] and NaOH to mimic the *in vivo* degradation that arises from the reaction with OH⁻ which is enhanced by raising the PH^[16]. Generally, the corrosion is rapid initially and tends to slow down, or even cease, after a cohesive film has been formed on the surface^[17]. However, when this pellicle is removed by sliding of surfaces that meet or tooth brush and dentifrice, an unaltered surface is exposed and the chemical attack continues, thus resin composites may show an increased abrasive wear rate^[18]. Since the wear evaluation depends on time consuming clinical trials, accelerated laboratory tests are available^[19, 20]. To simulate *in vivo* aspects of tooth brushing conditions, such as load and stroke rate, brushing simulating device was designed^[10]. In the laboratory studies, the abrasion resistance of resin composites has been evaluated by profilometrical

tracings, weight loss, photomicrographs or 3D laser scanning^[5,20-22]. Specimens in this study were immersed in the respective solutions for one week before subjected to testing as previous studies reported that the greatest change in hardness of composites occurred within the first 7 days after exposure to food simulating liquids^[23].

Results of this study revealed a significant increase in surface roughness of Filtek Supreme and Ketac N glass ionomer as compared to FilteK LS (silorane-based composite) which exhibited significantly lower surface roughness. Moreover, there was a significant increase in surface roughness of these materials after exposure to lactic acid and NaOH in comparison to the control group (deionized water).

Corrosive wear, as described by Sarkar^[16], involves a sequence of events beginning with water absorption that causes hydrolytic degradation of silane coupling and reinforcing fillers in the resin based materials. The absorbed water diffuses internally through the resin matrix, filler interfaces, pores and other defects, slowly dissolving the filler particles, compromising their reinforcing effects. The result is the formation of a corroded subsurface layer that is softer and more porous that can be easily removed by toothbrush or mastication forces. Therefore, any alteration of the surface of resin-based materials at low PH should predominantly be due to hydrolytic degradation^[5,24]. Moreover, it was

reported that the TEGDMA content in resin matrix led to an increase in water uptake, having higher hydrophilicity [25]. Besides, Yap et al [26], reported that zirconia glass fillers were more susceptible to aqueous attack.

In addition, the exposure of resin composites to plaque acids and food simulating media have shown to undergo softening [12,27], loss of surface integrity [14,16], and increase of surface wear [5, 24, 28]. Our results are also supported by previous studies which concerned storage media in increasing the degradation process of resin based composites and glass ionomer cements [29-34]. Consequently, the results of this study could be related to the wear process encountered in resin-based materials (Filtek Supreme) and glass ionomer cement (Ketac N) leading to loss of the softer resin matrix and protrusion of filler particles thus increasing the surface roughness. Similarly, the dissolution of the polyacid salts in the glass ionomer matrix in aqueous environment enhanced by the chemicals could account for the increase in roughness. Although, some investigators claimed that composites with larger fillers presented higher weight loss and roughening than the finer materials [35,36], yet others reported that for a specific composition, finer particles dissolve faster than coarser ones to create more interfaces—one for the paths of ion diffusion [37]. Thus as evidenced by the present study, Filtek supreme and Ketac N still suffer from loss of particles probably due to the heterogeneity in the structure of the material as they combine two types of filler; nano-particles and nanoclusters in their composition (table 1).

On the other hand, Filtek LS (Silorane) presented significantly lower surface roughness after storage in lactic acid and NaOH. This could be attributed to the fact that silorane has a unique silorane based resin matrix. The silorane-based composites (SBCs) are obtained from the reaction of oxirane and siloxane molecules. They have low polymerization shrinkage due to the ring opening oxiranemonomer

and increased hydrophobicity due to the presence of siloxane species [38]. Many studies have confirmed the stability and insolubility of silorane in biological fluids such as aqueous solutions containing epoxide hydrolase, procaine liver esterase or diluted HCL [39-41]. Moreover, silorane is marketed as posterior composite having higher wear resistance than anterior composites.

In general, there was a significant increase in surface roughness of all the tested materials after tooth brushing with Filteksilorane being the least affected. However, this increase was insignificant in the control group (deionized water) as compared to lactic acid and NaOH storage media. This appears in the same line with Suzuki et al [42], who reported a uniform tooth brushing abrasion with Filtek supreme with nano-clusters protruding from the surface. Greater or minor alterations on the material surface after tooth brushing with dentifrice depends on the composition and inherent characteristics of composite resins [8, 11] as well as the tooth brushing variables such as time and load [43]. Correr [44], reported that the simultaneous challenge of corrosive and abrasive wear produced a generalized increase in wear of resin-based materials, likely because the superficial exposed layer of the material was abraded away as soon as it reached a critical degree of softening. This would be a continuous process occurring during lifetime of the restoration. This holds true specifically that, it was found that rough specimens of reinforced nanohybrid composite material immersed in cola solution had the lowest surface hardness [45]. The synergistic effect of tooth brushing abrasion and erosion on resin composites and glass ionomer cements was also confirmed by another study by Wiegand [46]. The minor effects of erosive and or abrasive attack on Filteksilorane in this study could be related to the unique matrix composition devoid of methacrylates.

The SEM images correlated well with the results of the surface roughness, showing that all materials presented surface changes after erosive or abrasive

attack depending on the storage medium and the material composition. These changes ranged from minor surface irregularities to severe changes associated with voids and cracks. Similar results were observed by other studies [11,16, 35, 46-48].

CONCLUSIONS

Under the effect of the variables of this study, it could be concluded that:

1. Storage media and power-toothbrushing abrasion increased the surface-roughness of all tested materials.
2. Nanoionomer (Ketac-Nano) and Nanofill (Filtek-Supreme-Plus) were more affected by erosive and abrasive challenge than Filtek LS (silorane based composite)
3. The novel network matrix of Silorane-based restorative provided the material with a stable chemical structure that is more erosion and abrasion resistant than methacrylate-based restoratives.

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3M/ESPE.

REFERENCES

1. Fernanda CP, Linda W, Paulo HP, Joao BD, Paulo AD, Rafael FD. Evaluation of roughness and mass loss of Flowable composites after simulated tooth-brushing abrasion. *Braz Oral Res* 2004; 18(2): 380-384
2. Turssi CP, Purquerio BM, Serra MC. Wear of dental resin composites: Insights into underlying processes and assessment methods- A review. *J Biomed Mater Res* 2002; 65(2):280-285
3. De Moor RJ, Verbeek RM. Effect of acids on the fluoride release profiles of restorative glass ionomer cements. *Dent Mat* 1998; (14):261-268
4. Nicholson JW, Millar BJ, Czarnecka B, Limanowska-shaw H. Storage of polyacid modified resin composite (compomer) in lactic acid solution. *Dent Mat* 1999; (15): 413-416
5. Chadwick RG, McCabe JF, Walls AW, Storer R. The effect of storage media upon the surface microhardness and abrasion resistance of three composites. *Dent Mat* 1990; (6): 123-128
6. Francisconi LF, Honorio HM, Rios D, Magalhaes AC, Machado MA, Buzalaf MA. Effect of erosive PH cycling on different restorative materials and on enamel restored with these materials. *Oper Dent* 2008; 33: 203-208
7. Lambrechts P, Goovaerts K, Bharadwaj D, DeMunk J, Bergmans, Peumans M, Van Meerbeek B. Degradation of tooth structure and restorative materials: A review. *J Dent* 2006; 261(9): 980-986
8. Chimello DT, Dibb RGP, Corona SAM, Lara EHG. Assessing wear and surface roughness of different composite resins after tooth brushing. *Mat Res* 2001; (4): 285-289
9. Nicholson JW, Czarnecka B, Limanowska-shaw H. A preliminary study of the effect glass ionomercement and related dental cements on the PH of lactic acid storage solutions. *Biomaterials* 1999; 20:155-158
10. Galal HE. A SEM study for evaluation of the combined effect of the simulated tooth brushing abrasion and various beverages on surface characteristics of class v esthetic restorations. *M Sc Thesis* 2009; Faculty of Dentistry, AlAzhar university, Cairo, Egypt
11. Wang L, Garacia FCP, De Araujo PA, Franco EB, Mondelli RFL. Wear resistance of packable resin composites after simulated tooth brushing test. *J EsthetRestor Dent* 2004; 16: 303- 315
12. Asmussen E. Softening of BISGMA-based polymer by ethanol and by organic acids of the plaque. *Scand J Dent Res* 1984; 92: 257-261
13. Yap AUJ, Low JS, Ong LFKL. Effect of food simulating liquids on surface characteristics of composites and polyacid modified composite restoratives. *Oper Dent* 2000; 25: 170-176
14. Turssi CP, Hara AT, Serra MC, Rodrigues AL Jr. Effect of storage media upon the surface micro-morphology of resin-based restorative materials. *J Oral Rehabil* 2002; 29: 864- 871
15. Hojo-Komatsa M, Okuda R, Takahashi N, Yamada T. Acid profiles PH of carious dentin in active and arrested caries. *J Dent Res* 1994; 73: 1853-1857
16. Sarkar NK. Internal corrosion in dental composite wear: Its significance and simulation. *J Biomed Mat Res* 2000; 53: 371-380

17. Sulong MZ, Aziz RA. Wear of materials used in dentistry. A review
18. De Gee AJ, Wendt SL, Werner A, Davidson CL. Influence of enzymes and plaque acids on in-vitro wear of dental composites. *Biomaterials* 1996; 17:1327- 1332
19. Momoi Y, Hirosaki K, Kohno A, McCabe JF. In- vitro tooth brush-dentifrice abrasion of resin modified glass ionomer cements. *Dent Mat* 1997; 13: 82-88
20. De Gee AJ, Pallav P. Occlusal wear simulation with the ACTA wear machine. *J Dent* 1994; 22:521-527
21. Turssi CP, de Magalhaes CS, Serra MC, Rodrigues AL Jr. Surface roughness assessment of resin based materials during brushing preceded by PH cycling simulations. *Oper Dent* 2001; 26: 576-584
22. Ferracane JL, Mitchem JC, Condon JR, Todd R. Wear and marginal breakdown of composites with various degrees of cure. *J Dent Res* 1997; 76: 1508-1516
23. Kao EC. Influence of food simulating solvents on resin composite and glass ionomer restorative cement. *Dent Mat* 1989; 5: 201-208
24. Yap AUJ, Chew CL, Ong LFKL, Teoh SH. Environmental damage and occlusal contact area wear of composite restoratives. *J Oral Rehabil* 2002;29: 87-97
25. Kawai K, Iwami Y, Ebisu S. Effect of resin monomer composition on tooth brush wear resistance. *J Oral Rehabil* 1998; 25(4): 264-268
26. Yap AUJ, Tan SH, Wee SS, Lee CW, Lim EL, Zeng Y. Chemical degradation of composite restoratives. *J Oral Rehabil* 2001; 28: 1015-1021
27. Ferracane JL, Marker VA. Solvent degradation and reduced fracture toughness in aged composite. *J Dent Res* 1997; 71:13-19
28. De Gee AJ, Wendt SL, Werner A, Davidson CL. Early and long term wear of conventional and resin-modified glass ionomer cements. *J Dent Res* 1996; 17:1613- 1619
29. Geurtzen W. Substances released from dental resin composites and glass ionomer cements. *Eur J Oral Sc* 1998; 106: 687-695
30. Gopferich A. Mechanisms of polymer degradation and erosion. *Biomaterials* 1996; 17: 103-114
31. Ortengren U, Andersson F, Elgh U, Terselius B, Karlsson S. Influence of PH and storage time on the sorption and solubility behavior of three composite resins. *J Dent* 2001;29: 35- 41
32. Ferracane JL, Condon JR. Rate of elusion of leachable components from composite. *Dent Mat* 1990; 6: 282- 287
33. Saterre JP, Shajii L, Tsang H. Biodegradation of commercial dental composites by cholesterol esterase. *J Dent Res* 1999; 78:1459- 1468
34. Sahmali S, Demirel F, Saygili G. the interactions of tooth-colored dental restorative materials with aqueous lactic acid. *Poly AdvTechnol* 2003; 14: 387- 391
35. deMoaes RR, Ribeiro DS, Klumb MM, Brandt WC, Correr-Sobrinho L, Bueno. In vitro tooth brushing abrasion of dental resin composites: packable, microhybrid, nanohybrid and microfilled materials. *Braz Oral Res* 2008; 22 (2):112-118
36. Condon JR, Ferracane JL. In vitro wear of composite with varied cure, filler level, and after treatment. *J Dent Res* 1997; 76: 1405-1411
37. Kalachandra S. influence of fillers on the water sorption of composites. *Dent Mat* 1989; 5: 283-288
38. Weinmann W, Thalacker C, Guggenberger R. Silorane in dental composites. *Dent Mat* 2005; 21: 68-74
39. Eick JD, Smith RE, Pinzino CS, Kostoryz EL. Stability of silorane dental monomers in aqueous systems. *J Dent* 2006; 34: 405-410
40. Yesilyurt C, Yodas O, Altintas SH, Kusgoz A. Effects of food simulating liquids on the mechanical properties of a silorane-based dental composite. *Dent Mat J* 2009; 28(3): 362-367
41. Palin WM, Fleming GJP, Burke FJT, Marquis PM, Randall RC. The Influence of short and medium-term waterimmersion on the hydrolytic stability of novellow-shrink dental composites. *Dent Mat* 2005;21, 852-863
42. Suzuki T, Kyoizumi H, Finger WJ, Kanehira M, Endo T, Utterodt A, Hisamitsu H, Komatsu M. Resistance of nanofill and nanohybrid resin composites to tooth brush abrasion with calcium carbonate slurry. *Dent Mat J* 2009; 28(6):708-716
43. Heintze SD, Forjanic M, Ohmiti K, Rousson V. Surface deterioration of dental materials after simulated tooth brushing in relation to brushing time and load. *Dent Mat* 2010; 26(4): 306- 319
44. Correr GM, Alonso RCB, Sobrinho LC, Puppini-Rontani RM, Ferracane JL. In vitro wear of resin-based materials- Simultaneous corrosive and abrasive wear. *J Biomed Mat Res* 2005; 78B(1): 105-114
45. Yanikoglu N, Duymus ZY, Yilmaz B. Effects of different solutions on surface hardness of composite resin materials. *Dent Mat J* 2009; 28(3): 344-351

46. Wiegand A, Roos M, Attin T, Buchalla W. Erosion and abrasion of tooth-colored restorative materials and human enamel. *J Dent* 2009; 37: (12): 913-922
47. Mayworm CD, Camargo Jr SS, Bastian FL. Influence of artificial saliva on abrasive wear and microhardness of dental composite filled with nano- particles. *J Dent* 2008; 36(10): 703-710
48. Gazal m, Kern M. The influence of antagonistic surface roughness on the wear of human enamel and nano-filled composite resin artificial teeth. *J Prothet Dent* 2009; 101(5): 342-349