# Effect of Dentifrices with Different Abrasives on the Surface Roughness of a Nano Composite Resins materials

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## Abstract

**Background:** to evaluate the effect of different dentifrices on the surface roughness of two composite resins (nanofilled-based and nanoceramic – based composite resins). **Materials and methods**: Forty specimens (diameter 12 mm and height of 2mm) prepared from different composite resin materials: Z350 (nanofilled composite, and Ceram-X (nanoceramic) .they were subjected to brushing simulation equivalent to the period of 1 year. The groups assessed were a control group brushed with distilled water (G1), Opalescence whitening toothpaste$^{R}$ (G2), Colgate sensitive pro-relief (G3) and Biomed Charcoal Toothpaste (G4). The initial and final roughness of each group was tested by surface roughness tester. The results were statistically analyzed using ANOVA and Tueky test at 0.05 significance level. **Results**: the surface roughness of the two tested composites brushed with the tested dentifrices was statistically higher than the roughness found in control group. Comparison among the three types of dentifrices showed that there was a statistically high significant difference in the surface roughness among all subgroups. Charcoal Toothpaste showed the highest surface roughness increase. **Conclusion:** Whitening dentifrices increase the surface roughness of dental composite thereby compromising its durability. Changes in composite depended on the material itself and the dentifrices used.

***Key words:*** *Abrasive, Composite resin, Dentifrices, Surfaces roughness, Whitening.*

## Introduction

Restorative materials have a lot of refinement in the mechanical, physical ,chemical properties and esthetics since their introduction [(1)].The composites produced with the aid of nanotechnology became popular as they offer longevity and better esthetic [(2)]. The recent advances in nanotechnology yielded nano-filled and nano-ceramic composite resin materials [(3)] Nanofill composites are composted of nanoclusters and nanosilica particles, the nanocluster fillers are collections of particles of nano-size and act as one unit to achieve higher filler strength and loading up to 80% of the resin matrix's total weight [(3, 4)]. The organically modified nanoceramic composite was developed by combining the nanotechnology and ormocer technology. This composite contains methacrylate-modified, silicon dioxide–containing nanofiller of 1.1–1.5 μm in size that account for 76% of total weight and resin matrix that is replaced by a matrix full of highly dispersed methacrylate-modified polysiloxane particles[(2, 5)].

The dental materials' surface texture has a major influence on plaque accumulation, wear, discoloration and the aesthetical appearance of direct and indirect restorations [(6)]. The surface roughness can wear out the opposite tooth enamel and reduce patient satisfaction and comfort [(7)]. Tooth brushing with the aid of dentifrices decreases dental caries but might damage the surface of resin composite restorations, making it rougher, and more liable to staining and plaque accumulations [(8)]. Different dentifrices are available in the markets to provide fast , easy and low-cost whitening effect [(9)].

The wear caused by tooth brushing depend mainly on tooth brushing habits, the quality of the toothbrush (hard, medium, or soft), and the dentifrice abrasive used [(10)] the abrasive particles are insoluble minerals designed to remove microorganisms, stains and disorganize the bacterial biofilm giving a whitened appearance [(11)]. In dentifrices, the most widely used abrasives are hydrated silica, calcium carbonate ,calcium phosphate, sodium bicarbonate and calcium pyrophosphate [(12)].

Other abrasives include tricalcium phosphate, hydrated alumina, calcium sulfate and sodium metaphosphate [11]. Most whitening dentifrices act on extrinsic stain removal as they do not contain bleaching agents [13].

Activated charcoal dentifrices have the capacity of adsorbing pigments, chromophores and stains responsible for the color change of teeth [14]. However, charcoal's shape, composition and sizes of its particles could be abrasive and may increase the surface roughness of composite resin [15]. Long-term tooth brushing with abrasive toothpastes, can compromise the esthetic appearance and hasten the degradation of the restoration [16].

This study measures the surface roughness of a nanofilled and nanoceramic composite resin after brushing with different types of dentifrices. The null hypothesis is that the dentifrices do not change the surface roughness of restorative material.

## Materials and Methods

The composites chosen for this study(Table 1) were the following: Z350 (nanofilled composite, 3M ESPE,St. Paul, MN, USA)and The Ceram-X (nanoceramic composite,Dentsply DeTrey, Konstanz, Germany).Three brands of dentifrices containing different compositions were used :Opalescence whitening toothpaste$^{R}$ , Colgate sensitive pro-relief$^{TM}$ and Biomed Charcoal Toothpaste.

### Specimens'preparation

Forty specimens (disks) were made for each tested composite (2 X 12 mm).The specimens were photoactivated using a light curing device 1200Mw/cm2 Blue curing light (Guilin woodpecker medical instrument, China) for 20 seconds of exposure time to both top and bottom surfaces, respectively according to the manufacturer's instructions. Samples were polished with rubber abrasive points(Politip-P ,ivoclar Vivadent Inc,US) and stored in distilled water at 37ºC for 24 hours, to stimulate clinical situation [4].

### Specimens' Grouping

Specimens made from tested composite were randomly divided into four groups ($n$ = 10) as follows: G1 – brushed with distilled water (control group); G2 –brushed with Opalescence whitening toothpaste$^{R}$;G3 – brushed with Colgate sensitive pro-relief; G4 – brushed with Biomed Charcoal Toothpaste. The composition of testing toothpastes presented in Table 2.

### Brushing

A specially designed brushing apparatus was designed by the Department of Conservative and Aesthetic Dentistry, College of Dentistry, University of Baghdad. The brushing apparatus was set to run a horizontal course of 3.8 cm at a speed of 356 RPM, and a load of 200 g [17]. For all groups, the samples were fixed and brushed with corresponding dentifrice for 60 minutes, simulating to 1 year of brushing. Toothpaste was mixed with distilled water (ratio 1:1) (1, 2,9). After tooth brushing, to avoid interference with the results, specimens were washed with water to remove all the remnants. Similar toothbrushs (Signal,Spain) fixed to the brushing apparatus supports and adjusted so that the bristles would come into contact with the specimens.

### Surface Roughness Measurements

A profilometer (Hand-Held Roughness Tester, TR200, Time Group Inc. China) were used to determine the initial surface roughness (prebrushing) and the post brushing surface roughness. Specimens measured by the profilometer in different three areas, then the average value registered as the mean Ra of the specimen. The mean Ra values were automatically measured by the profilometer.

**Table 1: composition and manufacturers of tested composite resins**

| Composite resin Composition Particle size | Composition Particle | size | Load percentage | Manufacturer |
|---|---|---|---|---|
| Z350 (Nanocomposite) | Matrix:Bis-GMA, Bis-EMA, UDMA,TEGDMA Filler: zirconia and silica | 20nm silica filler 4-11nm zirconia filler | 78.5wt% (63.3 vol%) | 3 M ESPE, Sumaré, SP, Brazil |
| Ceram-x: Nanoceramic Resin composite | Matrix: Methacrylate modified polysiloxane, dimethacrylate resin Filler: Barium-aluminum-borosilicate glass, methacrylate functionalized silicon dioxide (nano filler) | (0.04-4 um) 10 nm | 76 wt% (57vol%) | Dentsply/Caulk, Milford DE, USA |

**Table2: Description of dentifrice used in this study**

| Dentifrice | Composition | Abrasive product | Manufacturer |
|---|---|---|---|
| Opalescence whitening toothpaste[R] | Sodium Fluoride 0.25%w/w (Anticavity) Glycerin, Water (aqua), Silica, Sorbitol, Xylitol, Flavor (aroma), Poloxamer, Sodium Lauryl Sulfate, Carbomer, FD&C Blue#1 (Cl 42090), FD&C Yellow#5 (Cl 19140), Sodium Benzoate, Sodium Hydroxide, Sparkle (Cl 77019, Cl 77891), Sucralose, Xanthan Gum. | Silica, Mica (CI 77019), titanium dioxide (CI 77891) | Ultradent products, inc.south Jordan, UT84095,USA |
| Colgate® Snesative PRO-Relief™ whitening | Sodium Monofluorophosphate 1.1%w/w (1450 ppm F) Calcium Carbonate, Aqua, Sorbitol, Arginine , Sodium Lauryl Sulfate, Sodium Monofluorophosphate, , Cellulose Gum, Sodium Bicarbonate, Tetrasodium Pyrophosphate, Sodium Saccharin Benzyl Alcohol, Sodium Saccharin, Xanthan Gum, LimoneneCI 177891 | Calcium Carbonate Sodium Bicarbonate titanium dioxide (CI 77891) | Colgate-palmolive manufacturing (Poland)Sp .z.o.o., Al. Colgate 2,58-100 Swidnica, Poland . |
| Biomed Charcoal Toothpaste | Aqua, Hydrogenated Starch Hydrolysate, Dicalcium Phosphate Dihydrate, Hydrated Silica, Glycerin, Sodium Coco-Sulfate, Cellulose Gum, Aroma, Calcium Hydroxyapatite, Zinc Citrate, Tetrasodium Glutamate Diacetate, Benzyl Alcohol, Sodium Bicarbonate, Xanthan Gum, Menthyl Lactate, Xylitol, Carbon Black, Charcoal Powder, Cymbopogon Flexuosus Herb Oil, Mentha Piperita Oil, Ananas Sativus Fruit Extract, Maltodextrin, Cinnamomum Camphora Bark Oil, Cedrus Atlantica Bark Oil, Betula Alba Leaf Extract, Plantago Major Leaf Extract, Arginine, Sodium Hydroxide, Sodium Benzoate, Potassium Sorbate, Limonene, Citral | Hydrated Silica, Sodium Bicarbonate 3 types of charcoal (bamboo, activated charcoal and wood charcoal | Biomedglobal,russia |

## Result

Descriptive statistics: Means, minimum, maximum and standard deviation of composite roughness values were listed in Table 3. According to the table there was an increase in the means of roughness values for tested composite after brushing with tested dentifrices, also the Z350 had the lowest roughness values and Ceram x had the highest value.

Inferential statistics: ANOVA test used for all groups showed that there is a high significant difference ($p< 0.001$) in surface roughness values among the groups for each composite resin after brushing with distilled water or different dentifrices which show a high significant difference in surface roughness Ra values among the tested composite materials as shown in Table 3

**Table 3: Descriptive and ANOVA test among the three tested composite**

| Descriptive Statistics | | | | | | | ANOVA | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | N | Minimum | Maximum | Mean | Std. Deviation | Mean Square | F | p-value | SIG |
| Z350 | Distilled water | 10 | .07 | .10 | .0840 | .01350 | 0.1254025 | 529.249 | 0.00 | HS |
| | Opalescence | 10 | .09 | .13 | .1110 | .01287 | 0.00023694 | | | |
| | Colgate | 10 | .26 | .30 | .2800 | .01633 | | | | |
| | Charcoal | 10 | .28 | .33 | .3000 | .01826 | | | | |
| Ceram x | Distilled water | 10 | .06 | .10 | .0810 | .01449 | 0.16433667 | 34.56081 | 0.00 | HS |
| | Opalescence | 10 | .08 | .13 | .1100 | .01633 | 0.004755 | | | |
| | Colgate | 10 | .10 | .50 | .3000 | .13333 | | | | |
| | Charcoal | 10 | .30 | .40 | .3310 | .02767 | | | | |

For intragroup comparison, Tueky test for all groups were done which showed highly significant increases in surface roughness value Ra of the two tested composite ($p> 0.001$) after brushing with distilled water and Opalescence whitening toothpaste$^{R}$ and non-significant differences ($p< 0.05$) in surface roughness value after brushing with Colgate sensitive pro-relief and Biomed Charcoal Toothpaste as shown in Table (4)

**Table 4: Tukey test for surface roughness of the tested composite**

| Tukey HSD Dependent Variable | | | Mean Difference (I-J) | Std. Error | P-Value | sig |
|---|---|---|---|---|---|---|
| Z350 | G1 | G2 | -.02700* | .00688 | .002 | HS |
| | | G3 | -.19600* | .00688 | .000 | HS |
| | | G4 | -.21600* | .00688 | .000 | HS |
| | G2 | G3 | -.16900* | .00688 | .000 | HS |
| | | G4 | -.18900* | .00688 | .000 | HS |
| | G3 | G4 | -.02000* | .00688 | .030 | NS |
| Ceram x | G1 | G2 | -.02900 | .03084 | .783 | NS |
| | | G3 | -.21900* | .03084 | .000 | HS |
| | | G4 | -.25000* | .03084 | .000 | HS |
| | G2 | G3 | -.19000* | .03084 | .000 | HS |
| | | G4 | -.22100* | .03084 | .000 | HS |
| | G3 | G4 | -.03100 | .03084 | .747 | NS |
| *. The mean difference is significant at the 0.05 level. | | | | | | |

Another analysis was the difference after brushing with the tested Dentifrices equation: Before-after= ΔRa*

The data revealed that the lower surface roughness difference was with the use of distilled water, followed by Opalescence whitening toothpaste$^{R}$, Colgate sensitive pro-relief and Biomed Charcoal Toothpaste as shown in table 5.

**Table 5: ΔRa difference between after and before surface roughness of the tested composite.**

| | | before | after | ΔRa |
|---|---|---|---|---|
| z350 | Distilled water | 1.48 | 1.56 | 0.08 |
| | Opalescence | 1.5 | 1.61 | 0.11 |
| | Colgate | 1.55 | 1.83 | 0.28 |
| | Charcoal | 1.6 | 1.9 | 0.3 |

***Cont...*** **Table 5: ΔRa difference between after and before surface roughness of the tested composite.**

| | | | | |
|---|---|---|---|---|
| Ceram x | Distilled water | 3.07 | 3.15 | 0.08 |
| | Opalescence | 3.1 | 3.21 | 0.11 |
| | Colgate | 3.15 | 3.45 | 0.3 |
| | Charcoal | 3.2 | 3.53 | 0.33 |

## Discussion

Direct composite resins are always exposed to chemical and mechanical challenges that can alter the material properties such as when associated with long term brushing , specially when the toothpaste contain hard abrasive particles, so the composite resin will degrade and compromise giving opposite results from what was expected from the whiting dentifrices [11, 12]. Different dentifrices with different compositions have been developed to improve the affectivity of cleaning and whitening of teeth, Few of them have hydrogen peroxide (1%) in its formulation which is the active principle of bleaching products used in the dental office because it can cause irritation of the gingival tissues and lead to dentin hypersensitivity [18]. Other substances used by cosmetic industries in whitening dentifrices are optical pigments such as titanium dioxide and blue covarine, which can color the enamel surface white, more than the effect in removing, stains [19].

Regardless of the addition of hydrogen peroxide or pigments to whitening dentifrice, abrasive substances are often present in their components to increase the friction during tooth brushing, which can jeopardize resin composite without contributing to whiten the teeth.so the purpose of this study was to evaluate the abrasiveness of three different dentifrices on the surface roughness of **nano-manufactured composite resins** after simulating one year of tooth brushing.

This study used parameters accommodated the clinical situation, such as the amount of toothpaste(ratio of 1:1), brushing load (200 gr), and brushing time [17]. Brushing time was calculated by the assumption that brushing for two minutes (120 seconds) twice daily, divided on an average of 24 teeth result in 10 seconds of brushing time for every tooth per day, brushing for one year was assumed to take 3650 seconds(60 min) [20].

**Effect of the dentifrice**

The results showed that, the surface roughness was significantly affected by the dentifrice factor, so rejecting the null hypothesis. This finding agrees with other studies that showed a correlation between tooth brushing with the use of abrasive dentifrice and the increase in the surface roughness of composite [11, 12, 21].

A study conducted by da Oliveira *et al*.[22], assessed the effect of simulated tooth brushing with different whitening dentifrices on the surface roughness of different composite resins which found a significant difference in the result for the dentifrice factor, supporting the findings of our study.

The increased Ra value may be caused by the mechanical action of the brushing and the abrasive material contained in the dentifrice [23]. The mechanical factor was controlled accordingly in all groups. There was a statistical difference in the roughness values after the brushing challenge (Table 3) regardless of the toothpaste type even with brushing with distilled water (no toothpaste).

Friction causes the filler particles to fall out from the matrix , leading to increase in the surface roughness of composite resins this effect becomes even greater if accompanied by abrasive toothpaste [24] [25].

The dentifrices containing silica alone are considered to have low abrasiveness but if combined with calcium carbonate ,sodium pyrophosphate, titanium oxide, and sodium phosphate, it is considered a high abrasive dentifrice [26].

Amaral *et al*. [27], study concluded that sodium bicarbonate is more abrasive than silica or calcium carbonate. This finding is consistent with the results of this study, in which the dentifrice Opalescence has silica as an abrasive agent only, so the surface roughness of it was the lowest. While Colgate® Snesative PRO-Relief™ whitening has calcium carbonate and sodium bicarbonate.

The highest increase in the Ra value occurred in Charcoal toothpaste which in addition to having hydrated silica and Sodium Bicarbonate contains activated charcoal which is too abrasive and can wear away tooth enamel [21].

**Effect of composite**

Regarding the composite assessed in this study, Z350 and Ceram X were chosen because both of them had nanoparticle fillers in their composition. Resin composites with nanofiller has good aesthetic result and good wear resistance [25]. Nanoclusters has been also improved to be better wear resistance as the silane would fill the gaps and voids that observed in micro-hybrid composites [28].

The composition of the resin matrix, filler particle type or content, matrix/filler interface, degree of polymerization and hardness of the resin composites could affect the surface condition after tooth brushing [29, 30]. Other parameters such as the polishing and light-curing method are also of fundamental parameter to the values of surface roughness. However, they were standardized and the two tested materials were submitted to the same parameters as for the polishing type / light-curing method [31]. For comparative Filtek Z350, the fillers are composed of zirconia/silica, classified as a nanofilled composite,while Ceram X the fillers are silica and radiopaque barium-aluminum-silicate glass, classified as nanohybrid.

In this study Filtek Z350 presented the smoothest surfaces. Since the filler loading of the nano-filled composites is higher than that of the nano-ceramic composites, and this nanofilled materials have the ability to provide more volume of filler in homogeneous distribution, which enables it to protect organic matrix wear [11].

The nano-ceramic composite resin Ceram x demonstrated significantly greater roughness than the nano-filled composite resins Filtek Z350 Ceram; Ceram X is a nano hybrid containing organically modified ceramic nano particles comprising polysiloxane back bone. These nanoceramic particles can be best described as inorganic–organic hybrid particles where the inorganic siloxane part provides strength and the organic methacrylic part makes the particles compatible and polymerizable with the resin matrix [32]. However, this modification of the matrix might cause a larger surface roughness of the Ormocer composite when compared to the conventional materials, due to the characteristic of its organic-inorganic resin matrix [30]. Many studies have proposed a correlation between surface roughness and filler size, and that composites contain large filler size tend to be rougher than composites contain smaller filler size(23, 29)This finding agrees with the results of this study , as the Filtek Z350, which incorporates the smallest filler particles (from 0.2 to 1.4 μm), presented the smoothest surfaces than the Ceram X composites (from 0.4 μm up to 4.0 μm) glass filler.

The present study had some limitations, the concentration of abrasive materials in the toothpaste were not mentioned in the product which is very important in determining the abrasiveness of dentifrices, also the brushing was performed with dentifrice diluted in distilled water, but in fact this dilution occurs in saliva and the saliva properties can reduce the abrasive effects on the composite, as the saliva provides a sliding surface attenuating composite wear.

**Conflict of Interest:** The authors declare that they have no conflict of interest

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