

The Effects of Charcoal Toothpaste on Microhardness and Surface Roughness of Nanofilled, Micro Hybrid Resin Composite, and Resin Modified Glass Ionomer

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ABSTRACT

This study evaluated the effects of charcoal toothpaste on the microhardness and surface roughness of nanofilled, micro hybrid resin composite, and resin modified glass ionomer. A total of 120 samples (40 samples per each material). Group A: forty samples were fabricated from Z350 XT (nanofilled) resin composite samples. Group B: forty samples were fabricated from Z250 (micro filled) resin composite. Group C: forty samples were fabricated from Fuji II. The samples of each group were divided into 2 halves (n=20) according to the testing method microhardness and surface roughness (Ra) then subdivided according to toothpaste using close up diamond attraction (charcoal) and close up everfresh (conventional) into 2 halves (n=10). All groups showed a decrease in surface microhardness with no statistically significant difference between groups A and B ($p > 0.05$), while Group C showed the highest reduction in surface microhardness with a statistically significant effect ($p < 0.05$). All tested groups showed an increase in the surface roughness values, while Group A recorded the least change in surface roughness (0.215), followed by Group B (0.269), and then Group C (0.320). Charcoal-based toothpaste decreased surface microhardness and increased the surface roughness of the three restorative materials compared to conventional toothpastes.

Keywords: nano filled resin composite, microhybrid resin composite, resin modified glass ionomer, charcoal toothpaste, surface roughness.

1-Introduction

Tooth color is a significant determinant in facial beauty and satisfaction with dentofacial appearance. According to recent studies, between 17% and 53% of individuals across various demographics are not pleased with the color of their teeth (1). Chemical compounds that alter teeth's natural color including hydrogen peroxide and carbamide peroxide, may cause teeth hypersensitivity and gingival inflammation. Nonetheless, several whitening treatments that have an abrasive action—like whitening toothpaste—have been used consistently without a dentist's expert advice. These materials include sizable abrasive particles, which exacerbate tooth wear by abrasion (2). In addition to the changes in enamel, the effect of charcoal-based toothpaste on restorative materials has been extensively researched (3).

Resin composites are frequently utilized in conservative dentistry restorative techniques because of its strong bond to the tooth structure and good esthetic qualities. Resin composite restorations provide pleasing visual properties, but they are prone to discoloration from external influences including food and drink consumption and plaque buildup (4). The color stability of composite resin may be influenced by its composition and the method of curing. The type of filler used can also affect how susceptible composite resin is to discoloration. Staining materials are more readily absorbed by nanofilled composite than by micro hybrid composite (3). The abrasion caused by brushing and toothpaste particle size might decrease polishing and increase surface roughness, which could impact plaque accumulation and the composite's esthetics and ultimately result in restorative failure (3) (4).

Resin modified glass ionomer (RMGI) is more prone to mechanical deterioration than resin composite, despite the fact that it creates a chemical contact with enamel and dentin and releases fluoride (5). Tooth brushing may have an impact on the material's surface qualities, according to several studies that examined various composite resins and RMGI for wear resistance, material loss during brushing routine, and surface roughness or degradation. Assessing the clinical performance of restorations might potentially be achieved by using in vitro simulated toothbrushing to gauge the degradation capacity of the restorations. However, there is little data on how toothbrushing affects the surface roughness of glass ionomer materials (6).

After water and other volatile components are extracted from carbon-based materials, a black, tasteless, and odorless powder known as activated charcoal is left behind. Charcoal's nanopores increase the surface area and make ion exchange in the oral cavity easier. The young population

was particularly concerned about the producers' claims that it can adsorb and remove stains, chromophores, and pigments that cause teeth to change color (7). Despite their beneficial properties, toothpastes containing charcoal have raised concerns about their potential adverse effects on oral and dental health. In addition to causing gingival recession, cervical abrasion, dentin hypersensitivity, and damage to soft tissue, abrasive toothpastes can also roughen hard tissue and restorations. Activated charcoal toothpaste has greater average particle sizes than regular toothpaste, and the coal's star-shaped particles also cause more surface wear (7).

This study aimed to evaluate surface hardness, and roughness of a commercial charcoal-containing toothpaste (Close up diamond attraction) on two types of commercially composite resin and resin modified glass ionomer to compare it with non-Charcoal and daily used toothpaste (Close up everfresh). The tested null hypotheses were as follows: (1) charcoal-based toothpaste would not affect the microhardness, and (2) or the surface roughness of the three restorative materials.

2. Experimental

Materials used in this study were listed in **Table 1**.

Table 1. Materials used in the study

Materials	Manufacturer	Composition
Filtek™ Z350 XT Nanofill universal Composite	3M ESPE, St. Paul, MN, USA	Nanofilled composite Bis-GMA, UDMA, TEGDMA, Bis-EMA, discrete non-agglomerated and non-aggregated silica and zirconia fillers of 20 nm and 4-11 nm in size. Filler loading: 63.3% by volume and 78.5% by weight Shade: A2
Filtek™ Z250 Universal microhybrid composite	3M ESPE, St. Paul, MN, USA	BIS-GMA, UDMA, and Bis-EMA Filler loading: 60% by volume silica/zirconia, of 0.01 µm to 3.5 µm with an average particle size of 0.6 µm. Shade: A2
Fuji II resin modified glass ionomer	GC Corporation, Tokyo, Japan)	Light-Cured Resin-Reinforced Glass Ionomer Restorative.

		Filler loading: 55% by volume FSG/Poly-HEMA with an average particle size 5.9 μm
Close up diamond attraction toothpaste	Close up, Unilever company, 6 th October, Egypt	Charcoal powder, flavor, cellulose gum trisodium phosphate, sodium fluoride sodium saccharin pvm/ma copolymer, c174160, mica/cl77019, PEG 32, Sorbitol, Water, Hydrated Silica, CI 77891 & Limonene.
Close up everfresh toothpaste	Close up, Unilever company, 6 th October, Egypt	Sodium Fluoride 1450 ppm, Sorbitol, Water Hydrated Silica, Sodium Lauryl Sulfate, PEG-32, Flavour, Cellulose Gum, Cocamidopropyl Betaine, Sodium Saccharin, , Zinc Sulfate, Sodium Hydroxide, CI-78891, CI-16255, Synthetic Fluorophlogopite, CI-15035, Eucalyptus Extract, Eugenol.

Study Design:

Three widely used commercial restorative materials, 2 resin composites and resin modified glass ionomer, were evaluated in current study. A total of 120 samples (40 samples per each material). Group A: forty samples were fabricated from Z350 XT resin composite samples. Group B: forty samples were fabricated from Z250 resin composite. Group C: forty samples were fabricated from Fuji II. The samples of each material were divided into 2 halves (20) according to the testing method microhardness and surface roughness then subdivided according to toothpaste used close up diamond attraction and close up everfresh into 2 halves (n=10).

Sample preparation

Teflon mold consists of 2 split halves held together with metal ring of 10 mm internal diameter and 4 mm thickness was used for samples preparation. All samples were prepared by single operator. Restorative materials were applied according to the manufacturers' instructions. The mold was placed on flat glass slab covered with Mylar's strips and then filled with composite materials according to incremental fill technique each increment 2 mm thickness before curing of last increment, the mold was covered with Mylar's strips, and a glass slab was pressed against the mold to adapt the materials completely to the inner portions of the molds (8).

For glass ionomer samples, Fuji II capsules activated, triturated and injected in the mold covered with Mylar strip and light cured. The excess material was removed, and the samples were photoactivated for 40 sec at the top surface using the Elipar Free Light 2 curing device (3M ESPE, St. Paul, MN, USA), all samples were light cured following the manufacturers' instructions and, transparent Mylar's strips were removed immediately after light polymerization and the top surfaces were finished with aluminum oxide disks (Sof-Lex, 3M Dental Products, 3M ESPE, St. Paul, MN, USA), in four textures: coarse, medium, fine, and extra-fine with 150, 360, 600, and 1,200 grit sizes. All of the groups were stored in distilled water for 24 H before testing (8).

Tooth-brushing simulation:

A custom-made machine was used to simulate brushing mechanism, the tooth-brushing machine was accomplished with horizontal movements of the toothbrush under a weight of 200 gm and a traveled course of 2 cm. The rotation was of 280 cycles/min, the total time of tooth brushing was of 120 min, so total cycles was 33000 cycles, simulated brushing time in the experiment refers to one year of brushing (9). Toothbrush (oral B medium) head was replaced with every 10000 cycles, while the slurry mixture (dentifrice, distilled water) was applied by a syringe every 5 minutes of the testing time. In order to resemble tooth brushing in the oral cavity, dentifrice and distilled water were used with ratio 1:1 (10).

Surface Microhardness measurements:

A microhardness testing machine (Wilson Tukon TM1102, Germany) was used to measure the Vickers hardness number (VHN) of each specimen before and after tooth brushing with used tooth pastes. The microhardness test was conducted using a diamond indenter with a 100-gm load for 10 sec. Five indentations evenly spaced over a circle and not closer than 1 mm to the adjacent indentation or margin of the specimen were created in each specimen at top surface and Vickers microhardness number means were calculated by the following equation:

$$\text{VHN: } HV=1.854 P/d^2$$

Where, HV was Vickers hardness in Kgf/mm², P was the load applied in Kgf and d was the length of the diagonals in mm and 1.854 was a constant number.

Surface Roughness measurements (Ra):

The surface roughness was measured by using (SJ-210 Surface roughness tester Mitutoyo, Tokio, Japan) before and after tooth brushing with the used tooth pastes Each

specimen is fitted to the specimen holder in which the surface to be measured in horizontal direction, then the specimen holder moves in vertical direction up to the specimen surface just touch the measuring tip. Device calibration is done using the standard calibration specimen before use.

Testing parameters:

- 1- Measuring distance 8 mm
- 2- Measuring Speed 0.5 mm/s. Returning 1mm/s
- 3- Measuring force 0.75 mN
- 4- Stylus profile: tip radius 2-micron, tip angle 60 degree
- 5- Evaluation parameter Ra values expressed in microns Five readings are recorded for each specimen at a distance 500 microns each.

Statistical Analysis

Statistical analysis of Vickers micro-hardness and surface roughness measurements were performed using two-way ANOVA followed by tukey's post hoc to test the interaction between groups, as well as the paired t-test which was used to compare the measurements of each specimen done before and after brushing, Analysis was performed via software version 25.0, SPSS (Statistical package for Social Sciences). Level of significance was P-value less than or equal to 0.05.

3-Results

Surface Microhardness results

All groups showed decrease in surface microhardness with no statistically significant difference between groups A and B ($p > 0.05$), when comparing (baseline & after brushing with close up everfresh or with close up charcoal). While Group C showed the highest reduction in surface microhardness with statistically significant effect ($p < 0.05$). All groups subjected to brushing with close up charcoal showed decrease in the surface microhardness when compared to everfresh groups with statistically significant effect ($p < 0.05$) and when comparing all treatments with each other across Group C as shown in **Table 2 and Figure 1**.

Table 2. Comparison of Vickers Microhardness measurements in variables (Z350xt, Z250, Fuji2) among different brushing regimens (before, after close up, and after close up charcoal), and interaction between variables and Treatments.

Variables	Treatments	Measurements of surface hardness		Comparison	P-value
		Mean	SD		
Group A	Baseline	78.350 ^a	8.584	B-C	0.688
	Close up	76.581 ^a	7.607	B-CC	0.143
	Close up charcoal	70.887 ^b	8.979	C-CC	0.036
Group B	Baseline	81.679 ^a	9.648	B-C	0.161
	Close up	77.270 ^a	6.063	B-CC	0.070
	Close up charcoal	72.580 ^b	6.974	C-CC	0.001
Group C	Baseline	61.908 ^d	6.807	B-C	0.037
	Close up	56.938 ^d	3.844	B-CC	0.007
	Close up charcoal	50.130 ^d	7.204	C-CC	0.007
P-value		<0.001			

SD (standard deviation), Statistically significant difference ($p < 0.05$).

B indicates before brushing, C indicates after brushing with close up everfresh, and CC indicates after brushing with close up charcoal

Means with the same superscript letters across one variable were insignificantly different as $P > 0.05$

Means with different superscript letters across one variable were significantly different as $P < 0.05$

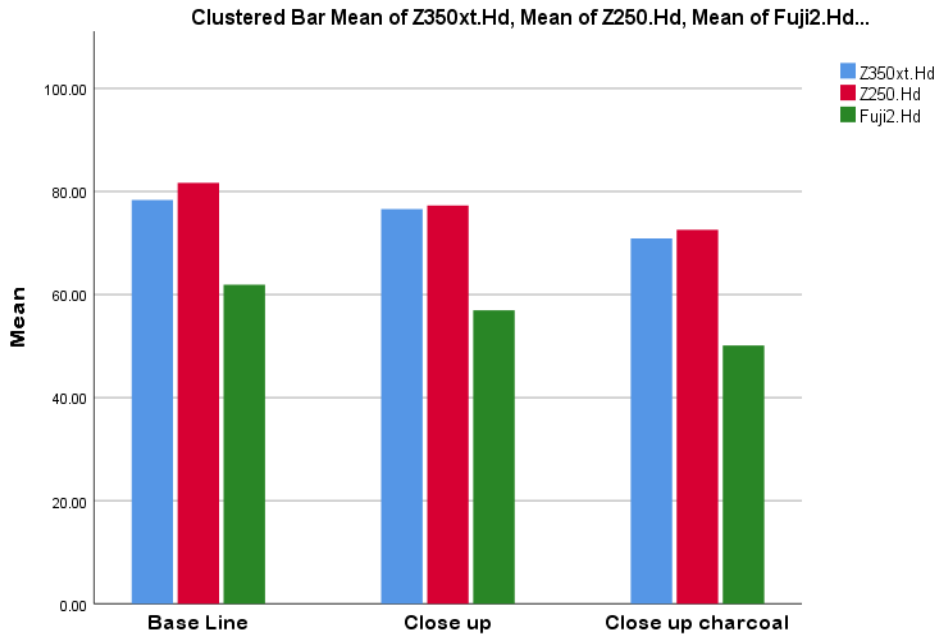


Figure 1. Clustered Bar graph comparing mean microhardness (kgp/mm²) among different groups.

Surface roughness results

According to surface roughness measurements, all surface roughness values showed increase when compared between (baseline & after brushing with close up everfresh) and (baseline & after brushing with close up charcoal) with statistically significant differences in all tested groups (A, B and C) with ($p < 0.05$). While taking into consideration comparing close up everfresh with close up charcoal the measurements value showed no statistically significant effect in all tested groups (A, B and C) with ($p > 0.05$). While Group A recorded the least change in surface roughness (0.215), followed by Group B (0.269), then Group C (0.320) as shown in **Table 3 and Figure 2**.

Table 3. Comparison of surface roughness measurements in variables (Z350xt, Z250, Fuji2) among different brushing regimens (before, after close up, and after close up charcoal), and interaction between variables and Treatments

Variables	Treatments	Measurements of surface Roughness		Comparison	P-value
		Mean	SD		
Group A	Baseline	0.096 ^a	0.057	B-C	0.001
	Close up	0.175 ^b	0.018	B-CC	0.007
	Close up charcoal	0.215 ^c	0.079	C-CC	0.155
Group B	Baseline	0.128 ^b	0.009	B-C	0.000
	Close up	0.210 ^c	0.033	B-CC	0.001
	Close up charcoal	0.269 ^c	0.070	C-CC	0.077
Group C	Baseline	0.163 ^b	0.088	B-C	0.001
	Close up	0.266 ^c	0.091	B-CC	0.002
	Close up charcoal	0.320 ^d	0.090	C-CC	0.192
P-value		<0.001			

SD (standard deviation), Statistically significant difference ($p < 0.05$).

B indicates before brushing, C indicates after brushing with close up everfresh, and CC indicates after brushing with close up charcoal

Means with the same superscript letters across one variable were insignificantly different as $P > 0.05$

Means with different superscript letters across one variable were significantly different as $P < 0.05$

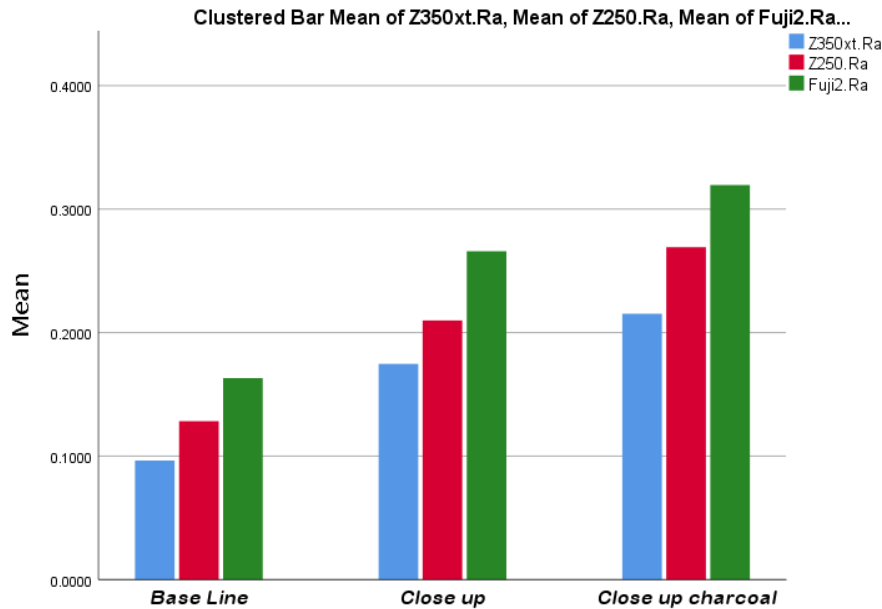


Figure 2. Clustered Bar graph comparing mean surface roughness (Ra) among different groups

4. Discussion

This study aimed to evaluate surface microhardness, and roughness of two types of commercially composite resin and resin modified glass ionomer after being brushed with either charcoal or conventional non-charcoal-based toothpaste. The null hypotheses were rejected because the charcoal-based toothpaste affected the surface microhardness, and the surface roughness of the three restorative materials.

Nanofilled, micro hybrid composites and RMGI were selected in this study as they are among the most frequently used materials for building up anterior restorations, as they present low surface roughness after polishing (10).

In the present study, samples brushed with the charcoal toothpaste recorded reduction of the surface microhardness values with no statistically difference between Group A and B. However, the Group C was the most affected. This could be related to the small difference in the filler loads in Group A and B (63% and 60%) respectively in comparison to the Group C (55%). This in agreement with (11) who used the same types of resin composites. The relationship between the abrasion caused by charcoal toothpastes appears to have accentuated the structural alterations in RMGIC and had a role in the decrease in its mechanical properties (5).

The surface roughness of any dental restoration is clinically interpreted as the bacterial adhesion to its surface, and subsequently promotes the formation of oral biofilms which directly

affects the periodontal health. A surface roughness above 0.2 μm has been reported to increase the colonization and adhesion of bacteria on composite surfaces (12). It also changes the color and gloss of composite restorations and impair the esthetic appearance (2).

Regarding the surface roughness results, samples subjected to brushing using charcoal toothpaste showed higher surface roughness values than samples subjected to brushing using charcoal free toothpaste. While Group A recorded the least change in surface roughness (0.215), followed by Group B (0.269), then Group C (0.320). This in agreement with the results of previous studies that showed was significantly higher surface roughness after the use of activated charcoal powder in comparison to the baseline measures (2)(3). This result could be attributed to different fillers' composition, size and loading of both tested materials. In the Filtek Z350 XT, nanomer and nanocluster particles readily abraded alongside the resin matrix during the polishing process. The surface would become smoother when the nanomer connection that creates nanoclusters separated (11). Additionally, silane was added to the nanomer's surface, which strengthens the bond it forms with the matrix during the curing process. The matrix system has a higher degree of polymerization because it has less double bonds and more Bis-GMA and UDMA (13). Larger and irregular filler sizes were achieved in the Filtek Z250 XT resin composite by grinding larger particles, which resulted in a lot of space between fillers (14). The larger filler would have left a sizable hole and increased surface roughness as it separated from the matrix. The surface roughness of Filtek Z350 XT, and Filtek Z250 XT resin composites difference could be also due to filler size (11 nm, and 0.6 μm ,) respectively.

A number of factors were reported to have contributed to significant differences in wear and surface roughness among the Glass Ionomer materials. One of these variables is the composition and characteristics of the matrix. It has also been demonstrated that the amount and size of glass in organic particles influence material wear and surface roughness (6). GIC materials are a class of materials that are biphasic in nature and are composed of unreacted glass particles encased in a matrix of poly-salt resin. The surface roughness and wear resistance of glass ionomer materials are significantly influenced by the size, shape, concentration, and composition of the glass particles (15). The softer matrix phases were favorably removed by toothbrushing, causing the harder, unreacted glass particles to protrude from the surface and add to the restorative material's rougher surface (6). According to the information provided, using

charcoal-based toothpaste may harm various forms of aesthetic restorations. Charcoal-free toothpaste is a safe replacement that can be used on a daily basis.

5. Conclusion

Under limitations of this in vitro study it was concluded that:

1. Tooth brushing increased the surface roughness and decreased the surface microhardness values of three restorative materials.
2. Charcoal-based toothpaste caused higher surface roughness of resin composites than conventional toothpastes.
3. RMGI was the most affected restoration than the nanofilled and micro hybrid resin composite.

- **Acknowledgment**

Not applicable with no funding was obtained for this study.

- **Conflict of Interest**

The Authors declare no conflict of interest.

6. References

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