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RESEARCH ARTICLE

TRIBOLOGICAL AND TOPOGRAPHICAL CHARACTERISTICS OF NANO-PROCESSED COATING FOR AESTHETIC RESTORATIVE MATERIALS

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AFM: Atomic Force Microscope
GIC: Glass Ionomer Cement
Ra: surface roughness
SEM: Scanning Electron Microscope
VHN: Vickers Hardness Number

ABSTRACT

Background: Tooth-colored restorative materials have been widely used for aesthetic purposes in restorative dentistry. The gradual loss due to degradation or wear of the damaged surfaces leads to the roughening of the restoration and accordingly influences its esthetic and clinical longevity.

Objectives: To assess the feasibility of nano-filled resin coating of aesthetic restorations materials which is as an essential step for GI and an optional protocol for resin composites. Thus, the tribological feature (wear resistance) and consequent topographical characteristics (microstructure, surface roughness and hardness) of the resin composite and GI either coated or uncoated are investigated.

Materials and methods: A total of forty samples were fabricated using nanohybrid composite (Tetric N-Flow Bulk Fill) and conventional GI (Fuji IX GP fast); 20 samples each. Half of the samples were covered with resin nano-filled resin coating (EQUIA Coat). Each sample was stored individually in 3 mL distilled water at 37°C for 24 hrs., dried and weighed. Then, specimens were subjected to tooth brushing abrasion wear (~100000 cycles) using especially designed tooth brushing holder device followed by reweighing to determine the amount of weight loss. Surface morphology was examined by SEM, surface roughness was mapped out using AFM as well as VHN were determined. The data was statistically analyzed using SPSS.

Results: The nanofilled resin coated samples for each tested material recorded insignificant wear resistance with its corresponding uncoated samples (0.0020±0.0000 & 0.0018±0.00045 for coated and uncoated resin composite respectively) and (0.0034±0.00055 & 0.0026±0.00055 for coated and uncoated GI respectively). The existence of coating evidently reduced the surface roughness of both aesthetic materials as examined by SEM and measured by AFM. Regarding surface hardness, the lowest significant mean values (55.94 ± 0.99 & 56.24± 2.34 were recorded by coated resin composite and coated GI, respectively) compared with uncoated ones (82.22± 3.94 & 71.82± 4.90 for uncoated resin composite and uncoated GI respectively).

Conclusions: The wear resistance of the nano-filled resin coating per se is analogous to those of the uncoated aesthetic restorative materials after exposure to prolonged brushing. The coating evidently reduced the surface roughness of both investigated aesthetic materials; however, it has significantly lower hardness values. Thus, on the clinical point of view, the capability of the nano-filled resin coating to reduced surface roughness of both aesthetic restorative materials and its persistence against abrasion wear would allow more glossy appearance and maintain healthy oral condition.

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INTRODUCTION

Tooth-colored restorative materials; resin composites and glass ionomer cements, have been widely used for aesthetic purposes in clinical restorative dentistry since their development in 1950's and 1970's respectively (Brigitte *et al.,* 2010).

Polymerization shrinkage is the main drawbacks of the resin composite restorations as it is associated with microleakage, marginal discoloration and recurrent caries (Shokati *et al.,* 2010). Meanwhile the main disadvantage of Glass ionomer cements (GICs) is the necessity to be coated during the early setting reaction because of its sensitivity to moisture contamination (Maryam and Fateme, 2013). Microstructure and its relevant surface morphology is one of the important factors that determine the success of the restorations. The surfaces might damage gradually, and the softened materials

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are lost by degradation or wear causing restorations' roughening and consequent color changes that influence esthetic and clinical longevity (Kakaboura *et al.,* 2007). Thus, the progressive improvements of the restorations are continued to confront thermal, mechanical, and chemical challenges in the oral cavity (Paula *et al.,* 2011). Glass ionomer cement restorations (GICs) are superior due to their direct chemical bonding to tooth structure and release of fluoride that helps in remineralization of dental tissues and anticariogenic properties, thermal compatibility with tooth enamel, biocompatibility and low toxicity*)*. Many generations of GICs were introduced in attempts to improve wear resistance and surface hardness, and esthetics (Nagaraja, and Kishore, 2005). In recent years, an encapsulated glass ionomer system with high mechanical properties had been introduced to the market as an alternative to amalgam and composite fillings in class I and II cavities. It is fast-setting and high-viscosity GIC coated with a nanofilled resin coating (Thomas *et al.,* 2016). On other hand, composite resins represent so far, the most esthetic direct restoration in the field of dentistry. Through the modifications in the filler size, the type of inorganic filler particles and the ratio between the filler particles and the organic matrix; the resin composite materials aredeveloped to withstand wear and stress. Nano-filled resin composite with filler size about 40 nm,permits the incorporation of a larger amount of filler particles and gives better mechanical and physical behavior (Ferracane, 2011).

The coating of glass ionomer is mandatory during the initial setting of the restoration. Additionally, it was found that coating glass ionomer with a nanofilled resin coating produced a proper sealing of GIC surface porosities, but improvement of the wear resistance was questionable (Lohbauer *et al.,* 2011; Bonifácio *et al.,* 2012). Regarding resin composite, there was no significant evidence suggested that surface sealants would improve the roughened surface of composite resins after tooth brushing (Lopes *et al.,* 2012); however, application of nanofilled protective resin coating on the rough surface of resin-based restorative materials proved an efficiency after submission to ultraviolet aging (Bagis *et al.,* 2014). Few studies had investigated the effectiveness of nano-filled resin coating for aesthetic restorations; as an essential step for GI and as an optional protocol for resin composites, in enhancement of their tribological characteristics and topographical features. Therefore, this study was concerned with studying the tribological characteristics represented by abrasion wear resistance to prolonged tooth brushing and surveying the consequent topographical features represented by surface microstructure, roughness and hardness of the coated and uncoated materials to evaluate the feasibility of the coating.

MATERIALS AND METHODS

A nano-filled resin coating (EQUIA Coat) was used to be applied on the surface of two commercially available aesthetic restorative materials; conventional glass ionomer (Fuji IX GP EXTRA) and nano-hybrid resin composite (TetricEvo Ceram Bulk Fill). Both selected materials have the same color shade. The investigated materials in this study were listed in (Table 1) below. A total of forty samples were processed made of light cured nano-hybrid composite and high viscous conventional glass ionomers; 20 sample each. A Teflon mold of 6 mm diameter and 2 mm thickness was used to fabricate the samples. The mold was placed on glass slide topped by polyester strip. The restorative materials were manipulated according to the manufacturer's instructions. They were extruded into the mold where another glass slide lined by polyether strip was pressed on the top of the paste to get smooth flat surface and get rid of the excess. For resin composite, the top and bottom of each sample were light cured for 20s. using a light curing unit (Ivoclar, vivadent). For GI, the samples were left undisturbed next to their extrusions for 3 min. After complete setting, the samples of each material were divided into two groups; n=10. One group was coated with double layers of nanofilled adhesive resin; EQUIA® coat, by microbrush and each layer was light cured for 20s. Only one specimen's surface was coated to simulate clinical situation. The other group was left uncoated. The polishing steps were not performed to avoid surface contamination. Later, all specimens were stored separately in 3 mL distilled water and kept in incubator at 37°C for 24 hours to mimic the clinical condition. Finally, each sample was weighed individually using digital balance (Adam-Equipment-PGW-453e; UK).

Wear abrasion testing: The surfaces of specimens were subjected to wear abrasion test using especially designed tooth brushing holder device; (Figure 1) There is a central circular hole of a 6±0.5 mm diameter and 1mm depth to adapt and fix the specimen such that the specimen is 1mm beyond the edge of the hole. For abrasion test, commercial electric tooth brush (Oral-B, TriZone 1000 with 40000 pulsation/min and8, 800 sweeps/min) supplied with extra soft nylon bristles brush head aligned parallel to the specimen's surface and under a standardized load of 200g.which was mounted on the brush head (Dina *et al.,* 2010). Each specimen was individually submitted to brushing (wear abrasion test) while few distilled water was dropped for 11 minute and 30 seconds achieving approximately 100,000 sweeps. A new toothbrush head was used for each tested group of specimens. After completion of the brushing, each specimen was removed, washed, dried with an absorbent paper and reweighed again to determine the weight loss in mg that represents wear according the following equation:

Weight loss (mg) = weight of the specimen after 24 hrs. Storage in dist. water - Weight after brushing

Surface morphology examination: Using Scanning electron microscopy (FE-SEM, JEOL-JSM 7600 FEG, USA), a specimen was selected to represent one of the investigated group at X5000 magnification. The selected specimens were vacuum dried, and gold sputtered to examine the surface morphology thoroughly.

Surface roughness measurements: Atomic force microscope (AFM, Omicron UHV-VT-XA, Germany) was used to capture 3-D microphotographs and to determine the nano-roughness of the investigated groups.

Surface hardness: The surface hardness was measured using Digital Vickers Hardness Tester (Nexus 4000^{TM}INNOVATEST, Model No.4503, Netherland) with applied load 100g. for 15 s., at least 8 readings were recorded for each group.

Statistical Analysis

The data were collected, tabulated and analyzed using SPSS. One way ANOVA was used for the primary analysis followed by Tukey's HSD statistics for Post-Hoc analysis (Homogeneous Grouping) at limit of confidence 95%.

Table 1. The materials used in this study

Materials	Trade Name	Composition	Manufacturer
Nano-filled resin Coating	EQUIA Coat	50% Methyl methacrylate, colloidal silica, Camphorquinone ≤ 1%, urethane methacrylate, phosphoric ester monomer	GC Europe, Leuven, Belgium
Packable Glass ionomer	GC Fuji IX GP FAST	10-15% poly acrylic acid, 70-80% alumino-silicate glass, 10-15% deionized water	
Nanohybrid resin composite	Tetric N-Flow Bulk Fill	Urethane dimethacrylate, Bis-GMA 27.8%, Triethyleneglycoldimethacrylate 7.3%, Barium glass, ytterbium trifluoride, mixed oxide, silicon dioxide 68.2%, additives, stabilizers, catalysts, pigments 1.1% (wt.%)	IvovlarVivadent AG, Schaan, Liechtenstein

Table 2. Descriptive statistical analysis of the wear (in mg) of the investigated groups, means with similar superscript letters are statistically insignificant

Group	Minimum	Maximum	Mean	±S.D.	P-value
Uncoated Composite	0.001	0.002	0.0018 ^{B}	±0.00045	
Coated Composite	0.002	0.002	0.0020 ^{B}	±0.00000	<0.001
Uncoated GI	0.002	0.003	0.0026 ^{AB}	±0.00055	
Coated GI	0.003	0.004	0.0034 ^{A}	±0.00055	

Table 3. Descriptive statistical analysis of the VHN of the investigated groups, means with similar superscript letters are statistically insignificant

Group	Minimum	Maximum	Mean	± S.D.	P-value
Uncoated Composite	77.6	86.9	82.22 ^{A}	± 3.94424	<0.001
Coated Composite	54.8	57.4	55.94 ^{C}	± 0.98894	
Uncoated GI	67.2	79.6	71.82 ^{B}	± 4.89765	
Coat GI	53.4	59.5	56.24 ^{C}	± 2.33838	

Figure 1. The device used in brushing (wear abrasion test)

RESULTS

Abrasion Wear: The brushing resulted in comparable insignificant mean values of weight loss for each restorative material. (Table 2) shows the weight loss in mg of the investigated groups. Either uncoated composite (0.0018±0.00045) or coated composite (0.0020±0.000) recorded insignificant values with uncoated GI (0.0026±0.00055). Similarly, both uncoated GI (0.0026±0.00055) and coated GI (0.0034±0.00055) had insignificant values.

Surface Microstructure

Surface roughness

(Figure 4 & 5) show 3-D microphotography of the investigated groups after abrasion wear. As shown in (Figure 4.A), there is moderate surface roughness (Ra) of uncoated resin composite (7.48058 nm) due to brushing.

Some nano-sized particles and micro-sized aggregates were dislodged from their sites leaving micro-pores (white arrows) and some were projected due to disintegration of resin matrix (black arrows). Similarly, (Figure 5.A) shows 3-D microphotography of uncoated GI. It is obvious that the surface is severely irregular due to plucking of coarse particles and protrusions of other ones. This surface recorded the highest roughness value (Ra=11.89 nm). (Figures 4B and 5B) represent the coated resin composite and coated GI respectively. They exhibited more or less comparable configurations. The uniform distribution of the nano-sized particles is apparent. Their average surface roughness (Ra) were (3.84 nm) and (3.61 nm) respectively.

Hardness: As shown in (Table3), uncoated resin composite samples recorded the highest significant mean value of VHN (82.22±3.94), followed by uncoated GI (71.82±4.90). Coated samples either resin composite or GI recorded the least significant VHN mean values (55.94± 0.99 and 56.24± 2.34) respectively.

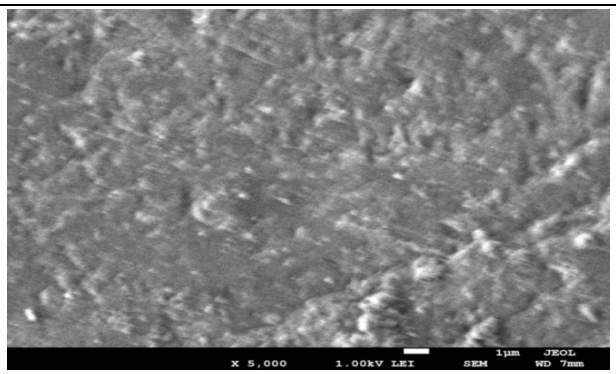

Figure 2. A SE microphotographs of uncoated resin composite at X5000. Brushing marks; scratches, are apparent. There are narrow porosities (dimples) due to the dislodged filler particles. Little projected fillers are also prominent.

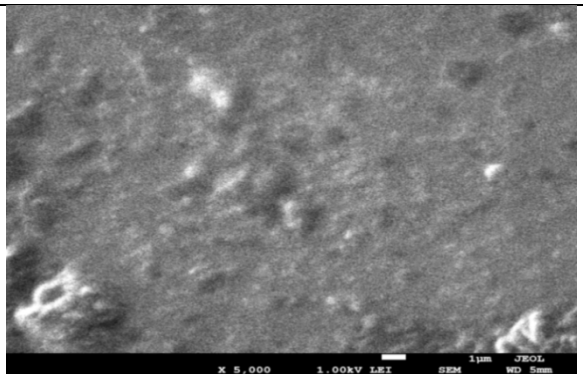

Figure 2. BSE microphotographs of coated resin composite at X5000. Degradation of the resin matrix is obvious with discrete projection of Nano particles topped the surface. Tiny porosities are distributed all over the surface.

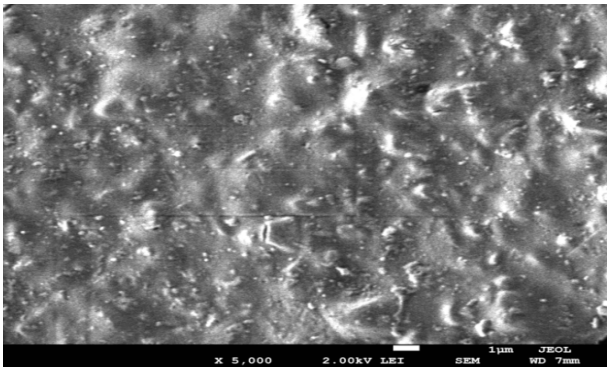

Figure 3. A SE microphotographs of uncoated GI at X5000. Severe irregularities of the surface owing to disintegration of the inter-spacing resinous component. The glass particles are partially fragmented and broken down due to brushing.

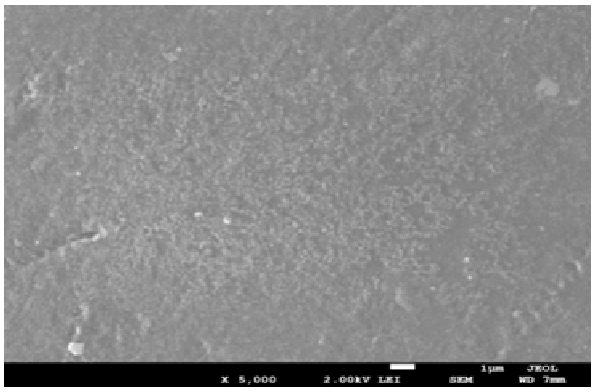

Figure 3. BSE microphotographs of coated GI at X5000. It was obvious that nano particles are homogenously distributed. Brushing scratch marks are randomly appeared.

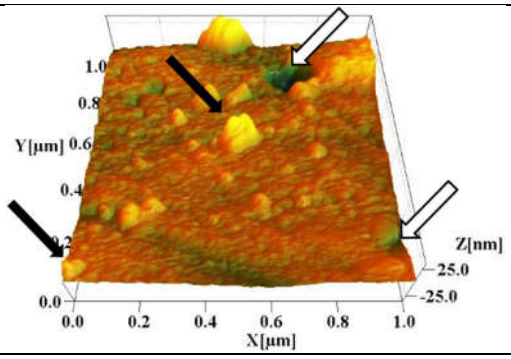

Figure 4. A3-D microphotograph topography of uncoated resin composite with mean surface roughness (Ra) =7.48058 nm.

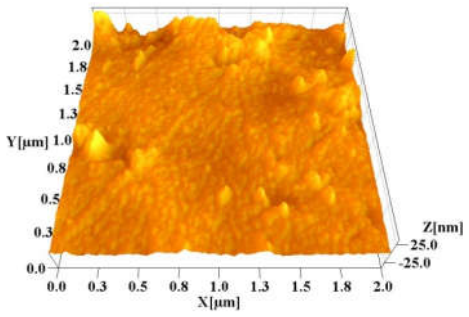

Figure 4. B3-D microphotograph topography of uncoated resin composite with mean surface roughness (Ra) =3.84196 nm.

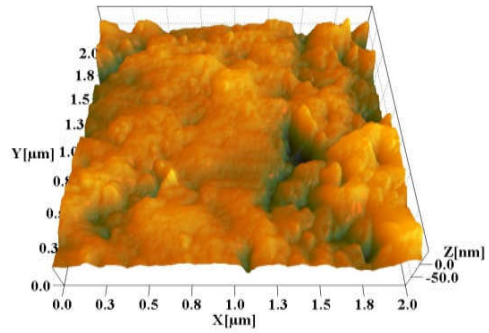

Figure5.A3-D microphotograph topography of uncoated GI with mean surface roughness (Ra) =11.8869 nm.

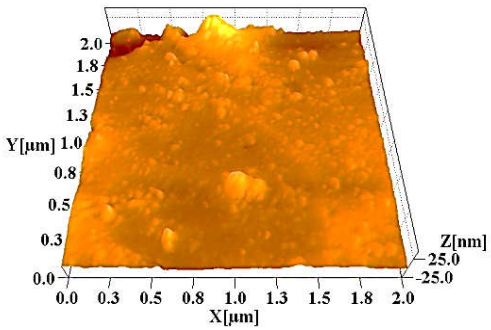

Figure 5. B3-D microphotograph topography of coated GI with mean surface roughness (Ra)=3.60769 nm.

DISCUSSION

Surface characteristics of the restorations are important parameters influence their wear, stainability, bacterial colonization and plaque accumulation, periodontal pathogenesis and secondary caries. Wear resistance is a prerequisite for dental restorative materials that directly affect the durability and esthetics of the restorations (Heintze *et al.,* 2010). Wear in the oral cavity is a complex phenomenon which depends on numerous factors. From a strictly tribology point of view, the term wear is defined as the gradual loss of material that result from the mechanical interaction between two bodies in contact and in relative movement where a third body or medium is present or not (De Souza *et al.,* 2013). The wear test applied in this study; brushing of the aesthetic restorative materials, is considered two body abrasion wear. The wear mechanism of resin composites and glass ionomer is governed by many factors related to their composition and structure i.e. material-dependent (Jain *et al.,* 2004). For resin composite, the filler content, shape, size and distribution. Also, the resin matrix type, interfacial adhesion between matrix and filler particles, the characteristics of the polymer matrix itself and its curing process affect the mechanical properties of the material (Oliveira *et al.,* 2012). On the other hand, it has been reported that powder/liquid ratios, molecular weight, viscosity and concentration of polacrylic acid affect the mechanical properties of GIC (Roeder, *et al.,* 2000). GIC is heterogeneous material with biphasic nature and consists of un-reacted glass particles embedded in a polysalt resin matrix (Mitra *et al.,* 2013). The investigated nano-hybrid resin composite; Tetric N-Flow Bulk Fill, has filler loading 63.8 wt.% of particle size ranged from 0.04-3 μm. Owing to these criteria of filler's size and content, it recorded the least but insignificant weight loss representing the best wear resistance and the highest significant hardness; (Tables 2 &3)respectively. It was proven that nano-hybrid resin composite with filler size about 40 nm, homogeneously distributed into organic matrix gives better mechanical and physical behavior (Ferracane 2011).

This investigated resin composite contains both discrete nano-particles and aggregated nano-cluster particles (Mitra *et al.,* 2003). It was reported that the wear of nano-filled composites occurs by breaking off individual primary particles or parts of the clusters rather than by debonding of larger particles (Braga *et al.,* 2010). When the filler particles are of average size more than 1μm, the relatively soft inter-particular resin is worn first while the inorganic fillers sited on the surface (Lu *et al.,* 2006). Brushing gradually abrade the resin among the filler particles of composite; the unsupported filler particles of composite are easily dislodged creating a discrete pore in the size of the fillers and leaving a particle-free resin layer which is abraded later, and the process continues (Condon and Ferracane, 1997). Thus, the resulting wear pattern exhibited smaller defects and to some extent uniform worn surface. Also, scratches (finer wear tracks) due to brushing comprised some particle detachment i.e. nano-clusters splitting rather than their complete dislodgement; as seen in SEM (Figure 2.A) &AFM (Figure 4A). Despite the tested GIC; GC Fuji IX GP Fast, is conventional type, it represents one of the GIC advances where smaller particles of size (5 μm) less than the conventional particle size of GI (10-20μm) are incorporated into cement glass powder i.e. a blend of submicroscopic and microscopic sized particles. These smaller particles occupy the spaces between the larger ones. This advance of GIC employed the advantages of combined different size filler technologies in a way similar to hybrid composites permitting more voluminous glass fillers (70-80% alumino-silicate glass) with a wider particle size distribution that strengthen the material with subsequent higher mechanical properties (Maya *et al.,* 2016). On brushing, the relatively soft resin matrix phase of GI is preferentially removed and worn first, and the harder, non-reacted and large glass particles protruding from the surface or plucked out leaving deep dumps. The worn surface of the GI showed more coarse wear pattern characterized by larger filler dislodgement, as seen in SEM (Figure 3A) & AFM (Figure 5A) (Yap *et al.,* 2004; Suzuki *et al.,* 2009). Reported similar configuration. The obtained results supported what the manufacturer claimed about the packability and wear resistance of the investigated GIC which recorded a wear value as equivalent as wear value of resin composite; (Table 2). However, it should be pointed out that all GIC fabricated samples were stored individually in 3 mL distilled water and kept in incubator at 37°C for 24 hours; then weighed, prior to abrasion wear testing.

The moisture sensitivity of GIC samples might interpret for more water imbibition during this storage period. Later, the samples were subjected to dry ageing after wear testing and before reweighed again. Consequently, uncoated GIC samples recorded more weight loss and higher wear value but insignificant with uncoated resin composite ones. During the initial stage ofGIC setting, the formed silica hydro-gel due to acid base reaction should be protected against water contamination to prevent cement dissolution and consequent low mechanical properties in addition to fragile, soft and porous surface prone to degradation. Once setting has taken place, loss of water due to dehydration should also be avoided; otherwise, cracking/crazing of the cement surface would occur. Finally, aging of the cement results in tightly bound water instead of loosely bound one (Mensudar and Sukumaran, 2015). The protective effect of coating on the early wear of GIC has been proven by several in vitro tests (Gurgan *et al.,* 2015). Despite the extreme improvement in resin composite restorative materials, their use is still limited by low wear resistance, and loss of anatomical form and superficial gloss. Moreover, finishing and polishing of the composite surface would produce micro-cracks and micro-defects producing rough surface. In an attempt to overcome these drawbacks, a low viscosity, good wettability and of high penetrating capacity resin coating is used to fill and seal the structural surface flaws resulting in micro-lamination effect. This approach is assumed to provide uniform, regular and smooth surface (Nahsan *et al.,* 2014). It was supposed that the protective micro-laminated coating provides glossy and wear resistant layer (Mensudar and Sukumaran, 2015). There was a debate about the effect of GIC coating (Lohbauer *et al.,* 2011) stated that coating contributed to overall GIC strength by improvement of the maturation process and not by inherent strength of the coating layer. Meanwhile (Gurgan *et al.,* 2015), had been proven by in vitro study the protective effect of coating on the early wear of GIC. (Lohbauer *et al.,* 2011) Found that coating glass ionomer with a nano-filled resin coating produced a proper sealing of GIC surface porosities but did not improve the wear resistance of the underlying cement. In contrast, (Bonifácio *et al.,* 2012) proposed that nano-filled resin coat had an improvement effect on the early wear of some types of GIC rather than other ones. The present results were in agreement with (AlJamhan *et al.,* 2011) who reported that nano-filled resin coating applied to conventional GIC improved the wear resistance and becomes comparable to

the wear resistance of resin composite, which meant that the coat protected the GIC restoration and increasedits wear resistance. Also, the present results confirmed the recent in vitro study of (Kanik *et al.,* 2017) who stated that the tooth-brushing of the resin coating protected and rendered the highly viscous GIC as wear resistant as resin composites in clinical situations for a long time; (Table 2) (Diem *et al.,* 2014). Assured that the application of nano-filled resin coating protected the conventional GIC and resin composite against wear that extended for three years clinical performance. Based on the previous discussion, coating is essential for GIC to protect against moisture contamination during the initial setting until maturation occurs up to the peak strength. Moreover, coating of resin composite is supposed to seal surface defects of the underlying material and to gain glossy appearance (Thomas *et al.,* 2016). Manufacturers have used nanotechnology in the production of functional materials and structures in the range of 0.1-100 nanometers (nm) (Mitra *et al.,* 2003). A new generation of nano-filled self-adhesive resin coating contains 10-15% uniformly dispersed single phase colloidal silica with an average particle size 30-40 nm and pH=2.5 is purchased to the dental market. The resin coating's composition and prpoetries allowed the formation of a thin layer of ~ 40-70 μm (Lu *et al.,* 2006) which is adequately adhere to the restorative material beneath. It is reasonable to believe that there was a gradual removal of this resin rich coating with brushing cycles (Amaral *et al.,* 2006). The wear of nano-filled coating might be explained on the basis of the low filler content (10-15%), the size of the filler (30-40 nm) and their uniform distribution throughout the resinous matrix that permitted even and consistent wear during brushing (Da Costa *et al.,* 2010). Nano-sized colloidal silica fillers and polymer matrix are abraded off together during brushing and/or plucking of nano-scale size filler leaving discrete nano-pores. Besides, the persistence of nano-filled resin coating without peeling off could be referred to the strong adhesiveness of acidic phosphoric ester monomer component; (Table 1) and as reported by (Sheila *et al.,* 2010). This was proven by the obtained results where the coated samples exhibited tribological characteristics as wear resistant as both uncoated resin composite and GIC; (Table2) with keeping the utmost smooth surfaces after brushing; SEM (Figures 2.B&3.B) and AFM (Figures 4B & 5B) (AlJamhan *et al.,* 2011). Had similar results after tooth brushing abrasion where resin composite, coated GIC and the uncoated GIC showed indifferent values.

In fact, the clinical studies are the gold standard for evaluating the properties of a new material. According to the current research, the employed 100000 cycles for in vitro abrasion wear did not represent clinical situation as there is hardly any correlation between the duration of the wear cycles with the times under clinical function. However, the resin coating in the range of 40-70 μm thick had been abraded within the range of 60000-120000 wear cycles (Lohbauer *et al.,* 2011). Furthermore, it was expected the durability of resin coating applied on the restoration'ssurface would lasting formore than a year-and a-half (AlJamhan *et al.,* 2011). The obtained results confirmed what manufacturer claimed that the surface coating protects GIC against wear and guaranteed its positive effectiveness for 3 months. The surface texture of dental materials is determining factor in staining and discoloration of the restorations and loss of surface gloss that impair esthetic. Surface roughness has an influence on the plaque accumulation, periodontal pathogenesis and secondary caries.The threshold of surface roughness for bacterial adhesion is ≥ 2 μm (Bollen *et al.,* 1997). Furthermore, the tongue tip can detect surface roughness in the range of 0.25-0.50 μm that contribute to patient's discomfortt (Jones *et al.,* 2004). Therefore, smoothness of restoration is utmost importance for its success. Unfortunately, esthetic restorative materials are heterogeneous in nature due to difference in hardness of resin matrix and filler and thus cannot abraded uniformly[38].During brushing, the soft matrix phases are preferentially removed, leaving the harder, non-reacted glass particles of GIC or ceramic filler particles of resin composite to protrude from the surface which determines surface roughness of the restoration [20]. The size and shape of the particles crucially affect the surface roughness; the larger the particle size, the rougher would be the restoration's surface (Oliveira *et al.,* 2012). AFM results of surface roughness exhibited excessive rugosity of GIC which is referred to the fact that the investigated material is conventional GI of average particle size 10-20 μm (Maya *et al.,* 2016). Thus, the dislodged glass particles and the projected ones resulted in the significant roughest surface, (Figures 5A). On contrast, the nano-filled resin coating in this study evidently confirmed the reduction of surface roughness after brushing; as proven by AFM (Figures 4B & 5B). In agreement with (Bagis *et al.,* 2014) who found significant improvement effect of nano-filled protective resin coating on the surface roughness of resin-based restorative materials.

The current results supported manufacturer's claim that nano-filled resin coating provided smoothness of the restorations. Hardness is an indication forthe resistance of a material to scratching. It should be pointed out that micro-hardness is a surface property but also related to the bulk properties. Hardness is an important surface characteristic of restorative materials as it has a direct relationship with their wear resistance (De Moraes *et al.,* 2008). As a matter of fact, increased surface hardness reduces the wear loss and surface roughness of a material due to greater resistance to abrasive mechanisms i.e. wear is reduced if the resin composite or GI is harder than the abrasive, and vice versa (Oliveira *et al.,* 2012). This study sponsored this opinion as soft nylon bristles are definitely softer than the surface of the investigated restorative materials. A study stated that a low negative correlation was existed between surface hardness and surface loss after abrasive procedure (Faraji *et al.,* 2017). Meanwhile, others reported that there is no correlation between surface roughness and hardness (Oya *et al.,* 2012). In this study, micro-hardness mean values of coated samples with nano-filled resin coating for both investigated materials (55.94 ± 0.99 & 56.24± 2.34for composite & GI respectively) were not significantly different, but significantly different than those of corresponding uncoated samples (82.22± 3.94 & 71.82± 4.90 for composite & GI respectively); (Table 3).This could be attributed to the employed two body wear process using soft nylon bristles. The bristles could abrade prominently the soft resin matrix rather than the harder filler particles; in particular, large and irregular particles.

Conclusion

1. The wear resistance of the nano-filled resin coating per se is analogous to those of uncoated aesthetic restorative materials.
2. The existence of the coating after exposure to wear abrasion test; prolonged brushing, proved its durability and serviceability.

3. The coating evidently reduced the surface roughness of both investigated aesthetic materials that would allow more glossy appearance and maintain healthy oral condition.
4. The nano-filled resin coating has significantly lower hardness mean values than those of the investigated aesthetic restorative materials.

Recommendation

According to the results of the current study, application of an adhesive nano-filled resin coating on the esthetic restorative materials; GICs and resin composites, is recommended on regular biannual basis.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper. The article is self-funded by the authors as they received no specific funding for this article.

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