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THE EFFECT OF OSCILLATING AND SONIC ELECTRIC TOOTHBRUSHES ON THE SURFACE TOPOGRAPHY OF DIFFERENT RESTORATIVE DENTAL MATERIALS

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ABSTRACT

Tooth brushing of the esthetic restorative materials may results in their wear and subsequently negatively affecting their biological, esthetic and mechanical properties.

The aim of the study was to compare the effect of oscillating-rotating (OS) and the sonic (V) power-driven toothbrushes on the wear of three different restorative materials.

Materials and methods: Three restorative materials were used; nano-hybrid composite Filtek™ Z250 XT, bulk fill resin composite Tetric N- Ceram Bulk Fill and highly viscous glass ionomer restoration Ketac™ Universal Aplicap™ . With a total of 42 samples (10x2 mm), 14disc shaped samples were prepared from each material and randomly divided into two groups then subjected to wear with the two electric toothbrushes (n=7) for 60 minutes under toothpaste slurry. Change in surface roughness (Ra) and weight loss before and after wear testing was recorded and subjected to one-way ANOVA followed by Tukey post-hoc tests (with significance level $P \leq 0.05$) to reveal the significant difference.

Results: The highest Ra and weight loss values were recorded in samples subjected to wear by V toothbrush in three tested materials. However, there was no statistically significant difference between the tested materials with OS toothbrush.

Conclusion: OS and V electric toothbrushes have the same effect on the surface topography of the tested restorative materials.

KEYWORDS: oscillating toothbrush; sonic toothbrush; wear; weight loss; Bulk-fill resin composite

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INTRODUCTION

Effective home-based dental hygiene is a fundamental component of plaque control, and toothbrush choice is an important consideration. Tooth brushing is the most common home-care oral hygiene procedure. It has a significant role in reducing dental plaque accumulation and subsequent acid production and caries incidence[1]. Nowadays, a wide variety of manual and power-driven toothbrushes are available at the market. Power toothbrushes (PTBs) are the latest technological device for oral hygiene care. The power-driven toothbrushes clean teeth by different techniques such as sonic, oscillating, oscillating-rotating, and ionic ways. Fortunately, the power-driven toothbrushes recorded better plaque removal than manual type [2-4]. Among various types of powered toothbrushes, existing evidence suggested that rotation-oscillation, ionic, and ultrasonic brushes performed better than manual toothbrushes in plaque reduction, with the most evidence existed for the rotation-oscillation brushes [5]. Moreover, the oscillating-rotating toothbrushes showed a significant reduction in the plaque removal and improving in gingivitis when compared with sonic toothbrushes [6,7]. Unfortunately, the oral hygiene methods are the most common factors that reduces the quality of restorative materials [8].

Many researchers investigated simulating tooth brushing over the surface properties of the restorative materials. They used simulated toothbrushing machines with manual toothbrush heads attached to the moving arms. However, for more simulation of the clinical situation, the use of power-driven toothbrushes will be more satisfactory [9-13]. **Komandla et al.,** mounted an oscillating-rotating of power-driven toothbrush in a customized apparatus to evaluate the effect of tooth brushing on glass ionomer restorations [14].

With the increasing aesthetic demands of the patients, the advent of bulk-fill composites is one of the most important achievements in this field. Bulk fill composites with low and high viscosities emerged on the market and were developed initially to fill cavities with a unique increment up to 4 or 5 mm [15]. This results in optimization of the clinical time by replacement of the traditional incremental technique which is based on multiple increments of 2 mm. Bulk fill resin composite materials reported reliable clinical results when compared with incrementally placed resin composites [16]. Likewise, Glass ionomer (GI) restorative material is placed in a bulk fill manner. Recently, the improvement of GIC's composition leads to the augmentation of the mechanical properties to the degree that the manufacturer recommended its use in stress-bearing areas [17].

Hence, the aim of the current study was to evaluate the effect of oscillating-rotating versus the sonic power-driven toothbrushes on the wear of conventional nanohybrid resin composite, bulk-fill resin composite, and glass ionomer restorative materials.

MATERIAL AND METHODS:

The sample size was calculated using G power version 3.1.9.7. It was calculated with a power of 95%, a significance level of 95%, and an effective size f = 0.8 to reflect the very large effects found in other research that study dental materials [18]. Therefore, the total sample size was 21 samples (n=7). Forty-two samples were prepared using Teflon split mold with an internal dimension of 10 mm diameter and 2mm in height; 14 samples from each material. The resin composite materials were extruded and packed inside the mold using a gold-plated instrument while glass ionomer capsules were mixed according to manufacturer's instructions then packed inside the mold. A celluloid strip was sandwiched between the upper surface of the compacted material and a glass slide of 1mm thickness was placed to flatten the surface, extrude excess material, and to produce

TABLE (1): The type, composition and manufacturer of the used restorative materials

Material/ specification	**Composition**	**Manufacturer**	**Lot number**
Filtek™ Z250 XT Nano-hybrid composite (Z250)	Matrix: Bis-GMA[1], UDMA[2], BIS-EMA[3], PEGDMA[4]& TEGDMA[5]. Fillers: (82% by weight) Surface-modified zirconia/silica with a median particle size of approximately 3 microns or less and non-agglomerated/non-aggregated 20-nanometer surface-modified silica part icles.	3M ESPE, Dental Products, Saint Paul, MN, USA https://www.3mespe.com.	NC07012
Tetric N- Ceram Bulk Fill/ Bulk-fill resin composite (Tetric)	Matrix (21%): Bis-GMA[1], Bis-EMA[3] & UDMA[2]. Fillers: barium aluminum silicate glass with two different mean particle sizes, filler content approximately 75-77% (wt.) and 17% polymer fillers or "Isofillers" Initiator: CQ[6] (plus an acyl phosphine oxide, together with a recently patented initiator Ivocerin	Ivoclar vivadent AG, 9494 Schaan/ Liechtenstein https://www.ivoclarvivadent.com/	Y45822
Ketac™ Universal Aplicap™/ Highly viscous glass ionomer restoration (GIC)	Powder: Oxide glass > 95 wt %. Liquid: Water (40–60 wt %, Copolymer of acrylic acid – maleic acid (30–50 wt %, Tartaric acid (1–10 wt) and Benzoic acid (<0.2 wt %)	3M ESPE, Dental Products, Saint Paul, MN, USA https://www.3mespe.com.	644202

1-Bis-GMA: Bis-phenol A glycol di-methacrylate
2-UDMA: Urethane dimethacrylate
3-Bis-EMA: Ethoxylated bisphenol A glycol dimethacrylate,
4-PEGDMA: Poly ethylene glycol di-methacrylate,
5-TEGDMA: Triethylene glycol di-methacrylate and
6-CQ: Camphorquinone.

a smooth surface. Resin composite samples were light cured for 20 seconds using LED light curing unit with 1500W/cm^2 (Radii Plus, SDI Limited, Australia). Meanwhile, GIC samples were left to set at room temperature for 2.5 minutes after mixing.

Two types of power-driven toothbrushes were used for assessing the wear resistance of the restorative materials. The first one was Oral-B® Pro-Expert (O-R) (manufactured for Braun, GmbH, Germany by Providence Enterprise ltd, Shenzhen, China). The toothbrush produces 9000 oscillations/ rotation per minute. The second one was Shuke ™ SK-601 (V) (Guangdong Shunde Foreign Trade Development Co Ltd, China). The toothbrush produces sonic movement of 26000 micro-vibrations per minute.

A custom-made device for holding the toothbrush and samples was designed. The device composed of four main parts (Figure 1): 1-Two vertical pillars to fix the body of the toothbrushing a horizontal plane. The connection of toothbrush body with metallic pillars was lined by rubber films to reduce the propagation of vibration and noise. 2- A threaded jig to allow for vertical adjustment of the samples to ensure the touching between samples and the bristles of toothbrush head. A cylinder hole with 10mm X 1.5mm was centralized in the upper surface of the jig to allow static positioning of the samples with 0.5mm projecting out from the jig hole. 3- A plastic cup surrounds the upper part of the threaded jig and fixed to it by sealing silicon to

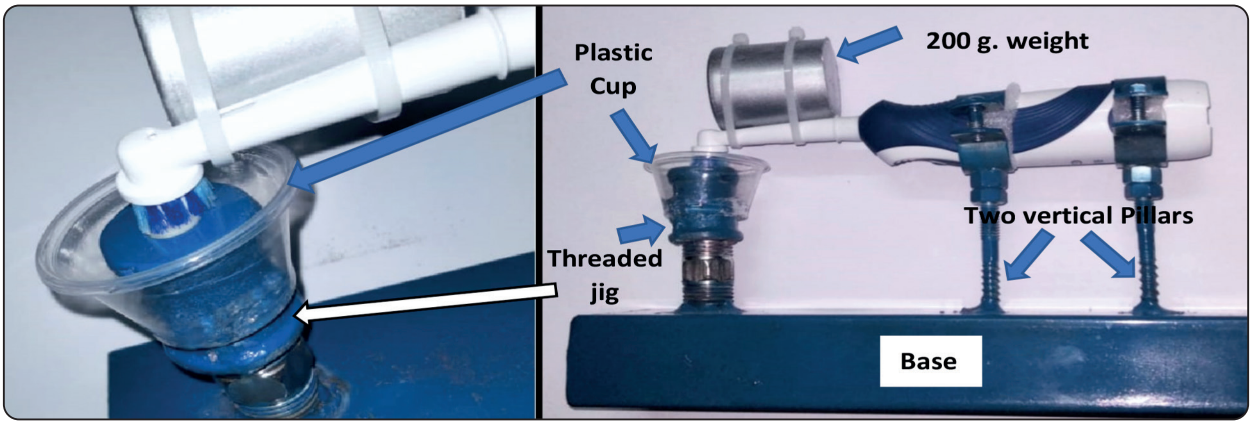

Fig. (1): The designed Toothbrush wear device

ensure immersion of the samples in the toothpaste slurry during the testing. 4- A metallic base to fix the two vertical pillars and the jig at a definite distance. 5- A weight of 200 g. was attached to the head of the brush.

Each sample was subjected to a wear test for 60 minutes which is equivalent to 2 years of tooth brushing. The time calculation was based on the recommended brushing time is 2 minutes per day for all the teeth, which also means that the toothbrush contacts each tooth for 5 seconds per day [19]. The samples were subjected to wear where they were completely immersed in toothpaste slurry (Signal cavity fighter, Unilever, Egypt) and 200 gm weight was applied over the head of the toothbrush. The slurry was prepared according to ISO/TS 1469-1 by mixing toothpaste with water with a ratio of 2:1 [18]. After the wear testing, the samples were washed with distilled water then cleaned inside an ultrasonic water-path (ultra-sonic cleaner; Codyson CD-4830, China) to remove any residue of the slurry.

The surface roughness (Ra) values were measured using surface roughness tester SJ-210 (Mitutoyo corporation, Japan) under 0.75 mN force with 0.5 mm/s speed. For each sample, the Ra value was calculated as the difference between the readings recorded before and after tooth brushing wear test. The stylus tip radius is 2 microns and 60° tip angle. The Ra reading was obtained from the mean of five readings recorded with 500 microns at a measuring distance of 8mm. As well, the samples are weighed before and after the toothbrush wear test using an analytical digital balance (HS 210I, GIROPES Baxtran, Spain) with 0.0001 gm accuracy. The weight loss values were calculated as the difference between before and after the toothbrush wear test.

Statistical analysis was performed with IBM® SPSS® Statistics Version 25 for Windows. The mean and standard deviation values were calculated for each group. Normality test was performed using Kolmogorov-Smirnov test and revealed normal distribution between values of each group. Homogeneity test was performed using Levene's test and revealed homogenous distribution between all variables. Therefore, one-way ANOVA and Tukey post-hoc tests were performed (with significance level was set at $P \leq 0.05$) to reveal the statistically significant difference between the variables.

RESULTS

Surface roughness results

The highest surface roughness value (Ra) was recorded in GIC samples subjected to toothbrush wear with V toothbrush (1.95 μm±0.67) followed by GIC samples subjected to toothbrush wear with R-O toothbrush (1.94 μm±0.69). On the other hand, the lowest surface roughness values (Ra) were recorded by Z250 samples subjected to wear with R-O toothbrush (0.39 μm±0.07). toothbrushing V exhibited more aggressive behavior than R-O toothbrushing, however, there was no statistically significant difference between the results of surface roughness values of all samples (p-value=0.053).

Weight loss results

The highest weight loss was recorded in GIC samples subjected to wear with V toothbrush (1.42 mg±0.61) followed by Tetric samples subjected to toothbrush wear with V toothbrush (1.34 mg±0.4). On the other hand, the lowest weight loss was recorded in Z250 samples subjected to wear with O-R toothbrush (1.06 mg±0.54). Again, toothbrushing V exhibited more aggressive behavior than R-O toothbrushing; however, there was no statistically significant difference between the results of the weight loss values of all samples (p-value=0.921).

TABLE (2): Surface roughness and weight loss values of the tested materials.

Tooth-brush	Surface roughness (μm)			Weight loss (mg)		
	Z250	Tetric	GIC	Z250	Tetric	GIC
R-O	0.39±0.07	1.08±0.24	1.94±0.69	1.06±0.54	1.18±0.56	1.2±0.56
V	1.64±0.90	1.77±0.53	1.95±0.67	1.24±0.50	1.34±0.40	1.42±0.61
P-value	0.053			0.921		

DISCUSSION

Tooth brushing is considered an effective method for preserving a good oral health environment. Unfortunately, it leads to loss of restoration gloss and an increase in surface roughness with subsequently plaque accumulation and deterioration of the mechanical properties [18,20,21]. Achieving good oral hygiene is affected by patient education, the complexity of restorations, and the dexterity of the patient [22]. As electric toothbrushes are more efficient in removing dental plaque than manual toothbrushes [23], therefore, motivating the patient for using electric toothbrushes will result in improvement in oral hygiene.

Subsequently, in the current study two types of commercially available electric toothbrushes, vibrating and rotating oscillating types were selected to evaluate their effect on the wear of bulk fill restorations.

Wear of restorative materials intraorally is a multi-factorial process that involves consistency and chemical properties of the diet, amount of applied force, properties of the antagonist material either restoration, natural tooth or toothbrush, and presence of abrasive particles in the toothpaste are also affecting the wear mechanism [24,25]. As well, wear is principally related to the composition of the restorative material such as the matrix nature and degree of its polymerization, fillers size, shape, size, orientation and distribution, and bonding between matrix and fillers. Therefore, standardization of the applied force and the used toothpaste was taken into consideration during designing the current study in a trial to limit the variables affecting the complex wear mechanism.

In the current study, the wear of the tested materials was measured by the change in surface roughness and the amount of weight loss. The results of the present study revealed that there is no statistically significant difference between the wear of the three tested materials under both electric toothbrushes.

Regarding to Z250, which is a nanohybrid resin composite, it is loaded with 81.8 (by wt%) fillers having size ranging from 20 nm for silica and 0.1–10 μm for zirconia/silica particles. **Naz et al.**, reported that resistance of Z250 to toothbrush wear may be referred to its nanosized particle size either individually or in clusters, the good bond between the matrix and fillers, and high filler loading [25].

Regarding Tetric, the material is loaded with lower percent of fillers than Z250 (75-77% by wt%). Moreover, its matrix is mainly UDMA which showed lower wear resistance than Bis-GMA [26]. Finally, Tetric contains pre-polymerized fillers (pre- cured filled organic matrix that is milled to the desired size and added as a filler particle to the matrix). These pre-polymers have a higher degree of conversion that might interpret for wear resistance results of Tetric which was comparable and insignificant with Z250 [18].

Regarding the investigated GIC, this is a new generation of highly viscous glass ionomer restorative material. Based on the microstructure findings under SEM, **Soliman and Othman** reported a dense microstructure with little voids and fewer glass particles. Thus, they claimed that the high strength and hardness of this type of GIC are referred to its microstructure [17].

However, the results of the present study reported no statistically significant difference among the tested material which is contradicted by other studies [27]. This may be referred to the time of wear test being lower than other tests. Similarly, there was no statistically significant difference between the results of both tested toothbrushes. Up to our knowledge, there was no research comparing the effect of both types of commercially available electric toothbrushes on restorative materials. However, the effect of both electric toothbrushes was used to evaluate the plaque removal and surface roughness of enamel and dentine. **Wiegand et al.,** reported dentine abrasion after tooth brushing by rotating-oscillating, sonic or ultrasonic action of the power toothbrushes [28]. Moreover, **Hernandé-Gatón et al.,** reported that electric toothbrushes can increase the surface roughness of white spot enamel lesions [29]. Furthermore, **Van der Weijden et al.,** reported that a rotating-oscillating toothbrush is more efficient in plaque removal than vibrating type [30].

CONCLUSION

Within the limitations of the current study, it can be concluded that rotating-oscillating and vibratory electric toothbrushes have a comparable effect on both wear and weight loss over the investigated restorative materials. As well, the tested materials elucidated analogous wear behavior.

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