Study Regarding the Effect of Toothbrush and Toothpaste on Surface Roughness of Different Restorative Materials

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The aim of this study was to assess the effect of toothbrushing with toothpastes having different relative dentine abrasivity (RDA) and toothbrushes having different bristles hardness on different composite resins, compomers and traditional glassionomer cements by surface roughness evaluation. All the samples were evaluated regarding the surface roughness using roughness checker (Taylor Hobson-Surtronic25, AMETEK Inc., Pennsylvania, USA) and the average roughness values (Ra) were recorded. In the conditions of this study all the tested materials were abraded by the toothpastes and toothbrushes. Hard bristles tootbrush associated with high RDA tootpaste abraded higher all the materials for filling when compared to hard bristles tootbrush associated with low RDA toothpaste and medium bristles toothbrush associated with low RDA toothpaste. Traditional glassionomer cement was the most affected by abrasion, followed by microhybrid composite resin, flowable composite and compomer.

Keywords: abrasion, toothpaste, toothbrush, composite resin, compomer, glassionomer cement

In oral cavity the teeth are exposed to wear as a result of four different processes: atrition, abrasion, erosion and abfraction. Abrasion is a wear process that affects dental hard tissues and the materials used for reconstruction. This process might occur on occlusal surface of the teeth, and in the cervical area of facial or lingual surfaces as well. In most of the cases, the cervical abrasion is due to toothbrushing, which acts by two components: the toothpaste and the toothpaste bristles [1, 2]. Factors like the brushing technique, the pressure applied on the toothbrush handle, the bristles hardness, the toothpaste abrasiveness, the frequency and the time of toothbrushing can influence the onset, severity and progression of cervical abrasion. The bristles and tufts modulus of elasticity, diameter, number of tufts, the number of bristles per unit area, and the trim length of bristles have also been reported to influence the abrasive potential of a toothbrush [3, 4].

Materials used for direct restorations can also be prone to different wear processes according to their site (cervical or occlusal), to the tooth that has been restored (frontal or lateral) and to the presence of opposite tooth [5, 6]. Atrition will occur due to the tooth-restoration contact and abrasion will appear due to the direct contact of the material for restoration and abrasive particles or objects. Few clinical studies evaluated the abrasive effect on dental hard tissues and on the materials for filling due to the multiple, combined ethiological factors of wear lesions in oral cavity, lack of reproductibility and time involved. Most of the studies are conducted in vitro and tried to simulate the conditions of the oral cavity [7]. In vitro tooth brushing tests are used to evaluate the wear resistance of restorative materials under specific standardized conditions [8, 9].

The use of posterior composite resins significantly increased during the time due to their good aesthetics, minimal cavity preparation, good adhesion to tooth structure and wear resistance. The producers claimed that some composite resins have almost similar wear resistance to enamel. Compomers resulted as by the association of composite resins and glass ionomer cement components [10, 11]. The advantages of these materials are related to a good adhesion to dental tooth structures, fluoride release, biocompatibility and a better strength when compared to conventional glass ionomer cements. Some components of compomers can influence their wear rate: particle size, filler treatment, monomer system and curing method [12].

The aims of the study were to evaluate and to compare the abrasive wear of four different materials used for direct restoration when toothpaste having different abrasiveness and toothbrush having different bristles hardness were used for toothbrushing.

Experimental part

Samples' preparation

Forty healthy molars were selected for this study. Eighty cervical cavities having 3 mm in width, 3 mm in long and 3 mm in depth were prepared on facial and lingual faces of the teeth. The long axis of the cavities corresponds to the long axis of the tooth face. The cavities were randomly distributed among four groups. In group A the cavities were filled with a condensable microhybrid composite resin (Filtek Z250, 3M ESPE), in group B with a flowable composite resin (Flow, Latelux), in group C with a compomer (Dyract, Denstsply), and in group D with a traditional glassionomer cement (Ketak Molar Easymix, 3M ESPE). In groups A, B, and C a universal adhesive system (Universal Single Bond, 3M ESPE) was used according to the producers indications. Two distinct layers of condensable composite resin were applied in the cavities included in group A and lightcured for 40 s using LED B lightcure unit (Guilin Woodpecker Medical Instrument Co., Ltd, China) having the power of 850-1000 mW\cm^2 and a wavelength of 420-480 nm. In group B the flowable composite resin was applied in a single layer and lightcured for 40 s. Two layers of compomer were used to fill the cavities in group C.

To simulate the toothbrushing, two different toothbrushes according to the bristles hardness: medium (Classic Deep Clean, Colgate) and hard (Interdental Reach, Johnson and Johnson) were used for this study. Toothpaste slurries were obtained by mixing one toothpaste having a low RDA-78 (Maximum Cavity Protection, Colgate), and respectively one having a high RDA-135 (Max White, Colgate) and water in 1:3 volume proportion. The samples of each group were randomly split in four subgroups: five samples were kept in distilled water (subgroup 1, control), five samples were

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subjected to toothbrushing using medium toothbrush and low abrasiveness toothpaste (subgroup 2), five samples were subjected to toothbrushing using hard toothbrush and low abrasiveness toothpaste (subgroup 3) and five samples were subjected to toothbrushing using hard toothbrush and high abrasiveness toothpaste (subgroup 4). To simulate the movements during toothbrushing, a machine created by the authors was used. The device is created to make forward and back movements with constant amplitude of 1.5 cm in each direction and a movement frequency of 60 cycle/minute. A 250 g loading force was applied on each toothbrush. In order to obtain reliable results, the simulated time for toothbrushing was calculated as a mean time needed for a person to brush a tooth during a year, 2 times a day, 2 min each toothbrush. For that reason the samples were continuously brushed for 4 h.

Roughness evaluation

All the samples were evaluated regarding the surface roughness using roughness checker (Taylor Hobson-Surtronic 25, AMETEK Inc., Pennsylvania, USA) and the roughness values (Ra, μm) were recorded as average of 10 measurements registered in different areas with a measuring force of 0.75 mN, a traversing speed of 0.5 mm/s and a cutoff length of 0.8 μm.

Results and discussions

Graph examples of the profilometric analysis are presented in figure 1. For each sample the length of stylus palpation was 250 μm, and the precision 0.4 μm.

The mean values of surface roughness and standard deviation of the samples in all groups and subgroups are presented in table 1.

The use of the same toothpaste in association with toothbrushes having different bristles hardness leaded to diverse wear results on tested materials. Higher Ra values were recorded in subgroup 3 when compared to subgroup 2. Regardless the hardness of toothbrush bristles, the highest Ra values were obtained in group C, followed by group A, B, and D. Using the same toothbrush with toothpastes having different RDA determined dissimilar results of materials wear. Higher Ra values were obtained in subgroup 2 when compared to subgroup 1 for all the groups. Independently of the toothpaste used for brushing, highest Ra values were obtained in group C, followed by group A, B, and D.

A statistically significant increase of the surface roughness of all tested materials was recorded after toothbrushing when compared to control group (ANOVA and post hoc Bonferroni statistical tests, $p < 0.05$).

Previous studies analyzed the resistance of different materials used for direct restoration on abrasion induced by tooth brushing [13-17]. A lot of factors influenced the results of these studies: the load of toothbrush applied on material, the flexibility of toothbrush bristles, the quantity of toothpaste, the duration of tooth brushing, the temperature during tooth brushing.

In our study toothbrushing using different bristles hardness and different RDA toothpastes leaded to different abrasion of composite resins, glass ionomer cement and compomer. The highest roughness values were recorded in this study for glass ionomer cement, followed by microhybrid condensable composite resin, flowable composite resin and compomer. The same tendency of materials roughness variation was recorded in previous studies [18, 19]. The roughness recorded for glassionomer cement was probably due to the initial roughness after the setting time and finishing procedure [20]. A lot of factors are implied in the different wear resistance of condensable and flowable composite resins: fillers properties, organic matrix type, and elastic modulus [21, 22]. The filler loading in volume, filler size, type and shape are major characteristics that interfere with abrasive process [21]. By abrasion, composite resins with bigger particles will lose weight more than composite with smaller particles [22]. Besides, the bigger the filler particles released from the resin matrix, the rougher the surface will result. The

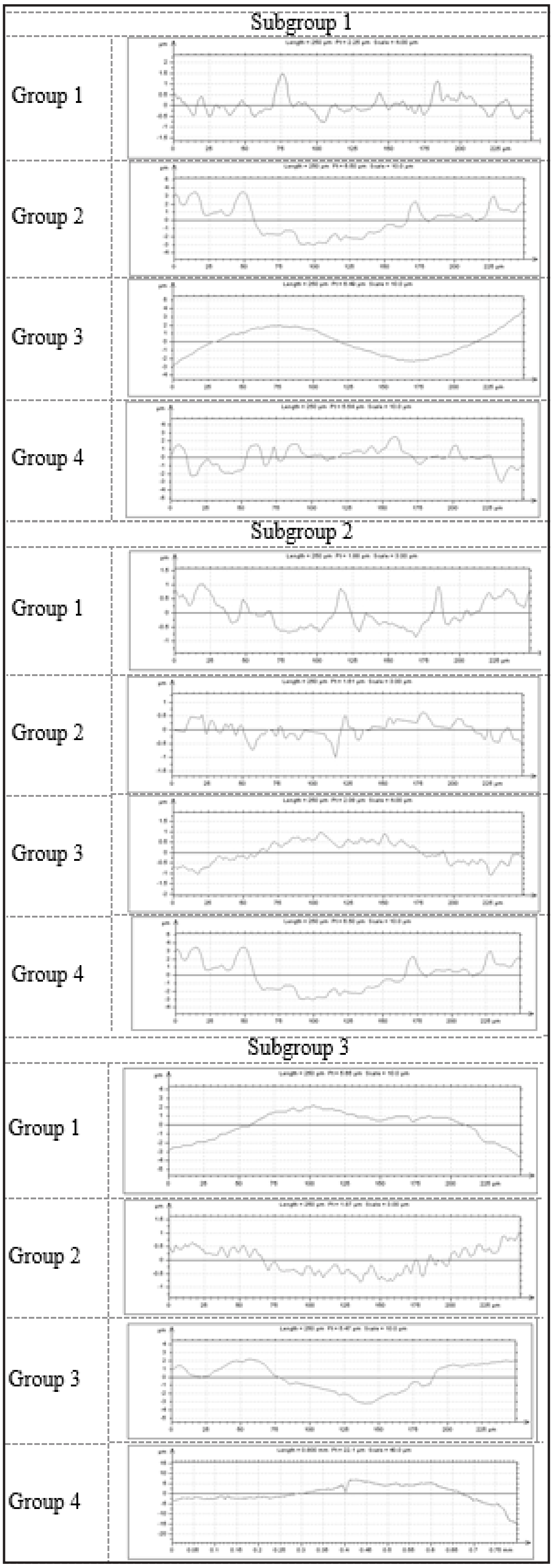

Fig. 1. Graph examples of the profilometric analysis

	Group A	Group B	Group C	Group D
Subgroup 1	0.123±0.04 Ax	0.105±0.05 By	0.427±0.03 Ca	0.109±0.04 Da
Subgroup 2	0.135±0.03 Ab	0.219±0.03Xb	0.553±0.04 Cb	0.155±0.03 Db
Subgroup 3	0.193±0.05 Ac	0.246±0.04 Bc	0.567±0.05 Xc	0.176±0.03 Dc
Subgroup 4	0.419±0.02 Ad	0.335±0.04 Bd	0.598±0.06 Cd	0.316±0.05 Dd
Similar capital letters in a column represent significant statistical difference between materials according to ANOVA and post hoc Bonferroni statistical tests ($p<0.05$). Similar small letters in a line represent significant statistical difference between groups, according to ANOVA and Bonferroni tests ($p<0.05$)				

Table 1
MEAN VALUES OF SURFACE ROUGHNESS (μM) ± STANDARD DEVIATION

smaller particles will improve the degree of particle packing, decreasing the free spaces between bigger particles. That might lead to an increased protection of resin matrix and an increased resistance of composite resin to abrasion [21, 22].

The filler loss during wear process can be determined by the combination of wear loading and of the shear forces [23, 24]. Due to the fact that elastic modulus of the fillers is higher than the resin matrix, they will take over much of this loading. The weak bond between fillers and resin matrix will lead to fillers fracture, fillers de-bonding or fracture lines at the filler-resin interface. The integrity of the resin matrix will be gradually compromised, and that might cause in the end the surface loss of the composite resin.

To simulate the toothbrush, in this study was used a machine having forward and backward movements of the toothbrush on the samples surface. Although similar devices were used in previous studies, the frequency and the time used for brushing or the loading force were different. That's why the comparison of the results coming from these studies is very difficult. In our study, an estimated number of brushing cycles during a year was simulated. Is very hard to calculate exactly the number of toothbrushing movements in a specific period of time due to the fact that the brushing technique varies a lot from a person to another. More than that, the pressure applied on the toothbrush head also varies a lot.

Conclusions

In the conditions of this study, all the tested materials were affected by abrasion due to toothbrush. The most affected material was glassionomer cement, followed by microhybrid condensable composite resin, flowable composite resin and compomer. For all the tested materials, an increased abrasive wear resulted by toothbrushing using hard toothbrushes when compared to medium toothbrush and by using toothpastes with high abrasiveness when compared to toothpastes with low abrasiveness.

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