International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 3 Issue 6, June – 2019, Pages: 32-40

Influence of Counterface Materials on the Wear and Friction Coefficient Behavior of Dental Composite Resin

Meshref A. A., Mazen A. A., El-Giushi M. A. and Ali W. Y.

Department of Production Engineering & Design, Faculty of Engineering, Minia University, EGYPT.

Abstract: *In order to investigate the effect of counterface materials on the wear and friction coefficient behavior of the dental composites resin, a series of counterface materials that use in the oral environment are used in the dry and wet conditions. In the wet condition, artificial saliva was used as lubrication liquid. These counterface materials are stainless steel, polymethyl methacrylate (PMMA), amalgam, porcelain, and buffalo teeth. To determine the wear and friction coefficient, all materials are tested with two-body abrasion, reciprocating sliding apparatus at room temperature. The results have shown that counterface materials had pronounced effect on the wear and friction coefficient of dental composites resin. Based on the results obtained, it was found that the buffalo teeth material as counterface leads to a higher resistance to wear, whereas the stainless steel material showed minimum resistance to wear in the dry condition. In the wet condition, the stainless steel and PMMA material had a higher resistance to wear then the other counterface materials (buffalo teeth, porcelain, and amalgam).*

Keywords: Counterface materials, wear, friction coefficient, dental composite resin, artificial saliva, two-body abrasion.

1. INTRODUCTION

Dental composite resins are increasingly used for restorative objectives because of good esthetic and the capability of establishing a bond to enamel and dentin. However, like all dental materials, composites have their own limitations, Such as the gap formation caused by polymerization contraction during setting, leading to marginal discoloration and leakage. In addition, they are subjected to higher wear rates than ceramics, and although some composites have wear rates similar to amalgam, many have higher wear rates. Refinements of mechanical properties of the composite materials have permitted its use in posterior teeth with greater reliability than was the case some years ago. These refinements included; development of smaller particle sizes of filler, better bonding systems, curing improvements and sealing systems [1].

The function of the research in tribology is to decrease and remove losses that occur due to friction and wear at all levels, where rubbing, grinding, polishing, and cleaning of surfaces take place. Friction is the impedance to motion that happens whenever one solid body is in contact with another solid body [2]. Wear is defined as a consequence of the interaction between surfaces moving in contact, causing gradual remove of material [3]. Sometimes it is mistakenly assumed that interfaces with high friction show a high rate of wear. This is not generally true; both friction and wear have to be determined. There are cases when solid interfaces of polymers show relatively low friction but fairly high wear, while ceramic surfaces show moderate friction but very low wear. In most cases, wear happens by surface interactions on the surface no uniformity [2]. Wear resistance is very significant to dental composite resins, especially when being used in heavily loaded regions. Failure rates are higher for larger restorations, and may still be an important mode of failure for patients with bruxism and clenching customs. Therefore, discussing the friction and wear behavior is of pivotal importance to the advance of dental material development [4].

The improvements in the durability of composites depend on a thorough understanding of the wear behavior of the resin matrix [5]. Understanding of dental friction and wear behavior would help the clinical management of tooth wear, which involves the replacement of missing tooth tissue with dental materials, together with an attempt to minimize the causal factors and develop new dental materials. Therefore tribology of dental materials has developed and is paid increasing attention by various researchers [6]. Fig.1 displays the main parameters affecting the friction and wear.

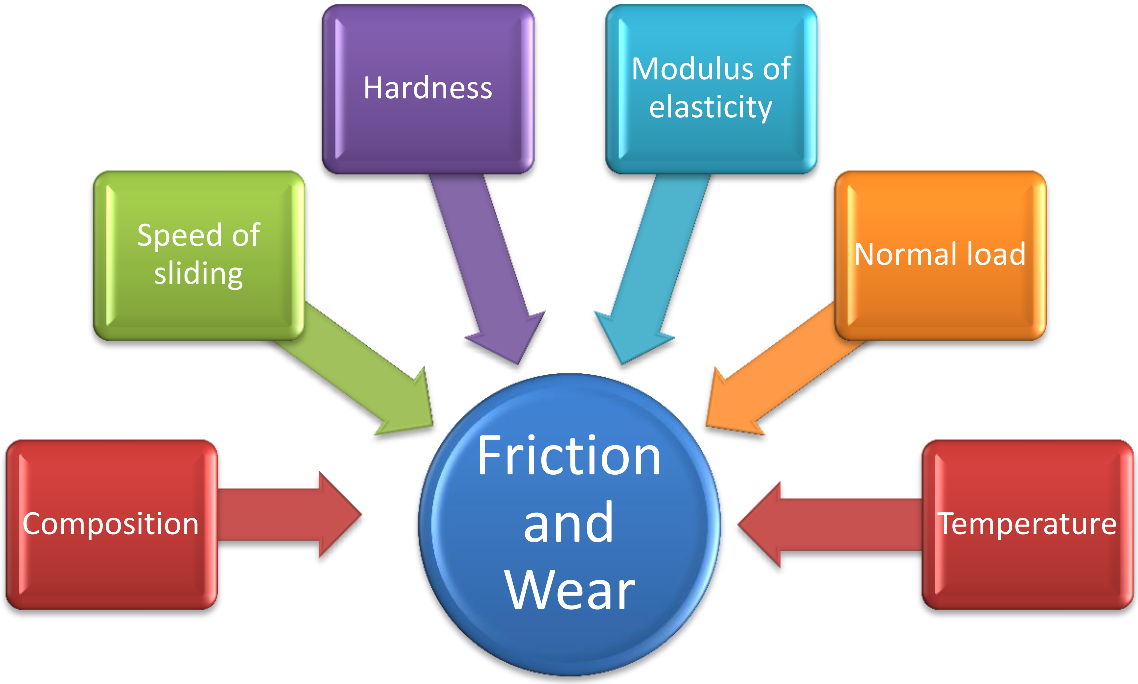

Fig. 1 Main factors affecting the friction and wear behavior [7].

Friction of dental amalgam is altered when any transfer of material from one member of the pair to the other member occurs. For example, when gold or dental composite slide against amalgam, amalgam material is transferred to the gold or composite surface and the friction then becomes that of amalgam on amalgam [5].
This investigation is useful for patient's teeth, dentists, and scientists who are studying dental materials. This investigation will study the effect of stainless steel, polymethyl methacrylate (PMMA), amalgam, porcelain, and buffalo teeth on the wear and friction coefficient behavior of the dental composites resin.

2. EXPERIMENTAL

The materials used in this investigation are shown in Tables 1 and 2.

Table 1. Details of dental composite resin

Description	Classification	Manufacturer	Shade	Curing	Lot no.
Visible light cure, Resin-based dental restorative material	Hybrid composite	Prime-Dent, U.S.A.	A1	Light cure	YL08Q

Table 2: The counterface materials used in this investigation

No.	1	2	3	4	5
Counterface materials	PMMA	amalgam	Stainless steel	porcelain	Buffalo teeth

3. PREPARATION OF TEST SPECIMENS

Dental composite resin was packed into plastic bars 6 mm in diameter and 10 mm long. The specimens were then cured from both sides using a visible light curing unit (LED) for 60 seconds using gradually strong curing mode. After curing, the specimens were removed from the bars and ground with emery paper (1000 grit size) and then polished. The dimensions and shape of specimen are shown in Fig. 2.

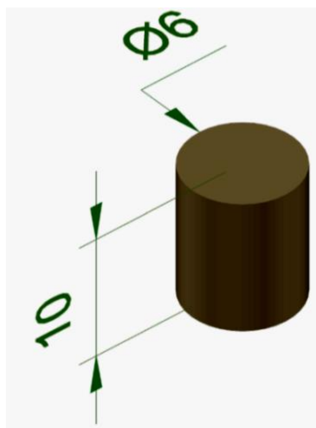

Fig.2 Shape and dimensions of specimen. (Dims. in mm)

4. Friction and Wear Test

To study the friction and wear of the dental composite resin, cylindrical specimen (6 mm in diameter and 10 mm in length) of dental composite resin was held stationary in a jig under normal loads 14 N against counterface materials using two-body abrasion test. The counterface materials were attached to the table of linear bearing. The table moved reciprocating motion at a speed of 190 cycle/ minute. The dental composite resin was tested in the dry and wet conditions. In the wet condition, artificial saliva was used as lubrication liquid. The composition of artificial saliva is shown in Table 3. To find out the accurate weight loss, the dental composite resin was weighted before and after wear test, then wear was determined by the weight loss using digital balance of± 0.0001g accuracy. The coefficient of friction was determined using the relationship:

$$\mu_s = F_s / F_N \quad (1)$$

where μ_s is the coefficient of friction, F_s friction force and F_N normal load. Fig 3 shows two-body abrasion, reciprocating sliding apparatus.

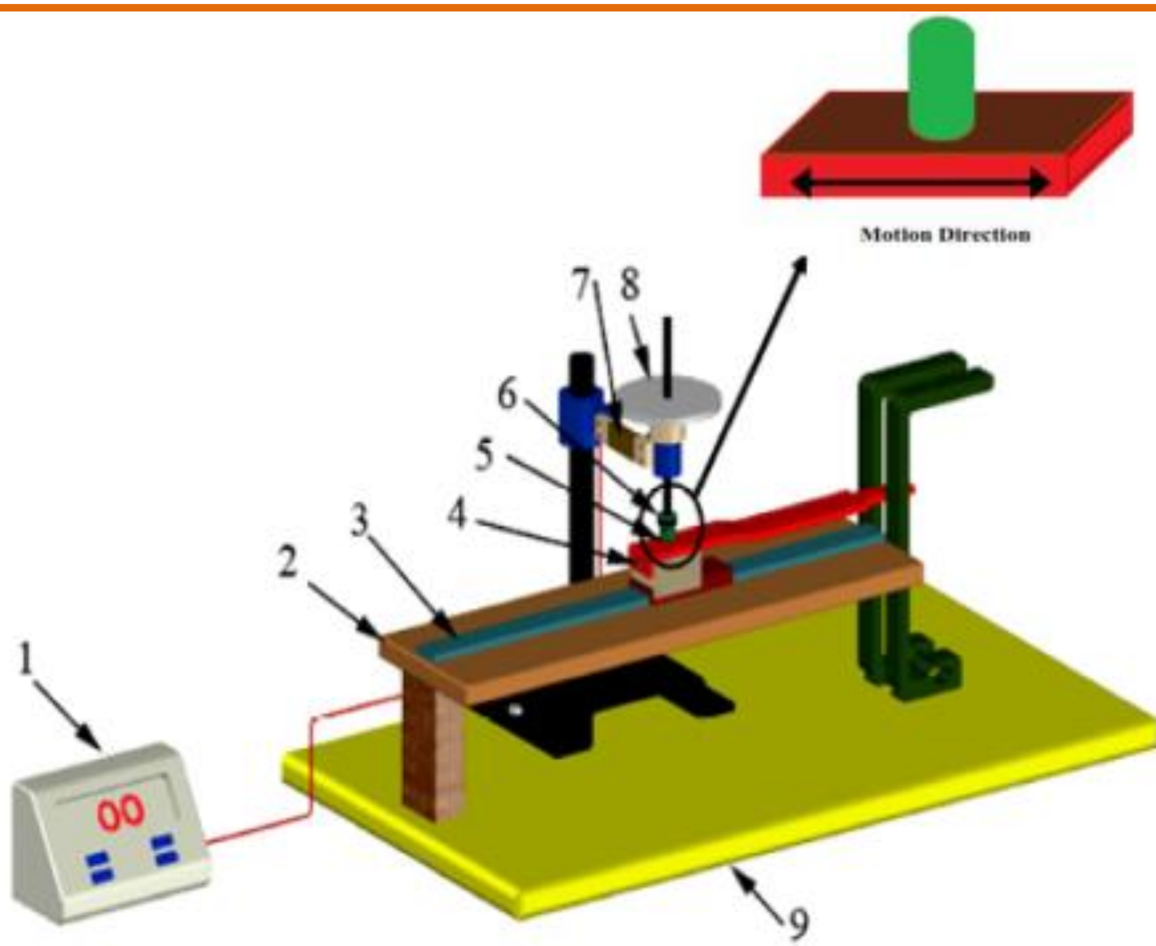

Fig. 3 Two-body abrasion, reciprocating sliding apparatus (1) Friction force screen (2) Plate (3) Linear bearing (4) Table (5) Test specimen (6) specimen jig (7) Load cell (8) Normal load (9) Base plate.

Table 3: The composition of artificial saliva

Compound	Na_2HPO_4	$NaHCO_3$	$CaCl_2$	H_2O	HCL-1M
Concentration	**0.4 g**	**1.7 g**	**0.15 g**	**800 ml**	**2.5 ml**

5. RESULTS AND DISCUSSION

Figure 4 shows the variation of the wear of dental composite resin against the counterface materials used in this investigation in the dry condition. The obtained results as presented in Fig. 4 revealed that counterface materials showed pronounced effect on the wear at all used counterface materials. From Fig. 4, it is clear that the stainless steel material as counterface has the higher value of the wear (7 mg), followed by the amalgam material (4 mg), then the porcelain and PMMA materials (3 mg), whereas the buffalo teeth material showed minimum wear (2 mg). In other words, the buffalo teeth material as counterface had a higher resistance to wear then the other counterface materials (stainless steel, amalgam, and porcelain and PMMA).

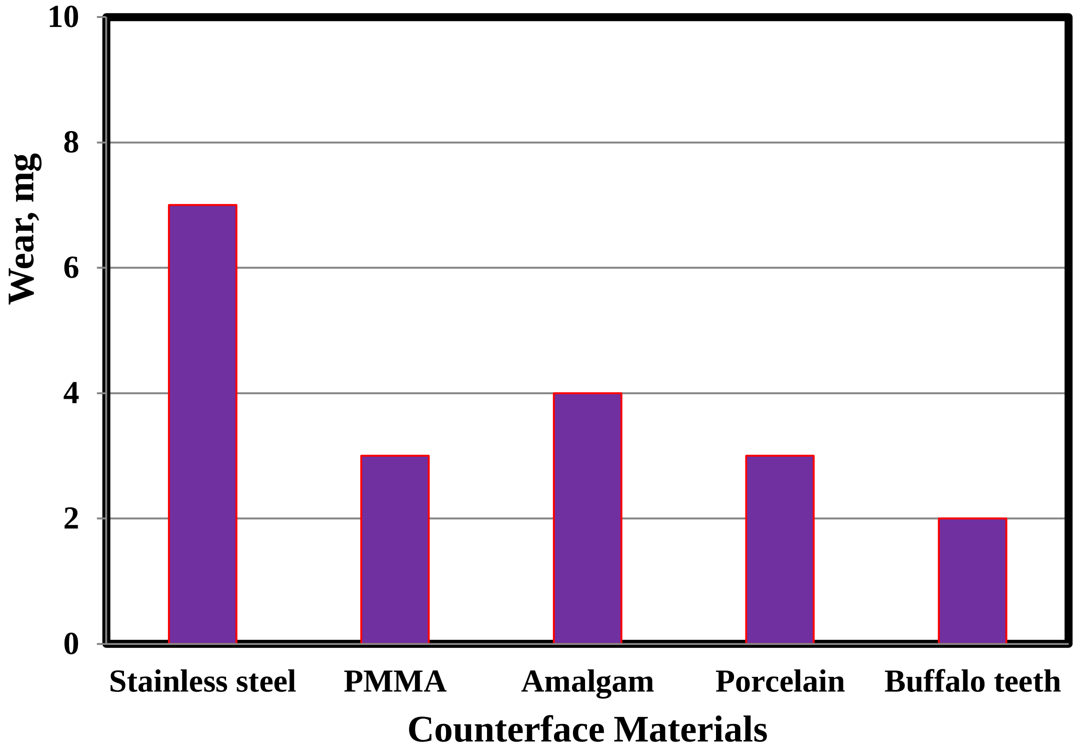

Fig. 4 Effect of counterface materials on the wear of dental composite resin cured with gradually strong mode at 60 seconds in the dry condition.

Figure 5 indicates the relationship between wear and test time for dental composite resin cured with gradually strong mode at 60 seconds in the dry condition. It is evident in Fig. 5 that the wear of stainless steel, PMMA, amalgam, porcelain, and buffalo teeth increased with increasing of the test time up to 6 minute. On comparing the wear according to the counterface materials, it was found that the buffalo teeth material as counterface leads to a higher resistance to wear, whereas the stainless steel material showed minimum resistance to wear.

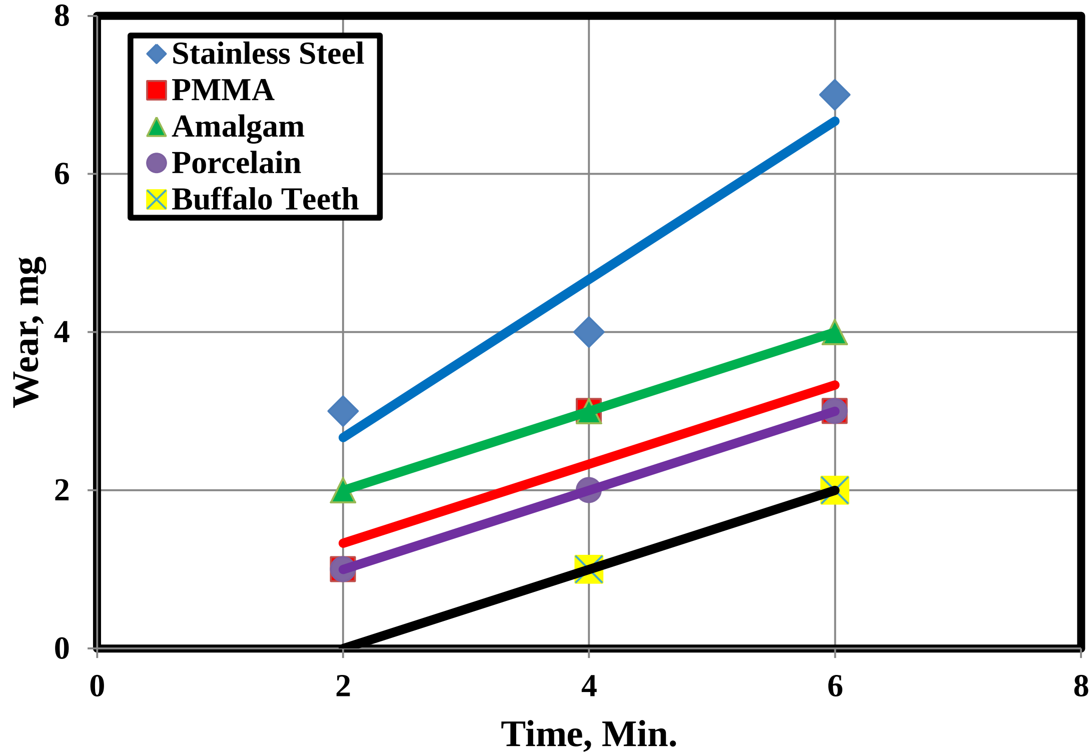

Fig. 5 Effect of test time on the wear of dental composite resin cured with gradually strong mode at 60 seconds in the dry condition.

Figure 6 shows the variation of the coefficient of friction against the counterface materials used in this study in the dry condition. The obtained results as presented in Fig. 6 revealed that counterface materials showed pronounced effects on the coefficient of friction at all used counterface materials. From Fig. 6, it is clear that the stainless steel material as counterface had the highest value of the coefficient of friction, followed by the buffalo teeth, then the amalgam material, then the porcelain, whereas the PMMA material showed the minimum coefficient of friction. In other words, the stainless steel material as counterface had a higher coefficient of friction then the other counterface materials (buffalo teeth, amalgam, and porcelain and PMMA).

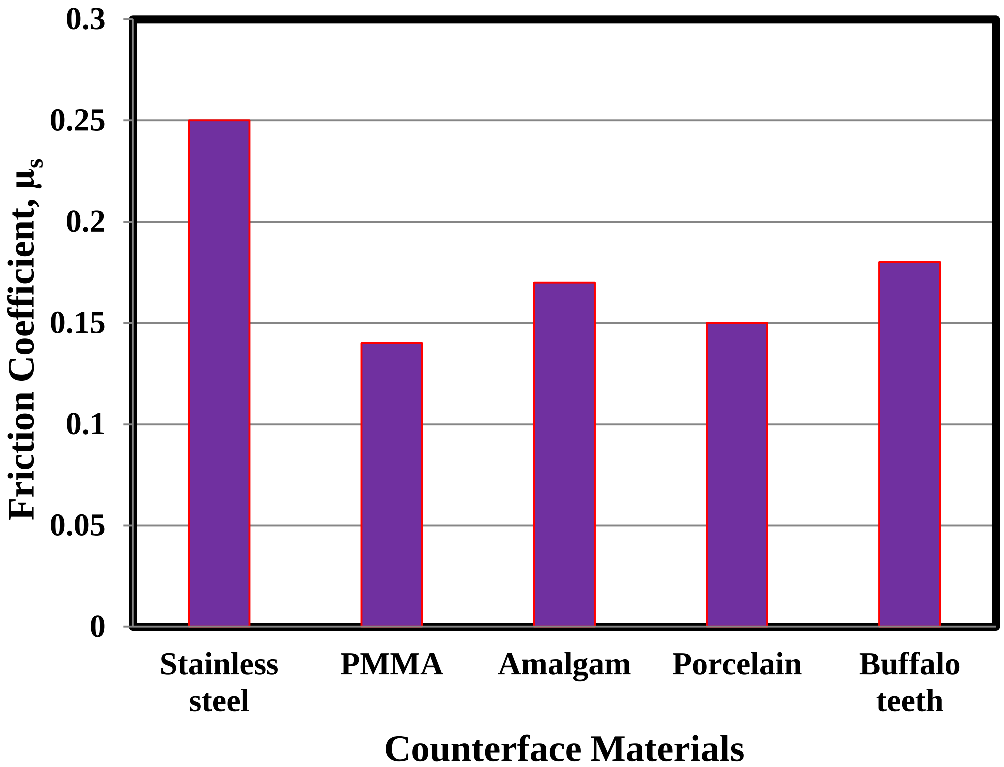

Fig. 6 Effect of counterface materials on the friction coefficient of dental composite resin cured with gradually strong mode at 60 seconds in the dry condition.

The effect of counterface materials used in this investigation on the wear of dental composite resin for the gradually strong mode cured for 60 seconds in the wet condition is indicated in Fig. 7. These data denoted that counterface materials showed pronounced wear by dental composite resin cured with gradually strong mode for 60 seconds at all used counterface materials. From Fig. 7, it is clear that porcelain and buffalo teeth materials as a counterface had the highest value of the wear (4 mg), followed by the amalgam material (2 mg), whereas the stainless steel material showed minimum wear (1 mg). In other words, the stainless steel and PMMA material as counterface had a higher resistance to wear then the other counterface materials (buffalo teeth, porcelain, and amalgam).

The wear of the dental composite resin is plotted as a function of test time for curing time 60 seconds in the wet condition as displayed in Fig. 8. The obtained results as shown in Fig. 8 revealed that the wear stainless steel, PMMA, amalgam, porcelain, and buffalo teeth increased with increasing the test time up to 12 minute. By comparing the wear results from the counterface materials, it was found that the buffalo teeth material as counterface had a lower resistance to wear, whereas the stainless steel material showed the maximum resistance to wear.

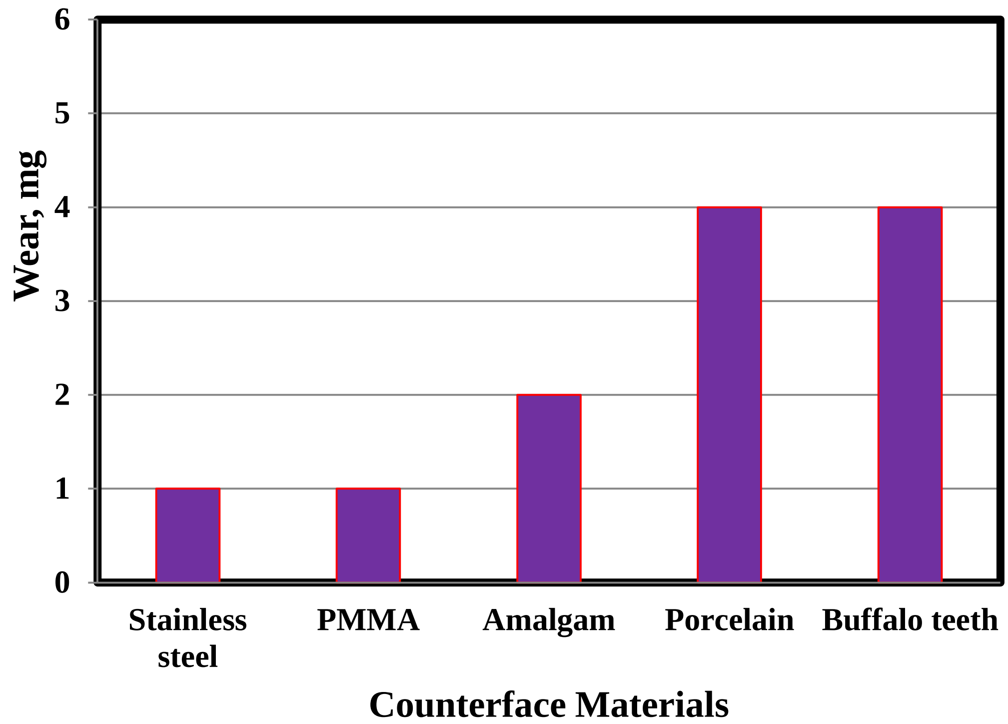

Fig. 7 Effect of counterface materials on the wear of dental composite resin cured with gradually strong mode for 60 seconds in the wet condition.

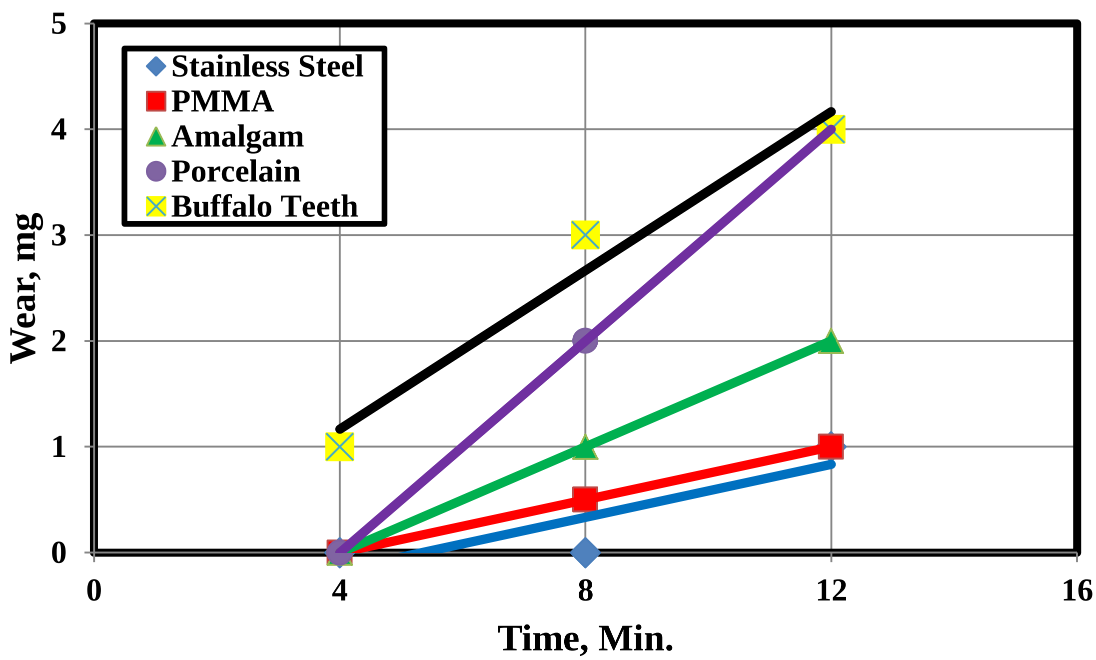

Fig. 8 Effect of test time on the wear of dental composite resin cured with gradually strong mode for 60 seconds in the wet condition.

Figure 9 shows the variation of the coefficient of friction against the counterface materials used in this study in the wet condition. The obtained results as presented in Fig. 9 revealed that counterface materials showed pronounced effects on the coefficient of friction at all used counterface materials. From Fig. 9, it is clear that the amalgam material as counterface had the highest value of the coefficient of friction, followed by the buffalo teeth, then the porcelain, then the PMMA material, whereas the stainless steel material showed the minimum coefficient of friction. In other words, the amalgam material as counterface had a higher coefficient of friction then the other counterface materials (buffalo teeth, porcelain, PMMA and stainless steel material).

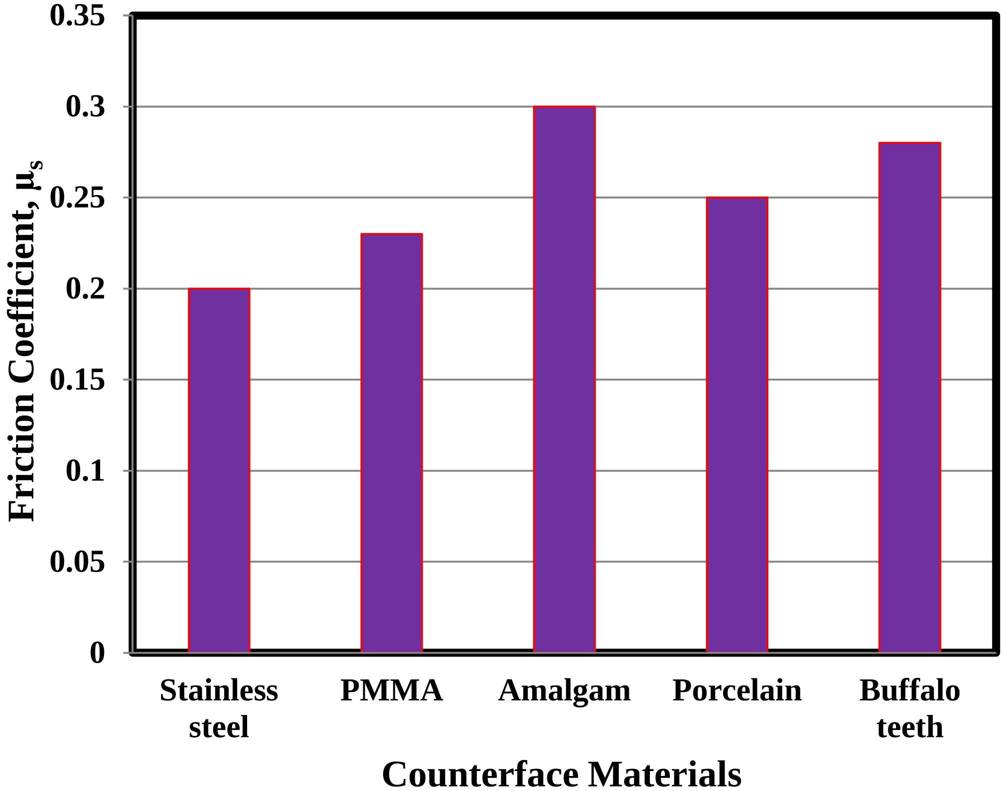

Fig. 9 Effect of counterface materials on the friction coefficient of dental composite resin cured with gradually strong mode for 60 seconds in the wet condition.

6. CONCLUSIONS

Within the scope of work of the present investigation, the results showed that**,** counterface materials had pronounced effects on the wear and coefficient of friction at all used counterface materials**.** Dental composite / buffalo teeth give a higher resistance to wear in the dry condition, while the dental composite / stainless steel have a higher resistance to wear in the artificial saliva condition. Friction coefficient results showed that dental composite / stainless steel give a higher coefficient of friction in the dry condition, while the dental composite / amalgam have a higher coefficient of friction in the artificial saliva condition.

REFERENCES

1. Ibrahim M. Hamouda, Hagag Abd Elkader, "Evaluation the Mechanical Properties of Nanofilled Composite Resin Restorative Material, Journal of Biomaterials and Nanobiotechnology, Vol. 3, pp. 238-242, (2012).
2. Witold B., Vera K., Domagoj V. Jenna W., "Tribology of Polymers and Polymer-Based Composites", Journal of Materials Education, Vol. 32, No. (5-6), pp. 273 – 290, (2010).
3. Liqun C., Xinyi Z., Xu G., Shouliang Z., "An in Vitro Investigation of Wear Resistance and Hardness of Composite Resins, Int J Clin Exp Med,Vol. 6, No. (6), pp. 423-430, (2013).
4.Yanni T., Yong L., Liam M. Grover, Baiyun H., "Wear Behavior of Light Cured Dental Composites Filled with Porous Glass–Ceramic Particles", Journal of the mechanical behavior of biomedical materials, Vol. 3, pp. 77 – 84, (2010).
5. ASM International, ASM Handbook Volume 18: Friction, Lubrication, and Wear Technology, American Society for Metals, Metals Park, Ohio, pp. 1360 – 1385, (1992).
6. Zhou Z. R. and Zheng J., Tribology of Dental Materials: A Review, J. Phys. D: Appl. Phys., Vol. 41 , pp. 1-22, (2008).
7. Meshref A. A., Mazen A. A., El-Giushi M. A. and Ali W. Y., Friction Behavior of Hybrid Composites Filled by Titanium Dioxide Nanoparticles, EGTRIB Journal, Vol. 14, No. 1, pp. 40 – 50, (2017).