Tribological Properties of a Medical Mouthguard Material in Reciprocating Rotation Sliding

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Abstract. Friction and wear of a medical mouthguard material were studied using a rotating-pivot wear tester under dry and water-lubricated conditions. The tester comprised a rotating ball made of stainless steel (SUS 304) and a fixed plate made of Ethylene Vinyl Acetate (EVA). The experiments were conducted under two rotation styles: the reciprocating rotation test (R-R test) and the unidirectional rotation test (U-R test). Compared the results in the R-R test with in the U-R test, the frictional torque and the EVA's wear rate in the R-R test were higher than in U-R test in the dry friction. In the water lubrication, however, they became small, and their values did not depend on the rotational styles. In the dry friction, the size of the wear debris generated in the R-R test was much larger than in the U-R test. The wear mechanisms were discussed based on the observation results of wear scars and wear debris.

Keywords: Mouthguard · Friction and wear · Reciprocating rotation

1 Introduction

Bruxism is an oral parafunctional activity that causes tooth wear and fracture [1]. In order to prevent tooth wear and fracture due to bruxism, mouthguards have been commonly prescribed in clinical practices [2]. Although it is easily worn out and perforated, there has been little reported works on this issue. To find a way for extending the life and developing a new mouthguard material, it is essential to study the wear mechanisms of mouthguard materials under various experimental conditions. In this study, the friction and wear of a mouthguard material were studied using a reciprocating rotation tester under dry and water-lubricated conditions. For a comparison, a unidirectional rotation test was also conducted.

2 Experimental Apparatus and Procedure

Experiments were conducted using a pivot-type wear tester shown in Fig. 1. The experimental conditions are listed in Table 1. The tester comprised a rotating ball and a fixed plate. The plate (thickness: 2 mm) was made of Ethylene Vinyl Acetate (EVA), which

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is commonly used in the medical field. The ball was made of stainless steel (SUS304) (diameter: 10 mm). The experiments were conducted under two rotation styles: the reciprocating rotation test (R-R test) and the unidirectional rotation test (U-R test). In the R-R test, the rotational angle was 180°, and the rotational direction was changed every 0.5 s: the frequency was 1 s^{-1}. In the U-R test, the rotational speed was 60 rpm; thus, the sliding distance was the same in two rotation styles. Wear scars and wear debris were observed using a scanning electron microscope (SEM).

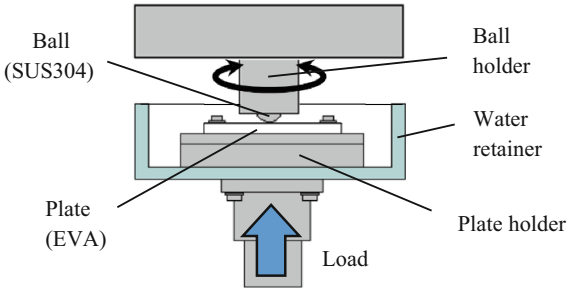


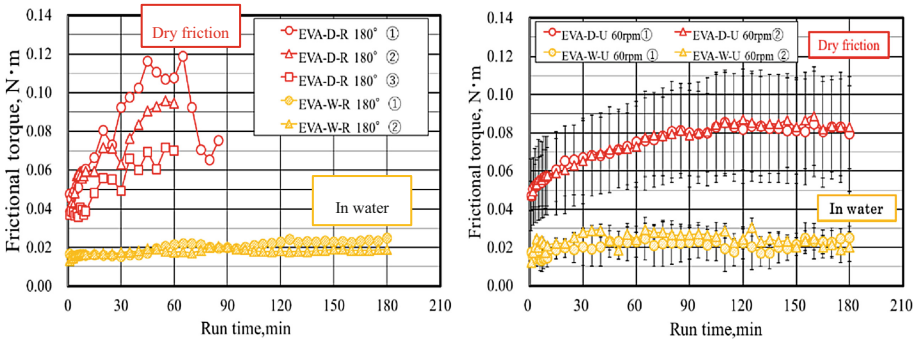
Fig. 1. Schematic of the experimental apparatus.

Table 1. Experimental conditions.

Rotation style	(1) Reciprocating rotation (R-R test), Rotational angle: ±180° (at 1 Hz)
	(2) Unidirectional rotation (U-R test) : 60 rpm
Load	59 N
Test duration	180 min
Lubrication method	(1) Dry friction
	(2) Submerged water-lubrication; Distilled water, 30 ml, ~30 ℃

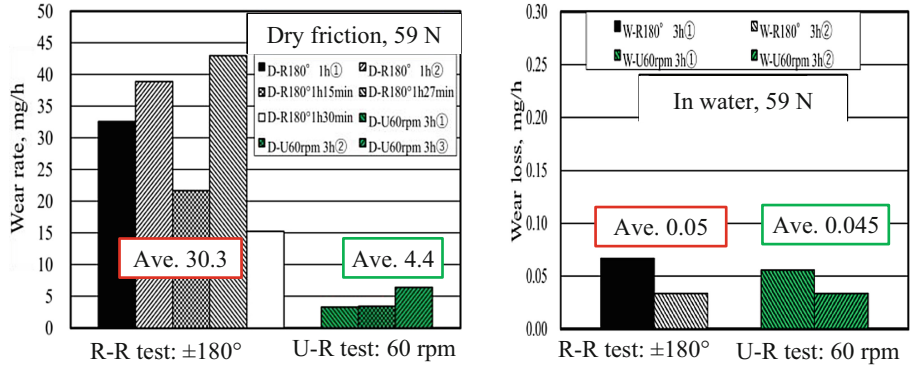
3 Results and Discussion

Figure 2 shows the effects of the rotation style on the frictional torque. In the R-R test, the frictional torque in the dry friction increases linearly up to 0.08–0.12 Nm. The plate was perforated after sliding of ~60 min. In the water lubrication, the frictional torque reduces to 0.015–0.025 Nm. In the U-R test, the frictional torque in the dry friction increases gradually up to 0.08–0.09 Nm, and tends to become constant, although it fluctuates largely. The EVA plate was not perforated. In the water lubrication, the frictional torque reduces as well as in the R-R test. Thus, the frictional torque in the R-R test is higher than in the U-R test only in the dry friction. Figure 3 shows the EVA's wear rate. The wear rate is 30.3 mg/h in the R-R test and 4.4 mg/h in the U-R test. The wear rate in the R-R test is seven times larger than in the U-R test. In the water lubrication, it reduces to 0.04–0.05 mg/h, and their values does not depend on the rotation styles.



(a) R-R test (b) U-R test

Fig. 2. Comparison of friction behaviors in R-R and U-R tests.



(a) In dry friction (b) In water lubrication

Fig. 3. Comparison of EVA's wear rate obtained in R-R test and U-R test.

4 Conclusions

(1) The frictional torque and the EVA's wear rate in the R-R test was higher than in the unidirectional rotation test (U-R test) in the dry friction.
(2) The water-lubrication effectively reduced friction and wear in both the rotation styles, and their values were not dependent on the rotation styles.

References

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