Increase in friction on a contact lens by embedded pigment -Verification using a dedicated pendulum apparatus-

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PURPOSE

Recently, many people use contact lenses (CLs) for visual correction and/or fashionable purpose. But, their usage without instruction from ophthalmologists sometimes causes adverse effects to their eyes by the harmful design of CLs. Especially, in the case of decorative CLs, a change in their physical characteristic by embedded pigments may also cause the adverse effects on eyes. Few studies have been, however, reported to measure the friction of CLs that can be used as a measure of the assessment of CLs although the high friction may cause the adverse effects. Furthermore, the past studies on friction coefficients of CLs have been performed on their narrow center area, where a pigment of decorative CLs does not exist[1].

We have developed an apparatus using a pendulum apparatus to measure a friction coefficient of whole surface of CL, which can mimic CL friction occurring with eyelid, and to assess the risk by usage of CLs, especially decorative CLs. In this study, friction coefficients of commercially available decorative color CLs were measured using the apparatus to clarify effects of embedded pigments on their friction.

Experiment

<Samples>

Commercially available decorative CLs. The embedding area of pigments has been located by TOF-SIMS[2].

Non-color commercially available CLs (No.0 and 1) is used as the negative control for this study.

Table 1. Characteristics of CLs used in this study

Sample No.	Base Curve	Diameter(mm)	Center thickness(mm)	Power	Water content (%)	Pigment location	Pigment detected on surface	Materials
0	8.5	14.2	0.085	−4	46	N/A	N/A	Narafilcon A
1	9.0	14.2	0.085	−4	46	N/A	N/A	Narafilcon A
2	8.7	14.2	0.100	0	38	eyelid	Yes	Polymacon
3	8.8	14.5	0.130	0	38	cornea	No	Polymacon
4	8.6	14.0	0.100	0	38.6	cornea	Yes	Polymacon
5	8.6	14.5	0.170	0	Not identified	cornea	No	Polymacon
6	8.7	14.5	0.100	0	38.6	cornea	Yes	Polymacon
7	8.9	14.5	0.133	0	38.5	cornea	No	Polymacon
8	8.6	14.0	0.100	0	38.6	cornea	Yes	Polymacon
9	8.6	14.2	0.120	0	38.5	cornea	No	Polymacon
10	8.6	14.5	0.120	0	38	cornea	No	Polymacon
11	8.7	14.0	0.050	0	38	cornea	Yes	Polymacon
12	8.5	Not identified	Not identified	0	Not identified	eyelid	Yes	Polymacon

<Principle of apparatus>

From the energy balance between frictional loss and the decrease in the potential energy of the pendulum, the friction coefficient f can be calculated by the equation described below[3].

$$f = \frac{L \cdot \Delta\theta}{4r}$$

$L\ (cm)$: Distance between the center of gravity and the fulcrum of the pendulum

$\Delta\theta\ (rad)$: Amplitude decay per a libation cycle

$r\ (cm)$: Radius of the sliding surface

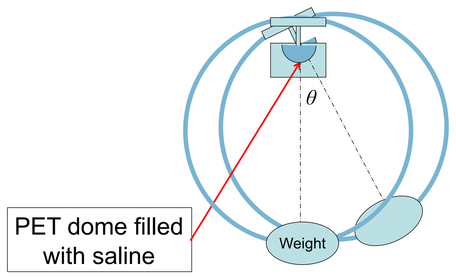
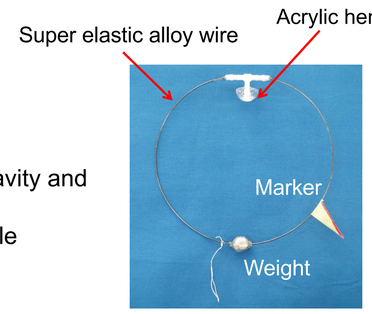
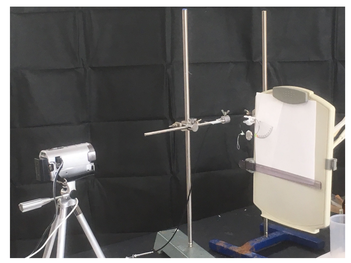


Figure 1. Scheme of the pendulum used in this study



Prototype pendulum



Overview of an apparatus

Figure 2. Photos of a pendulum and an apparatus used in this study

$\Delta\theta$ can be obtained from changes of the position of the marker on a protractor scale on the back wall recorded by a video camera of the apparatus during its free libation.

Results

<Validation of the apparatus>

Measured friction coefficients of non-color commercially available CLs (No.0 and 1) (n = 6) are shown in Table 2. As shown in the table, the difference of base curve did not affect the friction measurements of CLs using the present apparatus.

Table 2. Friction coefficients of CLs made of Narafilcon A with different base curves

Base curve	8.5	9
Friction coefficient	0.038 ± 0.006	0.034 ± 0.008

<Effects of pigment conditions>

Measured friction coefficients changed with the pigment location in decorative CL, as shown in Figure 3. This apparatus enabled the assessment the friction of eyelid side surface of a CL.

Measured friction coefficients did not change with the pigment exposure on the surface of decorative CL, as shown in Figure 4.

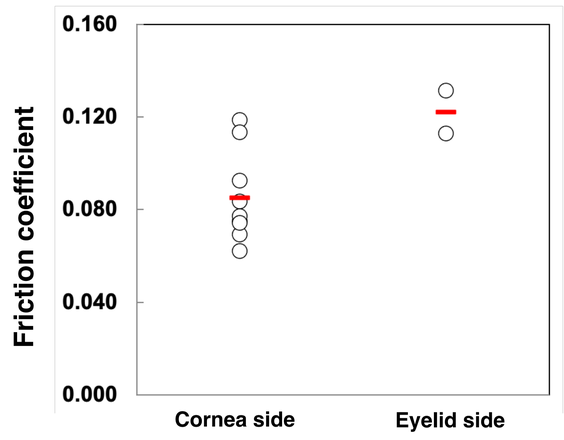


Figure 3. Friction coefficient of the different position of pigment location in decorative CLs (Red bar: average of the coefficients)

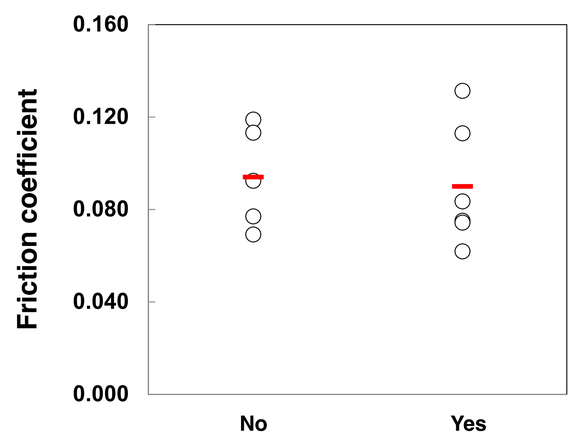


Figure 4. Friction coefficient of decorative CLs with or without pigment exposure (Red bar: average of the coefficients)

Discussion

The friction coefficient of CLs made of Narafilcon A reported in the previous study was 0.031 ± 0.028[1]. This value is consistent with those shown in the present study, supporting the validity of the present apparatus measuring the friction coefficient of CLs.

The past measurements were limited on the narrow area of a CL which could not measure the friction coefficient of whole surface of CLs. In the present study, this apparatus is proved to be able to measure the friction of whole surface of CL and useful for the assessment of CLs with the uneven surface aspects, which are sometimes found on a decorative CL.

As the results, friction coefficients on every decorative color CLs were higher than non-colored CLs. The friction rise depended on the location of pigment. The friction rise was little when pigment location is cornea side which was fixed at the apparatus during the measurement. Meanwhile, friction rise was large when pigment location is eyelid side. It was suggested from these results that increase in friction of a CL depends on the distance between the pigment layer and the sliding surface. However, the pigment exposure on the surface of decorative color CL did not show its friction rise as shown in Figure 4, suggesting that increase in the friction of CLs was caused just by the pigment existence.

Conclusion

1. **The apparatus used in this study can be used as a useful measure to evaluate a friction coefficient of CLs including decorative CLs mimicking clinical conditions.**
2. **Pigment existence and location may affect the friction of decorative CLs.**

References

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Acknowledgement

This study is supported by a grant for Research on Regulatory Science of Pharmaceuticals and Medical Devices (21mk0101192j0101) from the Japan Agency for Medical Research and Development.