Absorption-Dependent Negative Friction Coefficients in Tendon-Sheath Excursion

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Dear Editor,

The negative friction coefficient has been recently reported in the study of frictional force between the tip of an atomic force microscope and a graphite surface.¹ Adhesion-dependent friction model postulates that the adhesive force between the atomic force microscope tip and the graphite surface is stronger than the dispersion forces holding the graphite layers together. This reduces the frictional force with increasing load.⁵ A separate study also reported a more general phenomenon that involves the hysteresis of frictional force in between 2 sliding bodies.⁵ Here, we report another type of negative friction model, which is caused by the force absorption between 2 gliding biological tissues, tendon-sheath excursion, in zone II of the human finger in an *in-vitro* setting.

The classical dry friction theory was adopted to describe the hysteresis of frictional force on tendon-sheath gliding surface.⁴ Figure 1 shows the tendon gliding through the sheath at 50° angle of flexion. Tensile load was applied by hanging the distal tendon with a 4.9 N dead weight. The proximal tendon was attached to an Instron 3343 (Instron Corp, Canton, Massachusetts) mechanical tester to simulate tendon excursion. The proximal interphalangeal (PIP) joint was first flexed according to the experiment done by Moriya et al.³ When the tendon was moved forward by the mechanical tester, the tensile load increased initially but then became stationary. It should be noted that the stationary tensile load is lower than 4.9 N due to the force absorption by the tendon. When the tendon was moved backward, the 4.9 N dead weight maintained tension in the tendon, thus completing 1 excursion cycle. During the excursion, the normal force acting on the tendon-sheath gliding surface was increased when the angle of flexion was increased according to Sine rule. Tensile load between 10- and 20-mm displacement during the “forward” period was averaged to calculate the frictional forces.

Figure 2 demonstrates 2 experimental results when the PIP joint was flexed between 30° to 70° with 10° intervals. Interestingly, negative friction coefficient was observed when the angle of flexion was increased. It is possible that the increasing normal force on the tendon by the pulley associated with increasing angle of flexion induces changes in the fibrillar orientation resulting in increased packing density and reducing friction at the tendon-sheath interface.² It was also shown that collagen “fibrillar crimps”

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Figure 1. Hysteresis in the tensile load of tendon-sheath excursion.

Figure 2. Frictional force at individual angle of flexion was calculated by subtracting its averaged tensile load with respect to the one measured at 20° angle of flexion.

Note. Five repetitions were done for each angle of flexion to calculate the mean and standard deviation of frictional force.

become flattened under tensile load, absorbing the tensile force and acting as shock absorbers.

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An absorption-dependent negative friction coefficient could be a common case in bio-friction which involves large force transmission within fibrillar tissues.

Sincerely,
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