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Development of a Pin-On-Disk Test Fixture to Quantify Meniscus Wear Parameters

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Introduction

Background

- Meniscus degeneration increases the risk of osteoarthritis, but cause for degeneration is unknown.[1]
- Multidirectional loading causes strain softening and clinically relevant wear rates in polyethylene (**Fig. 1**).[2]
- The effects of multidirectional loading have not been tested on human soft tissue.

Challenge:

There is no existing test fixture that can measure the effects of multidirectional wear on soft tissue

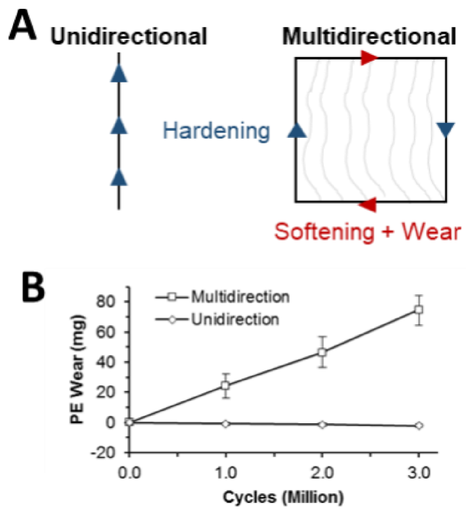

Figure 1: A) Schematic of multidirectional loading and B) Polyethylene wear

Purpose: Design and develop a pin-on-disk (POD) test fixture to measure wear parameters of human meniscus

Design Criteria

- Fixture should simulate physiological multidirectional motion of the knee (**Fig. 2**)
- Fixture should be able to measure the applied axial force
- Load cell must be protected from experiencing any torque or moments
- Fixture will need a water-tight tissue chamber in order to test hydrated soft tissue
- Fixture should be able to test varying sizes of soft tissue
- System should be able to continuously run for thousands of cycles

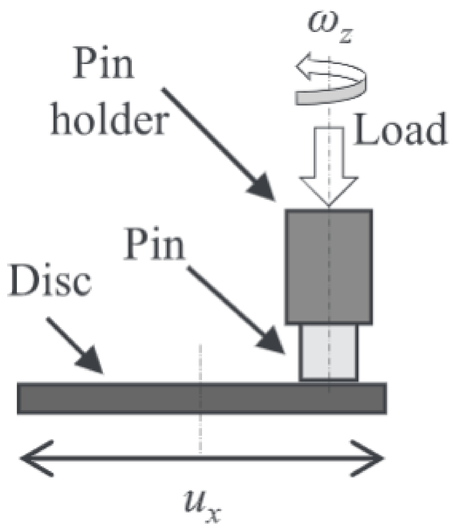

Figure 2: Schematic of the proposed pin-on-disk fixture. Motions include the horizontal translation of the disk and the axial rotation of the pin[3]

Design

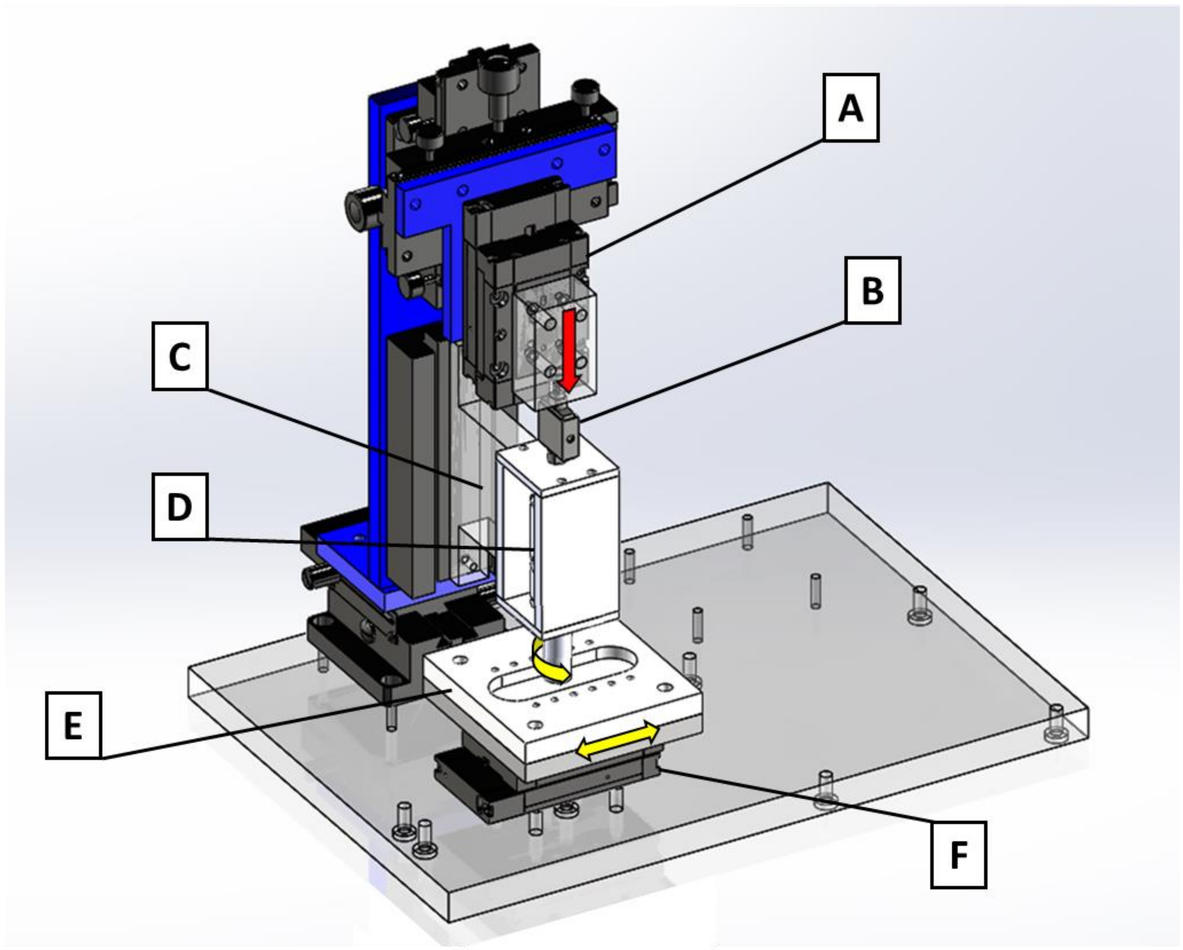

Figure 3: 3D model of the POD design with rotations + translations and axial force shown.

A. *Vertical Actuator*: Provides 4 N of axial force at 50% of physiological loads
B. *5-lb load cell: U*sed to measure the axial force being applied
C. *Custom Motor Mount*: Holds the DC motor to the vertical actuator and load cell and stabilizes the vertical axis to prevent damage to the load cell
D. *DC Motor*: Provides continuous rotation of the articular cartilage pin at 1 RPM
E. *Tissue Chamber*: Water-tight chamber with a customizable clamping mechanism to allow for multiple sizes of menisci samples.
F. *Horizontal Actuator*: Provides up to 4 mm of oscillating linear translation

Impact: This test fixture will enable us to characterize meniscus wear parameters and help determine activities that induce wear and degeneration in soft tissue.

References

[1] Englund, et al, 2008. [2] Bennett, D. et al, J. Orthop. Res, 2008. [3] Borjali, A. et al , Trib. Int., 2019

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