Target Outcome

- For use during patellofemoral joint testing, two properly equivalenced and calibrated pressure sensors.

Prerequisites

- An operating Tekscan sensor model number 5051
- An operating Tekscan handle or "dongle" (interface to the sensor).
- Tekscan software loaded on a laptop for use during the testing.
- Access to the gait lab to use the pressure bladder

Infrastructure

For more details see Infrastructure/ExperimentationMechanics.

Prerequisite Protocols

- Specifications/Specimens.
- Specifications/SpecimenPreparation
- Specifications/Registration
- Specifications/ExperimentationAnatomicalImaging

Protocols

Sensel Equivalencing

Primary Conditions

- Equivalent loading on all sensels

Secondary Conditions

N/A

Measurements

- Sensor output in raw format
- A Tekscan defined, sensor specific, equivalencing file

Operating Procedure

1. Acquire Tekscan sensor 5051 (Fig 1a) and Tekscan "dongle" (Fig 1b) for this test (decide on physical location and/or contact). The "dongle" is the hardware interface between the sensor and a USB plugin for a computer. Make sure the computer has the latest Tekscan software installed (version 7.6).
2. The sensor needs protected from the environment of the joint. Be sure to seal it in some way. A C-Line lamination sheet can be used to seal the sensor. Put one sheet with sticky side up, roll the sensor over it. Put another sheet with sticky side up, roll the sensor+sheet over it. Trim the edges.
3. After plugging in the hardware to both the sensor and a computer, ensure the sensor is communicating with the Tekscan software. Physically squeeze the sensor to verify in the real time window of the Tekscan software that the sensels respond to the load.
4. The foot pressure bladder hardware in the gait lab (ND1-07 behind the computers) will be used to evenly load the Tekscan sensor (Fig 1c). Check the operating oil in the compressor (Jun-Air) before plugging it in, turning it on and waiting for the tank to pressurize. Once ready, load the sensor on the pull out tray of the pressure bladder (Fig 1d). Place the sensor approximately in the middle of the tray. Slide the tray into the slot while ensuring the sensor does not bind.
5. Once the sensor is loaded, open the valve on top of the pressure bladder to load the sensor (Fig 1d). With the attached manometer (Fig 1d), verify the application of the maximum possible pressure (approximately 87 psi or 6 bars) and record the actual pressure and the sensor serial number.
6. Verify the sensor is loaded in the real time window of the Tekscan software and then perform the "equilibration" procedure in the drop down menu. Fill in the appropriate fields and save the equilibration file to the repository in the folder structure for the specimen being tested.
7. Close the valve on the pressure bladder and bleed the pressure from the system. Verify the load has been removed from the sensor in the real time window. Apply the sensor-specific equilibration file to the sensor. Close the bleed valve.
8. To verify the equlibration has been applied, reload the sensor with the pressure bladder. Verify the sensor reads an equivalent pressure across each sensel. If not, verify the equilibration file is applied and/or repeat the steps above. Equilbration-2 mode can be used to refine.
9. Once complete, save the sensor specific equilibration file for use during calibration and testing.
10. The protocol may need to be repeated run twice in order to successfully equilibrate the sensor.
11. The equilibration file should be uploaded in-house data management platform in the patellofemoral joint-testing of the Open Knee(s) specimen.

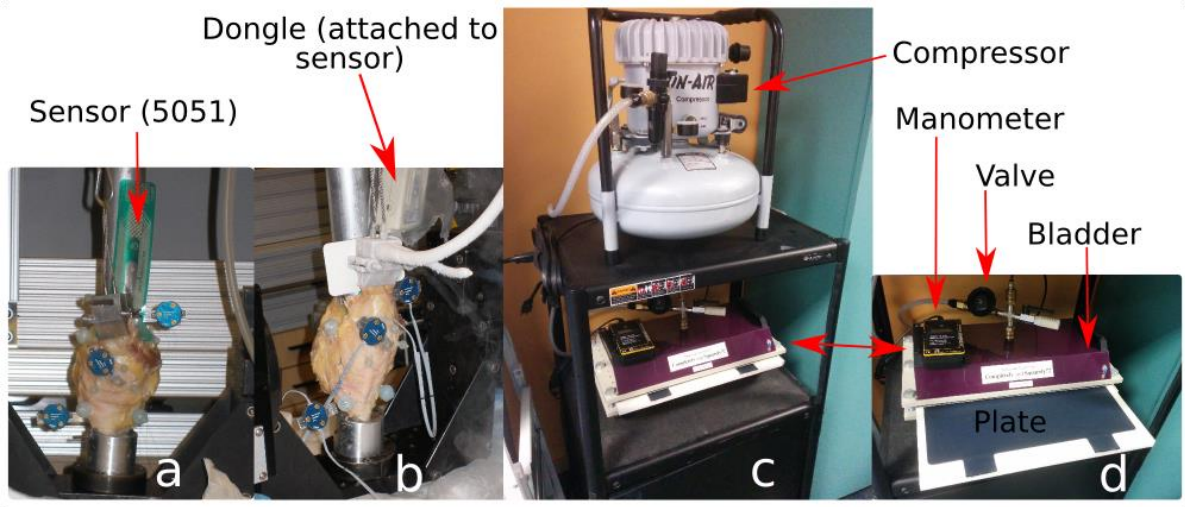

Figure 1. Pressure sensor in a joint (a), dongle attached to the sensor (b) and pressure bladder setup for equilibration of the Tekscan sensor (c and d).

Calibration

Primary Conditions

- Application of a known load of approximately 600 N to the sensor. Ideally, the sensor should be loaded using items of similar stiffness and geometry as a patellofemoral joint. This is being approximated by the following components in the setup shown.

1. The load cell is compressing the baseball.
2. The sensor is underneath the baseball.
3. The sensor is supported by a flat aluminum plate with 4 sheets of 0.3 mm thick rubber.

Secondary Conditions

N/A

Measurements

- Sensor output in raw format

General Guidelines

1. Utilize the "Calibration & Equilibration Guide.pdf" supplied with the Tekscan system as a general guide for which buttons to press in what order.
2. Utilize a uniaxial load frame. Models available are MTS 858, Instron 1321, and Instron 8511.
3. Select load cell with sufficient range (~2000 N to 4000 N)
4. Utilize fixturing materials and design that approximates a similar stiffness and geometry as a patellofemoral joint.

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2. After plugging in the hardware to both the sensor and a computer, ensure the sensor is communicating with the Tekscan software. Physically squeeze the sensor to verify in the real time window of the Tekscan software that the sensels respond to the load.
3. Turn on materials testing system.
4. Display load from load cell on screen.
5. Set overload limits to protect load cell.
6. Mount custom loading fixtures to machine and zero load cell.
7. Insert sensor and manually load the specimen using position control on the machine. Make certain to move the actuator slowly so as not to overload the sensors.
8. Verify the loading pattern is as expected.
9. Open the calibration screen in the Tekscan software (I-scan).
10. Perform a 5 point calibration: (approximately 50, 100, 200, 400, 600 N)
    1. Apply load
    2. Wait for it to stabilize (for a few minutes) and click on "Add" in Tekscan calibration screen.
    3. Enter force value from load cell
    4. Click on "Start" and wait until the progress bar is complete.
    5. Repeat for next load range. Note that low range must not be zero since the sensor needs to see sufficient load to calibrate. It should not be 0, but something nominal like 50N. High range should be in the ~500 to 600 N range. The precise values used are a function of the geometry and stiffness of the fixtures and these

suggested values may need to change. The objective is for the high range load to produce approximately 3-5 MPa of pressure on the sensor.

11. Save calibration file and name it with a filename that fits the following convention. "Sensor model-Serial number-Range-Date Calibrated"
12. The calibration file should be uploaded in-house data management platform in the patellofemoral joint-testing of the Open Knee(s) specimen.

References

- The Tekscan provided "power law" calibration approach has been shown to the within 2.7% RMS over the tested sensor range
    - Refer to http://www.ncbi.nlm.nih.gov/pubmed/19154074 for a description.
    - A custom approach to calibration is likely more accurate and could be explored if necessary.