Supporting Information

**Novel Force Measurement System for Soft Tissue Balance in Total Knee Arthroplasty Based on Flexible Pressure Sensors Arrays**

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Figure S1. Schematic illustration of the soft tissue measurement mechanism with a smart spacer

\[
\delta_{\text{imbalance}} = \frac{F_{MC} - F_{LC}}{F_{MC} + F_{LC}} \quad (1)
\]

Note: The imbalance of the knee joint can be calculated according to Equation 1 to assist the surgeon in assessing the knee joint balance.
Figure S2. Diagram of the multi-channel signal acquisition platform of the TKA Force-sensing System
Figure S3. Simulation results of the knee joint prosthesis at different bending angles (a) 0°, (b) 45°, (c) 90°, through Ansys software

Note: We used Ansys software to simulate the force state of the knee joint prosthesis at different angles and designed the position and size of the sensor arrays according to the stress distribution on the spacer. Through literature review and physician consultation, we discovered that soft tissue tension imparts a force of 0-50 N to the knee joint; therefore, we set the maximum load on both sides of the knee joint to 50 N. To reflect the contact situation of the knee joint prosthesis in different motion states, we selected three bending angles of 0°, 45°, and 90°. As shown in Figure S3, when the knee joint was bent at 0°, the stress on the spacer was distributed in the upper area. When the knee joint was bent at 45°, the contact stress was distributed in the middle of the spacer. When the knee joint was bent by 90°, contact stress appeared at the bottom of the spacer. Based on the above simulation results, we designed the shape and position of the sensor arrays on the spacer.
Figure S4. Screen-printing process and illustration of arrayed electrodes on the smart spacer.

Figure S5. (a) Response and (b) recovery time of the pressure sensor unit (c) Loading-unloading curves of the pressure sensor.
Figure S6. (a) Force response characteristics of the six sensors on the smart spacer (b) Extraction diagrams at three force values (10 N, 30 N, 50 N)

The properties of the pressure sensor arrays were tested by the signal acquisition platform, which was built by our laboratory. The specific information of the signal acquisition platform is shown in the experimental section.
Figure S7. The performance of the sensor unloading force at different temperatures
Figure S8. The errors of the measurement in the detection range.

Figure S9. 3D-print physical drawings of knee joint components
Figure S10. (a) Actual measurement signal of the sensor unit on the smart spacer (b) Force-voltage fitting curve of the sensor unit
Figure S11. Physical picture of the TKA Force-sensing System test
Figure S12. The oscillogram and force value display interface of the TKA Force-sensing System.
Figure S13. Analysis of the TKA Force-sensing System’s test results at three knee flexion angles (0°, 45°, and 90°)