**Figure 1:** Dynamic MRI frames of knee motion during a full flexion-extension-flexion cycle. Each frame represents a 2-degree increment in knee angle. Frame 0 shows maximum flexion, with subsequent frames progressing through extension and returning to flexion in the final frame.

**Figure 2:** Visualization of the reference point transformation for the tibia. Left: Binary edge of the tibia (white) from a frame during knee extension with reference points (orange dots) from the initial frame, showing misalignment due to bone movement. Right: The same binary edge with reference points (green dots) after applying the estimated optimal transformation parameters.

**Figure 3:** Schematic overview of the semi-automated pipeline for bone shape tracking. The process includes: (I) Canny edge detection for detection of bone boundaries; (II) Connected-component labeling to isolate edges; (III) Extraction of reference points along edges; and (IV) Computation of transformation parameters for frame-to-frame tracking. The final panel shows segmented tibia and femur overlaid on the MRI image after applying the transformations obtained from semi-automated tracking to manual segmentation performed in the first frame.

**Figure 4:** Example of semi-automatically tracked segmentation of the tibia (blue) and femur (orange) at different points during the knee motion cycle overlaid on the base CINE frames.

**Figure 5:** Comparison of relative bone motion parameters during knee flexion-extension cycles using semi-automatic and manual segmentation. Panels show anterior-posterior (left) and superior-inferior (right) centroid distances between tibia and femur. Top row represents extension phase (flexed to extended), bottom row shows flexion phase (extended to flexed). Shaded areas indicate variability across subjects: orange for manual and blue for semi-automatic segmentation.