**Figure 1:** Reconstructed dynamic CINE MRI frames of knee motion during extension and flexion. Each frame represents a 2° increment in knee angle. Frame 0 shows maximum knee flexion within the confines of the scanner bore, with subsequent frames progressing into extension and returning to flexion in the final frame.

**Figure 2:** Schematic overview of the semi-automated pipeline for bone shape tracking. The process includes: (I) Canny edge detection to detect bone edges; (II) Connected-component labeling to isolate cortical bone edges; (III) Establishing reference points along bone edges; and (IV) Computing transformation parameters for frame-to-frame tracking. The final panel shows the reference point transformation for the tibia, illustrating the binary edge (solid white line) with misaligned initial reference points (orange dots) due to bone movement between frames, and subsequently, the aligned points (green dots) after applying the estimated optimal transformation parameters.

**Figure 3:** Example of semi-automated tracking of the femur (orange) and tibia (blue) segmentations overlaid on the base CINE frames at different flexion angles during the knee motion cycle.

**Figure 4:** Comparison of relative bone motion of the tibia with respect to the femur during knee extension and flexion. The top row shows the knee extension phase (flexed to extended position), while the bottom row shows the knee flexion phase (extended to flexed position). The left panels depict horizontal tibial displacement, while the right panels depict vertical tibial displacement. Relative bone displacement was calculated by subtracting the femoral centroid coordinates from those of the tibia (semi-automated segmentation in pink; manual segmentation in lime-green). Shaded regions indicate standard deviations around group means. These displacements were measured in the 2D image coordinate system, with the origin at the top left corner and coordinates increasing downward and to the right.