(IV) Reference point transformation of the tibia, illustrating the binary edge (white) with initial reference points (orange dots) displaying misalignment due to bone movement, and after applying the estimated optimal transformation parameters (green dots)

**Figure 1:** Dynamic MRI frames of knee motion during an extension-flexion cycle. Each frame represents a 2° increment in knee angle. Frame 0 shows maximum knee flexion, 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 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 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 during knee flexion-extension cycles using semi-automated (blue) and manual (orange) segmentation methods. Panels show the anterior-posterior (left) and superior-inferior (right) distances between the centroids of the femur and tibia. The top row represents the extension phase (flexed to extended position); the bottom row shows the flexion phase (extended to flexed position). Shaded areas indicate the standard deviations around the group means.