

Current Utilization and Future Directions of Markerless Motion Capture and Gait Analysis in Arthroplasty

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Current Utilization

Gait analysis is an essential tool in the fields of orthopaedics and biomechanics for quantifying functional performance, joint mechanics, and recovery across musculoskeletal conditions. While marker-based motion capture has been the gold standard for gait and movement analysis, its time-intensive setup has limited widespread clinical use. More recently, markerless motion capture systems have demonstrated comparable accuracy to marker based systems with substantially faster, more practical implementation in clinical settings. This markerless motion capture technology has been adopted in orthopedics, mostly in sports medicine.

In arthroplasty, motion capture has also demonstrated the ability to detect gait deviations, including reduced range of motion, asymmetry, and compensatory movement strategies that are not fully captured by imaging or patient-reported outcomes. However, widespread clinical integration in arthroplasty remains limited, representing a key opportunity for innovation.

Demonstrations of Clinical Utility & Future Directions

At our institution, we have implemented a markerless motion capture system (Qualisys) with a pose-estimation engine (Theia) to evaluate gait before and after total joint arthroplasty.

This workflow eliminates the need for markers, reduces setup time, and enables data collection within standard clinic visits while patients wear their normal clothing. Using a multi-camera system, we generate three-dimensional skeletal models to quantify joint kinematics, spatiotemporal parameters, and limb asymmetry. Patients now undergo gait analysis at their standard preoperative and postoperative visits and receive an individualized report.

In one illustrative case, a patient with a severe valgus knee deformity underwent total knee arthroplasty, with postoperative gait analysis showing improved symmetry in knee flexion, hip adduction, and knee varus alignment. These changes and improvements, which can be difficult to fully assess with a visual examination alone, were objectively quantified using our markerless motion capture system. By pairing objective data with patient-reported outcomes, this framework supports a more comprehensive understanding of functional recovery and facilitates personalized, data-driven rehabilitation strategies.

Videos/Figure Links Below (could not embed in document)

Figure 1. Lower Body Kinematics. Plots represent right (red) and left (blue) limb motion, demonstrating the type of joint angle data generated by the markerless motion capture system. Solid lines indicate preoperative gait assessment while dashed lines indicate postoperative gait assessment. Of note, knee varus angle substantially increased in symmetry after total knee arthroplasty.

Figure 2. Preoperative Skeletal Model. Models are shown to patients during clinic visits and surgical consultations, allowing patients to visualize b