

Abstract: Understanding Orthopaedic Biomechanics: How Science Helps Us Improve Surgery

Biomechanics has become an essential foundation of modern orthopedic surgery, fundamentally transforming how clinicians understand various pathologies, develop targeted interventions, and assess patient outcomes across multiple subspecialties, including those focused on the hand, shoulder, and elbow; the spine, hip, and knee; and the foot and ankle. Traditionally rooted in cadaveric experimentation and mechanical testing, this field has transitioned into a dynamic, multidisciplinary arena that seamlessly blends engineering principles, advanced computational *In Silico* modeling, and clinical insights on surgical outcomes to enhance patients' quality of life and boost overall productivity.

This presentation delves into the remarkable evolution of orthopedic biomechanics, tracing its journey from conventional experimental models and a limited understanding of the musculoskeletal system to contemporary methodologies that facilitate both quantitative analysis and predictive clinical insights. A wide array of advanced tools—such as motion analysis, gait assessment, finite element modeling, sophisticated imaging techniques, and high-fidelity cadaveric simulations equipped with sensors—have profoundly enriched our comprehension of the intricate nature of joint kinematics, load distribution across structures, and the interactions between implants and surrounding tissues. These innovations have led to a transformative shift in implant design, surgical techniques, and rehabilitation strategies, all aimed at significantly improving patient outcomes.

In recent years, cutting-edge technologies such as robotics, computer navigation, mixed reality, and augmented reality have further expanded the boundaries of biomechanics. These advancements enable real-time diagnostics and detailed surgical pre-planning by focusing on specific outcome measures.

Looking ahead, personalized care emerges as the cornerstone of future orthopedic practices, with artificial intelligence poised to play a pivotal role in biomechanics. This includes enhancing our understanding of bone and soft-tissue injuries, degenerative processes, implant wear, and the intricate balance of human joints. A variety of innovative applications in orthopedic biomechanics will be showcased, highlighting the exciting potential that lies ahead in this rapidly evolving field.