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ROBOTIC SURGERY: A REVIEW OF METHODOLOGICAL EFFICACY IN TOTAL KNEE ARTHROPLASTY AS OF 2026

Sukhin Yurii
MD, PhD, Professor,
Head of the Department of Traumatology, Orthopedics, and Military Field Surgery,
Odesa National Medical University

Pavlychko Yurii
PhD, Associate Professor,
Department of Traumatology, Orthopedics, and Military Field Surgery,
Odesa National Medical University

Topor Vladimir
PhD, Associate Professor,
Department of Traumatology, Orthopedics, and Military Field Surgery,
Odesa National Medical University

Bovsunovsky Boris
Postgraduate Student,
Department of Traumatology, Orthopedics, and Military Field Surgery,
Odesa National Medical University

Boichenko Oleksandra
5th-Year Medical Student, Medical Faculty,
Odesa National Medical University

Relevance. To date, the integration of computer technologies into clinical medicine has improved the precision and speed of various diagnostic and surgical interventions. This is particularly evident in total knee arthroplasty (TKA)—an effective surgical treatment for late-stage knee osteoarthritis, a progressive musculoskeletal condition [1–4]. Over the past half-century, continuous advancements in diagnostic capabilities and joint replacement technologies have driven an increase in the volume of these procedures while reducing postoperative complication rates. A further increase in the frequency of total joint replacement surgeries is projected [5]. Despite documented improvements in patient quality of life following major lower extremity arthroplasty (both hip and knee), approximately 30% of patients express dissatisfaction with their outcomes. This sub-optimal satisfaction rate is primarily attributed to precision errors during implant positioning and alignment [6]. Achieving optimal outcomes in knee arthroplasty mandates adherence to surgical protocols, adequate surgical skills [7], and high accuracy in femoral and tibial bone resections. Proper implant seating depth,

accurate component rotation, and anatomical alignment are critical to ensuring optimal load distribution across the host bone interfaces and endoprosthesis components. Inaccurate bone cuts—in terms of both resection height and inclination angles—can lead to component instability, joint stiffness, and persistent postoperative pain [8]. Conventional manual instrumentation and navigation techniques do not consistently achieve accurate resection. The reliance on manual methods introduces a risk of human error, which can affect the success of the surgical treatment [9].

Objective. To investigate the clinical strengths and limitations of various robot-assisted surgical systems, evaluate the current state of technological development in this field, and compare their efficacy against traditional manual navigation systems.

Materials and Methods. This study is based on an analysis of peer-reviewed domestic and international literature, combined with institutional clinical experience utilizing a computerized navigation system at the Department of Traumatology and Orthopedics of Odesa National Medical University.

Results. Modern surgical navigation systems are categorized into computerized navigation systems and robotic systems. Computerized modalities are further subclassified into large, console-based navigation units (with or without pre-operative imaging) and handheld accelerometric navigation devices [11]. According to current international orthopedic experience and available evidence, computerized and robotic-assisted platforms offer distinct advantages over conventional manual techniques. These advanced systems allow for a multi-parametric intraoperative assessment with higher accuracy, introducing machine precision into the calculations required for endoprosthesis alignment. Regarding the technological distinctions among these modalities, the primary difference between console-based navigation and robotic systems lies in autonomy. Console-based systems serve as surgeon-controlled intraoperative guidance tools. In contrast, robot-assisted platforms actively perform or assist in executing specific stages of the procedure, such as bone resections or drilling. A promising indication for robotic systems lies in complex arthroplasty scenarios, including revision surgeries or cases involving patients with structural deformities that present contraindications to traditional mechanical alignment guides. Currently, the primary limitations restricting the widespread adoption of these navigation systems remain their high cost and an increase in the mean operative time. Based on our institutional experience with an imageless, large console-based navigation system, all seven treated patients demonstrated an uneventful postoperative recovery.

Although it is premature to draw definitive conclusions regarding long-term implant survivorship, early postoperative clinical outcomes demonstrate no significant difference between components positioned via mechanical instrumentation and those utilizing computerized navigation. Furthermore, despite an average prolongation of operative time (+15 to 25 minutes) associated with the computerized navigation setup, no correlation with increased postoperative complication rates was observed [12].

Conclusions. High-tech navigation systems in knee arthroplasty facilitate accurate component positioning, ensuring optimal axial load distribution between the medial and lateral compartments of the prosthesis. Precise component alignment enables early,

pain-free rehabilitation, which helps prevent complications such as joint contracture and chronic pain.

Compared to traditional manual instrumentation, advanced technological systems offer substantial clinical benefits. Their primary drawbacks—namely, high equipment costs and extended operative times—do not negatively impact the early postoperative phase, the rehabilitation stage, or short-term implant longevity.

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