

Evolving techniques and future perspectives in minimally invasive orthopedic surgery.

¹ Sirozhitdinov K.K., ² Baskov A.V., ² Baskov V.A.,

¹ Abdumadzhidov M.A. O.K.Saidnosirov

¹ *Republican Scientific and Practical Center for Sports Medicine*

² *Department of Neurosurgery, Federal State Budgetary Educational Institution of Higher Professional Education "Russian Medical Academy of Continuous Professional Education"*

*4. Head of the Department of Physiotherapy and Rehabilitation
Republican Scientific and Practical Center of Sports Medicine
Rehabilitation Physician*

Abstract

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Minimally invasive orthopedic surgery has transformed the management of musculoskeletal disorders by reducing surgical trauma, shortening hospitalization, accelerating rehabilitation, and improving clinical outcomes. Over the past two decades, technological innovations, including arthroscopic techniques, robotic-assisted surgery, computer-assisted navigation, laser technologies, three-dimensional (3D) imaging, and regenerative medicine, have significantly expanded the possibilities of orthopedic interventions. These advances enable surgeons to achieve greater precision while minimizing damage to surrounding tissues. This article reviews recent developments in minimally invasive orthopedic surgery and discusses future directions that are expected to further improve patient care and surgical efficiency.

Keywords: minimally invasive surgery, orthopedics, arthroscopy, robotic surgery, laser technology, regenerative medicine, artificial intelligence.

Orthopedic surgery has undergone remarkable changes with the introduction of minimally invasive techniques. Traditional open procedures often involve extensive soft tissue dissection, increased blood loss, prolonged hospitalization, and delayed rehabilitation. In contrast, minimally invasive procedures utilize small incisions, specialized instruments, and advanced visualization systems to reduce surgical trauma while maintaining excellent clinical outcomes. The growing demand for rapid recovery, reduced postoperative pain, and improved cosmetic results has accelerated the development of innovative surgical technologies. Modern orthopedic practice increasingly integrates digital imaging, robotic systems, and biologic therapies into routine clinical care.

Arthroscopic surgery remains one of the most significant achievements in minimally invasive orthopedics. High-definition cameras and improved arthroscopic instruments allow accurate diagnosis and treatment of intra-articular disorders involving the knee, shoulder, hip, ankle, and wrist. Procedures such as meniscal repair, anterior cruciate ligament reconstruction, rotator cuff repair, and cartilage restoration are now routinely performed arthroscopically.

Laser-assisted arthroscopy has also attracted considerable attention. Modern laser systems provide precise tissue ablation, effective hemostasis, and minimal thermal injury to adjacent structures. Laser technology may improve visualization by reducing bleeding and enable accurate removal of damaged cartilage or hypertrophic synovium. Although conventional mechanical instruments remain the standard of care, laser-assisted procedures continue to evolve with improvements in safety and energy delivery.

Minimally invasive orthopedic surgery continues to evolve rapidly through advances in arthroscopy, robotics, laser technology, navigation systems, artificial

intelligence, and regenerative medicine. These innovations improve surgical precision, reduce patient morbidity, and accelerate postoperative recovery. Continued interdisciplinary collaboration among orthopedic surgeons, engineers, and biomedical researchers will further expand the capabilities of minimally invasive techniques, ultimately leading to safer procedures and better patient outcomes.

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