may be limited, AI-driven personalized training pathways are especially valuable, ensuring high-quality skill acquisition even in low-case-volume settings.

6 Clinical Outcomes and Existing Challenges

6.1 Impact on surgical safety, precision, and efficiency

The primary goal of AI-assisted minimally invasive gynecologic surgery is to improve surgical safety by enhancing preoperative prediction, intraoperative visualization, and the standardization of complex procedures. Existing studies suggest that AI-based preoperative planning, intraoperative navigation, and robotic assistance can reduce the risk of injury to critical structures such as the ureters, blood vessels, and nerves through more accurate lesion localization, clearer identification of key anatomical structures, and more stable instrument control, thereby decreasing intraoperative complication rates (Polat and Arslan, 2024; Pipes et al., 2025; Wah, 2025). In scenarios involving complex pelvic anatomy, dense adhesions, or limited operative space, AI-driven risk alerts and anatomical labeling are particularly valuable, not only by improving visualization but also by helping surgeons maintain stable operative boundaries during high-risk steps (Arakaki et al., 2024; Osman et al., 2025).

In terms of precision, AI integrates preoperative imaging, intraoperative video, and system parameters to achieve more accurate delineation of lesion boundaries, anatomical planes, and resection margins. For tumor resection, lymphadenectomy, and management of deep infiltrating disease, such multimodal assistance facilitates a better balance between maximal resection and preservation of critical functions, thereby improving surgical quality and long-term functional outcomes (Polat and Arslan, 2024; Pipes et al., 2025). Some cross-disciplinary and robotic surgery studies further indicate that AI-assisted systems can enhance targeting accuracy, margin assessment, and procedural consistency, optimizing precision in complex surgical interventions (Suriya et al., 2025; Wah, 2025). However, it should be noted that most of these positive findings are derived from early-stage studies or cross-specialty experiences, and high-level validation specific to gynecology remains limited.

From an efficiency perspective, AI also demonstrates potential advantages. Through automated recognition of surgical steps, optimization of instrument pathways, context-aware assistance, and efficient use of intraoperative data, AI may shorten operative time, reduce redundant maneuvers, and improve workflow continuity (Osman et al., 2025). In robotic systems, AI-driven optimization of camera control, instrument trajectories, and localized task execution can further reduce surgeon workload and enhance procedural stability. Some studies even suggest that machine learning–enhanced telesurgery and task-level automation may surpass traditional mechanical control in precision. However, in real-world clinical settings, AI systems often require an initial adaptation and calibration period, and their efficiency benefits may not be immediately evident; such advantages typically emerge gradually as surgeons become familiar with the technology.

6.2 Current clinical evidence and application status

At present, the clinical application of AI in minimally invasive gynecologic surgery is transitioning from proof-of-concept to early clinical translation. Existing studies mainly focus on preoperative planning, intraoperative structure recognition, surgical workflow analysis, robotic motion analysis, and training assessment. However, most are single-center, small-sample, retrospective studies or early prospective explorations, resulting in an overall limited and fragmented evidence base (Brandão et al., 2024; Pipes et al., 2025). In gynecologic oncology, AI has been more extensively applied in imaging-based diagnosis, prognostic evaluation, and treatment planning, while intraoperative applications remain relatively limited, primarily focusing on ovarian surgery, hysterectomy, and selected robotic procedures (Paiboonborirak et al., 2025; Restaino et al., 2025).

From a practical perspective, some AI functions have begun to enter preliminary clinical use. Deep learning–based surgical video analysis systems are being used for postoperative quality assessment, skill feedback, and automated workflow segmentation; augmented reality and image-guided technologies are showing value in complex tumor resections and pelvic procedures; and AI within robotic platforms is mainly applied to motion analysis, task recognition, and outcome prediction. However, these technologies largely remain as assistive tools and have not yet evolved into standardized, scalable, and reproducible clinical pathways. A systematic review