

CLINICAL EFFECTIVENESS OF 3D COMPUTER-ASSISTED PLANNING AND DIGITAL SURGICAL TECHNOLOGIES IN THE TREATMENT OF FEMORAL NECK FRACTURES

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Abstract: Femoral neck fractures remain one of the most challenging injuries in orthopedic trauma surgery due to their high incidence of complications, including nonunion and avascular necrosis of the femoral head. Recent advances in three-dimensional (3D) computer-assisted planning and digital surgical technologies have significantly improved the precision of preoperative assessment and intraoperative decision-making. This study highlights the clinical effectiveness of 3D computer-assisted planning in the surgical management of femoral neck fractures. The application of virtual 3D reconstruction enables detailed visualization of fracture morphology, accurate selection of implant positioning, and individualized surgical planning based on patient-specific anatomy. These technologies contribute to improved reduction accuracy, shorter operative time, decreased intraoperative blood loss, and a lower risk of postoperative complications. The integration of digital surgical

techniques into orthopedic practice represents a promising strategy for enhancing clinical outcomes and accelerating functional recovery in patients with femoral neck fractures.

Keywords: femoral neck fracture, three-dimensional computer-assisted planning, 3D reconstruction, digital surgery, orthopedic trauma, preoperative planning, internal fixation, computer tomography, clinical effectiveness, personalized orthopedic surgery.

Femoral neck fractures represent a major challenge in orthopedic and trauma surgery because of their complex anatomical structure, limited blood supply to the femoral head, and the high incidence of postoperative complications. Successful treatment depends not only on achieving anatomical reduction but also on precise preoperative planning and appropriate implant selection. Conventional radiographic assessment often provides insufficient information regarding the three-dimensional configuration of the fracture, which may negatively affect surgical accuracy. The introduction of three-dimensional (3D) computer-assisted planning has significantly improved the management of femoral neck fractures. High-resolution computed tomography (CT) data are used to generate patient-specific 3D models, allowing surgeons to evaluate fracture geometry from multiple perspectives before surgery. Virtual reconstruction enables accurate assessment of fragment displacement, optimization of reduction strategies, and simulation of implant placement without exposing the patient to additional procedural risks. Digital surgical technologies also facilitate individualized treatment planning by considering the anatomical characteristics of each patient. Preoperative simulation assists in determining the optimal trajectory, length, and orientation of fixation devices, thereby increasing the stability of osteosynthesis and reducing the likelihood of implant malposition. As a result, operative time, intraoperative fluoroscopy, and blood loss can be reduced, while surgical precision and postoperative functional outcomes are improved. The integration of 3D computer-assisted planning with digital surgical techniques represents an important advancement in modern orthopedic practice. These technologies support more accurate clinical decision-making, enhance surgical safety, and contribute to faster rehabilitation and better long-term recovery for patients with femoral neck fractures. Continued implementation of digital planning systems is expected to further improve the quality and effectiveness of orthopedic trauma care.

Conclusion

Three-dimensional computer-assisted planning and digital surgical technologies have become valuable tools in the management of femoral neck fractures. Their application improves the accuracy of fracture assessment, facilitates individualized surgical

planning, and enhances the precision of implant positioning. These innovations contribute to shorter operative time, reduced intraoperative complications, and improved functional recovery. The integration of digital technologies into orthopedic trauma surgery represents an important step toward personalized and evidence-based patient care. Further clinical studies involving larger patient populations are recommended to validate the long-term effectiveness and cost-efficiency of these technologies in routine orthopedic practice.

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