Advances in Perioperative Care, Fixation Strategies, and Digital Innovation in Orthopedic Traumatology: An Integrated Review

Latibjonov Azizbek Erkinjon ugli
Fergana Medical Institute of Public Health, Fergana, Uzbekistan

Abstract
Orthopedic traumatology is undergoing rapid transformation driven by demographic shifts, evolving perioperative care models, advances in fixation strategies, and the integration of digital and artificial intelligence (AI) technologies. This narrative review synthesizes recent evidence from forty contemporary publications on fracture management, perioperative optimization, infection prevention, functional outcomes, and emerging technologies in orthopedic trauma. Particular emphasis is placed on fragility fractures, high-energy injuries, venous thromboembolism (VTE) prevention, antibiotic stewardship, and the growing role of AI in imaging and decision support. The reviewed literature highlights a trend toward earlier definitive care in selected high-risk patients, standardized multidisciplinary pathways, noninferiority of simpler or less invasive regimens in several settings, and cautious but promising adoption of AI tools. Persistent gaps include limited external validation of predictive models, heterogeneous reporting of functional outcomes, and underrepresentation of implementation science.

Keywords: *orthopedic trauma, traumatology, fracture fixation, perioperative care, anticoagulation, infection prevention, artificial intelligence, fragility fractures, outcomes*

Introduction
Orthopedic traumatology has evolved from a purely mechanical discipline centered on fracture reduction and fixation toward a holistic field that integrates perioperative medicine, rehabilitation, and health systems science. The growing burden of trauma in aging populations, alongside persistent high-energy injuries in younger patients, has created complex case-mixes that challenge traditional treatment pathways and resource allocation.[1][2][3]

Recent years have seen a proliferation of high-quality randomized controlled trials (RCTs), meta-analyses, and scoping reviews addressing questions that span fixation strategies, anesthetic and perioperative care, VTE prophylaxis, and infection management. At the same time, digital health, precision imaging, and AI-driven analytics have begun to reshape fracture diagnosis, risk stratification, and treatment planning, though their clinical integration remains uneven and often insufficiently validated.[4][5][6][7][8]

The aim of this review is to synthesize contemporary evidence from approximately forty recent publications covering: (1) perioperative and systems-level innovations in orthopaedic trauma care; (2) advances in fracture fixation and implant strategies; (3) VTE prophylaxis and infection prevention; (4) long-term functional and psychosocial outcomes; and (5) emerging roles of AI and digital tools. By structuring this synthesis in an IMRAD format, we highlight actionable practice points, unresolved controversies, and priority areas for future research relevant to clinicians, researchers, and policy makers in traumatology and orthopedics.[1][4]

Methods

This narrative review drew on peer-reviewed literature published predominantly between 2023 and 2026, focusing on orthopedic traumatology and related perioperative care. Searches were conducted in indexing services that aggregate major orthopedic and trauma journals, as well as curated editorial summaries and bibliometric analyses, to ensure inclusion of both landmark trials and representative contemporary work. Priority was given to RCTs, large cohort studies, systematic or scoping reviews, and high-impact observational analyses addressing fracture fixation, perioperative timing, VTE and infection prophylaxis, functional outcomes, and AI applications.[9][10][11][8] Editorial "What's New in Orthopaedic Trauma" series from the Journal of Bone and Joint Surgery (JBJS) for 2023–2025 were used as gateways to identify key clinical trials in fracture care, perioperative practices, and thromboprophylaxis. Additional sources included a scoping review of AI in orthopedic trauma, qualitative longitudinal research on recovery trajectories, and bibliometric analyses of traumatology and orthopedics research trends. To maintain breadth, we selected approximately forty distinct primary and secondary studies, balancing different anatomical regions (hip, distal radius, tibia, spine), injury severities, and methodological designs.[5][6][11][7][8][12][4] Because the goal was synthesis rather than meta-analysis, we did not perform formal risk-of-bias scoring or pooled quantitative analyses. Instead, we extracted key findings regarding comparative effectiveness, safety, and implementation aspects, and organized them thematically. This approach aligns with contemporary guidance for narrative and scoping reviews in rapidly evolving fields where methodological heterogeneity precludes formal meta-analysis.[11][5]

Results

Perioperative Models and Timing of Surgery

Evolving perioperative models have focused on optimizing timing of surgery for high-risk trauma patients, particularly older adults with fragility fractures and complex comorbidities. A JBJS guest editorial summarizing recent work highlighted a cohort of hip fracture patients with elevated troponin on admission, where accelerated surgical care was associated with reduced mortality compared with standard delayed management. This challenges longstanding practices of postponing surgery in the context of cardiac biomarker elevation and supports a paradigm shift toward expedited "control the trigger" strategies when comorbidities permit.[4]

In parallel, systematic summaries of orthopaedic traumatology emphasize the importance of coordinated co-management between acute care surgeons and orthopedic teams for multiply injured patients. Modern damage control orthopedics has matured into an individualized approach where early total care is selectively applied in physiologically stable patients, while staged procedures and temporary external fixation remain crucial in those with ongoing systemic instability. These models underscore the need for integrated trauma systems, standardized pathways, and close critical care collaboration to balance early mobilization benefits against the risks of perioperative decompensation, especially in polytrauma.[3]

Long-term recovery trajectories extend well beyond the acute hospital stay. A qualitative longitudinal study following trauma patients for 18 months revealed persistent pain, fluctuating functional recovery, and ongoing psychosocial challenges, highlighting the limitations of focusing solely on perioperative metrics and early radiographic union. These findings underline the importance of holistic, multidisciplinary follow-up care that incorporates physical therapy, pain management, and psychological support as integral components of modern traumatology practice.[12]

Fracture Fixation Strategies in Major Anatomical Regions

Proximal femur and hip fractures

Multiple RCTs and meta-analyses have refined our understanding of optimal fixation and arthroplasty strategies for femoral neck and intertrochanteric fractures in older adults. A meta-analysis of three RCTs summarized in a 2024 JBJS editorial compared internal fixation with hemiarthroplasty for nondisplaced femoral neck fractures. Hemiarthroplasty conferred better Harris hip scores at six months and higher quality of life at one year, while overall function converged by one to two years; however, internal fixation was associated with higher complication and reoperation rates but less blood loss and shorter operative times. This supports a patient-tailored approach where hemiarthroplasty may be favored in frail patients where reoperation risk is particularly undesirable, whereas internal fixation remains acceptable in select individuals prioritizing a less invasive initial procedure.[7]

Cost-effectiveness data from the World Hip Trauma Evaluation (WHiTE 5) trial—assessed in an economic evaluation—suggested a high probability (95–97%) that cemented hemiarthroplasty is cost-effective compared with hydroxyapatite-coated uncemented options in displaced intracapsular hip fractures. These results inform implant selection by underscoring the favorable balance between cost and outcomes for cemented constructs, particularly in publicly funded systems. Additionally, RCT data indicate that routine preoperative skin traction in intertrochanteric fractures does not meaningfully reduce pain or opioid consumption, calling into question longstanding but low-value preoperative practices.[8][7]

Distal radius and upper extremity fractures

In older adults with distal radius fractures, RCTs comparing closed reduction and casting with volar locking plate fixation have not consistently demonstrated clinically

meaningful differences in patient-reported outcomes, such as the Patient-Rated Wrist Evaluation (PRWE), despite more anatomic radiographic results with plating. Secondary analyses show comparable complication rates and highlight that radiographic perfection may not translate into superior function in this demographic. This aligns with a broader trend toward shared decision-making that incorporates patient preferences, comorbidities, and functional demands when choosing between operative and nonoperative options.[8]

Tibial and distal femoral fractures

Multicenter RCTs have evaluated fixation strategies for proximal tibial and distal femoral fractures, areas historically prone to malalignment and implant-related complications. A trial comparing intramedullary nailing versus locked lateral plating for extra-articular proximal tibial fractures found no significant differences in 12-month functional scores, residual disability, or complication rates, despite long-held beliefs about the superiority of specific constructs in preventing malalignment. Similarly, a Level I JBJS study comparing far cortical locking (FCL) with standard locking plates for distal femoral fractures reported comparable healing outcomes, with potential benefits of FCL in select subgroups such as patients with extensive medial comminution or younger individuals, though further research is needed.[7][4]

These findings collectively suggest that when high-quality surgical technique and postoperative protocols are in place, multiple fixation options can yield similar outcomes, and decisions may be driven by patient-specific morphology, surgeon expertise, and resource considerations rather than assumed superiority of a single device.[4][7]

Polytrauma and external fixation

Sophisticated trials from the Major Extremity Trauma Research Consortium (METRC) have compared modern external ring fixation with internal fixation for severe open tibial shaft fractures. At one year, the probability of major limb complications did not significantly differ between strategies, indicating that contemporary external fixation, when combined with appropriate soft-tissue management, can achieve outcomes comparable to internal fixation in selected severe injuries. This supports the continued role of staged external fixation as part of damage control orthopedics, rather than a purely temporizing measure, in specific clinical contexts.[8]

Venous Thromboembolism Prophylaxis and Antithrombotic Strategies

VTE prophylaxis remains a critical domain in orthopedic traumatology, given the high baseline risk of deep vein thrombosis and pulmonary embolism in immobilized patients. A large multicenter RCT from METRC evaluated aspirin (81 mg twice daily) versus low-molecular-weight heparin (LMWH, 30 mg twice daily) in over 12,000 adults with operatively treated extremity fractures or nonoperatively managed pelvic/acetabular fractures. Ninety-day mortality did not differ between groups, and aspirin was found to be noninferior to LMWH in preventing death, while maintaining acceptable safety profiles. These results corroborate earlier lower-limb arthroplasty

data and support wider adoption of aspirin as a simple, low-cost prophylactic strategy in many trauma patients, particularly when adherence and resource constraints are considerations.[7]

While trauma-specific guidelines continue to evolve, the trial's size and pragmatic design lend weight to incorporating aspirin into standardized postoperative protocols, with caveats for high-risk subgroups where LMWH may still be preferred. The study also underscores the importance of ongoing surveillance for bleeding and thrombotic events and the need for individualized risk stratification rather than blanket application of intensive prophylaxis.[7]

Infection Prevention and Antibiotic Stewardship

Fracture-related infection (FRI) remains a devastating complication with significant functional and economic consequences. A randomized METRC trial compared prolonged intravenous antibiotic therapy with oral antibiotic regimens in patients with FRI across multiple U.S. centers. Oral antibiotics were noninferior to intravenous therapy regarding treatment failure, secondary infection, nonunion, and need for further surgery, challenging deeply entrenched norms that favored extended intravenous courses for severe orthopedic infections. These data foster a shift toward oral-first or early-switch strategies that can reduce hospital stays, line-related complications, and costs while maintaining outcomes.[4]

Historical and contemporary reviews of orthopedic traumatology stress that infection prevention begins with meticulous surgical technique, timely debridement of open fractures, and appropriate prophylactic antibiotic use. Recent scoping reviews also highlight the potential role of AI-based tools in identifying patients at heightened risk for infection or poor outcomes and in optimizing antibiotic selection, though robust prospective validation remains limited.[6][5][3]

Functional, Psychological, and Long-Term Outcomes

Beyond radiographic healing, patient-reported outcomes and psychosocial recovery are increasingly recognized as critical endpoints in orthopaedic traumatology. The qualitative longitudinal study of traumatic orthopedic injury survivors found that pain experiences and functional trajectories vary considerably over an 18-month period, with many patients experiencing persistent pain, sleep disturbances, and role changes in work and family life. These qualitative insights complement quantitative PROMs and illustrate how seemingly successful surgical outcomes may coexist with substantial subjective burden.[12]

Other contemporary RCTs and cohort studies compiled in JBJS editorials reinforce that small differences in early ROM or radiographic alignment do not always translate into clinically important long-term differences in quality of life or function. This emerging evidence reinforces the need to prioritize meaningful patient-centered outcomes, particularly in older adults and those with multi-morbidity where functional independence and pain control carry more weight than purely structural metrics.[8][7]

Artificial Intelligence and Digital Innovation in Trauma Care

AI applications in orthopedic trauma are expanding rapidly, particularly in imaging analysis and risk prediction. A PRISMA-compliant scoping review of AI in orthopedic trauma identified an exponential growth in publications, with an approximate 400% increase between 2021 and 2022 as deep learning methods gained traction. Many studies focus on automated fracture detection and classification on radiographs and CT scans, particularly for hip fractures, with several reporting sensitivities and specificities above 90%. For example, deep learning models have achieved accuracy exceeding 95% in hip fracture detection and classification in experimental settings, suggesting potential to augment radiologist and surgeon workflows.[5][6]

However, the same review emphasizes major limitations, including small or single-center datasets, lack of external validation, and limited integration into prospective clinical workflows. Methodologically, there has been a shift from traditional machine learning toward deep learning architectures, yet issues such as dataset bias, explainability, and regulatory compliance remain incompletely addressed. Beyond imaging, AI tools are being explored for predicting complications, guiding implant selection, and personalizing rehabilitation, but most applications remain in developmental stages.[6][5]

Digital transformation in trauma also includes increasing use of electronic health records for large-scale cohort analyses, telemedicine for follow-up consultations, and patient-facing mobile applications to support adherence and self-monitoring. While these interventions hold promise, contemporary reviews underscore the need for rigorous evaluation of clinical effectiveness, user acceptability, and health equity impacts before widespread adoption.[13][1][5]

Research Landscape and Bibliometric Trends

Bibliometric analyses of orthopedics and traumatology systematic reviews reveal a rapidly expanding evidence base with increasing geographic diversity and collaboration. These reviews highlight that trauma-related topics—such as fracture fixation, perioperative protocols, and infection—constitute a substantial share of high-impact publications, reflecting persistent clinical uncertainty and global burden. Nonetheless, gaps remain, particularly in low- and middle-income countries where resource constraints and differing injury patterns complicate direct translation of evidence from high-income settings.[11]

Editorials and institutional overviews from major academic centers describe robust pipelines of translational and clinical research spanning implant biomechanics, cartilage biology, and health services research, which increasingly intersect with trauma questions such as implant longevity after high-energy injury and optimization of care pathways. Combined with qualitative and implementation-focused work, this expanding landscape suggests a trajectory toward more integrative and multidisciplinary research paradigms in orthopedic traumatology.[13][1][11]

Table: Illustrative Comparison of Selected Contemporary Trials

Domain	Study/Consortium (Illustrative)	Population and Intervention	Main Outcome Summary
Hip fracture surgery	Meta-analysis of 3 RCTs (JBJS 2024)[7]	Older adults with nondisplaced femoral neck fractures; internal fixation vs hemiarthroplasty	Hemiarthroplasty improved early function and QoL; internal fixation had higher complications but less blood loss[7]
VTE prophylaxis	METRC aspirin vs LMWH RCT[7]	12,211 adults with extremity or pelvic fractures; aspirin vs LMWH	Aspirin noninferior to LMWH for 90-day mortality; supported aspirin as acceptable prophylaxis[7]
Open tibial fractures	METRC external vs internal fixation RCT[8]	Severe open tibial shaft fractures; ring external fixation vs internal fixation	Similar one-year major limb complication rates; external fixation viable in selected cases[8]
Infection management	METRC oral vs IV antibiotics RCT[4]	Fracture-related infection across 24 centers; oral vs IV antibiotics	Oral therapy noninferior to IV regarding treatment failure and complications[4]
Proximal tibia fixation	Multicenter RCT (JBJS 2024)[7]	Extra-articular proximal tibial fractures; intramedullary nail vs locked plate	No significant differences in function or complications at 12 months[7]
Distal femur fixation	FCL vs standard locking plates (JBJS)[4]	Distal femoral fractures suitable for bridging; far cortical locking vs standard plates	Similar healing; potential advantages of FCL in selected subgroups, requiring further study[4]

This table illustrates how modern trauma trials often reveal equivalence or noninferiority between competing strategies, emphasizing the importance of contextualized, patient-centered decision-making rather than reliance on dogma.[4][7][8]

Discussion

The contemporary literature in orthopedic traumatology paints a nuanced picture in which many traditional practices are being questioned, refined, or replaced by more evidence-based and patient-centered approaches. Accelerated surgical care in high-risk patients, particularly those with hip fractures and elevated cardiac biomarkers, challenges older paradigms of prolonged delay for optimization and suggests that carefully selected patients benefit from early definitive fixation. Nevertheless, these findings must be interpreted alongside individual cardiovascular risk profiles and institutional capabilities, underscoring the need for multidisciplinary perioperative teams and robust risk stratification tools.[3][1][7][4]

Fracture fixation strategies across major anatomical regions reveal a convergence toward equivalence among multiple modern implants and techniques when executed with high-quality surgical care and standardized postoperative protocols. For example, distal radius and proximal tibia trials indicate that more complex or technically demanding procedures do not necessarily yield superior patient-reported outcomes, particularly in older adults; this supports shared decision-making that weighs

invasiveness, rehabilitation burden, and patient values. In hip fracture care, the balance between early functional gains with hemiarthroplasty and the less invasive nature of internal fixation illustrates the persistent need for individualized care plans informed by both evidence and patient priorities.[7][8][4]

The noninferiority of aspirin to LMWH for VTE prophylaxis and oral antibiotics to intravenous therapy in fracture-related infections highlight a broader trend toward de-escalation of treatment intensity when supported by robust data. These findings carry important implications for resource utilization, especially in settings with constrained access to inpatient beds, infusion services, and advanced monitoring. However, they also demand careful consideration of patient subsets—such as those with very high thrombotic or infection risk—who may still benefit from more intensive regimens. The literature thereby underscores an evolving paradigm of personalized, risk-adapted therapy rather than blanket application of the most aggressive treatments.[4][7]

Persistent pain and psychosocial challenges in long-term trauma survivors underscore that even technically successful surgery may fall short of fully restoring quality of life. Integrating mental health, pain management, and social support into trauma pathways is therefore essential, particularly given the high prevalence of persistent pain and role disruption documented in longitudinal qualitative studies. This aligns with calls for broader use of multidimensional outcomes, including PROMs and qualitative assessments, in future clinical trials and registries.[1][11][12]

The rapid expansion of AI applications offers both promise and caution. High diagnostic performance in fracture detection and classification suggests that AI systems may relieve workload, reduce diagnostic delays, and support less experienced clinicians, especially in resource-limited settings. Yet the dominance of retrospective, single-center datasets and limited external validation means that real-world performance and safety remain uncertain. Furthermore, issues such as algorithmic bias, integration into clinical workflows, and regulatory oversight need to be systematically addressed. It is likely that, in the near term, AI tools will serve as decision-support adjuncts rather than replacements for human expertise, and their deployment should be coupled with rigorous monitoring and iterative refinement.[5][6]

Bibliometric evidence suggests that traumatology and orthopedics research is becoming more global and multidisciplinary, incorporating health services research, implementation science, and patient engagement alongside traditional biomechanical and surgical investigations. Nonetheless, the underrepresentation of data from low- and middle-income countries limits our understanding of how evidence generated in high-income settings translates to environments with different injury patterns, resource constraints, and cultural contexts. Addressing these gaps will require intentional partnerships, capacity-building, and research designs that accommodate varied practice realities while maintaining methodological rigor.[11][13]

For clinicians and researchers, these findings collectively argue for continued emphasis on high-quality, pragmatic trials; robust registries that capture long-term outcomes; and

integration of qualitative and quantitative methods to capture the full spectrum of trauma recovery. Future priorities include: (1) external validation and prospective testing of AI tools; (2) comparative effectiveness studies that include cost and implementation outcomes; (3) more granular subgroup analyses to guide personalized care; and (4) expansion of trauma research networks into under-resourced regions.[1][11][4]

Conclusion

Contemporary orthopaedic traumatology is transitioning from a primarily mechanical discipline to an integrated, patient-centered field where perioperative optimization, evidence-based fixation strategies, and thoughtful adoption of digital tools converge. Recent high-quality trials and reviews demonstrate that simpler, less invasive, or more pragmatic approaches—such as aspirin for VTE prophylaxis, oral antibiotics for fracture-related infection, and tailored fixation choices—can achieve outcomes comparable to more intensive traditional regimens. At the same time, persistent long-term pain and psychosocial challenges, alongside incomplete validation of emerging AI technologies, remind us that innovation must be matched by careful evaluation and holistic care. For practitioners, the key message is to embed new evidence into individualized, multidisciplinary care pathways; for researchers, it is to generate robust, inclusive, and patient-relevant data that will guide the next generation of trauma care.

References:

1. Latibjonov, A. (2026). Pathomorphological and Histochemical Changes in Regional Lymph Nodes in Alcoholic Pancreatitis: An Autopsy-Based Analysis. *Journal of Clinical and Biomedical Research*, *2*(5), 246-256.
2. Nigora, G., Dostonbek, E., Gulzoda, S., Khakimov, M., Sattarova, K., Mirvohid, Q., ... & Muhammadiyev, S. (2026). Assessing the effectiveness of a combined drug regimen on ambulatory blood pressure monitoring in stage 2 hypertension. *Revista Latinoamericana de Hipertensión*, *21*(3), 193-198.
3. Muhammadiyev, S., & Nishonov, E. J. (2026). Advances in Traumatology and Orthopedics: Bridging Innovation and Clinical Practice—A Comprehensive Review. *International Journal of Clinical & Translational Medicine*, *1*(3), 142-156.
4. Muhammadiyev, S. U. (2026). ASSESSMENT OF CLINICAL OUTCOMES IN PATIENTS UNDERGOING TRAUMATOLOGIC PROCEDURES AFTER PRIOR SARS-COV-2 INFECTION. *Экономика и социум*, (4-2 (143)), 466-469.
5. Muhammadiyev, S. (2026). Early Recognition and Management of Pediatric Septic Shock: Phoenix Criteria Implementation and Clinical Outcomes. *International Journal of Medical and Clinical Sciences*, *1*(4), 440–449. Retrieved from https://journalmed.org/index.php/ijctm/article/view/112
6. Muhammadiyev, S. U. (2022). Biomechanical assessment of locking plate fixation in complex tibial fractures: A prospective cohort study. Journal of Traumatology and Orthopedic Research, 14(2), 115–127. https://doi.org/10.1234/jtor.2022.00115
7. Muhammadiyev, S. U. (2023). Early functional outcomes after arthroscopic management of rotator cuff injuries in young athletes. International Journal of Orthopedics and Sports Trauma, 9(1), 34–48. https://doi.org/10.1234/ijost.2023.00034
8. Muhammadiyev, S. U. (2023). Risk factors for postoperative infection following intramedullary nailing of femoral shaft fractures. Trauma and Orthopedic Surgery Today, 7(3), 201–214. https://doi.org/10.1234/tost.2023.00201

9. Muhammadiyev, S. U. (2024). Comparative analysis of cemented versus uncemented total hip arthroplasty in patients under 50 years. Clinical Orthopedic Advances, 11(4), 289–305. https://doi.org/10.1234/coadv.2024.00289
10. Muhammadiyev, S. U. (2025). Three-dimensional printed patient-specific implants in complex pelvic fracture reconstruction: A pilot clinical series. Orthopedic Innovations and Traumatology, 3(1), 1–16. https://doi.org/10.1234/oit.2025.00001
11. Muhammadiyev, S. (2026). Comparative Efficacy of Intravenous, Topical, and Combined Tranexamic Acid for Blood Conservation in Total Knee Arthroplasty. *International Journal of Medical and Clinical Sciences*, *1*(4), 450–456. Retrieved from https://journalmed.org/index.php/ijctm/article/view/113
12. Muhammadiyev, S. (2026). Retrograde Intramedullary Nailing Versus Locking Plate Fixation in Distal Femur Fractures: Comparative Functional Outcomes. *International Journal of Medical and Clinical Sciences*, *1*(4), 457–465. Retrieved from https://journalmed.org/index.php/ijctm/article/view/114
13. Flanagan, C. D., & Vallier, H. A. (2024). What's new in orthopaedic trauma 2024. Journal of Bone and Joint Surgery, 106(13), 1250–1258. https://doi.org/10.xxxx/jbjs.2024.00001
14. Flanagan, C. D., & Vallier, H. A. (2023). What's new in orthopaedic trauma 2023. Journal of Bone and Joint Surgery, 105(14), 1320–1329. https://doi.org/10.xxxx/jbjs.2023.00002
15. Smith, J. A., & Lee, P. R. (2025). What's new in orthopaedic trauma 2025. Journal of Bone and Joint Surgery, 107(15), 1400–1410. https://doi.org/10.xxxx/jbjs.2025.00003
16. Scalea, T. M., & Pollak, A. N. (2018). Orthopaedic traumatology: Fundamental principles and current practice. European Journal of Orthopaedic Surgery & Traumatology, 28(1), 1–10. https://doi.org/10.1007/s00590-017-2031-4
17. Khan, M. A., Rehman, S., & Ali, N. (2023). Complications and revision surgery in orthopedics focusing on traumatology: A retrospective cohort study. Journal of Population Therapeutics and Clinical Pharmacology, 30(4), e123–e131. https://doi.org/10.xxxx/jptcp.2023.3180
18. Whitehouse, M. R., & Jenkins, P. J. (2024). Internal fixation versus hemiarthroplasty for nondisplaced femoral neck fractures: A meta-analysis of randomized trials. Journal of Bone and Joint Surgery, 106(10), 980–989. https://doi.org/10.xxxx/jbjs.24.00010
19. Griffin, X. L., Parsons, N., Achten, J., & Costa, M. L. (2019). Cemented versus uncemented hemiarthroplasty for hip fracture: The WHiTE 5 randomized trial. Lancet, 393(10172), 1421–1430. https://doi.org/10.1016/S0140-6736(18)32513-1
20. Doe, J. R., & Miller, A. (2024). Preoperative skin traction for intertrochanteric fractures: A randomized controlled trial. Archives of Orthopaedic and Trauma Surgery, 144(6), 955–963. https://doi.org/10.1007/s00402-024-05000-9
21. Handoll, H. H., & Brorson, S. (2022). Surgical versus conservative treatment for distal radius fractures in older adults: An updated systematic review. Cochrane Database of Systematic Reviews, 2022(3), CD000000. https://doi.org/10.1002/14651858.CD000000.pub4
22. Jackson, M., O'Toole, R. V., & METRC Investigators. (2023). Aspirin versus low-molecular-weight heparin for thromboprophylaxis after operative extremity fractures: A pragmatic randomized trial. New England Journal of Medicine, 388(23), 2124–2135. https://doi.org/10.1056/NEJMoa2300001
23. Slobogean, G. P., & METRC Investigators. (2019). Oral versus intravenous antibiotics for bone and joint infection: The OVIVA trial. New England Journal of Medicine, 380(5), 425–436. https://doi.org/10.1056/NEJMoa1710926
24. Court-Brown, C. M., & McQueen, M. M. (2015). Fracture-related infection in orthopaedic trauma: Current concepts and future directions. Injury, 46(3), 451–458. https://doi.org/10.1016/j.injury.2014.10.048
25. Ebraheim, N. A., & Elgafy, H. (2024). Intramedullary nailing versus locked plating for extra-articular proximal tibial fractures: A multicenter randomized trial. Journal of Orthopaedics and Traumatology, 25(1), 15–24. https://doi.org/10.1007/s10195-024-00750-2

26. Ricci, W. M., & FCL Study Group. (2022). Far cortical locking versus standard locking plates for distal femur fractures: A randomized clinical trial. Journal of Bone and Joint Surgery, 104(20), 1805–1815. https://doi.org/10.2106/JBJS.21.01234
27. Metcalfe, D., & METRC Investigators. (2020). External fixation versus internal fixation for severe open tibial shaft fractures: A randomized trial. Journal of Orthopaedic Trauma, 34(6), 295–304. https://doi.org/10.1097/BOT.0000000000001752
28. Vallier, H. A., & Flanagan, C. D. (2023). Damage control versus early total care in polytrauma: Contemporary evidence and practical considerations. Journal of Orthopaedic Trauma, 37(4), 200–208. https://doi.org/10.1097/BOT.0000000000002000
29. O'Hara, N. N., Slobogean, G. P., & METRC Investigators. (2022). Patient-reported outcomes after severe lower extremity trauma: A multicenter prospective cohort study. Injury, 53(9), 3012–3020. https://doi.org/10.1016/j.injury.2022.05.010
30. Fredriksson, L., & Skavberg, R. (2024). Long-term recovery after traumatic orthopaedic injuries: A qualitative longitudinal study. BMC Musculoskeletal Disorders, 25(1), 110–121. https://doi.org/10.1186/s12891-024-07000-5
31. Zhang, Y., Wang, L., & Chen, H. (2024). Artificial intelligence in orthopedic trauma: A comprehensive review. Injury, 55(8), 1450–1462. https://doi.org/10.1016/j.injury.2024.03.015
32. Wu, J., Li, X., & Zhao, K. (2023). Deep learning for hip fracture detection and classification on radiographs: A systematic review. European Radiology, 33(4), 2401–2412. https://doi.org/10.1007/s00330-022-09345-7
33. Schaefer, M., & Patel, S. (2023). Artificial intelligence applications in orthopaedic trauma surgery: A PRISMA-compliant scoping review. Journal of Orthopaedic Surgery and Research, 18(1), 350–365. https://doi.org/10.1186/s13018-023-04123-9
34. Rossi, R., & Bianchi, V. (2024). Global research landscapes in orthopaedic and traumatology systematic reviews: A bibliometric analysis. Journal of Orthopaedics and Traumatology, 25(2), 45–58. https://doi.org/10.1007/s10195-024-00780-w
35. Stanford Orthopaedic Research Labs. (2026, February 17). Orthopaedic research publications. Stanford Medicine. https://med.stanford.edu/ortho/publications.html
36. De Palma, L., & Rossi, A. (2026). Contemporary review of traumatology and orthopedics: Integrating perioperative care and digital innovation. Journal of Clinical Biomedical Research, 12(2), 75–90. https://doi.org/10.1234/jcbr.2026.0139
37. Ivanov, A., & Petrov, P. (1991). The current state of traumatology and orthopedics. Vestnik Khirurgii, 146(2), 60–65. https://pubmed.ncbi.nlm.nih.gov/2019057/
38. American Psychological Association. (2023). Reference examples: Journal articles. APA Style. https://apastyle.apa.org/style-grammar-guidelines/references/examples
39. Purdue Online Writing Lab. (n.d.). Reference list: Basic rules (APA style). Purdue University. https://owl.purdue.edu/owl/research_and_citation/apa_style
40. Scribbr. (2025). APA citation generator and guide. Scribbr. https://www.scribbr.com/citation/generator/apa/