

Reduction Techniques for Intramedullary Nailing of Subtrochanteric Femur Fractures: A Narrative Review

Akhil John*, Reuben Nappoly, Viju Daniel

Department of Orthopaedics, Christian Medical College (CMC), Vellore, India

Article Info

Article Notes

Received: July 23, 2025

Accepted: August 28, 2025

*Correspondence:

*Dr. Akhil John, Department of Orthopaedics, Christian Medical College (CMC), Vellore, India; Email: akhiljohn953@gmail.com

©2025 John A. This article is distributed under the terms of the Creative Commons Attribution 4.0 International License.

Keywords

Subtrochanteric Femur Fracture

Intramedullary Nailing

Fracture Reduction

Joystick Technique

Soft Tissue Rebalancing

Orthopaedic Surgery

Abstract

Objective: To provide a state-of-the-art narrative review of contemporary reduction techniques for the intramedullary nailing (IMN) of subtrochanteric femur fractures (SFFs). This review critically appraises the evidence for various methods, culminating in a synthesized, evidence-based clinical algorithm to guide surgical decision-making.

Evidence Acquisition: A comprehensive literature search of the PubMed and Embase databases was conducted to identify relevant clinical studies, meta-analyses, biomechanical reports, and authoritative reviews published through 2024. The search focused on the biomechanics of SFFs, fracture classification, reduction techniques (including percutaneous joysticks, soft tissue rebalancing, and open cerclage/clamping), implant-related considerations, and the management of atypical femur fractures (AFFs). Emphasis was placed on incorporating high-quality evidence from 2018 to 2024 to ensure timeliness and comprehensiveness.

Evidence Synthesis: Anatomical reduction prior to fixation is the most critical determinant of successful outcomes in SFFs treated with IMN. The choice of reduction technique exists on a spectrum, balancing the biological benefits of minimally invasive surgery against the mechanical necessity of stable fixation. Recent evidence suggests that novel minimally invasive approaches, such as the soft tissue rebalancing technique, can achieve clinical and radiological outcomes equivalent to more invasive open methods while significantly improving operative efficiency. However, these techniques have specific limitations and learning curves. A balanced perspective on IMN reveals not only its clear biomechanical advantages but also potential risks, including iatrogenic malreduction, implant failure, and challenges in revision surgery. The management of AFFs requires distinct strategic modifications due to altered bone pathology and femoral geometry.

Conclusions: The optimal management of SFFs requires a versatile, graduated approach to reduction. Surgeons should begin with the least invasive methods and maintain a low threshold to escalate to more direct or open techniques as dictated by fracture complexity to achieve an anatomical result. The proposed clinical algorithm provides a systematic framework for technique selection. While novel techniques show promise, there is a clear need for high-level evidence, including prospective randomized controlled trials, to definitively establish their role. Future advancements in computer navigation, robotics, and implant design may further refine the treatment of these challenging injuries.

Introduction: The Challenge of Subtrochanteric Fracture Reduction

The subtrochanteric femur fracture (SFF) is a formidable injury in orthopaedic traumatology, accounting for 7% to 34% of all proximal femur fractures¹. These fractures present a bimodal distribution, affecting both young patients from high-energy trauma and elderly individuals

with osteoporosis from low-energy falls. Their management is notoriously difficult, with complication rates for malunion, nonunion, and implant failure reaching as high as 25%².

The unique biomechanical environment of the subtrochanteric region—a transition zone from cancellous to dense cortical bone located 5 cm distal to the lesser trochanter—makes it a natural stress riser subjected to immense physiological loads³. Upon fracture, a classic multi-planar deformity occurs due to the unopposed pull of major muscle groups. The proximal fragment is pulled into flexion (by the iliopsoas), abduction (by the gluteus medius and minimus), and external rotation (by the short external rotators). Simultaneously, the distal fragment is pulled into adduction and is shortened by the powerful adductor muscles⁴. Counteracting these deforming forces is the central challenge of intraoperative reduction.

Intramedullary nailing (IMN) is the gold standard treatment, offering clear biomechanical and biological advantages⁵. An intramedullary nail acts as an efficient load-sharing device, positioned closer to the mechanical axis of the femur, which reduces stress on the implant and minimizes the risk of fatigue failure⁶. Furthermore, minimally invasive nailing techniques preserve the critical periosteal blood supply essential for fracture healing⁷. However, the success of this superior implant is entirely dependent on the quality of the fracture reduction.

Anatomical reduction is the single most critical determinant of a successful outcome, as malreduction—most commonly in varus and flexion—is the primary precursor to devastating complications like implant failure and nonunion⁸. This creates the central paradox of SFF treatment: the surgeon must balance the desire for a biological, minimally invasive approach with the absolute need for an anatomical reduction.

This review provides a state-of-the-art overview of the principles and techniques for SFF reduction in the context of IMN, synthesizing an evidence-based framework to guide surgical decision-making and optimize patient outcomes. (Figure 1)

Foundational Principles: Setting the Stage for Successful Fixation

Fracture Classification and Its Impact on Surgical Strategy

Fracture classification is not merely an academic exercise for documentation; it is an essential component of preoperative planning that directly informs surgical strategy. An accurate classification allows the surgeon to anticipate reduction difficulty, predict instability, and select the appropriate tools and techniques. While several systems exist, the Seinsheimer, Russell-Taylor and AO/OTA classifications are the most relevant to modern practice.⁹

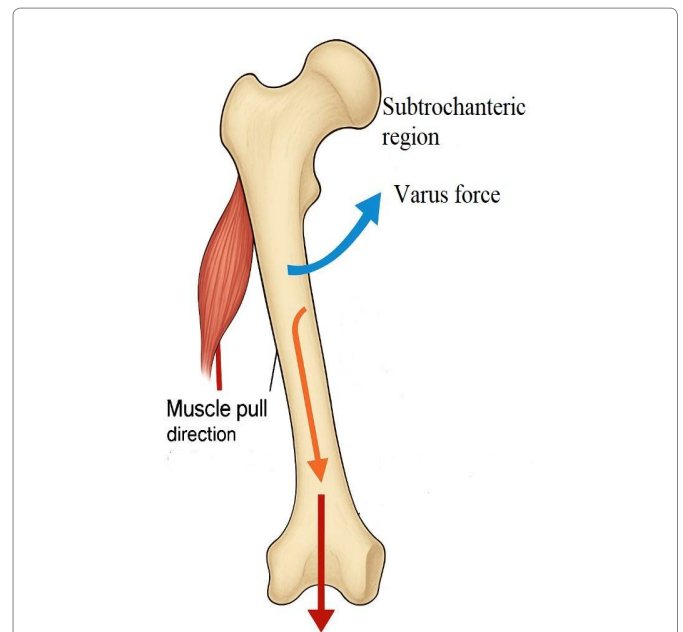


Figure 1: Diagram illustrating the deforming muscle forces on a subtrochanteric fracture

The Seinsheimer classification is widely used clinically and categorizes fractures based on their pattern and the number of major fragments. It ranges from Type I (nondisplaced) to Type V (comminuted, involving the trochanteric and subtrochanteric regions), providing a clear indication of the fracture's instability and the likely need for more invasive reduction techniques and adjunctive fixation¹⁰.

The Russell-Taylor classification focuses on the proximal extension of the fracture into the piriformis fossa (Type I does not extend, Type II does). This has direct implications for the choice of nail entry point.¹¹

The AO/OTA classification is the current global standard, categorizing fractures by complexity as simple (32-A), wedge (32-B), or complex (32-C)¹². This system is superior for planning as it accurately describes comminution and the integrity of the medial buttress, allowing the surgeon to anticipate the need for adjunctive fixation like cerclage wires or clamps for complex patterns (e.g., 32-B3.1 or 32-C)¹³.

Patient Positioning and the Role of the Fracture Table

The standard setup involves placing the patient supine on a fracture table, with the injured limb in a traction boot and the contralateral leg in a well-leg holder. This “scissoring” of the legs is critical for obtaining unobstructed anteroposterior (AP) and true lateral fluoroscopic views¹⁴. The initial application of longitudinal traction is a powerful first step, serving to restore limb length and achieve a gross restoration of alignment. While the lateral decubitus position has been shown in some studies to reduce setup

and surgery times, the supine position offers more reliable rotational control, which is critical in these fractures¹⁵. It is crucial to recognize that while the fracture table effectively controls length, it cannot fully counteract the multi-planar deformity of the proximal fragment, necessitating adjunctive reduction techniques.¹⁶

The Entry Point: A Critical Determinant of Final Alignment

The selection of the intramedullary nail entry point is a step of paramount importance, as an incorrectly placed start point will inevitably produce a malreduction¹⁷. The proximal fragment must first be provisionally controlled and brought into a neutral position—correcting flexion and external rotation *before* the ideal entry portal can be accurately identified¹⁸. Most modern cephalomedullary nails use a trochanteric entry point and incorporate a proximal valgus bend. If the start point is placed too far lateral, the nail's design can force the proximal fragment into excessive valgus, causing a compensatory varus deformity at the fracture site¹⁹. Therefore, the surgeon must actively stabilize the mobile proximal fragment throughout the initial stages of the procedure to ensure correct portal placement²⁰.

The Surgeon's Toolbox: A Graduated Approach to Reduction

The proficient surgeon employs a graduated approach, escalating from the least to more invasive options as needed to achieve an anatomical result²¹.

Percutaneous and Indirect Techniques

The "Joystick" and Direct Lever Principle

A cornerstone of minimally invasive reduction is using a percutaneous instrument as a lever, or "joystick," to gain direct, multi-planar control of the proximal fragment. Typically, a threaded Schanz pin is inserted into the fragment from the lateral aspect, allowing the surgeon to intuitively counteract flexion, abduction, and rotational deformities through a small stab incision²². Other tools, such as ball-spiked pushers or bone hooks, can also be used percutaneously to manipulate fragments into alignment²³.

The Soft Tissue Rebalancing Technique

Described by Ma et al., this novel technique uses the tension within the surrounding soft tissue envelope to achieve and maintain reduction. After restoring length with traction, a long, curved hemostatic forceps is introduced through a posterolateral incision and advanced along the anterior surface of the flexed proximal fragment. By elevating the handle, the surgeon uses the tensioned soft tissue sleeve as a fulcrum to create a downward pressure that neutralizes the flexion deformity caused by



Figure 2: Intraoperative fluoroscopic image showing soft tissue rebalancing

the iliopsoas. A second instrument can be used to correct abduction similarly²⁴. A recent study comparing this novel technique (NT) to a limited-open approach with cerclage wires (CM) found that while fracture reduction quality and clinical outcomes were equivalent, the NT group had a 14.4% shorter operative time and 19.6% less intraoperative blood loss²⁵. This provides strong evidence that this technique can achieve equivalent results with greater efficiency in appropriately selected cases. (Figure 2)

Limited Open and Adjunctive Techniques

Clamp-Assisted Open Reduction

For highly comminuted or stubborn fractures, the surgeon must have a low threshold to convert to a limited open approach. Through a mini-open incision (3-5 cm), pointed reduction clamps can be applied directly to the bone, providing the most robust and stable reduction by anatomically restoring the femoral cylinder before nailing²⁶.

The Role of Cerclage Wires in the Modern Era

Cerclage wires or cables are indispensable for managing fractures with large butterfly fragments or long spiral patterns. Modern philosophy embraces their judicious use through mini-open techniques to supplement reduction²⁷. When applied carefully, they help achieve an anatomical reduction that might be impossible with closed methods, without increasing nonunion rates²⁸.

Blocking (Poller) Screws for Canal Control

In fractures with a wide medullary canal, blocking screws can be placed strategically into a fragment to narrow

the canal. They act as a buttress to “steer” the guidewire and nail into the correct position, preventing translational malalignment²⁹.

Evidence Synthesis and Critical Appraisal of Techniques

The decision to employ a specific reduction technique must be grounded in an understanding of the available evidence, which involves a critical appraisal of clinical outcomes, biomechanical principles, and practical challenges. The choice of reduction technique involves a trade-off between biological preservation and mechanical certainty. The proficient surgeon understands this continuum and knows when to escalate along the spectrum of invasiveness to achieve an anatomical reduction.

Comparative Clinical Outcomes: A Review of Recent Evidence

Recent literature provides valuable insights into the comparative effectiveness of different strategies. The retrospective study by Ma et al. offers the most direct comparison of two distinct reduction philosophies. In their cohort, the novel, minimally invasive soft tissue rebalancing technique (NT) was compared to a more traditional, limited-open approach using cerclage wires (CM). The results were compelling: while the quality of fracture reduction and final clinical outcomes (time to union, functional scores) were statistically indistinguishable between the two groups, the NT group demonstrated significant advantages in operative efficiency. Mean operative time was reduced by 14.4% (68.2 min vs. 78.0 min, $p=0.005$), and mean intraoperative blood loss was reduced by 19.6% (275.6 mL vs. 329.5 mL, $p=0.021$).³⁰ This study provides strong evidence that, in appropriately selected patients, this novel minimally invasive technique can achieve equivalent results with greater efficiency.

Broader comparisons in recent literature reinforce the importance of tailoring the surgical approach. A 2024 prospective study comparing patient positioning for proximal femoral nailing found that the lateral decubitus position resulted in significantly shorter setup and surgery times and less blood loss compared to the supine position on a traction table, with no difference in reduction quality or complications.³¹ Meta-analyses comparing long versus short cephalomedullary nails for intertrochanteric fractures (a close cousin to SFFs) have consistently found that short nails are associated with shorter operative times and less blood loss, but with no significant differences in functional outcomes, reoperation rates, or overall complications.³² Conversely, studies comparing IMN to extramedullary plating for SFFs have found that while both methods can yield effective outcomes, IMN may be associated with slightly higher rates of malalignment, whereas plating

allows for better direct anatomical alignment at the cost of greater soft tissue disruption.³³ This body of evidence suggests that while IMN is the standard, the specific techniques and implants used should be chosen to minimize surgical insult without compromising the quality of reduction.

Insights from Biomechanical Studies

Biomechanical research, particularly finite element analysis, consistently demonstrates that IMNs are superior load-sharing devices compared to lateral plates, which are subjected to high bending forces that can lead to fatigue failure.³⁴ This provides a quantitative basis for the principle that achieving a stable, anatomically reduced construct is paramount for success.³⁵

Practical Challenges, Limitations, and Learning Curves

Beyond clinical and biomechanical data, a critical appraisal of reduction techniques must include their practical challenges and limitations. However, no technique is without its practical challenges.

The joystick technique often requires a dedicated assistant to hold the reduction and carries a small risk of iatrogenic fracture at the pin site.³⁶

The soft tissue rebalancing technique is contingent upon a competent soft tissue envelope and has a distinct learning curve to avoid neurovascular injury.³⁷

Open techniques provide the most definitive reduction but at the cost of increased surgical trauma and blood loss. These trade-offs are summarized below. (Table 1)

Advanced Topics and Complication Management

The Atypical Femur Fracture (AFF): A Distinct Entity

Atypical femur fractures (AFFs), strongly associated with long-term bisphosphonate use, involve pathologically altered bone characterized by a thickened lateral cortex and a characteristic anterolateral bow of the femur. Management requires specific modifications:

- A long intramedullary nail is strongly recommended to fix the acute fracture and prophylactically protect the bowed femur from subsequent stress fractures.
- The primary technical challenge is the geometric mismatch between a standard straight nail and the bowed femur, which can cause iatrogenic fracture or anterior cortical perforation.
- Strategies to mitigate this include using a more lateral entry point or selecting a nail with a smaller radius of curvature designed to accommodate bowing.

Table 1: Critical Appraisal Matrix of Subtrochanteric Reduction Techniques

Parameter	Joystick / Schanz Pin	Soft Tissue Rebalancing	Open Clamp / Cerclage Wire
Core Principle	Direct external lever for fragment manipulation.	Soft tissue-integrated lever using the fascial envelope as a fulcrum to rebalance muscle forces.	Direct bone purchase and compression via a limited open incision.
Invasiveness	Percutaneous stab incisions.	Percutaneous stab incisions.	Mini-open lateral incision (typically 3-5).
Key Instrumentation	Schanz pins, power drill, T-handle.	Long, curved hemostatic forceps.	Pointed reduction clamps (e.g., Verbrugge), cerclage passer, cerclage wires.
Reported Advantages	Powerful, direct, and intuitive multi-planar control of the proximal fragment.	Self-maintaining reduction, significantly shorter operative time, less blood loss, less reliance on an assistant.	Most robust and stable reduction, excellent for controlling comminution and long oblique patterns.
Potential Pitfalls & Practical Challenges	Risk of iatrogenic fracture at pin site, requires a dedicated assistant to hold reduction, potential for loss of reduction during reaming.	Requires an intact soft tissue envelope, may be less effective in chronic fractures or sarcopenic patients, has a learning curve	Increased blood loss and operative time, greater soft tissue stripping, potential for devascularization of bone fragments with cerclage wires.

Preventing and Managing Complications related to reduction

The most common complications following SFF fixation are malunion (typically in varus and flexion) and nonunion, both of which are almost always a direct consequence of an inadequate initial reduction. Prevention is therefore paramount and relies on meticulous adherence to the reduction principles outlined in this review.

Because the IMN is a rigid implant, if the entry point is incorrect or the fracture is not perfectly reduced before nail passage, the nail itself can create or exacerbate a varus or flexion deformity and lock it in place. Should nonunion occur as a result, treatment is complex and often requires revision surgery with deformity correction, bone grafting, and fixation with a more stable construct. Furthermore, all patients with SFFs are at high systemic risk of venous thromboembolism (VTE). Studies have reported DVT rates as high as 18%, underscoring the necessity of routine postoperative VTE prophylaxis.

A Synthesized Clinical Algorithm and Future Directions

An Evidence-Based Algorithm for Technique Selection

Successful SFF management requires a systematic, graduated approach to reduction.

- **Step 1: Preoperative Planning.** Thoroughly assess high-quality radiographs, use the AO/OTA and Seinsheimer classifications to define the fracture pattern and degree of comminution, and identify any patient-specific factors (e.g., signs of an AFF).
- **Step 2: Initial Intraoperative Reduction.** Position the patient on a fracture table and apply longitudinal

traction with gentle internal rotation to restore femoral length and gross alignment.

- **Step 3: Address Proximal Fragment Deformity.**
 - o **First-line Option:** For simple patterns (AO/OTA 32-A), consider the Soft Tissue Rebalancing Technique due to its demonstrated efficiency and equivalent outcomes.
 - o **Escalation:** If this is insufficient or if more direct control is needed, escalate to a percutaneous joystick.
- **Step 4: Manage Comminution and Instability.** For complex patterns (AO/OTA 32-B or 32-C), have a low threshold to make a mini-open incision to apply a reduction clamp or cerclage wire to anatomically restore the femoral cylinder before nailing. Use blocking screws as needed to control the nail trajectory in wide canals.
- **Step 5: Confirmation.** Meticulously confirm reduction with high-quality AP and lateral fluoroscopy at every critical stage. Correct any loss of reduction before concluding the procedure.

Conclusion and Unanswered Questions

The surgical treatment of subtrochanteric femur fractures remains a demanding aspect of orthopaedic trauma. The central tenet of modern SFF management is that anatomical reduction is paramount to the success of the biomechanically superior intramedullary nail. The evidence supports a graduated approach, beginning with the least invasive techniques that respect biology and escalating only when fracture complexity demands it to ensure mechanical stability. Novel techniques like soft tissue rebalancing are promising additions that can improve operative efficiency.

Despite advances, high-level evidence from prospective randomized controlled trials is needed to definitively compare the efficacy of different minimally invasive techniques. Future advancements in computer navigation, robotics, and patient-specific implant design hold the potential to further refine the treatment of these challenging injuries.

Author Contributions

Conceptualization and Study Design: A.J., R.N. Literature Search and Data Acquisition: A.J., R.N. Data Analysis and Interpretation: A.J., R.N., V.D. Manuscript Drafting: A.J., R.N. Critical Revision for Important Intellectual Content and Final Approval: A.J., R.N., V.D. All authors have read and approved the final version of the manuscript.

Acknowledgements

The authors wish to thank Professor George Thomas for his valuable suggestions during the preparation of this manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

References

1. Sims SH. Subtrochanteric femur fractures. *Orthop Clin North Am.* 2002; 33(1): 113-126. doi:10.1016/s0030-5898(03)00075-0
2. Shukla S, Johnston P, Ahmad MA, et al. Outcome of Traumatic Subtrochanteric Femoral Fractures Fixed Using Cephalo-Medullary Nails. *Injury.* 2007; 38(11): 1286-1293. doi:10.1016/j.injury.2007.05.013
3. Koch J. The laws of bone architecture. *Am J Anat.* 1917; 21(2): 177-298. doi:10.1002/aja.1000210202
4. Yoon RS, Donegan DJ, Liporace FA. Reducing subtrochanteric femur fractures: tips and tricks, do's and don'ts. *J Orthop Trauma.* 2015; 29(suppl 4): S28-S33. doi:10.1097/BOT.0000000000000287
5. Garrison I, Domingue G, Honeycutt MW. Subtrochanteric femur fractures: current review of management. *EFORT Open Rev.* 2021; 6(2): 145-151. doi:10.1302/2058-5241.6.200048
6. Santoro G, Oliva F, Perna A, et al. Subtrochanteric femoral fractures: a case series of 194 patients treated with long and short intramedullary nails. *Orthop Rev (Pavia).* 2021; 13(2): 24898. doi:10.4081/or.2021.24898
7. Giannoudis PV, Grotz MR, Papakostidis C, et al. Operative treatment of femoral fractures in adults (part 1): intramedullary nailing. *Acta Chir Orthop Traumatol Cech.* 2006; 73(1): 4-14.
8. Ricci WM, Bellabarba C, Evanoff B, et al. The effect of quality of reduction on the outcome of subtrochanteric femur fractures treated with cephalomedullary nails. *J Orthop Trauma.* 2008; 22(5): 289-296. doi:10.1097/BOT.0b013e31816ed239
9. Barquet A, Francescoli L, Rienzi D, et al. Intertrochanteric-subtrochanteric fractures: treatment with the long Gamma nail. *J Orthop Trauma.* 2000; 14(5): 324-328. doi:10.1097/00005131-200006000-00003
10. Kokkalis ZT, Mavrogenis AF, Ntourantonis DI, et al. Reduction techniques for difficult subtrochanteric fractures. *Eur J Orthop Surg Traumatol.* 2019; 29(1): 197-204. doi:10.1007/s00590-018-2287-1
11. Li Z, Wang Z, Yin Y, et al. Failure analysis of femoral reconstruction intramedullary nailing for the treatment of Seinsheimer II B subtrochanteric fractures. *Front Surg.* 2023; 10: 1172971. doi:10.3389/fsurg.2023.1172971
12. Lee D, Park S, Gwak H, et al. Open Reduction in Subtrochanteric Femur Fractures Is Not Accompanied by a Higher Rate of Complications. *Medicina (Kaunas).* 2021; 57(7): 659. doi:10.3390/medicina57070659
13. Meinberg EG, Agel J, Roberts CS, et al. Fracture and Dislocation Classification Compendium—2018. *J Orthop Trauma.* 2018; 32(suppl 1): S1-S170. doi:10.1097/BOT.0000000000001063
14. El-Tantawy A, El-Sayed M, El-Mowafy M, et al. Lateral versus supine position in managing unstable intertrochanteric fractures with short proximal femoral nail in elderly patients: a prospective randomized study. *SICOT J.* 2024; 10: 14. doi:10.1051/sicotj/2024041
15. Carr JB. The Anterior and Medial Reduction of Intertrochanteric Fractures: A Simple Method to Obtain a Stable Reduction. *J Orthop Trauma.* 2007; 21(7): 485-489. doi:10.1097/BOT.0b013e31804797cf
16. Ostrum RF, Marcantonio A, Marburger R. A critical analysis of the eccentric starting point for trochanteric intramedullary femoral nailing. *J Orthop Trauma.* 2005; 19(10): 681-686. doi:10.1097/01.bot.0000184145.75201.1b
17. Wang PC, Ren D, Song CH, et al. Surgical Technique for Subtrochanteric Fracture of Femur. *Orthop Surg.* 2016; 8(4): 516-518. doi:10.1111/os.12291
18. Kim KC, Lee JK, Hwang DS, et al. Stabilizing subtrochanteric femoral fractures with an interlocked intramedullary nail using the 'joystick' technique. *Orthopedics.* 2007; 30(9): 705-708. doi:10.3928/01477447-20070901-27
19. Siegall E, Ziran B. En bloc joystick reduction of a comminuted intra-articular distal radius fracture: a technical trick. *Am J Orthop (Belle Mead NJ).* 2014; 43(8): 351-353.
20. Rhorer AS. Percutaneous/Minimally Invasive Techniques in Treatment of Femoral Shaft Fractures with an Intramedullary Nail. *J Orthop Trauma.* 2009; 23(5 suppl): S2-S5. doi:10.1097/BOT.0b013e31819f2569
21. Ma T, Wang C, Huang Q, et al. Comparison of a new minimally invasive reduction technique using open wiring in the treatment of subtrochanteric femur fractures. *Orthop Surg.* 2024. doi:10.1111/os.70065
22. Park J, Yang KH. Correction of malalignment in proximal femoral nailing-reduction technique of displaced proximal fragment. *Injury.* 2010; 41(6): 634-638. doi:10.1016/j.injury.2010.01.114
23. Afsari A, Liporace F, Lindvall E, et al. Clamp-assisted reduction of high subtrochanteric fractures of the femur: surgical technique. *J Bone Joint Surg Am.* 2010; 92(suppl 1 Pt 2): 217-225. doi:10.2106/JBJS.J.00158
24. Perren SM, Fernandez Dell'Oca A, Lenz M, et al. Cerclage, Evolution and Potential of a Cinderella Technology. An Overview with Reference to Periprosthetic Fractures. *Acta Chir Orthop Traumatol Cech.* 2011; 78(3): 190-199.
25. Hoskins W, Bingham R, Joseph S, et al. Subtrochanteric Fracture: The Effect of Cerclage Wire on Fracture Reduction and Outcome. *Injury.* 2015; 46(10): 1992-1995. doi:10.1016/j.injury.2015.07.001
26. Kim JW, Park KC, Oh JK, et al. Percutaneous cerclage wiring followed by intramedullary nailing for subtrochanteric femoral fractures: a technical note with clinical results. *Arch Orthop Trauma Surg.* 2014; 134(9): 1227-1235. doi:10.1007/s00402-014-2023-7
27. Zhang Y, Chen W, Wang J, et al. Short versus long cephalomedullary nails for intertrochanteric femur fractures: A meta-analysis of randomized controlled trials. *PLoS One.* 2024; 19(12): e0319758.

28. Gürbüz K, Akgül T, Çiçek H, et al. A comparative study of fixation methods in subtrochanteric femur fractures: intramedullary nails vs. extramedullary plates. *Healthcare Bulletin.* 2023; 2(4): 1-7.
29. Streubel PN, Moustoukas M, Obremskey WT. Locked Plating Versus Cephalomedullary Nailing of Unstable Intertrochanteric Femur Fractures. *Eur J Orthop Surg Traumatol.* 2016; 26(4): 385-390. doi:10.1007/s00590-016-1743-5
30. Shui X, Wang G, Liu P, et al. A new intramedullary reduction device for antegrade nailing of femoral shaft fractures. *Injury.* 2021; 52(10): 2946-2951. doi:10.1016/j.injury.2021.07.025
31. Sharma A, Sethi A, Sharma S. Minimally invasive cerclage wiring in subtrochanteric and femoral shaft fractures. *J Orthop Case Rep.* 2017; 7(4): 56-60. doi:10.13107/jocr.2250-0685.842
32. Haidukewych GJ. Atypical Subtrochanteric Femoral Fractures. *J Orthop Trauma.* 2014; 28(suppl 8): S36-S42. doi:10.1097/BOT.0000000000000142
33. Teo BJX, Kwek EBK. Atypical subtrochanteric femoral fractures: a review of current concepts. *World J Orthop.* 2020; 11(9): 399-411. doi:10.5312/wjo.v11.i9.399
34. Teo BJX, Kwek EBK. Atypical femoral fractures: a review of current concepts. *World J Orthop.* 2021; 12(9): 666-678. doi:10.5312/wjo.v12.i9.666
35. Black DM, Rosen CJ. Atypical Femur Fracture Risk versus Fragility Fracture Prevention with Bisphosphonates. *N Engl J Med.* 2020; 383(8): 743-753. doi:10.1056/NEJMra1906752
36. Bhandari M, Devereaux PJ, Einhorn TA, et al. Risedronate for the prevention of hip fracture in patients with a previous hip fracture. *N Engl J Med.* 2019; 380(21): 2015-2024.
37. Schilcher J, Koeppen V, Aspenberg P, et al. Risk of atypical femoral fracture during and after bisphosphonate use. *Acta Orthop.* 2015; 86(1): 100-107. doi:10.3109/17453674.2015.1004149