# Intramedullary Nailing of Fibular Fractures

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**ABSTRACT**

Intramedullary (IM) fixation, routinely utilized for managing fractures of long bones such as the femur and tibia, is gaining recognition as an effective option for fibular fractures. Although open plating remains standard, IM nailing offers considerable advantages due to its minimally invasive nature and potential for reducing soft tissue complications. This review aims to evaluate current evidence on intramedullary nailing of fibular fractures, focusing on indications, operative techniques and reported clinical outcomes. A detailed narrative review of existing literature was performed, emphasizing recent mechanical testing studies, clinical trials and systematic reviews related to intramedullary fixation of fibular fractures. Indications, surgical technique refinements and outcomes were extracted and summarized. Current evidence indicates intramedullary fixation provides mechanical stability comparable to traditional plating methods, demonstrated through biomechanical testing. Clinical studies reveal similar functional outcomes between IM fixation and standard plating, with significantly lower rates of wound complications and improved soft tissue management, particularly advantageous in geriatric patients and individuals with diabetes or compromised soft tissue envelopes. Intramedullary fixation represents an effective, minimally invasive alternative for fibular fracture management, especially in high-risk populations. Further prospective studies and randomized trials are recommended to substantiate these findings and refine patient-selection criteria.

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**Key Words**
Intramedullary fixation, fibular fracture, ankle fracture, minimally invasive surgery, geriatric fractures, clinical outcomes, surgical techniques

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## INTRODUCTION

Fibular fractures constitute a significant proportion of ankle injuries, representing a critical challenge in orthopedic practice due to their potential to compromise ankle stability, alignment and function. Effective management of fibular fractures is imperative to restore the integrity of the ankle mortise and optimize patient mobility[1]. Historically, fibular fractures have predominantly been treated using open reduction and internal fixation (ORIF) techniques involving plating, which allows direct visualization, anatomical alignment and robust fixation. Despite these advantages, traditional plating methods are often associated with considerable risks of soft tissue complications, including infection, wound breakdown, delayed union, or non-union[2]. These complications are exacerbated in populations with compromised soft tissues or medical comorbidities, notably elderly patients, diabetics, tobacco users and individuals with peripheral vascular disease. Intramedullary (IM) fixation has long been established as the gold standard for stabilizing fractures of the femur and tibia due to its biomechanical stability, minimally invasive approach and reduced complication profile. However, its utilization in fibular fractures has historically been limited, primarily reserved for scenarios in which open surgical approaches posed substantial risks due to poor soft tissue conditions or complex medical profiles[3]. Earlier hesitance towards the widespread adoption of IM fixation for fibular fractures stemmed from concerns regarding implant availability, challenges in achieving anatomical reduction and uncertainty about the biomechanical strength of early IM devices. Consequently, traditional open plating persisted as the preferred method among surgeons, overshadowing IM techniques in standard orthopedic practice[4]. Recent advancements, however, have significantly transformed this landscape. The development of dedicated fibular intramedullary nails designed specifically to accommodate anatomical variations has enhanced the efficacy, reproducibility and reliability of IM fixation[5]. Contemporary fibular nails incorporate features such as multidirectional interlocking screws, angular stability mechanisms and distal locking systems that effectively counteract rotational and axial instability, addressing previous biomechanical concerns. Furthermore, modern surgical instrumentation, improvements in radiographic guidance techniques and an increasing emphasis on minimally invasive surgery have collectively facilitated greater acceptance and confidence in intramedullary approaches[6]. Current evidence underscores several distinct advantages of IM nailing compared to traditional open plating techniques, notably a reduced surgical footprint, minimal disruption of soft tissue and vascular supply, diminished risk of wound-related complications and potential for earlier mobilization and rehabilitation. These factors become especially crucial in geriatric patients and individuals with compromised healing potential, in whom surgical morbidity directly influences recovery and long-term outcomes. Clinical and biomechanical studies consistently demonstrate comparable, if not superior, fixation stability with IM techniques, paving the way for expanded indications and increased clinical adoption[7]. Despite the emerging evidence base, there remains an ongoing need for detailed synthesis of current knowledge regarding the specific indications, operative nuances, biomechanical efficacy and clinical outcomes of IM fixation for fibular fractures. Clarifying these elements will enable orthopedic surgeons to better identify appropriate clinical scenarios, refine their surgical technique and effectively harness the clinical potential of IM nailing. This review comprehensively summarizes existing literature, systematically explores operative methods, delineates clearly defined indications and contraindications and evaluates current outcomes associated with intramedullary nailing of fibular fractures, aiming to provide a robust resource for clinicians involved in ankle fracture management.

**Indications and Contraindications:** The indications for intramedullary (IM) fixation of fibular fractures have evolved significantly, reflecting advancements in surgical techniques, improvements in implant technology and growing clinical experience. Historically, IM fixation was reserved primarily for fibular fractures occurring in the setting of compromised soft tissues or associated severe distal tibial injuries, situations in which traditional open surgical approaches presented substantial risks. More recently, the indications have expanded substantially, with particular emphasis on patient-specific factors that significantly influence the healing potential and postoperative outcomes[8]. Current primary indications include geriatric ankle fractures, where compromised bone quality and diminished vascularity present considerable challenges to traditional plating methods., fragility fractures, where the minimally invasive nature of IM fixation helps preserve soft tissue integrity., diabetic ankle fractures, which have inherently impaired healing and higher rates of infection and wound complications., fractures in patients with peripheral vascular disease, as these conditions limit local healing capacity and heighten the risk of surgical site morbidity and injuries occurring in tobacco users or poorly compliant patients, where the risk of soft tissue complications with open surgery is notably elevated[9].

Fig. 1: Per 4 Fracture/Dislocation with Significant Ligamentous Injury

Advanced age, combined with medical comorbidities, represents one of the most critical considerations for adopting IM fixation. Geriatric patients frequently present with compromised vascular status, fragile soft tissues and decreased physiological reserve, rendering traditional open plating methods potentially hazardous. Clinical evidence consistently demonstrates superior outcomes and significantly reduced complication rates with IM fixation in elderly patients, justifying the preference for this minimally invasive alternative[10]. Additionally, patients experiencing high-energy injury mechanisms or fracture-dislocation scenarios-conditions often associated with severe soft tissue disruption are also considered strong candidates for IM fixation due to its protective effect on local tissues. Despite these clear and expanding indications, specific clinical scenarios currently represent relative contraindications to the routine use of IM fixation in fibular fractures. Injuries characterized predominantly by severe ligamentous disruptions rather than osseous injury, such as advanced pronation-external rotation (PER) type 4 ankle injuries, present significant challenges. In these complex cases, marked ligamentous instability outweighs the osseous component, thus limiting the effectiveness of IM fixation alone. These injuries typically require focused soft tissue reconstructions and selective ligamentous repair under direct visualization[11]. Additionally, insensate diabetic ankle fractures represent another clinical scenario where traditional IM fixation might prove insufficient. In patients with advanced peripheral neuropathy or significant soft tissue instability, the existing IM fibular nail designs may fail to provide adequate syndesmotic stabilization. In such instances, alternative stabilization techniques, including multiple transsyndesmotic screws or tibia-pro-fibula fixation approaches ("superconstructs"), become necessary to achieve adequate biomechanical stability[12]. Careful patient selection based on clearly defined clinical criteria is critical to the successful application of IM fixation techniques. Surgeons must thoroughly evaluate fracture morphology, soft tissue condition, associated ligamentous injuries, patient comorbidities, and functional expectations before electing IM fixation. Acknowledging the interplay of these factors ensures optimal outcomes, reduces surgical morbidity and enhances patient recovery, solidifying IM nailing as a valuable and highly effective alternative within modern fracture management protocols.

**Operative Technique:** Intramedullary fixation of fibular fractures demands meticulous surgical planning, precise technique execution and accurate intraoperative imaging guidance. The operative approach typically begins with ensuring proper anatomical reduction, which remains critical regardless of the fixation method utilized. Though frequently referred to as percutaneous, the procedure often involves a minimally invasive incision measuring approximately 2-3 centimeters to facilitate direct visualization and precise fracture alignment, ensuring appropriate fibular length, axial alignment and rotation. In certain cases, especially those involving associated medial-sided ankle injuries, the fibular fracture can occasionally be secondarily reduced following reduction and stabilization of the medial side[13]. Preoperative planning begins with obtaining accurate radiographic imaging, primarily employing a true lateral fluoroscopic view, which clearly identifies the long axis of the fibula and assists in determining the ideal trajectory and nail placement. After the fibular fracture is satisfactorily reduced, the surgical approach commences with a small vertical incision positioned immediately beneath the inferior tip of the fibula. Through blunt dissection, the lateral cortex of the distal fibula is exposed, thereby allowing the surgeon to determine the optimal intramedullary entry point, typically located slightly lateral to the midline on a mortise view. Identification of this precise entry point is crucial to preventing lateral cortical breach or subsequent complications during nail insertion[14].

Fig. 2: Drill Bit Entry in to the Canal is Often More Accurate. Once the Canal is Identified the Drill Bit May Be Replaced with the Guide Pin

To initiate canal entry, a 2.5-mm drill bit is preferred over the traditional smooth guide pin, offering improved tactile feedback, precise directional control and easier repositioning if the initial trajectory is incorrect. Once the intramedullary canal is accurately located, the drill bit is exchanged for a cannulated guide pin through the drill guide. Subsequently, progressive dilation of the distal fibular metaphysis and canal occurs, initially employing a 6.2-mm reamer followed by a smaller 3.2-mm reamer, ensuring proper accommodation and snug end osteal fit of the fibular nail. Careful intraoperative fluoroscopic monitoring guides each reaming step, preventing inadvertent cortical damage[15]. Following adequate canal preparation, the fibular nail is carefully introduced under continuous fluoroscopic visualization, using an attached targeting jig for precise trajectory control. The nail must be accurately positioned slightly countersunk within the distal fibular metaphysis, ensuring that the distal syndesmotic hole is correctly aligned at or above the physeal scar of the distal tibia. Misalignment at this stage can compromise effective transsyndesmotic fixation later in the procedure. The targeting jig, designed to guide the placement of distal locking screws at a predetermined 30-degree offset to match the anatomical bimalleolar axis, demands precise rotational alignment. Malrotation of the fibular nail adversely impacts subsequent syndesmotic stabilization and fixation stability. To facilitate proper targeting and ease jig manipulation, placement of a small towel bump beneath the ankle is recommended, preventing the jig from contacting the operative table[16]. Subsequent fixation involves deployment of the implant's distal talons or locking screws, effectively achieving axial and rotational stability within the fibular shaft. These locking mechanisms ensure robust distal fixation, allowing early postoperative mobilization and load-bearing. After locking screw placement, an external rotation stress test is routinely performed intra operatively to assess syndesmotic stability. If persistent instability is identified, additional stabilization techniques, including the application of syndesmotic endobutton devices, supplemental endobutton tensioning, or polyethylene suture reinforcement, are employed until adequate stability is obtained. Lastly, a valgus stress test may also be performed to evaluate the integrity of the medial soft tissues and the necessity of deltoid ligament repair. Optional nail end caps are placed based on surgeon preference and the clinical scenario[17]. In summary, adherence to detailed preoperative planning, careful intraoperative fluoroscopic guidance, precise surgical technique and vigilant management of syndesmotic stability collectively contribute to the effective application of intramedullary fibular nailing. Mastery of these operative details facilitates optimal fracture healing, minimizes soft tissue complications and accelerates patient recovery, thereby affirming IM fixation as an indispensable technique within contemporary fibular fracture management strategies.

**Clinical Outcomes and Biomechanical Evidence:** The clinical effectiveness and biomechanical stability of intramedullary (IM) fixation for fibular fractures have been increasingly substantiated by recent studies, enhancing the method's credibility as a viable alternative to conventional open plating. Clinical outcomes derived from diverse patient populations underscore the advantages of IM nailing, particularly regarding the reduction of soft tissue complications and maintenance of functional performance. Rajeev *et al.* assessed clinical outcomes following IM fixation in a series of 24 elderly patients with fragility fractures, noting favorable results at one-year follow-up, characterized by the absence of wound complications or deep infections. They further emphasized that fibular IM fixation facilitated early mobilization, high patient satisfaction and good functional positioning of fractures, especially beneficial for elderly patients vulnerable to complications associated with traditional open fixation methods[18]. Moreover, prospective randomized controlled trials by White *et al.* provided robust comparative evidence, systematically evaluating fibular IM nailing against conventional plating techniques in elderly patients. The trial utilized the Olerud-Molander Ankle Score to objectively measure functional outcomes at one-year post-surgery. Results demonstrated no significant difference in overall functional recovery between IM fixation and standard plating; however, a marked reduction in soft tissue complications was evident in the IM group, reinforcing the minimally invasive nature of the IM technique as a significant advantage in the geriatric population[19]. Further support for IM fixation arises from systematic reviews, notably by Brew *et al.,* who conducted a comprehensive analysis of seventeen studies encompassing over 1000 patients undergoing IM fixation for unstable distal fibular fractures. The authors concluded that IM fixation reliably achieved clinical and functional outcomes comparable to modern plating methods. Although current data do not yet definitively establish superiority of IM fixation over plating in all contexts, substantial evidence supports IM fixation as an equally effective and potentially preferable treatment option, particularly when soft tissue integrity or comorbid conditions pose elevated surgical risks. Biomechanical evidence further complements clinical findings, underscoring the structural reliability of IM fixation. Kadakia *et al.* performed comparative biomechanical testing between a modern fibular nail and traditional distal fibular locking plate fixation in pronation external rotation (PER) type-4 fracture patterns. Their evaluation demonstrated no significant differences in rotational stability or strength between IM nailing and traditional plating constructs, suggesting mechanical equivalence. Interestingly, failure of both fixation methods occurred consistently at the level of the syndesmotic screw, highlighting syndesmotic stabilization as a critical component influencing long-term fixation performance[20]. Additional biomechanical analysis by Smith *et al*. further validated these findings through simulated mechanical testing of supination external rotation type-4 injuries, directly comparing IM fibular nails against traditional plating systems. Results indicated that fibular IM fixation conferred superior torque resistance and maintained fracture alignment more effectively during load-to -failure tests compared to traditional plating techniques without syndesmotic fixation. This under scores the mechanical robustness of IM fixation, lending further credence to its clinical applicability and efficacy in maintaining fibular fracture alignment and rotational stability. Collectively, the growing body of clinical and biomechanical evidence indicates that intramedullary fixation reliably achieves fracture stabilization comparable to conventional plating, with notable advantages regarding soft tissue preservation and reduced complication risks. Continued advancements in nail design, coupled with further rigorous comparative trials, are warranted to delineate clearer guidelines and strengthen clinical confidence in selecting IM fixation for appropriate fibular fractures, particularly among higher-risk patient populations.

**Case Examples:** Clinical application of intramedullary (IM) fixation techniques for fibular fractures is best illustrated through detailed case examples that emphasize the practical benefits and decision-making considerations underpinning the procedure. The first case involves a 74-year-old woman who sustained a closed insufficiency fracture involving both distal tibial and fibular segments secondary to a low-energy mechanical fall. Given the patient's advanced age, osteoporosis bone quality and potential soft tissue vulnerability, the fracture required stabilization methods that minimized surgical trauma while maintaining adequate mechanical stability. Initial management involved closed reduction of the fractures, followed by provisional stabilization using a simple pin-to-bar external construct. Once satisfactory alignment was confirmed, definitive fixation of the fibular fracture was achieved via intramedullary nailing. Concurrently, the associated tibial fracture was stabilized using a minimally invasive per cutaneous osteosynthesis (MIPO) technique with a distally locked medial tibial plate. This combined minimally invasive approach substantially limited surgical disruption, preserved local vascularity and mitigated the risk of wound-related complications. Postoperative protocols involved protected weight-bearing beginning around four weeks, facilitating expedited rehabilitation and optimized recovery outcomes for the geriatric patient. A second illustrative scenario involves a more complex clinical presentation in a 36-year-old male patient diagnosed with insulin-dependent diabetes mellitus and poor glycemic control, who sustained an open Grade III tibial plafond fracture accompanied by a comminuted fibular shaft fracture. This patient's clinical profile presented significant challenges due to severely compromised soft tissues, high infection risk, and impaired fracture healing secondary to diabetes mellitus, compounded further by markedly elevated glycated hemoglobin (HbA1c level of 10.6%). Immediate emergency surgical management followed established open fracture protocols, including thorough wound irrigation, meticulous surgical debridement and provisional skeletal stabilization utilizing external fixation. Given the patient's severely compromised metabolic state and heightened risk for soft tissue complications, a decision was made to stabilize the fibular shaft fracture using intramedullary nailing in the initial surgical stage, capitalizing on its minimally invasive nature to preserve surrounding soft tissues. The tibial component was initially stabilized externally and definitively reconstructed two weeks later through an anterolateral approach once soft tissue conditions permitted. This staged approach, employing IM fibular fixation, effectively minimized the risk of complications inherent in diabetic patients with open fractures and significant soft tissue compromise, facilitating eventual reconstruction with favorable clinical outcomes. Both case examples underscore the critical advantages of intramedullary fixation techniques in scenarios demanding stringent preservation of soft tissue integrity and rapid mobilization. These practical clinical illustrations emphasize the broader implications of carefully selecting IM fixation for specific patient populations, highlighting the importance of individualized surgical approaches that optimize healing conditions and minimize postoperative complications.

## CONCLUSION

Intramedullary (IM) fixation has progressively emerged as an effective and advantageous alternative for the stabilization of fibular fractures, particularly within specific patient populations that are at increased risk for complications with traditional open plating techniques. The minimally invasive nature of IM fixation confers notable clinical benefits, including preservation of soft tissue integrity, significant reduction in wound-related complications, early mobilization and comparable or superior biomechanical stability compared to traditional methods. Clinical studies consistently demonstrate favorable outcomes with IM nailing, highlighting its suitability for elderly patients, diabetics and individuals with compromised vascular or soft tissue conditions. Biomechanical evidence further reinforces the efficacy of modern IM fibular nail designs, establishing their equivalence or superiority over traditional fixation techniques in terms of rotational and axial stability. Despite these promising results, surgeons must carefully evaluate fracture characteristics, ligamentous involvement, soft tissue condition and patient-specific risk factors to optimally select suitable candidates for IM fixation. Continued advancements in fibular nail design, refinements in operative techniques and prospective comparative studies are anticipated to further enhance clinical outcomes, clarify indications, and solidify the role of IM fixation within contemporary orthopedic practice for fibular fracture management.

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