Bent Nail, Broken Mechanics: Effective Surgical Management of Femoral Non-union in Post-Polio Residual Paralysis – A Case Report

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Abstract

Background: Femoral shaft fractures in limbs affected by post-polio residual paralysis (PPRP) are prone to non-union and implant failure due to altered biomechanics, deformities and compromised bone quality.

Case Report: A 36-year-old male with PPRP presented with painful inability to bear weight following implant failure of a previously nailed femoral fracture. Radiographs showed hypertrophic non-union with a bent retrograde nail and screw back-out. Exchange nailing was performed using modified positioning to accommodate severe PPRP-related deformities.

Results: The distorted nail was successfully removed, deformity corrected gently, and a larger, longer nail implanted. At 1-year follow-up, radiographs confirmed complete union. The patient achieved pain-free full weight-bearing and functional knee motion with tailored rehabilitation.

Conclusion: Exchange nailing is an effective solution for hypertrophic non-union with implant failure, even in complex PPRP-affected limbs, when individualized surgical planning and rehabilitation are employed.

Keywords: Post-polio residual paralysis, Femoral non-union, Bent intra-medullary nail, Implant failure, Exchange nailing, Deformity correction.

Introduction

Femoral shaft fractures in limbs affected by post-polio residual paralysis (PPRP) present unique challenges due to altered biomechanics, muscle imbalance, joint contractures and compromised bone quality. These factors increase the risk of non-union and implant failure following standard fixation methods. Hypertrophic non-union, in particular, reflects adequate biological healing potential but insufficient mechanical stability, often necessitating revision procedures such as exchange nailing. Implant bending and screw back-out, although uncommon, further complicate management by distorting anatomy and increasing surgical difficulty. This case report describes the successful surgical management of a hypertrophic femoral shaft non-union with implant failure in a PPRP-affected limb, highlighting the importance of individualized pre-operative planning, modified intraoperative technique, and tailored rehabilitation in achieving functional recovery.

Case Report

A 36-year-old male with a known history of PPRP of the right lower limb presented to the emergency department following a road traffic accident. He reported sudden onset, progressively worsening pain localized to the right thigh, accompanied by an inability to bear weight on the affected limb. The pain was aggravated by movement and relieved with rest and immobilization. The patient had no other comorbidities. Notably, he sustained a right femoral fracture 10 months prior, for which retrograde intramedullary nailing was performed.

On clinical examination, there was a limb length discrepancy of

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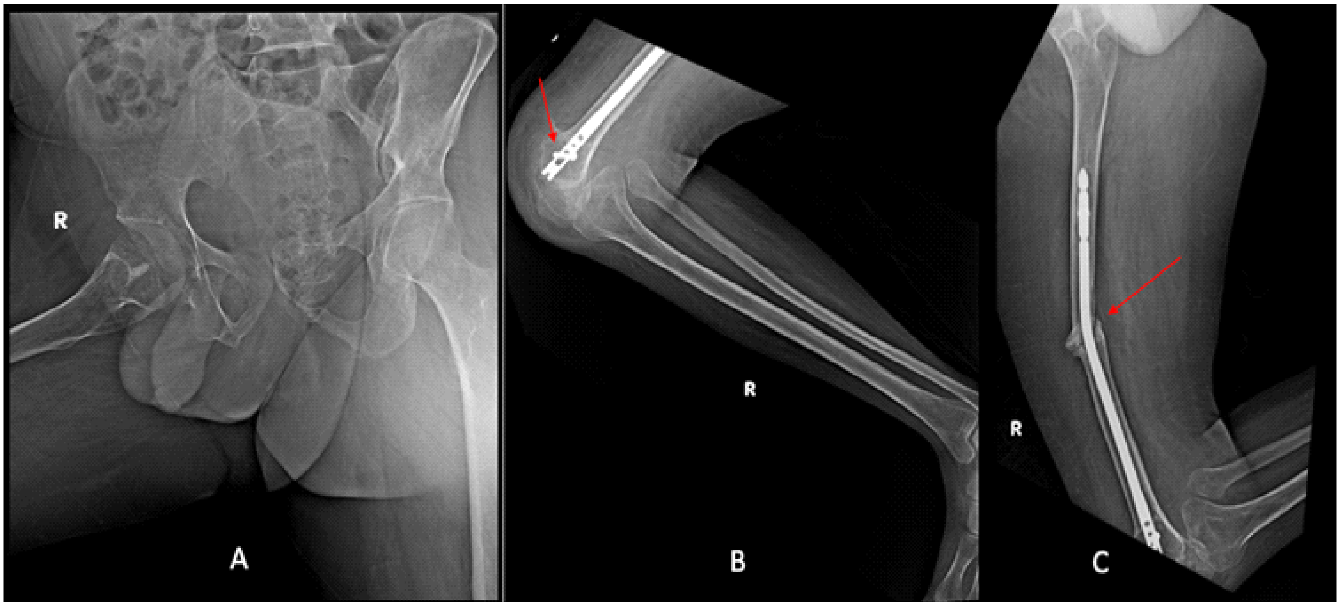

Figure 1: (a, b, c) show the pre-operative radiographs with a bent retrograde femur intramedullary nail in situ with hypertrophic non-union.

3-cm, fixed internal rotation, and flexion deformity of the hip, along with fixed external rotation and valgus positioning of the knee. The patella was laterally displaced and a fixed flexion deformity of 25° was observed, attributed to his underlying PPRP. Visible swelling was noted at the junction of the middle and distal third of the right thigh, with the presence of previous surgical scars. Localized tenderness and pain-induced restriction of motion at the hip and knee joints were present. No neurovascular deficits were detected. Radiographic evaluation revealed hypertrophic non-union at the previous fracture site, accompanied by a bent retrograde intramedullary nail and distal locking screw back-out, consistent with implant failure (Fig. 1). Given the distorted femoral anatomy and mechanical implant failure, the patient was planned for implant removal followed by exchange nailing after thorough preoperative planning. During surgery, the patient was positioned with the knee flexed to 50°, exceeding the standard 30°, to accommodate the PPRP-associated deformity. Through a 5-cm incision along the old scar over the inferior patellar pole, the entry point was exposed after retracting the patellar tendon laterally. Under fluoroscopic guidance, proximal and distal locking screws were removed and the non-union site was opened. Hypertrophic non-bridging callus and femoral bending were noted. Gentle manual manipulation corrected the deformity without causing further fracture. Using a slap hammer and continuous fluoroscopic navigation, the old nail was extracted through the opened non-

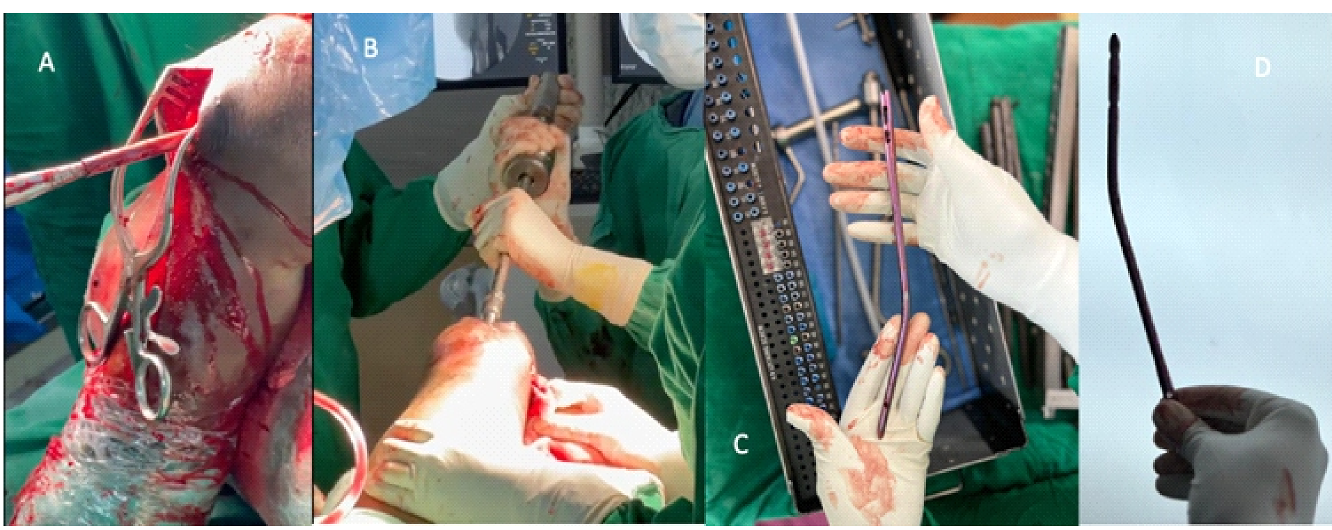

Figure 2: (a) The position of the knee while inserting the nail removal bolt into the nail. (b) The removal of the nail through a slap hammer. (c and d) The extracted bent retrograde femur intramedullary nail.

Figure 3: (a, b, c, d) depict the post-operative radiographs of the entire length of the femur and knee in anteroposterior and lateral views showing the correction of the deformity, acute docking at non-union site and exchange nailing.

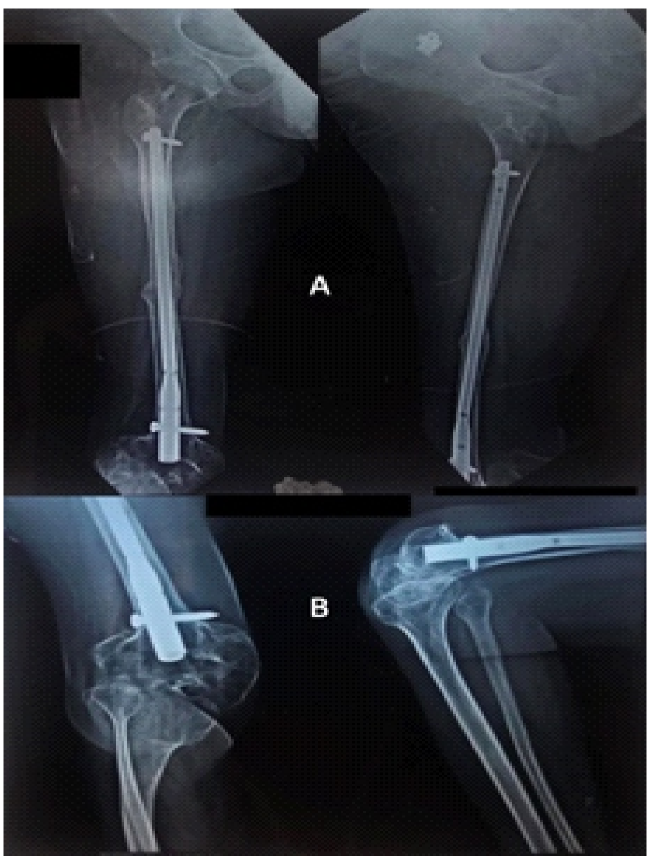

Figure 4: Images (a and b) show the 1-year follow-up radiographs of the patient showing complete consolidation of the non-union site with bridging callus and not peri-implant osteolysis.

union site (Fig. 2). Acute docking of the non-union was achieved with bone reduction forceps, followed by insertion of a guide wire. Sequential reaming was conducted and a larger diameter, longer intramedullary nail was implanted with proximal and distal locking screws placed. The wound was closed in layers.

Postoperatively, no complications were noted with radiographs showing proper alignment of the femur with implants in situ (Fig. 3). A tailored physiotherapy program was administered for 4 months (Table 1). At 1-year follow-up, radiographs confirmed fracture consolidation without peri-implant osteolysis (Fig. 4). The patient achieved knee flexion up to 90°, ambulated full weight-bearing without support or pain and limb length discrepancy was managed effectively with a heel raise (Fig. 5).

Discussion

Implant failure following femoral intramedullary nailing remains a significant challenge in orthopaedic trauma, especially in complex or compromised bone cases. The most commonly reported causes include mechanical overload of the implant due to delayed or non-union of the fracture, leading to increased cyclic stress and eventual fatigue failure of the nail [1]. Another important factor is technical errors during primary fixation such as undersized nails, inadequate locking screw placement or failure to achieve optimal fracture stability, all of which predispose to implant bending or breakage [1, 2]. Biological factors, including poor local blood supply, infection or compromised bone biology, further impair fracture healing and increase implant stress [1, 2]. Nail bending is a rare but serious mechanical complication that generally occurs when the fracture site continues to bear load insufficiently protected by the implant, causing metal deformation under repeated loading cycles. Backing out of locking screws due to toggling or micromotions at the fracture site can exacerbate instability and accelerate implant failure. Cases of nail bending often necessitate complex implant removal and revision surgery due to distorted anatomy and biomechanical disruption [2].

PPRP leads to characteristic musculoskeletal deformities primarily caused by asymmetric muscle weakness, joint contractures, and compensatory biomechanical alterations [3]. Commonly seen deformities include fixed flexion and internal rotation contractures of the hip, valgus knee deformity with external tibial rotation, and lateral displacement of the patella, as exhibited in this patient. Muscle imbalance around the affected limb causes abnormal loading patterns, joint instability, and altered gait mechanics [3, 4]. These deformities contribute to secondary complications such as limb length discrepancy, osteoporosis due to disuse, and increased risk of falls and fractures [4]. When fractures occur in such limbs, the altered anatomy and compromised soft tissue pose significant

Figure 5: (a, b, c, d) depict the clinical presentation of the patient with achieving up to 90° range of motion at knee with pain-free weight-bearing walk without assistance.

Table 1: Structured physiotherapy prescribed to the patient

Phases	Physiotherapy regimen
Phase 1 (Week 1–3)	• NWBW with support
	• Static and dynamic quadriceps and hamstring exercises as tolerated
	• Hip abductor and adductor strengthening as tolerated
	• Heel slides as tolerated
	• Hip strengthening – Straight leg raises
	• Knee rom 25°–60°
	• Ankle pumps
Phase 2 (Week 3–6)	• Continued Phase 1 exercises+PWBW with support
	• Knee ROM 25°–75°
Phase 3 (Week 7–12)	• Continued phase 2 exercises+FWBW with support
	• Knee rom 25°–90°
Phase 4 (Week 13 and 14)	• Continue phase 3 exercises+FWBW without support
	• Hydrotherapy
Phase 5 (Weeks 15 and 16)	• Proprioception
	• Gait re-training

NWBW: Non-weight-bearing walk, PWBW: Partial weight-bearing walk, FWBW: Full weight-bearing walk

challenges in achieving stable fixation and proper alignment, often necessitating individualized surgical approaches and careful intraoperative positioning. The risk of non-union and implant failure is heightened in PPRP cases due to poor bone stock, altered healing environment and mechanical stress concentration on osteosynthesis devices [3, 4].

Non-union is a frequent complication in femoral shaft fractures, characterized radiographically as either hypertrophic or atrophic based on callus formation and biological activity at the fracture site [5]. Hypertrophic non-union, as observed in this case, shows abundant callus formation reflecting an active biological attempt at healing, but mechanical instability prevents consolidation. Radiographs typically reveal visible callus surrounding an unstable fracture with sclerotic fracture edges without bridging bone. In contrast, atrophic non-unions demonstrate minimal callus and poor biological response [5]. The hypertrophic non-union in our patient was identified by a prominent callus at the fracture site alongside implant failure, confirmed by the bent retrograde intramedullary nail and backing out of the distal screw. This mechanical failure perpetuated instability and inhibited union, which is consistent with the known pathophysiology of implant fatigue in a biologically active but mechanically compromised environment [6]. Such presentations require surgical intervention focused on improving mechanical stability while supporting biological healing [6, 7].

Pre-operative planning in cases of hypertrophic non-union complicated by implant failure requires meticulous assessment of patient anatomy, implant integrity, and pre-existing deformity to formulate an effective surgical strategy. Comprehensive radiographic and fluoroscopic evaluation guides decisions regarding implant removal, access to the non-union site, selection of optimal nail size, and appropriate locking screw configuration [8]. In deformed limbs, such as those encountered in PPRP, positioning challenges necessitate modification of standard surgical approaches. Altered limb positioning, customized incision placement and adaptability in intraoperative technique are essential to accommodate joint contractures, muscle imbalance, and soft-tissue constraints [4, 8].

Several surgical options exist for managing femoral shaft hypertrophic non-union associated with implant failure. Exchange nailing remains the most widely accepted technique. This method involves removal of the failed implant, thorough debridement and reaming across the non-union site, followed by insertion of a longer and larger-diameter intramedullary nail [9, 10]. The procedure enhances axial and rotational stability while providing biological stimulation through reaming-induced endosteal blood flow. Alternative strategies include augmentation plating with or without bone grafting, plate fixation following nail removal or, in select cases, external fixation [11, 12]. Augmentation plating can provide superior rotational control but may be associated with increased soft-tissue morbidity. Plate fixation with bone grafting is preferred in atrophic non-unions or when intramedullary instrumentation is contraindicated due to canal anatomy or deformity (Table 2) [12].

The surgical technique for exchange nailing relies on meticulous pre-operative planning, accurate implant selection, and consistent intraoperative imaging guidance [9, 10]. Nail removal can be technically challenging in the presence of implant bending, broken screws, or loosening, often requiring specialized extraction tools and careful manipulation to avoid iatrogenic fracture [10]. Achieving acute docking and proper alignment at the non-union site is essential before reaming and

Surgical technique	Advantages	Disadvantages	Indications
Exchange nailing	• Re-establishes both axial and rotational stability • Enhances biological healing via the reaming process • Causes minimal disruption to surrounding soft tissues	• Technically demanding when dealing with bent nails • Carries a risk of recurrent failure if underlying causes are not corrected	• Hypertrophic non-union with good healing potential • deformity correction needed
Augmentation plating	• Offers improved rotational stability • Delivers supplementary mechanical reinforcement	• Associated with greater soft-tissue disruption • Carries an elevated risk of infection	• Suitable for atrophic non-unions • Useful in cases with rotational instability • Beneficial when intramedullary nail fixation is inadequate.
Bone grafting	• Promotes biological healing • Particularly beneficial in cases of compromised bone quality	• Necessitates an additional surgical procedure • May lead to a longer recovery period	• Appropriate for atrophic non-unions or biologically compromised healing
External fixation	• Allows customizable alignment adjustments • Preserves soft tissues with a minimally invasive approach	• Carries a risk of pin-site infections • May cause patient discomfort • Provides comparatively lower long-term stability.	• Suitable for temporary or bridging stabilization • Useful in cases with significant soft-tissue compromise • Considered when internal fixation is contraindicated

Table 2: Summary of the various surgical technique options available for treating femoral non-union

nail insertion. In the presented case, increased intraoperative knee flexion beyond conventional angles was required to overcome PPRP-related contractures, allowing optimal access for implant removal and exchange while minimizing soft-tissue trauma.

Postoperative rehabilitation emphasized early mobilization while maintaining the stability of the healing fracture. Physiotherapy focused on the gradual restoration of joint mobility, muscle strength, and functional gait, with tailored strategies to accommodate pre-existing PPRP-related deformities. Addressing muscle imbalance, preventing contractures, and managing limb length discrepancy were central to optimizing recovery. The patient followed a structured, 4-month rehabilitation protocol, progressing from protected to full weight-bearing with assistive devices and eventually achieving independent, pain-free ambulation. Knee flexion improved to approximately 90° and limb length discrepancy was effectively managed with a heel raise. Although standardized functional outcome measures such as the lower extremity functional scale or SF-36 were not prospectively recorded, clinical improvement was evident. Future follow-up will incorporate validated scoring systems to more comprehensively assess rehabilitation efficacy and long-term functional outcomes.

A key limitation of this report is its focus on a single patient, which inherently restricts the generalizability of the findings to the broader population of patients with PPRP. Patient-specific factors such as varying deformity patterns, bone quality, and fracture characteristics may influence outcomes differently in other cases. In addition, the absence of long-term functional assessment and objective biomechanical evaluation limits the ability to comprehensively understand the sustained impact of the surgical intervention and the mechanical factors contributing to implant failure. Future studies involving larger patient cohorts and incorporating standardized functional outcome measures and biomechanical analyses are needed to validate and expand upon the observations presented here.

Conclusion

Exchange nailing remains a reliable and effective option for managing femoral shaft hypertrophic non-union complicated by implant failure. Success depends on thorough pre-operative assessment, judicious implant selection, and meticulous surgical execution to restore stable mechanical fixation and facilitate biological healing. In complex cases with underlying deformities such as those associated with PPRP, modifications in patient positioning, surgical approach, and intraoperative techniques are essential. Post-operative rehabilitation must likewise be individualized to accommodate pre-existing limb deformities and optimize functional recovery. Although perfect anatomical restoration may not be feasible in such challenging scenarios, achieving a stable union, pain-free weight-bearing, and acceptable joint mobility constitutes a meaningful and successful outcome, as illustrated in this case.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

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