International Journal of Research in Orthopaedics
Bijwe R et al. Int J Res Orthop. 2026 May;12(3):772-775
http://www.ijoro.org

Case Report

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20261228

Strain-guided revision of failed femoral shaft nonunion using a hybrid dual-plane construct around a retained dynamic hip lag screw

Rajesh Bijwe[1], Ahmed Al-Barwani[1]*, Mohammed Heiba[1], Ruqaiya Al-Washahi[2], Mahmood Al-Hatmi[3], Ali Kashoob[1]

[1]Department of Orthopaedics, Khoula Hospital, Muscat, Sultanate of Oman
[2]Department of Radiology, Oman Medical Speciality Board, Muscat, Sultanate of Oman
[3]Department of Orthopaedics, Ibri Hospital, Ad Dhahirah, Sultanate of Oman

Received: 07 February 2026
Accepted: 19 March 2026

***Correspondence:**
Dr. Ahmed Al-Barwani,
E-mail: barwani4ever@gmail.com

ABSTRACT

Femoral shaft nonunion remains a challenging complication after high-energy trauma and internal fixation, and although exchange intramedullary nailing is widely accepted as the standard surgical strategy for aseptic femoral shaft nonunion, complex anatomical and mechanical situations may require alternative approaches. We report the case of a 45-year-old male who developed a painful aseptic femoral shaft nonunion with implant failure following fixation of an ipsilateral femoral shaft and femoral neck fracture. Revision surgery was performed using a strain-guided strategy. The dynamic hip screw (DHS) barrel plate was removed while the lag screw inserted for the femoral neck fracture was intentionally retained. Following meticulous debridement to bleeding bone, medullary canal recanalization and defect grafting, a hybrid dual-plane construct consisting of an anterior plate and a long barrel DHS plate was applied with controlled interfragmentary compression. Postoperatively, the patient progressed with protected weight bearing and subsequent gradual rehabilitation. Serial radiographs demonstrated maintained alignment, stable fixation and progressive bridging callus, and final follow-up confirmed solid fracture union with complete resolution of thigh pain and functional improvement. This case demonstrates that deliberate strain-guided construct redesign, selective implant retention and multiplanar stability can represent an effective and reproducible alternative strategy for femoral shaft nonunion in carefully selected patients, particularly when conventional exchange nailing is limited by associated proximal femoral fixation.

Keywords: Femoral shaft nonunion, Strain-guided fixation, Hybrid dual-plane plating, Dynamic hip screw, Implant retention, Femoral neck and shaft fracture, Revision internal fixation, Interfragmentary strain, Biological augmentation, Construct redesign

INTRODUCTION

Femoral shaft nonunion remains a challenging complication following high-energy trauma and complex internal fixation. Despite modern implants and evolving surgical techniques, nonunion rates after femoral shaft fracture fixation continue to be reported between 1% and 10%, particularly in patients with severe initial injury patterns and mechanically demanding constructs.[1,2]

Current understanding of fracture healing emphasizes that nonunion is a multifactorial process in which mechanical stability, biological potential and the exclusion of fracture-related infection (FRI) are all critical determinants of outcome. This concept is well summarized by the "diamond concept" of bone healing, which highlights the interaction between the mechanical environment, osteogenic cells, growth factors, vascularity and scaffold.[3]

In revision surgery, successful treatment depends on identifying the dominant cause of failure—mechanical, biological or infective—and addressing it through a targeted strategy.[4,5] Mechanical failure of the index construct remains one of the most frequent and correctable causes of aseptic femoral nonunion and is commonly associated with excessive interfragmentary motion, fatigue failure of implants and an unfavourable strain environment at the nonunion site.[6,7]

Unlike most published reports on femoral shaft nonunion revision that focus primarily on implant exchange or augmentative fixation, this case highlights a strain-guided reconstructive strategy for a mechanically failed femoral construct performed around a retained dynamic hip screw (DHS) lag screw. The report emphasizes decision-making when complete implant removal may compromise bone stock and alignment, and illustrates how a hybrid dual-plane construct—combining an anterior neutralisation plate with a long barrel plate and controlled interfragmentary compression—can be used to convert a high-strain, shear-dominant environment into a compression-dominant construct while simultaneously addressing a segmental anteromedial bone void.

CASE REPORT

A 45-year-old male with well-controlled hypertension was referred to our institution primarily for assessment of post-traumatic ankle arthrosis. During the same consultation, he reported persistent and progressively worsening pain in his right thigh with increasing difficulty in weight bearing.

The patient had sustained a high-energy motorcycle accident in March 2023. He underwent operative fixation of a right femoral shaft fracture associated with a right femoral neck fracture at another hospital. His immediate postoperative recovery was uncomplicated (Figure 1).

Figure 1: Initial post-operative (A) anteroposterior; and (B) lateral radiographs demonstrating complex fixation of ipsilateral femoral neck and shaft fractures using a dynamic hip screw with supplementary dual lateral plate constructs.

During follow-up, and in the absence of any new traumatic event, he developed progressive mechanical pain localized to the mid-thigh. He had been advised protected weight bearing because of his concomitant ankle pathology. Revision of the index femoral fixation was recommended at the original treating institution; however, the patient declined to return and sought further management at our centre.

On examination, the surgical scars were healed. There was localized tenderness over the femoral shaft and pain with functional loading. No erythema, swelling or sinus formation was observed. There were no systemic features suggestive of infection.

Plain radiographs of the right femur (Figure 2) demonstrated implant failure with breakage of the lateral plate, loss of construct stability and absence of bridging callus at the fracture site, consistent with an established femoral shaft nonunion associated with mechanical failure.

Based on the clinical and radiological findings, a diagnosis of painful aseptic femoral shaft nonunion with implant failure was made. Preoperative assessment did not reveal clinical or laboratory evidence suggestive of active infection. Revision surgery was therefore indicated.

Revision fixation was performed in October 2023. The DHS barrel side plate was removed, while the lag screw inserted for the femoral neck fracture was intentionally retained in situ. At the nonunion site, abundant fibrous tissue was identified and completely excised. The medullary canal was opened by drilling to enhance biological stimulation. All removed material and multiple deep tissue samples were sent for microbiological analysis.

The nonunion was anatomically reduced and temporarily stabilized using Kirschner wires. An anterior plate was applied and fixed to control bending and rotational forces. A long barrel DHS plate was then introduced over the existing lag screw and secured to the femoral shaft. A compression screw was inserted to achieve controlled interfragmentary compression.

A residual anteromedial cortical void was noted at the nonunion site and was filled with autologous iliac crest cancellous bone graft mixed with bone substitute (Cronas). Final fluoroscopic imaging confirmed restoration of alignment and a stable hybrid dual-plane construct.

No macroscopic features of infection were observed intra-operatively. All tissue cultures subsequently returned negative.

The postoperative course was complicated by transient anaemia and short-lived renal impairment, both of which resolved with conservative management. The patient was mobilised under physiotherapy supervision with protected weight bearing, followed by gradual progression based on clinical and radiographic assessment.

At serial follow-up, the patient reported complete resolution of thigh pain and progressive functional improvement. Radiographs demonstrated maintained alignment, stable implants and progressive bridging callus across the previous nonunion site. The most recent follow-up radiograph confirmed fracture union (Figure 3).

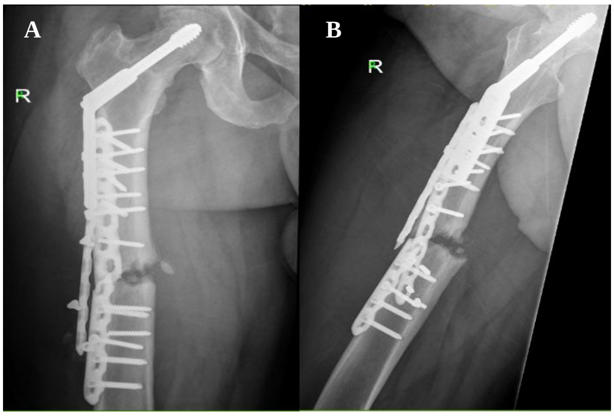

Figure 2: Pre-revision (A) anteroposterior; and (B) lateral radiographs demonstrating femoral shaft nonunion with implant failure.

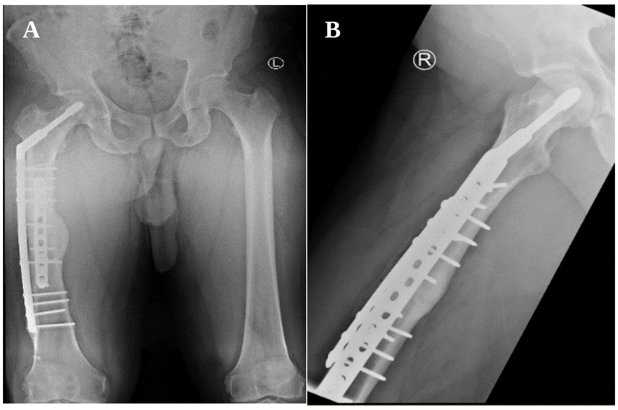

Figure 3: Ten-month post-revision (A) anteroposterior and (B) lateral radiographs demonstrating stable fixation with complete fracture union.

DISCUSSION

The defining feature of the present case is not the achievement of union itself, but the deliberate redesign of the mechanical environment at the nonunion interface. The index failure demonstrated a classic high-strain scenario, in which persistent interfragmentary motion under cyclic bending and torsion led to fatigue failure of the plate rather than progressive biological consolidation. From a mechanobiological perspective, implant breakage should therefore be interpreted as evidence that the construct, rather than the biological environment alone, represented the dominant limiting factor. Experimental and clinical data consistently demonstrate that excessive strain favours fibrous tissue persistence and prevents mineralised tissue formation, irrespective of biological potential.[6,7]

A central and genuinely debated decision in femoral shaft nonunion revision is whether to exchange the implant, most commonly by exchange intramedullary nailing, or to augment stability around the existing construct. Exchange nailing is widely regarded as a reliable and effective workhorse and is commonly considered the standard surgical strategy for aseptic femoral shaft nonunion, with consistently high union rates reported in large clinical series and systematic reviews.[13] Its success, however, is most predictable when the dominant deficiency is primarily axial instability and when biological stimulation from reaming and nail upsizing is expected to be sufficient.

In the present case, the clinical situation was mechanically and anatomically constrained by the presence of an associated femoral neck fracture fixed with a retained DHS lag screw. Our objective was therefore to achieve union through the least destructive and most controlled revision strategy. Conversion to an intramedullary construct would have required extensive proximal hardware manipulation and canal instrumentation, with the potential risks of prolonged surgical time, increased blood loss, iatrogenic bone loss and, critically, destabilisation of the femoral neck fixation. Moreover, radiographic and intra-operative findings, including fatigue failure of the lateral plate, strongly indicated that uncontrolled bending and torsional deformation constituted the dominant mechanical deficiency. Consequently, a stability-dominant, strain-reduction strategy was selected rather than construct replacement.

This approach consisted of meticulous debridement to bleeding bone, medullary recanalisation, targeted defect grafting and hybrid dual-plane plating built around the retained lag screw, combined with deliberate interfragmentary compression. The anterior plate was used to directly address sagittal plane bending and rotational instability, while the long barrel DHS plate restored axial load sharing and overall alignment. This multiplanar construct design allowed functional separation of stability roles and provided more effective suppression of the deformation modes most responsible for maintaining a high-strain environment.

Controlled interfragmentary compression further reduced the effective fracture gap and limited micromotion at the nonunion interface, converting a shear-dominant mechanical environment into a compression-dominant one that is more permissive for bone formation.[6,7] The associated anteromedial cortical void represented an additional mechanical and biological disadvantage by amplifying strain and concentrating stress across the remaining cortices. Filling this defect with autologous cancellous bone graft augmented with bone substitute therefore served a dual purpose by improving load sharing and restoring the local biological environment.[3,11]

In summary, this case demonstrates that successful revision of a mechanically failed femoral shaft nonunion can be achieved through explicit strain-guided construct design, selective implant retention to preserve bone stock and orientation, and concurrent biological optimisation. The novelty lies not in the individual techniques employed, but in their deliberate integration to convert a high-strain, multidirectional motion environment into a low-strain, compression-dominant interface capable of supporting biological repair. This problem-oriented framework may assist surgeons in selecting and tailoring revision strategies for complex femoral nonunion, particularly when retained proximal implants and cortical defects complicate conventional reconstructive pathways.

CONCLUSION

This case demonstrates that successful revision of a mechanically failed femoral shaft nonunion can be achieved through deliberate strain-guided construct redesign, selective retention of a stable proximal DHS lag screw and concurrent biological optimization. By directly targeting the dominant deformation modes responsible for maintaining a high-strain environment and combining multiplanar stability with controlled interfragmentary compression and defect grafting, a low-strain, compression-dominant interface capable of supporting biological repair was created. This report advances current understanding by illustrating that, in the presence of an associated femoral neck fixation, hybrid dual-plane plating around retained proximal hardware can provide a safe and effective alternative to exchange nailing in carefully selected cases, offering a practical framework for individualized, mechanism-based revision of complex femoral shaft nonunion.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Mills LA, Simpson AHRW. The relative incidence of fracture non-union in the Scottish population. BMJ Open. 2013;3:e002276.
2. Zura R, Xiong Z, Einhorn T, Watson JT, Ostrum RF, Prayson MJ, et al. Epidemiology of fracture nonunion in 18 human bones. JAMA Surg. 2016;151:1-9.
3. Giannoudis PV, Einhorn TA, Marsh D. The diamond concept of fracture healing. Injury. 2007;38(Suppl 4):S3-6.
4. Calori GM, Albisetti W, Agus A, Iori S, Tagliabue L. Risk factors contributing to fracture non-unions. Injury. 2007;38(Suppl 2):S11-8.
5. Megas P. Classification of non-union. Injury. 2005;36(Suppl 4):S30-7.
6. Perren SM. Evolution of the internal fixation of long bone fractures. J Bone Joint Surg Br. 2002;84:1093-110.
7. Claes L, Heigele C. Magnitudes of local stress and strain along bony surfaces predict fracture healing. J Biomech. 1999;32:255-66.
8. Metsemakers WJ, Morgenstern M, McNally MA, Moriarty TF, McFadyen I, Scarborough M, et al. Fracture-related infection: A consensus on definition from an international expert group. Injury. 2018;49(3):505-10.
9. Govaert GAM, Kuehl R, Atkins BL, Trampuz A, Morgenstern M, Obremskey WT, et al. Diagnosing fracture-related infection. J Orthop Trauma. 2020;34:8-17.
10. McKee MD, Waddell JP, Yoo D, Schemitsch EH. Revision surgery for femoral nonunion. J Orthop Trauma. 2001;15:1-6.
11. Hernigou P, Poignard A, Beaujean F, Rouard H. Percutaneous autologous bone-marrow grafting for nonunions. J Bone Joint Surg Am. 2005;87:1430-7.
12. Park K-C, Oh C-W, Kim J-W. Double plating for femoral shaft nonunion. Injury. 2019;50:1516-22.
13. Walcher MG, Day RE, Gesslein M, Bail HJ, Kuster MS. Augmentative Plating versus Exchange Intramedullary Nailing for the Treatment of Aseptic Non-Unions of the Femoral Shaft-A Biomechanical Study in a Sawbone™ Model. J Pers Med. 2023;13(4):650.

Cite this article as: Bijwe R, Al-Barwani A, Heiba M, Al-Washahi R, Al-Hatmi M, Kashoob A. Strain-guided revision of failed femoral shaft nonunion using a hybrid dual-plane construct around a retained dynamic hip lag screw. Int J Res Orthop 2026;12:772-5.