

Use of focal extracorporeal shock wave therapy (f-ESWT) in the treatment of a femur non-union complicated by intramedullary nail rupture: a case report

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ABSTRACT

Background: Intramedullary nail rupture is a known mechanical complication of femoral non-union, resulting from fatigue of the material from prolonged cyclic weight-bearing in the absence of bone consolidation. Focal extracorporeal shock wave therapy (f-ESWT) represents a non-invasive option, with efficacy reported in the literature comparable to surgery in hypertrophic non-union.

Clinical case: A 65-year-old man, subjected to intramedullary nailing for a diaphyseal fracture of the left femur, develops a delay in consolidation and subsequently transverse rupture of the nail at the foci level, in the absence of infectious signs. Given the patient's desire to delay a second major surgery, the multidisciplinary team proposed a course of f-ESWT as a first-line option, reserving surgical revision for a later time.

Intervention: Three sessions in one month of f-ESWT (3000 pulses/session, energy flux density 0.822 mJ/mm²) associated with protected partial weight-bearing and rest.

Results: Radiographically confirmed bone tissue improvement approximately 1 month after the beginning of treatment, with resumption of partial weight-bearing using a single elbow crutch and improvement in pain.

Conclusions: In selected cases of hypertrophic non-union with nail failure but moderate residual stability, f-ESWT may constitute a reasonable non-invasive alternative to immediate surgical revision, to be evaluated in a multidisciplinary setting.

Keywords

Focal extracorporeal shock wave therapy, Non-union, Femur fracture, Intramedullary nail rupture.

Introduction

Non-union complicates 5-10% of diaphyseal fractures treated with osteosynthesis, with estimates of up to 50% in selected subgroups [1]. A less frequent but clinically relevant scenario is **rupture of the intramedullary nail**: when bone consolidation does not

occur at the expected time, the implant is subjected to repeated full weight-bearing that can exceed the fatigue limit, leading to fracture of the material at the level of the foci. This complication is well described in the literature as a consequence - rather than a cause - of non-union.

The classic management involves surgical revision (larger diameter nail with reboring, possible augmentation plate, bone grafting). However, for hypertrophic non-union, characterized by

abundant but non-ponticellating callus, expression of preserved bone biology and a predominantly mechanical problem, the literature has validated f-ESWT as a non-invasive alternative, with cure rates comparable to surgery [2]. This case report describes the application of f-ESWT in a patient with femur hypertrophic non-union complicated by nail rupture, discussing the rationale of the therapeutic choice in light of the available evidence.

Case presentation
History and initial treatment

65-year-old male patient, overweight, smoker, with a positive history of systemic arterial hypertension. In March 2026 he had a car accident, suffering a closed, multi-fragmentary diaphyseal fracture of his left femur. He underwent closed-track reduction and osteosynthesis with an intramedullary titanium nail. The immediate post-operative course was free of complications.

Clinical course and appearance of nail failure
Physiotherapy (Motor Re-educational Program) was started with weight-bearing as tolerated and continued with partial weight-bearing and aids (2 elbow crutches) and monitoring.

About 4 months after surgery, following a twisting movement, the patient reported acute onset of intense pain in the left thigh with loss of function. Standard radiography showed **transverse rupture of the intramedullary nail at the fracture site**, with proximal and distal screws still intact.

Therapeutic management
Rationale for the choice

The case was discussed in a multidisciplinary setting (orthopedic surgeon, physiatrist) together with the patient. Three elements guided the shared decision to propose a course of f-ESWT before a possible major surgical revision:

- 1. The hypertrophic **morphology** of non-union, the subtype that best responds to shock waves in literature, with cure rates up to three times higher than oligotrophic/atrophic forms [1] and results comparable to surgery in a randomized controlled trial dedicated to hypertrophic non-union of long bones [2];
- 2. The **acceptable residual stability** guaranteed by the peripheral bone callus and the screws still intact, which made a non-invasive attempt plausible before exposing the patient again to the risks of a major reoperation (infection, further mechanical failure) [3];
- 3. The **explicit preference of the patient** to avoid, if reasonably possible, a second major surgery.

The threshold of failure beyond which surgical revision should be carried out (nail with a larger diameter with possible bone grafting) remained shared, according to the approach commonly described for femoral non-union with a broken implant [3].

Treatment Protocol

A piezoelectric generator of focal shock waves was used, with focus centering on the focus of non-union. The protocol provided:

- **1 session every 2 weeks**, for a total of 3 sessions;
- **3000 pulses** per session;
- **Energy flux density of 0.822 mJ/mm²**.

Alternative protocols for the femur are also described in the literature, for example 6000-10000 pulses at 0.62 mJ/mm² in a single session [4]: the choice of protocol must consider the heterogeneity of the available devices and the absence, to date, of a single standardized protocol [1]. At the same time, partial weight-bearing and rest were maintained, with progressive resumption of the weight-bearing.

Follow-up and results

Timing (from the beginning f-ESWT)	Rating	Outcome
Baseline	VAS pain	5/10 at rest, 8/10 at full weight-bearing
2 weeks	Clinical	Second session of f-ESWT; Toe-touch weight-bearing
4 weeks (~1 month)	Rx	Improvement of bone tissue at the foci level, with the appearance of new bone texture
4 weeks (~1 month)	Clinical	Partial weight-bearing with a single elbow crutch; Pain improvement

No treatment-related complications occurred (no infection, no local adverse reactions). At the available follow-up (1 month) no surgical revision was necessary; remote clinical-radiographic checks are scheduled to assess the evolution towards bone consolidation and possible major surgery.

Discussion

This case illustrates the use of f-ESWT in a scenario less typically represented in the literature: non-union with **concomitant intramedullary nail rupture**. Most of the published series on f-ESWT concern non-union with implants still intact [1,2,4]; When there is an implant rupture, the "default" approach described in the literature is surgical revision, with removal of the broken nail (technically challenging) and reinsertion of a nail with a larger diameter, often associated with bone grafting [3,5]. Historically reported success rates of re-intervention alone are high but not uniform, with studies reporting failure rates of up to 27-42% [3].

Focal shock waves act through a **mechano-transduction** mechanism: the controlled micro-trauma induced at the level of the bone callus stimulates the proliferation and activation of osteoblasts, neoangiogenesis and the release of growth factors such as VEGF, BMP-2 and TGF-β1, reactivating the biological cascade of bone healing [5]. This explains why the efficacy is much greater in hypertrophic forms, where the problem is mainly mechanical and the biological component is preserved, than in atrophic forms, where the biological substrate is insufficient and f-ESWT alone have shown modest results [1,6].

This case must be read with the limits of a single case report and a short follow-up (1 month): the improvement observed at the

radiographic and clinical level does not allow to establish, at the moment, whether and when complete bone consolidation will be achieved. The rationale of the choice (hypertrophic biology, residual stability, patient preference) is consistent with the literature but there is no specific high-level evidence for the "non-union with nail rupture" scenario; The decision should therefore always be individualized in a multidisciplinary setting, reserving surgical revision for cases with marked mechanical instability, large interfragmentary gap, atrophic biology or signs of infection, situations in which f-ESWT alone are not generally indicated as a first-line treatment.

Patient perspective

The patient reported a perceived improvement in pain and increased confidence in the weight-bearing, while still requiring the support of a crutch for walking. He expressed satisfaction with the path taken, waiting for subsequent checks to assess the evolution of consolidation and the possible need for revision surgery.

Conclusion

In selected cases of hypertrophic femoral non-union complicated by intramedullary nail rupture, in acceptable residual stability and absence of infectious signs, a course of f-ESWT may represent a reasonable first-line option prior to surgical revision, with a better safety profile. In the case described, the 1-month follow-up showed an encouraging clinical-radiographic improvement but not yet complete consolidation: remote checks are needed to confirm its evolution. The therapeutic choice must however

remain individualized, shared with the patient and based on a multidisciplinary assessment, with revision surgery maintained as a rescue option in case of non-response.

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