

Case Report

Blisters, biology and rings: single-stage Ilizarov fixation for a high-energy AO/OTA 42C3 tibial shaft fracture in an octogenarian: a case report

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ABSTRACT

High-energy tibial shaft fractures in geriatric patients present significant challenges due to osteoporotic bone, compromised soft tissues and multiple medical comorbidities. Conventional fixation methods may be limited in the presence of fracture blisters or poor physiological reserve, making minimally invasive strategies increasingly relevant. An 88-year-old previously independent male with hypertension and prior cerebrovascular accident sustained a high-velocity road traffic injury resulting in an AO/OTA 42C3 comminuted tibial shaft fracture and 4F2B fibula fracture with ipsilateral rib fractures. Early circumferential fracture blebs precluded plating and staged external fixation was avoided due to advanced age and comorbidities. A single-stage four-ring Ilizarov circular fixator was applied using tensioned wires and selective Schanz pins, prioritizing biological fixation and soft-tissue preservation. Postoperatively, the patient followed a staged rehabilitation protocol with adjunctive teriparatide therapy. Radiographs demonstrated progressive callus formation and fracture union at one year with acceptable varus and recurvatum alignment. The postoperative course was uneventful and implant removal was performed after consolidation. Functional outcomes beyond one year could not be assessed due to loss to follow-up. Single-stage Ilizarov circular fixation can be an effective definitive option for complex high-energy tibial fractures in medically complex elderly patients when conventional fixation is contraindicated. Careful consideration of soft-tissue status, comorbidities and biological fixation principles is essential to optimize outcomes.

Keywords: Tibial shaft fracture, Ilizarov fixator, Geriatric trauma, Fracture blisters, Circular external fixation, AO/OTA 42C3

INTRODUCTION

Tibial shaft fractures are among the most common long-bone injuries encountered in orthopaedic trauma and are increasingly seen in the elderly due to population ageing and continued exposure to high-energy mechanisms such as road traffic accidents. In geriatric patients, these injuries present unique challenges, including osteoporotic bone quality, multiple medical comorbidities and reduced physiological reserve, all of which influence treatment

decisions and healing outcomes.^{1,2} Furthermore, the subcutaneous location of the tibia predisposes to significant soft-tissue compromise, where swelling, fracture blisters and skin vulnerability may limit the feasibility of conventional open fixation.

Although intramedullary nailing and plating remain standard options for many tibial diaphyseal fractures, circular external fixation based on Ilizarov principles offers a biologically friendly alternative in cases with

severe comminution or compromised soft tissues, allowing stable fixation while minimizing surgical insult. However, evidence regarding its role as a definitive single-stage strategy in very elderly and medically complex patients remains limited.

This report describes the management of an exceptionally elderly yet previously active patient with a high-energy comminuted tibial shaft fracture complicated by significant soft-tissue injury, highlighting the rationale for a minimally invasive Ilizarov-based approach within the evolving framework of geriatric trauma care.

CASE REPORT

An 88-year-old male with known comorbidities of hypertension and a previous cerebrovascular accident, on regular medications, presented to the emergency department following a road traffic accident. He sustained trauma to the right hemithorax and right lower limb and was brought on a stretcher with complaints of severe pain and inability to bear weight on the affected extremity. The pain was sudden in onset, progressive, localized to the right leg, aggravated by minimal movement and relieved with immobilization. There was no history of fever, giddiness, loss of consciousness, vomiting or ear-nose-throat bleeding. Notably, patient had been independently ambulatory and functionally active prior to the injury.

On clinical examination, contusions were noted over the right chest wall with abrasions over the right leg. No scars, sinuses or engorged veins were present. The right leg showed visible deformity with diffuse swelling. Palpation elicited tenderness along the entire tibial shaft with palpable crepitus. Knee movements were painful but preserved, while hip and ankle range of motion remained full. There was no clinical evidence of foot drop and distal neurovascular examination was normal.

Radiographs demonstrated a comminuted, multi-fragmentary tibial shaft fracture at the junction of the proximal and middle thirds along with fibula, classified as AO/OTA type 42C3 and 4F2B (Figure 1). Associated fractures of the right 7th, 8th and 9th ribs were identified and planned for conservative management. In view of the compromised soft-tissue envelope, the limb was initially immobilized in a below-knee slab with Böhler–Braun splint elevation to allow swelling to subside. Preoperative planning initially favoured definitive fixation with an anteromedial long locking compression plate (LCP).

Within 24 hours of immobilization, however, extensive circumferential bleb formation developed over the right leg, suggestive of significant soft-tissue injury consistent with a high-energy mechanism (Figure 2). Open reduction and internal fixation was therefore deferred due to the heightened risk of wound complications and infection. Although a staged protocol with temporary spanning external fixation followed by definitive fixation was considered, this approach was avoided because of the

patient's advanced age, medical comorbidities and limited physiological reserve, which made tolerance of multiple surgical procedures undesirable. Despite continued limb elevation and observation, the skin condition failed to improve even after 10 days. Given the risks of delayed stabilization, potential non-union and the need to minimize surgical burden in an elderly yet previously active patient, a minimally invasive definitive strategy using an Ilizarov ring external fixator was chosen.



Figure 1 (A-F): Pre-operative radiographs demonstrating the fracture configuration. A and B show the knee joint in anteroposterior (AP) and lateral views. C and D depict the proximal half of the tibia, while E and F illustrate the distal half of the tibia with the ankle joint in AP and lateral projections.
 *The radiographs demonstrate a complex mid-shaft tibial fracture (AO/OTA Type 42-C3) associated with a fibular fracture (AO/OTA type 4F2-B).

Under combined spinal-epidural anaesthesia, the patient was positioned supine on the operating table. Considering the anticipated osteoporotic bone quality, a four-ring Ilizarov construct was applied, consisting of two 180-mm rings proximal and two 180-mm rings distal to the fracture site. Stabilization was achieved using tensioned Kirschner wires supplemented with two Schanz pins placed on rings two and three. Owing to the severe comminution, the construct was intentionally less rigid, prioritizing biological fixation and soft-tissue preservation rather than immediate full weight-bearing stability.

The postoperative course was uneventful. Radiographs demonstrated satisfactory fracture stabilization with mild residual recurvatum and varus alignment, which were considered acceptable in light of the primary goal of achieving union in this elderly patient (Figure 3). The patient was maintained non-weight bearing for eight

weeks, followed by gradual progression to partial weight bearing for three weeks and eventual full weight bearing. The skin condition and inflammation subsided with scab formation, showing signs of healing (Figure 4). Given the patient's age and presumed osteoporotic bone quality, adjunctive teriparatide therapy was administered to facilitate fracture healing.

The patient was reviewed at monthly intervals for 1st 6 months, followed by bi-monthly follow-up until 1 year (Figure 5). At approximately one-year post-injury, radiographic evaluation demonstrated satisfactory fracture union with adequate bridging callus formation across fracture site, following which implant removal undertaken. Post-removal immobilisation consisted of above-knee slab for period of 2 weeks (Figure 6), after which graduated mobilisation was initiated using a rigid knee-ankle-foot orthosis (KAFO). Patient subsequently defaulted from follow-up and was lost to further clinical review.



Figure 2 (A-D): Clinical photographs demonstrating presence of circumferential bleb formation around injured limb, indicative of significant soft-tissue compromise at presentation.

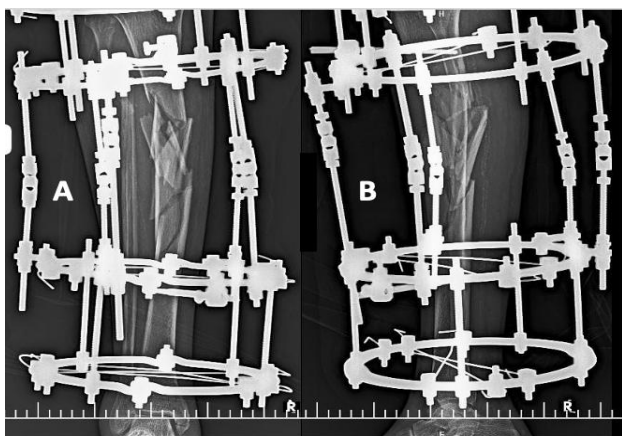


Figure 3 (A and B): Post-op radiographs of application of Ilizarov circular external fixator with satisfactory alignment and stabilization of tibial fracture.

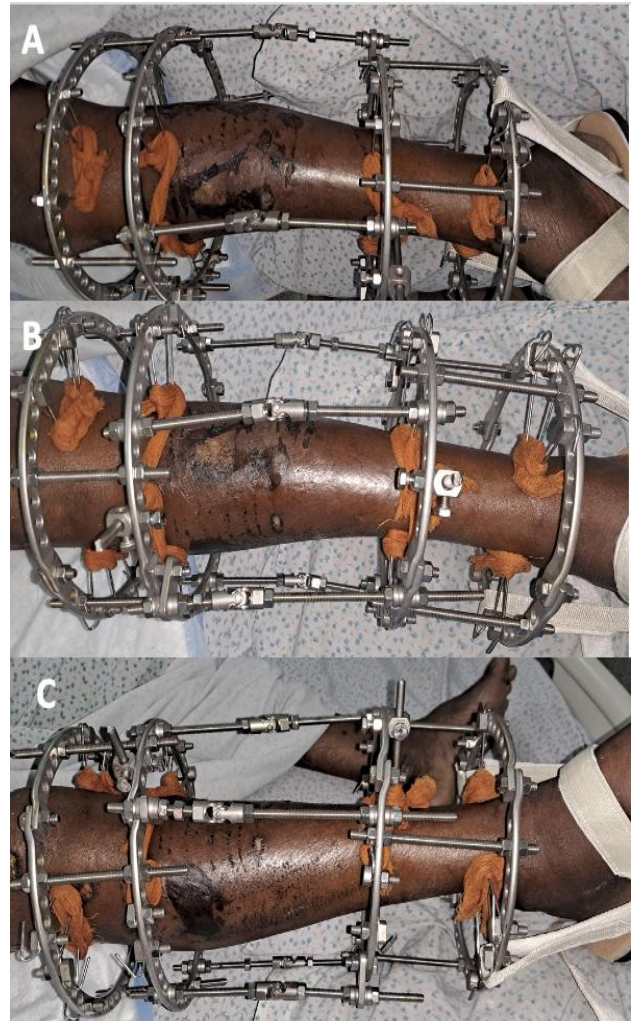


Figure 4 (A-C): Sequential clinical images demonstrating progressive wound healing, resolution of inflammatory changes, and absence of new bleb formation during the early post-operative period.

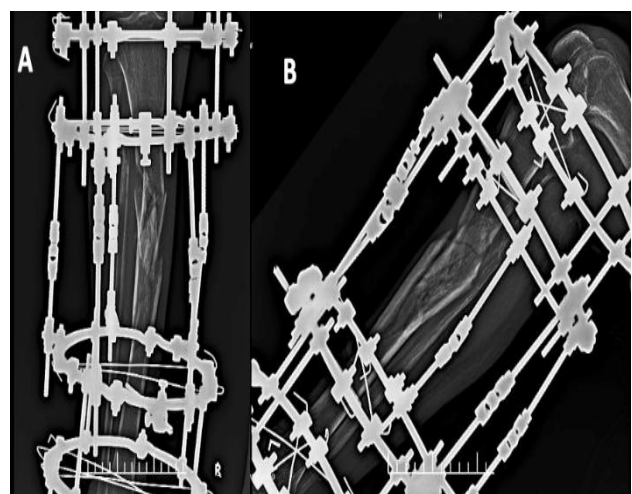


Figure 5 (A and B): Follow-up radiographs at six months post-operatively showing evidence of bridging callus formation across the fracture site, consistent with ongoing fracture union.



Figure 6 (A and B): Radiographs obtained after removal of external fixator demonstrating complete fracture consolidation with robust bridging callus and maintained limb alignment.

DISCUSSION

High-velocity lower-limb trauma among elderly individuals is being encountered with increasing frequency, reflecting both global population ageing and continued exposure to road traffic environments. Tibial shaft fractures constitute a significant proportion of long-bone injuries in this demographic.^{1,2} In a population-based study, Larsen et al reported an incidence of 16.9 per 100,000 person-years, demonstrating a bimodal age distribution and highlighting the contribution of high-energy mechanisms such as road traffic accidents and sports-related trauma, particularly among males.¹ Similarly, Anandasivam et al analysing 27,706 adult tibial shaft fractures from the National Trauma Data Bank, confirmed this bimodal pattern; although falls predominated in older patients, motor vehicle accidents remained an important mechanism and associated injuries were common across age groups.² Notably, almost 60% of patients sustained at least one additional skeletal or visceral injury, with rib and thoracic trauma among the most frequent concomitant findings, underscoring the polytrauma potential of these injuries.²

Evidence examining injury patterns in senior road users further indicates that elderly individuals involved in traffic collisions tend to sustain more severe thoracic and lower-extremity injuries, with greater morbidity and mortality compared with younger cohorts.^{3,4} Against this epidemiological background, the present case of an 88-year-old, previously independent and functionally active male who sustained a high-energy road traffic accident resulting in a comminuted AO/OTA 42C3 tibial shaft fracture and 4F2B fibula fracture with multiple ipsilateral rib fractures reflects the recognised pattern of combined chest and lower-limb trauma in geriatric patients, while

also highlighting the uncommon occurrence of such severe injury at an advanced age.

Comorbid conditions play a critical role in shaping outcomes among geriatric patients sustaining lower-extremity fractures, contributing to increased perioperative complications, delayed fracture healing and higher overall morbidity. In an NSQIP-based analysis evaluating octogenarians undergoing fixation for tibial shaft fractures, advanced age and associated medical comorbidities were linked to greater transfusion requirements and prolonged hospitalization, although adjusted 30-day mortality rates remained relatively low.⁵ Similarly, Pollard et al demonstrated that octogenarians with tibial plateau fractures had nearly threefold higher odds of postoperative anaemia requiring transfusion (OR 2.83) and a longer hospital stay (OR 2.72) compared with patients aged 65 to 79 years, findings attributed to frailty, osteoporotic bone quality and prevalent cardiovascular comorbidities such as hypertension.⁶

Hypertension, reported in up to 73% of elderly fracture patients with underlying cerebrovascular disease, has been associated with metabolic derangements including hypoproteinemia, electrolyte imbalance, anaemia, venous thromboembolism and pulmonary complications, thereby amplifying the physiological stress response to trauma.⁷ A prior cerebrovascular accident further compromises mobility and functional recovery, increasing the risk of falls and postoperative decline, while polypharmacy and diminished physiological reserve often limit tolerance for extensive or staged surgical interventions.^{7,8} In the present case, the coexistence of hypertension and a history of stroke raised concerns regarding wound healing, systemic complications and the patient's ability to withstand multiple procedures. Consequently, a single-stage, minimally invasive strategy using an Ilizarov ring fixator was favoured to reduce operative burden while facilitating fracture union, reflecting the balance between heightened perioperative risk and the preserved potential for recovery observed in carefully selected comorbid elderly patients.

Clinical presentation of high-velocity tibial shaft fractures in the geriatric population commonly includes severe localized pain, inability to bear weight, visible deformity, diffuse swelling and marked tenderness with crepitus at the fracture site, frequently accompanied by additional injuries related to polytrauma mechanisms.^{9,10} Educational and clinical summaries describe the typical scenario as acute leg pain with non-weight-bearing status and deformity following high-energy events such as motor vehicle accidents or falls from height, while adjacent joint movements may remain preserved unless the injury extends proximally or distally.¹⁰ Thompson et al further highlights sudden onset pain exacerbated by motion, associated abrasions or ecchymosis and the necessity for meticulous neurovascular assessment to exclude vascular compromise or evolving compartment syndrome, particularly in high-energy trauma.⁹ Epidemiologic analyses corroborate that these features predominate in

elderly patients, with concomitant thoracic injuries, including chest wall contusions and rib fractures, reported in a significant proportion of road traffic-related cases, often despite preserved distal perfusion in hemodynamically stable presentations.² In the present case, the 88-year-old patient exhibited acute progressive right leg pain, inability to bear weight, visible deformity with swelling, diffuse tibial tenderness and crepitus, painful yet preserved knee motion, full hip and ankle range of motion, intact distal neurovascular status and associated right-sided chest contusions and abrasions. These findings closely align with the established clinical profile of a high-energy tibial shaft fracture in a comorbid geriatric individual without overt vascular or neurological compromise.

Soft-tissue conditions overlying tibial fractures following high-energy trauma often present as abrasions, contusions or extensive fracture blister (bleb) formation, reflecting significant underlying soft-tissue injury as described in the Tscherne classification.^{11,12} Strauss and Harris reported fracture blisters as relatively uncommon, with an incidence of approximately 2.9%, typically developing within 6 to 72 hours after injury as post-traumatic edema increases interstitial pressure, disrupts dermo-epidermal cohesion and induces local hypoxia secondary to vascular and lymphatic compromise, particularly in regions with thin soft-tissue coverage such as the distal tibia and ankle.¹³ The Tscherne system categorizes closed injuries from C0 to C3, where C2 indicates deep contaminated abrasions and C3 represents extensive contusion, crushing or degloving injuries; haemorrhagic blisters, associated with deeper dermal separation, demonstrate longer healing times (approximately 16 days) compared with serous blisters (approximately 12 days), thereby necessitating delayed operative intervention to reduce infection risk.^{11,12}

Supporting these observations, Varela et al and subsequent studies have documented blister formation in nearly 3% to 6% of high-energy tibial fractures, with circumferential blistering frequently leading to surgical delays averaging 10 to 21 days due to concerns regarding wound healing, compartmental compromise and postoperative infection if early incisions are made.^{13,14} In the present case, the development of extensive circumferential blebs within 24 hours despite limb elevation was consistent with a Tscherne C3 soft-tissue injury pattern, prompting a 10-day postponement of open fixation in accordance with established recommendations advocating conservative blister management to preserve the soft-tissue envelope, particularly in geriatric patients.

Imaging assessment of tibial shaft fractures is primarily based on anteroposterior and lateral radiographs that include the entire tibia and fibula along with the knee and ankle joints, enabling evaluation of fracture configuration, displacement, shortening, rotational alignment and degree of comminution.¹⁵ Within the AO/OTA framework, diaphyseal tibial fractures are categorized as 42A (simple), 42B (wedge) and 42C (complex multi-fragmentary), with

subtype 42C3 describing highly irregular, extensively comminuted patterns often extending beyond 4 cm and frequently occurring at the proximal-middle third junction in high-energy injuries.^{15,16} Larsen et al demonstrated that the AO/OTA 42 classification achieves an overall accuracy of 75% to 86% with moderate-to-substantial interobserver reliability (kappa 0.53-0.79) when applied to plain radiographs in 101 adult cases, although greater variability was noted in complex 42C patterns due to fragment overlap.¹⁷ While computed tomography can provide enhanced fragment delineation in markedly comminuted injuries, standard radiographs remain sufficient for most initial classifications and operative planning.¹⁷ In the present case, radiographs clearly identified a comminuted multi-fragmentary AO/OTA 42C3 fracture at the proximal-middle third junction with associated deformity, along with ipsilateral rib fractures, facilitating appropriate planning for Ilizarov ring fixation and confirming the absence of intra-articular extension, consistent with established imaging and classification principles for high-energy tibial trauma.

Management of high-velocity tibial shaft fractures in the geriatric population emphasizes preservation of the soft-tissue envelope, biologically friendly fixation and reduction of perioperative physiological stress, particularly in the setting of osteoporosis, medical comorbidities and an increased risk of delayed union.¹⁸⁻²¹ Although intramedullary nailing is widely regarded as the standard treatment for many closed tibial diaphyseal fractures, high-energy injuries complicated by fracture blisters, severe soft-tissue compromise or associated polytrauma often necessitate a damage-control approach with temporary external fixation to mitigate the risks of compartment syndrome and infection before definitive stabilization.^{19,20} Circular external fixation using the Ilizarov technique has demonstrated particular utility in complex multi-fragmentary patterns such as AO/OTA 42C3 fractures or in situations with compromised skin conditions, offering multiplanar stability, adjustability and the potential for early functional rehabilitation. Reported union rates exceeding 90% in elderly cohorts, including octogenarians and nonagenarians with osteoporotic bone, have been described, with adjunctive therapies such as teriparatide contributing to enhanced callus formation.^{18,21} Comparative studies also suggest lower deep infection rates and acceptable alignment outcomes with circular frames compared to plating in the presence of significant soft-tissue injury, although meticulous pin-site care remains essential.^{19,20} In the present case, plate fixation was deferred due to extensive circumferential bleb formation and a single-stage four-ring Ilizarov construct utilizing tensioned wires and selective Schanz pins was chosen to minimize surgical burden in a medically complex elderly patient. A deliberately less rigid construct was employed to favour biological healing, followed by staged progression from non-weight bearing to full weight bearing alongside teriparatide therapy. This strategy resulted in radiographic union at one year with acceptable alignment, consistent with current evidence supporting

circular external fixation as an effective definitive solution for high-energy tibial fractures in comorbid geriatric patients while avoiding the risks associated with multiple staged procedures.

Limitations

This case report carries several inherent limitations characteristic of single-patient observations. Foremost, long-term functional outcomes beyond the one-year radiographic union could not be assessed, as the patient was lost to follow-up, preventing evaluation of sustained mobility, pain status or late complications such as pin-site issues or refracture. The absence of advanced imaging, including computed tomography, limited precise characterization of the degree of comminution and precluded objective assessment of bone quality, which may have influenced both classification reproducibility and surgical planning. In addition, the use of teriparatide as an adjunctive therapy was not compared with a control or alternative strategy, making it difficult to distinguish the relative contribution of pharmacologic augmentation versus the biological advantages of circular fixation. Finally, the lack of formal frailty assessment or standardized comorbidity indices restricts the broader applicability of the findings to geriatric populations with differing physiological reserves. Collectively, these limitations underscore the need for larger prospective studies to better define the role of Ilizarov-based strategies in managing high-energy tibial fractures among medically complex elderly patients.

CONCLUSION

High-energy tibial shaft fractures in the geriatric population represent a complex intersection of fragile soft tissues, osteoporotic bone quality and significant medical comorbidities, necessitating individualized treatment strategies that balance stability with biological preservation. This case highlights that in carefully selected elderly yet functionally active patients, a single-stage circular external fixation approach can serve as a viable definitive alternative when conventional plating or staged protocols are contraindicated due to compromised skin conditions and limited physiological reserve. The use of an Ilizarov ring construct allowed minimally invasive stabilization, protection of the soft-tissue envelope and successful fracture union with acceptable alignment, while avoiding the cumulative risks associated with multiple procedures. Beyond demonstrating technical feasibility, this report underscores the importance of integrating comorbidity profile, pre-injury functional status and soft-tissue assessment into decision-making for geriatric trauma. Although long-term functional outcomes could not be evaluated, the radiographic success observed suggests that circular external fixation remains a valuable limb-salvage strategy in complex high-velocity injuries among medically complex elderly patients. Larger prospective studies are required to clarify optimal indications, rehabilitation protocols and the potential

adjunctive role of pharmacologic therapies in enhancing healing within this growing patient population.

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