



개방성 경골 원위부 Pilon 골절 환자에서 조기 재활 후 성공적인 임상 경과: 증례 보고

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Successful Clinical Outcome Following Early Rehabilitation after Open Pilon Fracture of the Ankle: A Case Report

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Open pilon fractures are challenging because of the risk of infection and post-traumatic arthritis. Early rehabilitation following stable fixation is controversial. This paper reports a case of successful functional recovery after early postoperative rehabilitation in an open pilon fracture. A 59-year-old male presented with a left open pilon fracture (Gustilo-Anderson type II) after a 1.5 m fall. The initial surgery involved fibular open reduction and internal fixation and tibial external fixation. After soft-tissue recovery, tibial open reduction and internal fixation was performed using stable internal fixation. Passive ankle range of motion exercises began at 2 weeks, and partial weightbearing started at one month. Bone union was achieved without infection. At 3.5 years, ankle dorsiflexion was 15° and plantarflexion 35°, with an American Orthopaedic Foot and Ankle Society score of 90 and a visual analogue scale pain score of 1/10, indicating excellent function and satisfaction. Early rehabilitation under stable fixation can result in favorable long-term outcomes in complex open ankle fractures.

Key Words: Pilon fracture, Open fracture, Ankle joint, Early rehabilitation, Functional outcome

Pilon fractures involve the distal tibial plafond and often result from high-energy trauma, producing severe articular comminution and soft-tissue damage.^{1,2)} Historically, extended immobilization was advised to prevent wound complications; however, this approach frequently leads to ankle stiffness, muscle atrophy, and poor functional recovery.³⁾ Recent studies have suggested that early, controlled motion after stable fixation may improve outcomes without increas-

ing complication rates.⁴⁻⁶⁾ However, most existing studies and systematic reviews have primarily investigated closed or less severe fractures, leaving a paucity of evidence regarding the safety and efficacy of early rehabilitation in open pilon fractures. It remains uncertain whether early joint mobilization can be safely implemented when rigid internal fixation and adequate soft-tissue recovery are achieved. The present case aims not to generalize outcomes but to provide long-term, evidence-based documentation of successful early rehabilitation after stable fixation in a Gustilo-Anderson type II open pilon fracture, which is rarely reported in the literature.

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CASE REPORT

A 59-year-old male presented on August 18, 2021, with se-

vere left ankle pain and bleeding following a 1.5 m fall from a ladder. Physical examination revealed a 3×2 cm medial open wound with bone exposure. Radiographs and computed tomography scans showed a comminuted open pilon fracture of the distal tibia and fibula (Gustilo-Anderson type II) (Fig. 1, 2). On the day of injury, the patient underwent fibular

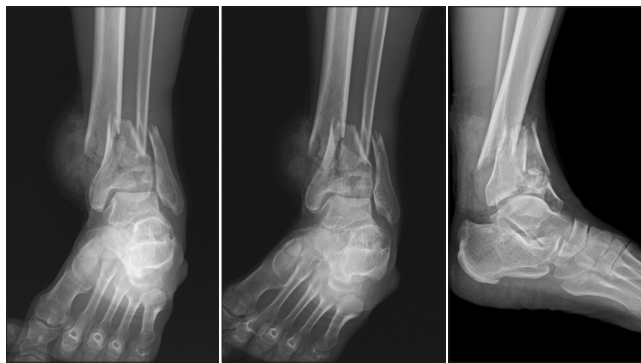


Figure 1. Preoperative radiographs showing an open pilon fracture of the left ankle with comminuted intra-articular involvement.

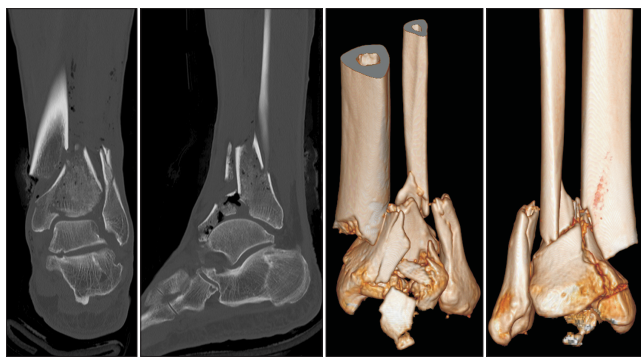


Figure 2. Initial CT and 3D reconstruction images demonstrating severe comminution and displacement of the distal tibial plafond and distal fibular fracture. CT: computed tomography, 3D, three-dimensional.

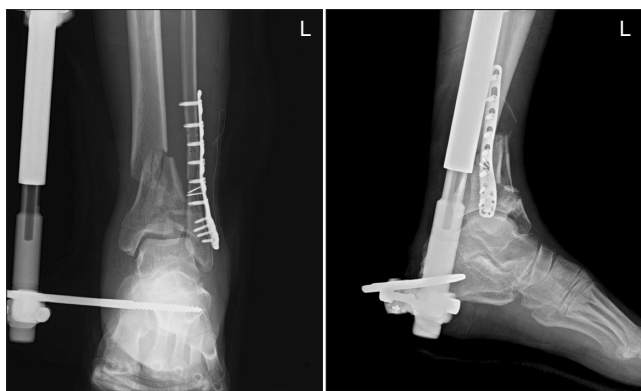


Figure 3. Immediate postoperative radiographs after fibular fixation and tibial external fixation.

open reduction and internal fixation (ORIF) and application of a tibial external fixator (Fig. 3). Daily wound dressing and intravenous antibiotics were administered. After soft-tissue recovery, definitive tibial ORIF was performed using a low-profile locking plate system to achieve anatomical reduction and stable fixation (Fig. 4).

1. Rehabilitation protocol

During the first 0~2 weeks postoperatively, the patient's ankle was immobilized with a cast. He was instructed to perform toe wiggling exercises and quadriceps strengthening exercise (QSE) and straight leg raise (SLR) to maintain lower limb muscle strength and prevent venous stasis.

From 2~4 weeks, the patient was allowed partial weight-bearing using crutches while wearing a removable plastic splint. In a non-weightbearing position, passive range of motion (ROM) exercises of the ankle and metatarsophalangeal (MTP) joints were initiated, in addition to continuing QSE and



Figure 4. Definitive ORIF radiographs showing anatomical reduction. ORIF: open reduction and internal fixation.

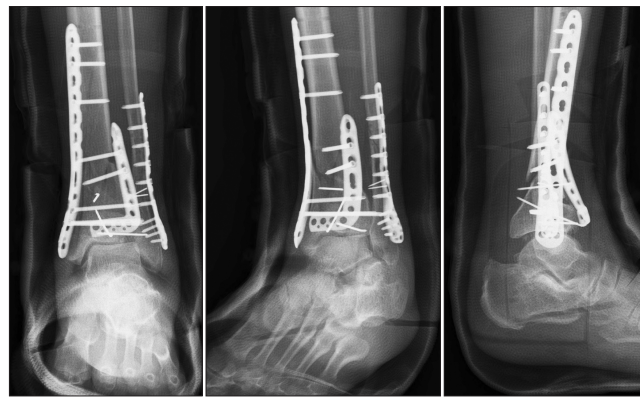


Figure 5. Radiographs at postoperative 2 weeks showing early passive ROM after ORIF. ROM: range of motion, ORIF: open reduction and internal fixation.

SLR exercises.

After 4 weeks, the patient progressed to full weightbearing without orthosis and maintained passive ankle and MTP joint

ROM exercises together with QSE and SLR to prevent joint stiffness and maintain muscle tone.

From 6 weeks onward, he attended a fitness center and

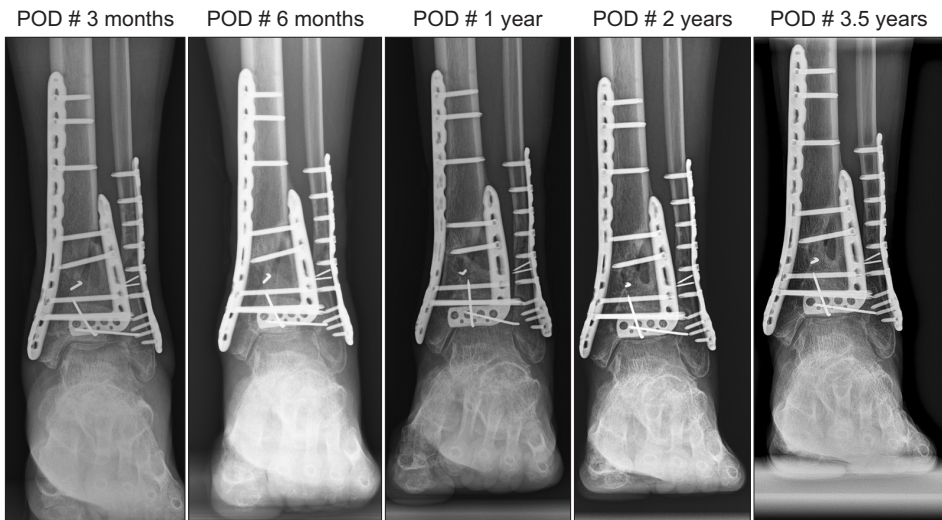


Figure 6. Serial follow-up radiographs demonstrating progressive bone union up to 3.5 years postoperatively. POD: postoperative day.



Figure 7. Clinical photographs at the 3.5-year follow-up demonstrating well-healed skin and the absence of deformity.



Figure 8. Clinical photographs at the 3.5-year follow-up demonstrating preserved ankle motion.

began progressive resistance and strengthening exercises, focusing on the ankle and lower limb muscles for gait restoration and endurance improvement (Fig. 5).

Serial radiographs at 3, 6, 12, 24, and 42 months demonstrated progressive bone union and stable fixation without infection or hardware failure (Fig. 6). At 3.5 years, the patient exhibited 15° dorsiflexion and 35° plantarflexion on the affected side (contralateral: 20°/40°) with full, pain-free ambulation (Fig. 7, 8).

The American Orthopaedic Foot and Ankle Society ankle-hindfoot score was 90, and visual analogue scale pain score was 1/10, reflecting excellent long-term function.

2. Ethics approval and consent to participate

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Written informed consent was obtained from the patient for publication of this study and any accompanying images. The study was approved by the Institutional Review Board of the Chung-Ang University Hospital (IRB no. 2511-009-19600).

DISCUSSION

Open pilon fractures are characterized by severe comminution and extensive soft-tissue injury, which make early definitive fixation particularly risky. Several studies have emphasized that performing internal fixation before soft-tissue recovery markedly increases the likelihood of wound breakdown and deep infection.¹⁻³⁾ Therefore, a staged approach—initial external fixation for temporary stability followed by delayed internal fixation once swelling subsides and the soft-tissue envelope recovers—has become the standard of care.^{4,7,8)} In this case, temporary external fixation was used immediately after injury, allowing for soft-tissue rest and wound monitoring. Definitive ORIF was performed only after the tissue stabilized, enabling anatomic reduction while minimizing postoperative complications. This approach resulted in successful union and clean wound healing, confirming that delayed ORIF after soft-tissue readiness is the most critical step for preventing infection and ensuring favorable outcomes in open pilon fractures.^{7,8)}

Once firm fixation is achieved, early motion and rehabilitation play a decisive role in functional recovery and pain relief. Biomechanical and clinical studies have demonstrated that early joint mobilization enhances cartilage nutrition, prevents capsular adhesion, and restores proprioception.⁵⁻⁷⁾ Historically, delayed motion was preferred due to concerns about implant failure or wound complications, especially in open fractures. However, with modern plating techniques and rigid fixation, early mobilization can be safely initiated when the wound is stable.^{5,6)} According to previous literature, ankle ROM exercises are generally started after soft-tissue healing—typically at 4 to 6 weeks postoperatively—and partial or full weightbearing is delayed until 8 to 12 weeks to prevent wound complications and fixation failure.⁵⁻⁸⁾ In the present case, early rehabilitation was defined as the initiation of passive ankle ROM at 2 weeks and partial weightbearing at 4 weeks after definitive fixation. Our protocol was therefore earlier than conventional practice, made possible by stable fixation and satisfactory soft-tissue recovery.

In this case, rehabilitation followed a structured timeline: initial immobilization and isometric exercise for 2 weeks, controlled passive motion and partial weightbearing at 2~4 weeks, full weight-bearing after 4 weeks, and progressive strengthening after 6 weeks. This systematic progression led to excellent motion and pain-free ambulation at 3.5 years. These findings reinforce that early, stability-based rehabilitation should be considered an integral part of postoperative management for complex ankle injuries. Although this report presents only a single case, it highlights the possibility that early rehabilitation, when guided by fixation stability and soft-tissue readiness, can lead to favorable long-term outcomes.

The rehabilitation strategy may vary depending on the degree of fracture comminution, fixation stability, and soft-tissue condition. Therefore, the present report does not intend to generalize the outcomes but rather to illustrate that early, stability-based rehabilitation may be feasible in carefully selected cases with rigid fixation and adequate soft-tissue recovery. Further research is warranted to validate this approach in a larger patient population.

In conclusion, Early rehabilitation following stable fixation of open pilon fractures can lead to excellent long-term functional outcomes. When rigid fixation and sufficient soft-

tissue recovery are ensured, controlled early motion is feasible and may prevent stiffness without compromising wound integrity. Stable fixation, careful soft-tissue management, and individualized exercise progression are crucial to success.

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