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Case Series

Single-Stage Open Reduction and Internal Fixation Combined with Incisional Vacuum-Assisted Closure for Pilon Fractures: A Retrospective Series of Eleven Cases

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Abstract

Aim: Pilon fractures, often resulting from high-energy trauma, are traditionally managed with staged fixation due to their known high risk of soft-tissue complications. This retrospective study evaluates the feasibility and outcomes of single-stage Open Reduction and Internal Fixation (ORIF) combined with immediate postoperative Vacuum-Assisted Closure (VAC) of the surgical wounds in selected patients with pilon fractures and favorable local soft-tissue conditions.

Methods: Eleven selected patients with complex 3- or 4-part pilon fractures were included in this study. None of the cases received external fixation and the definitive ORIF was performed using plates and screws at a mean of 12 days post-injury (range, 3-20) after ensuring adequate soft tissue integrity (no or mild edema, positive ankle wrinkle sign, no bullae or soft tissue degloving). The cohort included nine males and two females, with a mean age of 43 years. One patient presented with an associated ipsilateral foot compartment syndrome in association with multiple metatarsal fractures and received foot fasciotomy and metatarsal ORIF with K-wires, two weeks before the pilon ORIF. All incisions received a VAC dressing within 8 hours of surgery, which was maintained until complete wound healing.

Results: All cases achieved fracture union, as noticed radiographically at an average of 4.5 months postoperatively. At a mean follow-up of 17 months, only one patient (9.1%, the patient who presented with foot compartment syndrome and received foot fasciotomy) developed a deep wound infection and was successfully managed with three surgical debridement sessions, with maintenance of wound VAC, without hardware removal. No cases of hardware failure, nonunion or other cases of deep infection were observed.

Conclusion: Single-stage ORIF combined with incisional wound VAC may represent an alternative to the staged fixation for high-energy pilon fractures when soft-tissue conditions are favorable. In cases associated with soft tissue compromise nearby, it may be advisable to utilize the gold standard staged fixation. The small sample size warrants larger comparative studies for generating stronger evidence.

Keywords: Pilon Fractures; Fracture Fixation; Internal; Open Reduction; Vacuum-Assisted Closure; Soft Tissue Injuries; High-Energy Trauma; External Fixators

Introduction

Pilon (tibial plafond) fractures are complex injuries comprising roughly 3-10% of tibial fractures. These fractures commonly result from axial compression during high-energy trauma such as falls from height or motor vehicle accidents. Pilon Fractures (PF) often involve soft-tissue damage, significant articular comminution and a high risk of post-traumatic arthritis despite meticulous reduction [1,2].

The incidence of wound complications following Open Reduction and Internal Fixation (ORIF) of high-energy ankle and pilon fractures ranges widely, with studies reporting rates reaching 19-50% [1,3-6]. Risk increases significantly in open injuries, with factors such as age over 65, low serum albumin, peripheral neuropathy, late surgical fixation of open fractures, diabetes, smoking and low surgical volume also contributing [7,8]. These complications often prolong hospital stay, necessitate additional treatment and can lead to poorer functional outcomes [7-9].

Historically, the management of PF has emphasized a staged approach, initially involving external fixation to allow soft tissue stabilization, followed by definitive Open Reduction and Internal Fixation (ORIF) once the edema subsides, to minimize wound complications [1,9]. Early single-stage ORIF, in contrast, has been classically linked to soft tissue breakdown and deep infection, prompting caution in acute treatment strategies [10-15] and suggesting that staged surgical fixation, with external fixation as a first stage, yielded better outcomes [16,17]. With the advancement of surgical techniques, a few recent studies found that, in selected patients, single-stage ORIF without external fixation for PF can achieve comparable soft tissue and overall outcomes to the two-stage protocol, with even less cost and better patient satisfaction [18-22]. In these studies, however, wound infection remained a major complication, reaching 6.25-13% [18-22].

At the same time, Vacuum-Assisted Closure (VAC) therapy is being increasingly used alongside other treatments in various surgical situations. Research shows it helps improve the growth of granulation tissue, lowers bacterial levels and speeds up wound healing after fixation [23-26]. Several studies have also found that using VAC therapy directly on incisions, especially in acute wound care, leads to positive results [25,26]. For pilon fractures, a few articles have explored how incisional VAC therapy can be useful, particularly when fixation is done in stages (i.e., using external fixation in the first stage and definitive ORIF in the second stage) [27,28]. External fixation is, however, often cumbersome, associated with decreased patient satisfaction and increased pin tract infections and muscle scarring [29]. The staged surgery itself may increase the cost and risks of the delay of definitive surgery in limited-resource and rural settings.

With the increasing evidence that favors single-stage ORIF in pilon fractures and the supporting outcomes of wound VAC in pilon fractures [18-22,27,28]. This study reviews the outcomes of combining these techniques of immediate postoperative incisional wound VAC after single-stage fixation of pilon fractures. We hypothesized that this combination may potentially reduce infection rates, enhance wound healing and shorten recovery times, addressing some of the most challenging aspects of managing pilon fractures.

Materials and Methods

Patients

After receiving approval from the Institutional Review Board (IRB), we conducted a retrospective review of all pilon fracture cases treated with single-stage Open Reduction and Internal Fixation (ORIF) [18-22]. We included patients with high-energy type C pilon fractures (3- or 4-part) who underwent ORIF surgery followed by postoperative incisional wound Vacuum-Assisted Closure (VAC). Patients who received external fixation or did not complete the standard follow-up care were excluded from the study. Patients' clinical and radiographic data were reviewed to extract the demographics, surgical notes, bone healing, functional outcomes and complications. Cases received single-stage ORIF based on the surgeon's decision, considering the evidence in the literature, when the local soft tissue condition showed mild, soft-tissue edema, preserved ankle wrinkle sign (Fig. 1,2) and in the absence of open fractures, fracture blisters or soft tissue degloving [18-22]. In our institution, cases with marked edema, fracture blisters, open wounds >1 cm (Gustilo-Anderson higher than grade I), local skin or soft tissue degloving, any history of associated acute or chronic soft tissue or bone infections, diabetes mellitus, current tobacco use and patients less than 18 or older than 65 years old typically receive staged fixation. Wound VAC was decided pre- or intraoperatively, at the surgeon's discretion, for cases with residual preoperative mild to moderate edema, mild contusions, cases with difficult wound closure intraoperatively and cases with a surgery duration of >120 minutes [30].

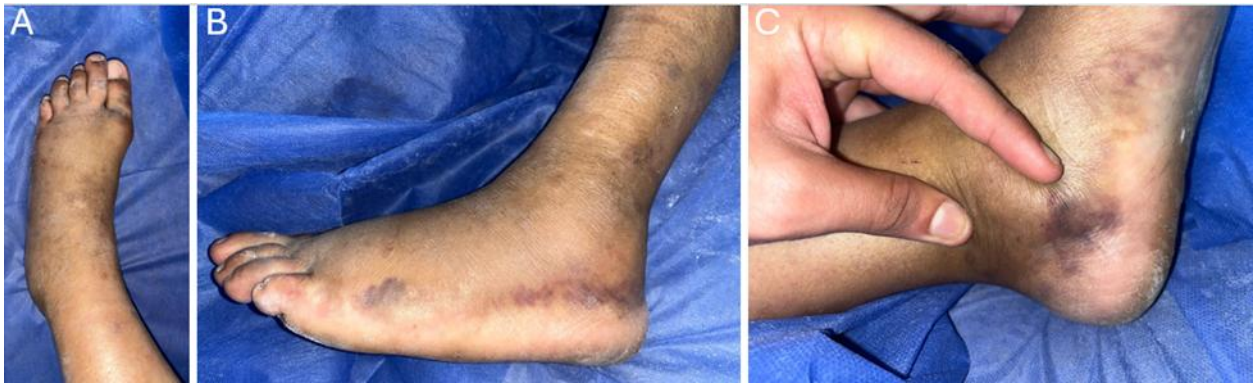

Figure 1: A-C: Clinical photo of a 37-year-old male who presented with a left comminuted pilon fracture 12 hours after the injury. Note the preserved wrinkle sign (C).

Figure 2: A-C: A 72-hour post-injury clinical photo of a 26-year-old male who presented with right comminuted pilon fracture. Note the preserved wrinkle sign (C).

Surgical Technique

All patients underwent Open Reduction and Internal Fixation (ORIF) performed via an anteromedial, anterolateral, universal anterior or posterolateral approach, depending on fracture morphology. Non-locking and locking plates and screws were used to stabilize the articular surface and metaphysis. None of the cases required bone grafting.

Intraoperatively, the goal was to achieve anatomical reduction of each fracture fragment and secure them using contoured plates (without relying on screw-only fixation). For three-part fractures, all fragments were addressed through a full-length approach: the Posterolateral (PL) approach for the fibula and PL fragment, followed by either the Anterolateral (AL) approach for the AL fragment or the Anteromedial (AM) approach for the AM fragment. In four-part fractures, we utilized a posterolateral approach for the fibula and PL fragment, an anterolateral approach for the AL fragment and a minimally invasive AM approach for the AM fragment. Alternatively, a universal anterior approach was employed to address both AL and AM fragments. Fracture fixation was performed in a systematic sequence progressing from posterior to anterior. The Posterolateral (PL) fragment was addressed first, followed by fibular fixation, then the Anterolateral (AL) fragment and finally the Anteromedial (AM) fragment [1,2,11,12]. Surgical exposure typically began with a PL approach in the prone position to facilitate reduction and fixation of the posterior elements and fibula. After completing the posterior work, the patient was repositioned to the supine position for anterior approaches, allowing access to the AL and AM fragments for definitive fixation.

All patients received immediate (within 8 hours) postoperative VAC therapy to manage soft tissue edema, help reduce wound complications and promote wound healing. The use of VAC therapy in this context was based on the surgeon's decision,

supported by its favorable outcomes in pilon fractures as well as its demonstrated ability to enhance local blood flow, reduce bacterial colonization and accelerate granulation tissue formation [23-28]. The VAC dressing was applied intraoperatively or within 8 hours after discharge from the operating room. The wound was covered with a non-adherent dressing, followed by a polyurethane foam dressing sealed with an occlusive film. The VAC system was connected and set to continuous suction at -125 mmHg. Dressings were changed every 72 hours until wound stability was achieved (typically, the wound is stable at 7-14 days). To prevent skin maceration, a one-day break from VAC therapy was scheduled after every three days of continuous use.

Postoperative Care and Follow-Up Protocol

All patients were instructed to remain non-weight-bearing for 8-12 weeks, with progressive weight-bearing initiated only after radiographic evidence of fracture healing. Early ankle range-of-motion exercises were encouraged to minimize stiffness and promote functional recovery. Anti-deep venous thrombosis prophylaxis was utilized in all patients in the form of oral anticoagulants.

Typical clinical follow-up assessments were performed at 2, 6 and 12 weeks and then scheduled at 6 and 12 months postoperatively to evaluate wound healing, radiographic outcomes, ankle range of motion and overall functional outcomes. Radiographic evaluations were obtained at each visit to monitor fracture alignment, hardware position and progression toward union. Outcome measures focused on bone healing and complication rates, with specific documentation of any infection, wound dehiscence, hardware irritation, chronic pain, hardware failure, malunion or nonunion.

Results

Eleven patients fit the study selection criteria and were included in this study. Patients were 9 males and 2 females with a mean age of 43 years (range, 30-62 years) and a mean body mass index of 28 at the time of presentation. All patients presented within 24 hours of the injury after suffering pilon fractures after motor vehicle accidents (7 cases) or falling from height (4 cases) and all were managed in the emergency setting with closed reduction and slab formation, with instructions for limb elevation, ice, and anti-edema medications. One patient had associated ipsilateral multiple metatarsal fractures and foot compartment syndrome and underwent immediate foot fasciotomy with K-wire fixation of the metatarsals and closed reduction of the pilon fracture in the first stage, followed by second-stage fixation of the pilon fractures 2 weeks later.

Surgeries were performed at a mean of 12 days (range 3-20) after ensuring favorable soft tissue conditions and preserved ankle wrinkle sign. Non-locking plates (Fig. 3, 4) were mostly utilized and fibular fixation was performed in the same setting as tibial fixation. The surgical approach depended on the fracture configuration and all patients received at least two surgical approaches. Average surgical duration was 160 minutes and the incisional wound VAC was utilized in all cases for an average of 15 days postoperatively (range 7-40).

The average follow-up for all cases was 17 months (range: 9-31). All cases achieved fracture union, noticed radiographically at a mean of 4.5 months. One patient (9.1%, the patient who received fasciotomy for the foot) developed a deep wound infection, successfully treated with three sessions of surgical debridement, along with antibiotics and VAC therapy, without hardware removal. No cases of implant failure, malunion or nonunion were observed. At the last clinical visit, the mean ankle plantarflexion was 35 degrees (range, 25-40) and the mean dorsiflexion was 8 degrees (5-15).

Figure 3: Case presentation. A 26-year-old male presented with a right comminuted pilon fracture of 6 hours duration. A, B) 3D reconstruction ankle CT scan at presentation; C, D) Immediate postoperative plain radiographs after ORIF through a universal anterior and posterolateral approach. Performed 2 weeks after the presentation. The VAC device was applied over the wound intraoperatively; E, F) 1-day; G) 10-day; H-J) 2-month postoperative clinical photos showing the wound condition. K-P) 4-month postoperative radiographs and clinical photos showing fracture healing, wound healing and patient weight bearing on the affected limb.

Figure 4: (A-F): Clinical presentation photos, plain radiographs and CT scan of a 41-year-old female who presented with comminuted pilon and distal fibular fractures; G, H) Immediate postoperative radiographs after surgical fixation, using the posterolateral and anteromedial approaches, were performed 2 weeks after presentation; I, J) 1-week, K, L) 2-week; M, N) 3-week post-surgery clinical photos showing progressive wound healing on the VAC therapy; O, P) Six-week postoperative radiographs showing progressive fracture healing. At this stage, progressive, assisted toe touch weight-bearing was allowed.

Discussion

Managing pilon fractures remains a clinical challenge due to the high risk of wound complications and delayed healing. Our findings suggest that incisional wound VAC therapy, when applied after single-stage fixation in patients with pilon fractures, may offer significant clinical benefits. In this series of 11 patients, all fractures healed after a mean follow-up of 17 months, with only one patient who also experienced compartment syndrome of the foot-requiring repeated wound debridement due to a deep infection.

Incisional negative pressure wound therapy (iNPWT), often referred to as a wound VAC, is designed for closed surgical incisions at high risk of complications. The technique involves placing a foam or gauze dressing over the sutured incision, sealing it with an adhesive film and applying controlled suction, typically around -125 mmHg. This negative pressure helps remove excess fluid, reduce swelling, improve local blood flow and stabilize the incision, which collectively lowers the chances of hematoma, seroma and wound breakdown [23-26]. Clinical studies in orthopedic and other high-risk surgeries have shown that iNPWT can significantly reduce surgical-site infections and wound dehiscence compared to standard dressings, while also supporting faster recovery and better scar quality [31,32].

iNPWT has gained attention in managing pilon fractures due to their high risk of complications involving soft tissues. In the two-stage protocol described by Wang, et al., patients with type C pilon fractures first underwent debridement and reduction with external fixation, followed by internal fixation guided by vacuum sealing drainage applied over the incision between stages [27]. This approach resulted in effective control of wound exudate, reduced tension across the surgical site and facilitated early soft-tissue recovery without skin necrosis or infections [27]. He, et al., evaluated a strategy focusing on "soft tissue control" during operative treatment of complex pilon fractures. They combined careful timing of internal fixation with adjunctive soft-tissue management, which included negative-pressure dressings to protect closed incisions. Their cohort demonstrated low rates of wound dehiscence and superficial infections (only 1/36 cases, 2.8%) [28].

A broader perspective is provided by a 2025 systematic review and meta-analysis encompassing closed incisions in orthopedic trauma, including pilon and tibial fractures. Incorporating data from 3,994 patients, the analysis confirmed that iNPWT significantly lowered rates of deep surgical-site infection (Odds Ratio "OR" 0.60), superficial infection (OR 0.34) and wound dehiscence (OR 0.41), while also reducing hospital length of stay by approximately 0.9 days compared to traditional dressings. These findings support the favorable outcomes observed in pilon-specific studies and highlight iNPWT's role in minimizing post-operative complications and promoting more efficient recovery [32].

In the previous studies, however, surgeries were mostly performed as a 2-stage setting, utilizing external fixation in the first stage. Although external fixation is commonly employed as the first stage in the gold standard, staged surgical management of pilon fractures, it brings its own set of drawbacks. Foremost among these is the very high risk of pin tract infections, which, in severe instances, may progress to osteomyelitis or septic arthritis, often necessitating additional antibiotics, surgeries or even premature fixator removal. Patients frequently report discomfort, impaired mobility and noticeable scarring around the pin sites, all of which negatively impact quality of life during the interim period before definitive internal fixation. Furthermore, in settings with limited resources, such as rural hospitals, any delay in transitioning to Open Reduction and Internal Fixation (ORIF) exacerbates these complications, heightening both patient morbidity and overall healthcare burden [29,33-35]. Importantly, adding a separate definitive ORIF procedure in a staged protocol inevitably escalates surgical and hospital-related costs, from increased anesthesia time to prolonged inpatient stays. Not only does this approach consume more resources, but it also extends recovery time and can delay a patient's return to daily activities or work and hence the efforts for achieving comparable results utilizing one definite surgery are always worthy of research [18-21,36,37]. Notably, a 2025 short-term outcome trial comparing two-stage (external fixation followed by ORIF) versus selective single-stage primary ORIF for pilon fractures found no significant differences in infection rates or fracture healing outcomes, though hospital stays were noticeably longer in the staged group [36]. These findings suggest that, in selected patients with favorable soft-tissue conditions (e.g., low-level Tscherne grades), a primary ORIF may achieve equivalent surgical outcomes at lower overall cost and morbidity [36,37].

In our study, all fractures achieved union and only the patient with foot compartment syndrome required surgical revision. While VAC therapy has shown success after fasciotomy any combined local soft tissue injury from compartment syndrome and high-energy pilon fractures may complicate outcomes [38,39]. In our infection case, it remains unclear whether the technique contributed to or helped manage the complication, as the hardware stayed in place and VAC therapy continued through three debridements. It may be prudent, however, to avoid single-stage ORIF combined with incisional VAC therapy in the cases associated with nearby compartment syndrome, high-grade open fractures or significant bone or soft-tissue loss. In such scenarios, the gold standard techniques, such as staged fixation with or without the Masquelet method, remain preferable [40]. Excluding the compartment syndrome case, no infections occurred in the remaining patients, while the overall infection rate was 9.1% across the cohort.

The limitations of this study warrant careful interpretation of its findings. Foremost among these is the small sample size, which inherently restricts the statistical power and generalizability of the results. While the study aimed to review the feasibility of the technique in a limited cohort, such numbers make it difficult to draw robust conclusions. Another significant limitation lies in its non-comparative design. Without a control group, the evidence presented remains observational, increasing susceptibility to selection bias and confounding factors. Consequently, establishing a definitive causal link between the surgical approach and the absence of postoperative infection is challenging. Additional variables such as patient comorbidities, soft-tissue conditions, surgical timing and duration and perioperative care could have influenced outcomes. The utilization of VAC therapy itself adds additional costs and limits patient comfort, and the costs of VAC therapy versus staged fixation were not compared. To strengthen the evidence base, future research should employ larger, randomized controlled prospective studies with standardized protocols and long-term follow-up.

Conclusion

Single-stage surgical fixation and immediate wound VAC therapy for pilon fractures may be a viable technique in well-selected patients who have no extensive soft tissue compromise. The presence of a high-grade open fracture or associated extensive soft tissue damage warrants the use of the gold standard staged fixation. Larger studies are required to elicit stronger evidence.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement

Not applicable.

Ethical Statement

An Institutional Review Board approval was obtained for this research (FMASU IRB R23/2026].

Informed Consent Statement

Informed consent was taken for this study.

Authors' Contributions

All authors contributed equally to this paper.

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