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Surgical fixation of pilon injuries: a comparison of the anterolateral and posterolateral approach

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Abstract

Purpose This study looks to compare patient outcomes in those with pilon fractures fixed with the anterolateral approach versus those with the posterolateral approach.

Methods 135 patient charts of those with surgically treated pilon fractures over a 7-year period were retrospectively reviewed, recording demographic information, fracture description, surgical intervention timeline, operative outcomes, patient outcomes, and complication rates.

Results Of the 44 included patients (32 anterolateral and 12 posterolateral), most were older than 40 years of age (65.9%) and male (63.6%). There was no difference seen between anterolateral approach and posterolateral approach tourniquet times ($p=0.80$), operating room time ($p=0.40$), or estimated blood loss ($p=0.73$). There was also no reported difference in decrease in Numerical Rating Scale pain scores ($p=0.38$), FOTO (Focus on Therapeutic Outcomes) percent increase ($p=0.13$), active flexion–extension axis range of motion ($p=0.35$), or inversion–eversion axis ($p=0.25$) range of motion after an anterolateral approach versus a posterolateral approach. Finally, statistically similar complication rates ($p=0.75$) were seen between anterolateral and posterolateral approaches, but patients who underwent a posterolateral approach surgical fixation were trending towards significantly using more post-operative outpatient opioid medications for pain control compared to those who underwent surgical fixation with an anterolateral approach ($p=0.09$).

Conclusions Pilon injuries that lend themselves to anterolateral fixation have similar outcomes peri-operatively and post-operatively compared to injuries lending to posterolateral fixation. Both approaches can be used as dictated by the injury not fearing poorer outcomes or increased complication rates. However, surgeons must be wary of high complication rates associated with all pilon injury patterns.

Level of evidence Therapeutic Level IV.

Keywords Pilon · Distal · Tibia · Intra-articular · Anterolateral · Posterolateral

Introduction

While relatively uncommon, the complicated nature of intra-articular distal tibia fractures pushes surgeons to continually explore surgical techniques that lead to improved outcomes. First described in 1911 by Destot [1] as a "pilon fracture" and later as a tibial "plafond fracture" by Bonin in 1950 [2], the devastating nature and the many long-term complications [3] associated with these fractures require well-planned and executed surgical fixation along with continued post-operative rehabilitation and monitoring. Often classified by the Ruedi–Allgower classification based on displacement and comminution [4] and the AO/OTA classification (AO/OTA 43), these fractures are said to result from one of the two distinct mechanisms of injury.

Pilon fractures secondary to rotational forces are associated with a spiral fracture line with minimal to moderate displacement of large articular fragments, minimal comminution, and minimal soft-tissue injury. In contrast, a high-energy trauma causes axial compression-type pilon

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fractures with fracture location based on flexion angle of ankle at time of injury along with increased comminution, soft-tissue injury, and articular cartilage damage [3, 5]. The most common fracture patterns in these injuries are axial failures of the tibia with an intact fibula, varus angulation of the tibia with tension failure laterally and compression medially, and valgus angulation with compression laterally [6]. Along with a thorough workup for other injuries, especially spinal injuries in high-energy axial force traumas [7], a complete inspection for soft-tissue damage must be done. It is the fracture pattern, soft tissue, compromise, as well as the presence of other injuries that determines what surgical fixation method is initially used [8].

In hopes of anatomically restoring the articular surface and stabilizing the joint to restore motion and functional recovery [9, 10], surgeons have turned to operative intervention over non-operative treatment in a majority of cases [11]. In the presence of extensive soft-tissue injury, vascular injury, or polytrauma, delaying definite fixation [12–14], initially using external fixation and converting to internal fixation once soft-tissue swelling and inflammation has decreased, has yielded positive outcomes. The Ilizarov external fixator has also shown comparable patient outcomes in treating these fractures [15]. When internal fixation, with or without bone graft, is appropriate, the surgical approach used is not only dependent on location of soft-tissue injury (over incision sites and hardware placement) and comminution pattern but also surgeon preference and comfort level. Currently, both medial and lateral approaches exist, with surgeons utilizing either or a combined approach as the soft-tissue injury and comminution pattern dictates [16, 17]. Pilon fractures with medial soft-tissue injury and valgus deformity fracture patterns with lateral comminution require lateral approaches [18].

In the treatment of pilon fractures, post-operative complications, especially wound complications rates which have been reported as high as 68% overall [19, 20], that exist when medial or lateral approaches are utilized. Multiple studies have explored different lateral injuries fixed with lateral approaches [21, 22], reporting complication rates comparable to medial injuries [23, 24], but no study has performed a direct comparison of different pilon injuries surgically fixed by anterolateral and posterolateral approaches. Studies have also noted high complication rates and poor outcomes after posterior fixation of pilon injuries, but the question of whether these complication rates are due to the injury itself or the surgical approach used to fix these injuries remains. This study provides a direct comparison of pilon injuries that lend to anterolateral fixation versus injuries lending themselves to posterolateral fixation, comparing patient outcomes and complication rates to see if there is truly a difference between different pilon injuries that lend themselves to both types of lateral fixation.

Materials and methods

Approval of this retrospective chart review was given by our hospital's Institutional Review Board (IRB). Between the years of 2010 and 2017, 135 patient charts of those with surgically treated pilon fractures within our health network were reviewed. The authors considered a pilon fracture (AO/OTA Classification 43) [25] any intra-articular distal tibia fracture, with or without fibula involvement, that was not otherwise considered solely a bimalleolar or trimalleolar fracture. Every patient between the ages of 18–89 who underwent surgical intervention utilizing a single anterolateral or posterolateral incision for pilon fixation (as well as the fibula component if required) with a minimum of 12 month follow-up was included in this study. In each case, a standard anterolateral approach paralleling the fourth metatarsal and the anterior border of the tibia and fibula [26] or a standard posterolateral approach between the lateral border of the Achilles tendon and the posterolateral border of the fibula [6] was utilized.

For each patient, demographic information, fracture description, surgical intervention timeline, operative outcomes, patient outcomes, and complication rates were recorded. Operative outcomes included tourniquet time, operating room time, and estimated blood loss, while recorded patient outcomes included difference in numerical rating system (NRS) pain scores, difference in Focus on Therapeutic Outcome (FOTO) scores, range of motion, and post-operative opioid medication usage for pain control. Data were analyzed using simple descriptive statistics, Mann–Whitney rank sums test, and Chi-squared testing as appropriate for statistical comparison due to the high standard deviation of our outcomes relative to the means (IBM SPSS Version 23 Statistics for Windows, Armonk, NY: IBM Corp). For all analyses, $p \leq 0.05$ denotes statistical significance. No direct human or animal contact or treatment was involved in this study.

Results

Overall, 44 patients (average follow-up of 3.71 years) with pilon fractures surgically treated by 10 orthopedic surgeons using either an anterolateral or posterolateral approach for open reduction internal fixation were included in our study. Thirty-two (72.7%) pilon fractures were operatively fixed using an anterolateral approach and 12 (27.3%) fractures with a posterolateral approach. A majority of our sample population was older than 40 years of age ($n = 29$, 65.9%) and male ($n = 28$, 63.6%) (Table 1). Overall, there were 2 (4.5%) AO/OTA 43A injuries, 21

Table 1 Demographic breakdown of sample population by age, gender, and surgical approach used for definitive operative fixation

	Age					Gender		Total
	≤ 30 years	30 years-39 years	40–49 years	50–59 years	≥ 60 years	Male	Female	
Anterolateral approach	6 (13.6%)	6 (13.6%)	8 (18.2%)	6 (13.6%)	6 (13.6%)	22 (50.0%)	10 (22.7%)	32 (72.7%)
Posterolateral approach	2 (4.5%)	1 (2.3%)	2 (4.5%)	3 (6.8%)	4 (9.1%)	6 (13.6%)	6 (13.6%)	12 (27.3%)
Total	8 (18.2%)	7 (15.9%)	10 (22.7%)	9 (20.4%)	10 (22.7%)	28 (63.6%)	16 (36.4%)	44 (100%)

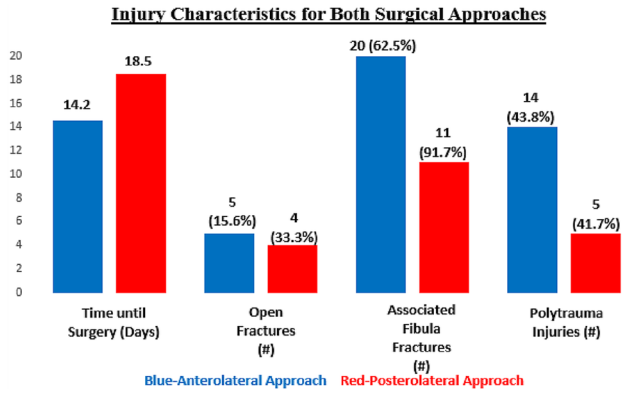

Fig. 1 Injury characteristics for both surgical approaches. Days from injury to surgery day, number of open fractures, number of injuries with associated fibula fractures, and number of polytrauma injuries for each surgical approach. *MVC* Motor Vehicle Crash

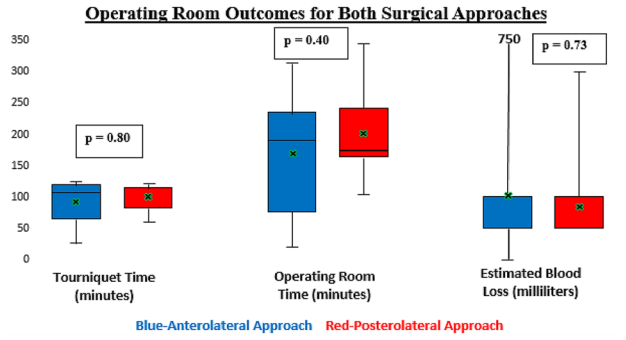

Fig. 2 Operating room measures for both surgical approaches. Tourniquet time, operating room time, and estimated blood loss are reported for both the anterolateral and posterolateral approaches. *X* = average

(47.7%) AO/OTA 43B injuries, and 21 (47.7%) AO/OTA 43C injuries. Among patients treated with an anterolateral approach, 2 patient had AO/OTA 43A injuries, 16 had AO/OTA 43B injuries, and 14 had AO/OTA 43C injuries. Among patients treated with a posterolateral approach, 5 had AO/OTA 43B injuries and 7 had AO/OTA 43C injuries. Twenty-four (55.8%) patients presented with a pilon fracture after a fall (18 treated with an anterolateral approach and 6 with a posterolateral approach). Sixteen (36.4%) patients presented after a motor vehicle accident (12 treated with an anterolateral approach and 4 with a posterolateral approach).

Thirty-five (79.5%) of our patients had closed injuries, with 29 being treated with an anterolateral approach and 6 with a posterolateral approach. Nine (20.5%) patients had open injuries, with 5 being treated with an anterolateral approach and 4 with a posterolateral approach. Two of our patients were diagnosed with ipsilateral lower extremity compartment syndrome in addition to their pilon fracture that required surgical intervention (both were in patients treated with an anterolateral approach). Additionally, 19 (43.2%) patients also presented after a poly-traumatic injury, including 11 (25.0%) patients who suffered ipsilateral lower extremity fractures (Fig. 1).

Patients who were treated with an anterolateral approach (average = 14 days) had a statistically similar wait time compared to patients who were treated with a posterolateral approach (average = 18.5 days) ($p = 0.56$). Overall, 24 (54.5%) patients were initially stabilized with external fixation before definite treatment (16 patients were eventually treated with an anterolateral approach and 8 with a posterolateral approach). One patient experienced an intra-operative complication, losing lower extremity pulses during open reduction internal fixation (ORIF) and fasciotomy for compartment syndrome, while no other patient had any intra-operative complications. Patients treated with an anterolateral approach had a statistically similar average post-operative hospital length of stay of 2.8 days compared to those treated with a posterolateral approach who had an average length of stay of 3.3 days ($p = 0.34$).

Our results showed that there was no statistical difference ($p = 0.80$) in tourniquet time used to control bleeding between an anterolateral approach (average = 94 min, $n = 16$) and a posterolateral approach (average = 98.6 min, $n = 5$). There was also no statistically significant difference in the operating room time (average = 164.2 min versus 204.3 min, $p = 0.40$) and estimated blood loss (average = 104.7 mL versus 84.2 mL, $p = 0.73$) between anterolateral and posterolateral approaches (Fig. 2).

Patients who were treated with an anterolateral approach reported a statistically similar decrease in Numerical Rating Scale (NRS) pain scores compared to those treated with a posterolateral approach (average = 2.8 versus 4.2, $p = 0.38$). Patients from both groups also had statistically similar

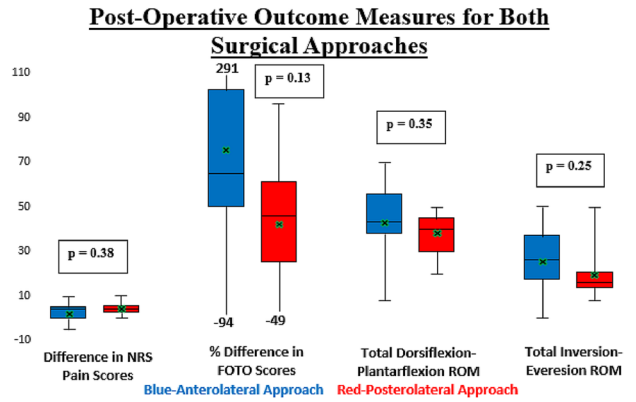

Fig. 3 Post-operative outcome measures for both surgical approaches. Difference in NRS (Numerical Rating System) pain scores, difference in FOTO (Focus on Therapeutic Outcomes) scores, Total ROM (Range of Motion) in dorsiflexion–plantarflexion axis, and total ROM in inversion–eversion axis. *X* = average

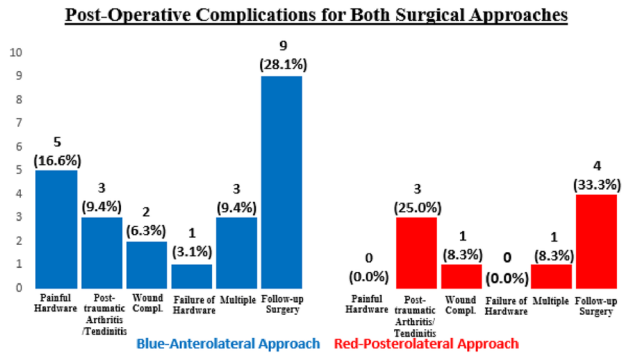

Fig. 4 Post-operative complications for both surgical approaches. Painful hardware, post-traumatic arthritis, wound complications, failure of hardware, multiple complications, and follow-up surgery incidence reported for both surgical approaches. Using a Chi-squared test, there was no statistically significant difference found in complication rates between surgical approaches ($p = 0.75$)

percent change in FOTO (Focus on Therapeutic Outcomes) scores as recorded by physical therapists (average = 74% in 23 patients versus 38% in 7 patients, $p = 0.13$). At final follow-up, patients treated with an anterolateral approach has similar ankle active range of motion in the flexion axis (average = 42.2 degrees in 22 patients versus 37.7 degrees in 9 patients, $p = 0.35$) as well as the inversion–eversion axis (average = 25.8 degrees in 19 patients versus 20.3 degrees in 7 patients, $p = 0.25$) (Fig. 3). Using our state's online drug monitoring program, it was also noted that post-operative outpatient opioid usage was trending towards a significant difference ($p = 0.09$) between patients after an anterolateral approach (average = 6612.3 milimorphine equivalents) and a posterolateral approach (average = 6758.0 milimorphine equivalents).

Finally, there was no statistically significant difference in complication rates between those treated with an anterolateral approach versus a posterolateral approach ($p = 0.75$). Overall, 19 (43.2%) patients experienced post-operative complications. Nine of the complications were in 43B injuries and 10 in 43C injuries. Of the 14 (out of 32, 43.8%) patients with complications after an anterolateral approach, 5 complained of symptomatic hardware, 3 experienced eventual post-traumatic arthritis or tendinitis which was not treated operatively, 2 had wound complications, 1 experienced failure of hardware, and 3 had multiple complications (2 developed wound complications and symptomatic hardware and 1 developed symptomatic hardware and post-traumatic arthritis which was not operatively treated). Nine (28.1%) of these patients needed follow-up surgery. Of the 5 (out of 12, 41.7%) patients with complications after a posterolateral approach, 3 experienced wound complications, 1 developed post-traumatic arthritis which was treated with a tibiotalar fusion, and 1 patient had multiple complications (wound complication and failure of hardware). Four (33.3%) of these patients needed follow-up surgery (Fig. 4).

Discussion

The devastating nature of pilon injuries pushes surgeons to constantly search for improved surgical techniques that will help maximize bone healing to improve patient functional outcomes while also minimizing post-operative complications [19, 20, 27, 28]. Medial soft-tissue injury, wound complications, and more lateralized comminution patterns have directed many surgeons to utilize lateral approaches to the ankle for definite operative fixation. In comparing operative and patient outcomes after undergoing fracture fixation using an anterolateral approach versus a posterolateral approach, this study looks to see if one injury pattern lending to a specific fixation approach is riddled with worse outcomes compared to the other.

Our results showed that there is no significant difference in tourniquet time, operating room time, and estimate blood loss between the two surgical approaches. A tourniquet was not used for every patient, since it is dependent on injury pattern, vascular injury, polytrauma, and surgeon preference. Those utilizing an anterolateral approach must protect the superficial peroneal nerve proximally, the deep peroneal nerve, and the anterior tibial artery [26]. Surgeons utilizing the posterolateral approach must look to protect the superficial peroneal nerve proximally, the sural nerve distally, and the tibial nerve and posterior tibial vessels behind the flexor hallucis longus [6]. Damage to these structures intra-operatively can affect tourniquet usage, estimated blood loss, and post-operative functional improvement and complication rate. Included in operating

room time is the amount of intra-operative imaging used to achieve satisfactory reduction and optimal construct placement. Imaging is important in all fractures, AO/OTA 43A to 43C, to help achieve an anatomic reduction, especially at the articular surface [10], that can be hindered by comminution and soft-tissue structures. The amount of imaging taken depends on surgeon preference as well as difficulty and success of reduction and fixation.

Patients also reported similar functional outcomes, regardless of which surgical approach was used. While our results for post-operative flexion axis range of motion are similar to those numbers reported by Ketz et al. [23, 29], FOTO scores and inversion–eversion axis range of motion are not well reported in the literature. Still, the importance of restoring subtalar joint motion (inversion–eversion) has been well documented, aiding in tibiotalar joint contact restoration and ultimately ankle motion and functionality [30]. The lack of therapist and surgeon reporting of some of these outcomes, especially inversion–eversion axis range of motion, might also skew results from their true value.

Our results showed that patients who underwent surgical fixation with a posterolateral approach were trending towards using opioids at a higher rate than those with an anterolateral approach, a trend that might be due to the relatively more challenging nature of fixing posterior pilon fractures [31]. Furthermore, these averages would also change if polytrauma patients were not included in the analysis. While post-operative orthopedic pain has been reported as notoriously hard to control [32, 33], different methods of pain control, such as peri-operative blocks [34, 35] and multimodal analgesia [36, 37], have been studied as alternate methods to control pain.

One of the biggest concerns with pilon fractures in the post-operative course is complications, especially wound complications, that might require follow-up surgery and hinder biological and functional recovery. While both approaches did have statistically similar complication rates, both rates, as well our overall complication rate, continued to be high. These rates are comparable to the 54% McFerran et al. [38] and the 47% Bhattacharya et al. [22] already documented in the literature. However, the rate of wound complications, 18.2% overall and comparable among both cohorts, is lower than the 31% Bhattacharya et al. reported [22]. Our rates of post-traumatic arthritis are also lower than those listed in the literature [27, 28], but the incidence in our sample may likely increase to those rates already documented if followed for the next 20 years as Horisberger et al. did. Teeny et al. [39] reported the higher complication rates associated with higher severity of fractures, most probably affected by articular comminution patterns as well as degree of soft-tissue injury, a trend seen in our cohort as well (9 complications in 43B and 10 in 43C injuries).

The statistically similar operating room course, patient outcomes, and complication rates show that pilon injuries that lend to an anterolateral fixation can be treated just as successfully as injuries that lend to a posterolateral fixation. Understanding the anatomic location of the fracture utilizing the 4-column theory [40], and determining how many columns are involved, can help guide pre-operative planning of surgical approach and fixation strategies. The approach and fixation used is dictated by soft-tissue injury and fracture pattern, and these results reinforce that surgeons do not have to use approaches other than what is naturally dictated to fix these fractures. If there was a difference seen between cohorts, it must be considered whether the difference is due to the severity of injury, fracture pattern, or the actual surgical approach utilized, a consideration that must be given while analyzing the previous results as well [19–23, 41].

All fractures in this cohort were stabilized using distal tibia plates. However, many other methods of fixation exist, including minimally invasive osteosynthesis (MIO). MOI techniques, including external fixation or arthroscopic guided reduction with Kirschner wires, screws, and minimally invasive plates (MIPO) placed in bridging fashion for fixation, are helpful in injury patterns, where the surgeon is worried about further soft-tissue injury and periosteal stripping that can disrupt bloody supply to the fracture site in addition to what has been caused by the injury [42]. Many studies exist evaluating results and complications after MIPO, detailing its utility as a fixation option [43–45].

This study has a few weaknesses that should be discussed. First, our retrospective chart review only encompassed 44 patients. While this is a small sample size, the high energy and uncommon nature of pilon injuries make it hard for a study of this nature to gather large numbers. Furthermore, many of our hospital's pilon fractures were excluded due to the use of other surgical approaches or multiple incision approaches. Our sample population is predominantly male and older than 40 years of age, demographics that are representative of our suburban population but not necessary the global orthopedic population. Our patient population includes both isolated and poly-traumatic pilon injuries, even though operating room and functional outcome variables can be affected by other injuries. As with all chart reviews, outcome measurement is dependent on the accuracy of numbers reported as well as the rate at which these outcomes were reported. Finally, our patients did not have standardized outcome scores documented in their post-operative course. Future studies should focus on prospective evaluation of patients with pilon fractures over a longer period of time, reporting accurate operating room variables, patient functional outcomes, a standardized post-operative outcome score such as the American Orthopedic Foot and Ankle Score, and opioid use across multiple patient types and population areas.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval IRB approval was obtained both from the St. Luke's University Health Network IRB Committee and the Temple University School of Medicine IRB Committee. This article does not contain any studies with human participants or animals performed by any of the authors.

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