# What is the current understanding regarding the effect of duration of external fixation on infection and nonunion rates in lower extremity fractures?

Lauren Bertoy[1], Erik R. Nakken[1], Jaimo Ahn[1]
[1]University of Michigan, Ann Arbor, MI
bertoyla@med.umich.edu

**Disclosures:** Lauren Bertoy (N), Erik R. Nakken (N), Jaimo Ahn (N)

**INTRODUCTION:** External fixation has become the favored orthopaedic tool for damage control orthopaedics due to speed of application, reduced blood loss, and relative minimal invasiveness for staged treatment of fractures where there are soft tissue concerns. Pin site infections are a common complication of external fixator use, with incidence reported between 3-80% in the literature. Because pins provide a direct communication with the intramedullary cavity, pin site infections can result in devastating consequences such as osteomyelitis, loss of fixation, and loss of alignment. The optimum timing of conversion from external fixation to definitive internal fixation is still debated, and the decision to convert should consider overall patient stability, condition of soft tissues, possible need for further debridement, and risk of infection carried by longer indwelling external fixator time. However, the reported risk of infection varies widely across the literature, and thus it is difficult to accurately incorporate into clinical decision making. Our objective is to provide a concise reference for insights into external fixation and outcomes, infection, and nonunion.

**METHODS:** To identify studies reporting infection and nonunion rates after the use of external fixators as primary treatment for lower extremity fractures in adults patients, we searched PubMed and Embase for relevant terms including 'external fixation,' 'infection,' 'nonunion,' 'timing,' duration,' and 'conversion.' We excluded studies reporting on pelvic and upper extremity fractures, pediatric patients, animal models, use of external fixators for definitive treatment, use of external fixators for limb lengthening, and studies greater than 30 years old. Final literature included review of lower extremity external fixation with conversion to intramedullary or internal implantation in adult patients. Variables collected included fracture location, average duration of external fixation, percentage of open fractures, rates of pin site infection, superficial infection, deep infection, and nonunion. We used the MINORS tool for validity of observational research.

**RESULTS:** Our initial search yielded 974 publications for review, of which 69 were included for full text review. Of these, 22 articles met the remaining criteria and were included in our analysis. This generated a total of 1171 fractures including fractures of the femoral shaft, tibial plateau, tibial shaft, distal tibia, pilon, and calcaneus. An overview of the 22 studies showing the fracture type, duration of external fixation, and complications as reported by each study is shown in Table 1. The average duration of external fixation prior to conversion to internal fixation was 14.2 days. Open fractures constituted 49.1% of the analyzed fractures. Average rates of pin tract infection, superficial infection, and deep infection were 11.6%, 7.0%, and 6.2%, respectively. The average nonunion rate was 4.9%.

**DISCUSSION:** Duration of external fixation was not strongly correlated with infection or nonunion. Previous studies have reported that the risk of infection increases after external fixator indwelling time exceeds 22 days in closed fractures; a separate study reported that the risk of infection increases by 83% if external fixator duration exceeds 28 days. With the exception of two included studies, all studies reported an average duration of external fixation that was below either of these previously reported cutoffs. In our review, the average pin site infection rate of 11.6% is within the wide range of reported rates. This variability can be attributed to heterogenetiy and subjectivity in diagnosing pin site infection. The deep infection rate of 6.2% is comparable to previous studies. One limitation of our study is that duration of external fixation is confounded by other variables including fracture type, closed vs. open fracture, and overall physiologic stability of the patient. Additionally, infection and nonunion rates are affected by variables such as degree of soft tissue damage, length of hospital or ICU stay, and patient factors independent from external fixator indwelling time. Thus, it is difficult to isolate the effect of external fixation duration alone.

**SIGNIFICANCE/CLINICAL RELEVANCE**: Duration of external fixator application prior to definitive internal fixation does not appear to correlate with incidence of infection or nonunion. The decision to convert from external fixation to internal fixation should take into account external fixator indwelling time; however, this appears to be less important than factors such as overall physiologic stability of the patient and condition of soft tissues.

**Table 1:**

| Author | Year | Location of Fracture | N (fractures) | Avg EF duration (days) | % Open Fractures | % Pin Tract Infection | % Superficial Infection | % Deep Infection | % Nonunion |
|---|---|---|---|---|---|---|---|---|---|
| Harwood et al | 2006 | femoral shaft | 111 | 14.1 | 29.7 | - | 3.6 | 7.2 | - |
| Galvin et al | 2015 | femoral shaft | 125 | 6.9 | 0.0 | - | 0.8 | 1.6 | 1.6 |
| Nowotarski et al | 2000 | femoral shaft | 59 | 7.0 | 32.2 | 8.2 | - | 1.7 | 3.4 |
| Van den Bossch et al | 1995 | femoral shaft | 20 | 21.0 | 100.0 | 0.0 | - | 0.0 | - |
| Scalea et al | 2000 | femur | 43 | 4.0 | - | - | 7.0 | 7.0 | - |
| Parekh et al | 2008 | distal femur/proximal tibia | 52 | 5.0 | 67.3 | 1.9 | - | 15.4 | - |
| Mody et al | 2009 | femur/tibia | 58 | 9.0 | 87.9 | - | 22.4 | 17.2 | 13.8 |
| Matsumura et al | 2019 | femur/tibia | 63 | 12.4 | 100.0 | - | - | 4.8 | 4.8 |
| Salar et al | 2020 | femur/tibia | 80 | 18.3 | 31.3 | - | 10.0 | 18.8 | - |
| Santolini et al | 2023 | femur/tibia | 94 | 6.7 | 0.0 | - | 4.3 | 1.1 | 1.1 |
| Bilir et al | 2020 | femur/tibia | 34 | 11.8 | 100.0 | 70.6 | - | 5.9 | 20.6 |
| Barwar et al | 2020 | tibial plateau | 23 | 13.3 | 0.0 | - | - | 0.0 | 0.0 |
| Egol et al | 2005 | tibial plateau | 57 | 15.0 | 28.1 | - | - | 5.3 | 3.5 |
| Canton et al | 2020 | proximal tibia | 24 | 6.0 | 25.0 | - | - | 0.0 | 0.0 |
| Yokoyama et al | 2006 | tibia | 42 | 65.6 | 100.0 | 4.8 | 7.1 | 16.7 | - |
| Gill et al | 2016 | tibia | 84 | 12.0 | 100.0 | - | - | 7.1 | 4.8 |
| Cheyrou-Lagreze et al | 2022 | tibial shaft | 55 | 32.9 | 100.0 | - | 0.0 | 10.9 | - |
| Sohn et al | 2011 | distal tibia | 10 | 15.0 | 100.0 | - | 20.0 | 0.0 | - |
| Yuce et al | 2020 | distal tibia | 47 | 15.5 | 0.0 | - | 4.3 | 4.3 | - |
| Buyukkuscu et al | 2022 | ankle | 48 | 7.0 | 0.0 | 4.2 | - | - | - |
| Shu et al | 2021 | pilon | 32 | 8.3 | 0.0 | 3.1 | 4.2 | - | - |
| Farrell et al | 2015 | calcaneus | 10 | 4.8 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 |