Definitive Plates Overlapping Provisional External Fixator Pin Sites: Is the Infection Risk Increased?

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Objectives: The purpose of this study was to compare the infection risk when internal fixation plates either overlap or did not overlap previous external fixator pin sites in patients with bicondylar tibial plateau fractures and pilon fractures treated with a 2-staged protocol of acute spanning external fixation and later definitive internal fixation.

Design: Retrospective comparison study.

Setting: Two level I trauma centers.

Patients/Participants: A total of 85 OTA 41C bicondylar tibial plateau fractures and 97 OTA 43C pilon fractures treated between 2005 and 2010. Radiographs were evaluated to determine the positions of definitive plates in relation to external fixator pin sites and patients were grouped into an "overlapping" group and a "nonoverlapping" group.

Intervention: Fifty patients had overlapping pin sites and 132 did not.

Main Outcome Measure: Presence of a deep wound infection.

Results: Overall, 25 patients developed a deep wound infection. Of the 50 patients in the "overlapping" group, 12 (24%) developed a deep infection compared with 13 (10%) of the 132 patients in the "nonoverlapping" group ($P = 0.033$).

Conclusions: Placement of definitive plate fixation overlapping previous external fixator pin sites significantly increases the risk of deep infection in the 2-staged treatment of bicondylar tibial plateau and pilon fractures. Surgeons must make a conscious effort to place external fixator pins outside of future definitive fixation sites to reduce the overall incidence of deep wound infections. Additionally, consideration must be given to the relative benefit of a spanning external fixator in light of the potential for infection associated with their use.

Key Words: external fixator, internal fixation, infection risk, Tibial plateau, pilon

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Orthopaedic surgeons are constantly faced with the difficult task of treating high-energy extremity injuries. Of these, bicondylar tibial plateau fractures and pilon fractures have specific injury characteristics, commonly involving metaphyseal comminution, tenuous soft tissue envelopes and soft tissue injury, and articular surface damage, which create risks for complications and unsatisfactory results.[1,2] A staged protocol of spanning external fixation followed by definitive internal fixation is commonly used to avoid common associated complications.[3,4] This strategy is not without its own inherent risks, unique disadvantages, and potential complications.[5–7] Pin tract infections and superficial and deep infections can occur in up to 25% of cases.[8–10] Additionally, the presence of a pin site infection associated with a provisional external fixator may be a nidus for infection at the time of definitive fixation.[11,12]

Current practice by most orthopaedic surgeons is to avoid placement of external fixation pins within anticipated surgical incision sites to prevent potential deep infections after definitive fixation. However, with the recent popularity of less invasive or submuscular plate applications and the biomechanical advantage of long plates for metaphyseal fracture components, this overlap may be unavoidable. It remains unknown if there is an association between late infection and placement of definitive fixation in the vicinity of temporizing external fixation pin sites.[13] The purpose of the current study was to determine if there is an association between the proximity of provisional external fixation pin sites to definitive plate fixation and the development of deep infection in bicondylar tibial plateau and pilon fractures treated with a 2-staged operative protocol.

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PATIENTS AND METHODS

Patients who were treated for bicondylar tibial plateau fractures and complete articular pilon fractures at 2 level I trauma centers between 2005 and 2010 were identified from hospital records. Inclusion criteria were aged >18 years, OTA classification 41C and 43C fractures treated with 2-staged provisional external fixation followed by delayed open reduction internal fixation, and patients with follow-up available through radiographic healing. Patients were excluded if their injury was associated with compartment syndrome requiring fasciotomy or if they had follow-up of less than 3 months. All cases were reviewed to ensure that there was no evidence of active pin site infection at the time of conversion to definitive open reduction and internal fixation (ORIF) and those with pin site infections were excluded. The study was approved by the institutional review boards of our hospitals.

Hospital records and radiographs were reviewed on all patients to collect demographic data including gender, age, and medical history including smoking status, presence or absence of diabetes, and history of previous steroid use. Charts and radiographs were then reviewed for fracture specific data. This included date of injury, OTA classification, mechanism of injury, laterality, associated injuries, open fracture classification, and time from injury until external fixation. Definitive treatment data were then collected including time from external fixation until definitive fixation, type of definitive fixation, use of a tourniquet, and distance between definitive fixation and external fixation pin sites. Patients were then grouped into an "overlapping" group (Figs. 1, 2) and a "nonoverlapping" group.

Finally, follow-up data were collected. This included date of last follow-up visit, incidence of infection, incidence of other complications, evidence of fracture healing, and any additional treatments including both surgical intervention and antibiotic use after initial definitive fixation. Infections were classified as deep or superficial depending on their physical appearance and the treatment required for eradication of the infection. For the purposes of this study, any infection requiring surgical debridement was considered deep and was used as the primary outcome. Data were collected and analyzed via a Microsoft Excel Database (Microsoft Corp, Redmond, WA). Statistical analysis was performed using a 2-tailed Fisher exact test with a statistically significant result corresponding to a P value <0.05.

Eighty-five OTA 41C bicondylar tibial plateau fractures and 97 OTA 43C pilon fractures were included in the study.[14] Patients with tibial plateau fractures were older than those with pilon fractures (49 vs. 41, $P < 0.001$; Table 1) and significantly more patients sustained a fall in the pilon group ($P < 0.001$; Table 1). The mean duration of follow-up was 12.5 months and complete radiographic information was available on all patients including preoperative and immediate postoperative radiographs. Patients were grouped into "overlapping" and "nonoverlapping" groups as described above. Demographic data for both groups can be seen in Tables 2 and 3. There were no statistically significant differences between the demographic data of the 2 groups.

The average time from injury to external fixator placement was 0.5 days (range: 0–6 days), and this did not differ between the overlap and nonoverlap groups. The

FIGURE 1. Case example of a patient who sustained a distal tibial fracture from a fall. There was articular comminution and significant swelling, so he was treated with provisional external fixation for 18 days. Given the extension of metadiaphyseal comminution, he was treated with a long bridging plate that overlapped the 2 external fixation pin sites.

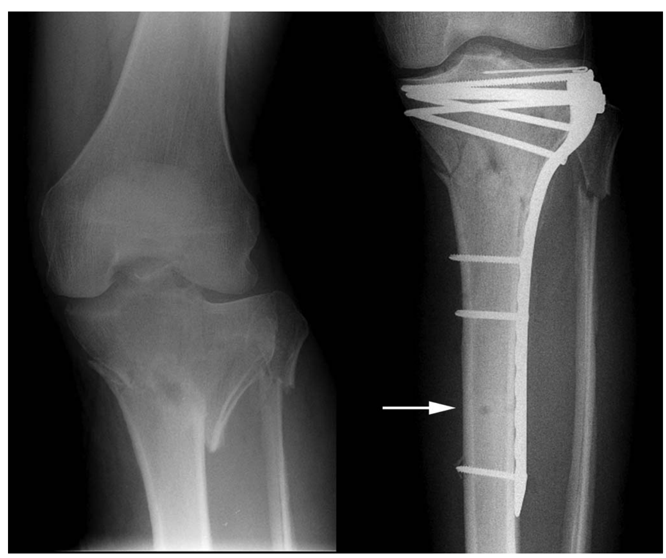

FIGURE 2. Case example of a 37-year-old male who was in a motorcycle accident and sustained a closed bicondylar fracture of his tibial plateau. Due to the substantial soft tissue injury, he was treated with initial closed reduction and spanning external fixation. His definitive plate fixation construct overlapped the most proximal tibial external fixation pin site. He subsequently developed a deep infection.

TABLE 1. Overall Patient Demographics

	Tibial Plateau Fractures (85)	Pilon Fractures (97)	*P*
Mean age at time of injury	49 (23–77)	41 (18–68)	**<0.001** (Student *t* test)
Male	56	74	0.14 (Fisher exact test)
Smoker	32	39	0.76 (Fisher exact test)
Injury mechanism	1 (crush)	3 (crush)	**<0.001** (χ^2 goodness of fit test)
	38 (fall)	60 (fall)	
	12 (MVC)	22 (MVC)	
	15 (MCC)	7 (MCC)	
	9 (ped struck)	1 (ped struck)	
	10 (other)	4 (other)	

Bold indicates results that are statistically significant.
MCC, motor cycle collision; MVC, motor vehicle collision.

average time from external fixation to ORIF was 20 days (range: 2–156 days), which was similar between the 2 groups. All external fixator pins were bicortical and inserted using a predrilling technique, and all external fixation procedures were performed at the institution where the definitive procedure was performed.

At the time of definitive ORIF, the skin condition was deemed acceptable by the attending surgeon based on the reappearance of skin wrinkling and resolution and reepithelialization of fracture blisters. Surgical procedures were performed by junior or senior level residents under the direct supervision of the attending faculty, although the experience level of the primary surgeon was not acquired as a specific data point. Specific surgical approaches for definitive treatment of each injury were not collected, but no single incision midline approaches were used for the tibial plateau fractures.

RESULTS

Overall, 27% of patients (50/182) had "overlapping" plates and pin sites and 132 did not. Overlap occurred in 33% (40/120) of OTA C3 fractures, 22% (8/36) of OTA C2 fractures, and 8% (2/26) of OTA C1 fractures. None of these were significantly different ($P > 0.05$). Twenty-five patients developed a deep infection: 12 (24%) in the "overlapping" group and 13 (10%) in the "nonoverlapping" group. In the nonoverlapping group, the average pin site plate distance was 74 mm (range: 6–199 mm; SD: 47.9 mm). Using a 2-tailed Fisher exact test, the difference in rates of deep infection in the "overlapping" and "nonoverlapping" groups was found to be significant ($P = 0.033$). Of the 25 patients who developed a deep infection, 14 were in the pilon group and 11 were in the tibial plateau group.

Multiple other factors that may be associated with development of a deep infection were analyzed between those that developed a deep infection and those that did not. The average days in the external fixator for each group were compared using an unpaired Student *t* test and found to be nonsignificant. Smoking status, diabetes status, steroid use, presence of open fracture, and tourniquet use were all compared using 2-tailed Fisher exact tests. Of these, only smoking was significantly associated with development of a deep infection (60% vs. 36%, $P = 0.03$; Table 4).

DISCUSSION

Management and treatment protocols for high-energy tibial plateau and pilon fractures continue to change as understanding of fracture care, including biomechanics of fixation and soft tissue management, evolves. These fractures have historically been prone to high rates of complications including infection, malunion, loss of fixation, soft tissue loss, posttraumatic arthritis, and painful hardware.[1,2] To effectively manage the soft tissue injury, modern treatment of these

TABLE 2. Pilon Demographic Data

	Overlapping (17)	Nonoverlapping (80)	*P* (Fisher Exact Test)
Smoker	8	31	0.59
DM	2	6	0.62
Steroid use	0	3	1.00
Open fracture	5	21	0.77

Bold indicates results that are statistically significant.
DM, diabetes mellitus.

TABLE 3. Tibial Plateau Demographic Data

	Overlapping (33)	Nonoverlapping (52)	*P* (Fisher Exact Test)
Smoker	16	16	0.11
DM	8	6	0.14
Steroid use	0	1	1.00
Open fracture	6	5	0.32

Bold indicates results that are statistically significant.
DM, diabetes mellitus.

TABLE 4. Other Risk Factors Associated With Development of a Deep Infection

	Infection (25)	No Infection (156)	*P* (Fisher Exact Test)
Smoker, n (%)	**15 (60)**	**56 (36)**	**0.03**
DM, n (%)	5 (20)	17 (11)	0.20
Steroid use	0	5 (3)	1.00
Average days in ex-fix, n (range)	20 (5–55)	20 (2–156)	0.94 (Student t test)
Open, n (%)	8 (32)	29 (19)	0.18
Tourniquet, n (%)	2 (8)	26 (17)	0.37

Bold indicates results that are statistically significant.
DM, diabetes mellitus.

fractures has focused on immediate provisional external fixation before definitive management by open reduction internal fixation. Several disadvantages are inherent in provisional external fixation, including the eventual conversion from external fixation to internal implants, which may lead to overlap between the pin site and the plate. In this study of high-energy tibial plateau and pilon fractures treated in a staged fashion, we found an association between pin site plate overlap and the development of deep infection.

In the current era of increasing subspecialty training, many of these high-energy fractures are acutely managed via an external fixator by one surgeon and referred to tertiary care centers for definitive fixation by another surgeon. In these situations, the original surgeon may not be aware of the eventual operative plan. Although it is current practice to place external fixator pins remote from planned definitive incisions, there is little evidence available regarding the risk of infection relative to external fixator pin position. Concurrently, the recent increased use of submuscular less invasive implant insertion has led to an increasing rate of overlap between external fixator pin sites and definitive fixation that may be unavoidable. We chose to study the risk of pin site plate overlap in fractures around the proximal and distal tibia given the increased risk of infection due to the subcutaneous nature of the bone. Nowotarski et al[15] found a low (1.7%) infection rate when converting femoral shaft external fixation to definitive intramedullary nailing within several weeks, which was likely due to the robust muscular envelope and redundant blood supply.

Recently, Laible et al[16] reviewed 79 high-energy tibial plateau fractures treated with provisional external fixation. These authors reported that 6 patients (8%) subsequently developed a deep infection. Of these, 2 had pin site plate overlap and 4 did not, leading the authors to conclude that there was no correlation between pin site overlap and infection. In the present study, a larger cohort of patients was evaluated, with nearly twice the number of infections (11 vs. 6). In the tibial plateau fractures in our series, 7 of the 11 infections had pin site plate overlap, and we found a statistically significant correlation between pin site plate overlap and infection when analyzing a large series of both pilon and tibial plateau fractures. This difference between these studies may have been due to lack of adequate power to determine a correlation in the study by Laible et al, given the lower absolute number of patients and infections in that study.

We found a clinically and statistically significant increase in the rate of deep infection for pilon and tibial plateau fractures treated with definitive fixation overlap of a previous external fixator pin site, despite the absence of active pin site infections at the time of plate fixation. Infection rates for the nonoverlapping groups, 11% and 8%, respectively, for pilon and tibial plateau fractures, are similar to previously published rates.[5–7,11] Conversely, infection rates in the overlapping groups were far higher, 30% and 21%, respectively, than previous reports. Deep wound infections are a multifactorial process. We attempted to correct for other variables by collecting demographic data that is pertinent to increased infection rates such as smoking status, a diagnosis of diabetes mellitus, steroid use, and open fractures. Although we found that smoking was associated with deep infection, as has been demonstrated previously, we also found that pin site plate overlap was an independent risk factor for deep infection as well.

The inherent limitations of our study relate mostly to the retrospective nature of the study design. It is possible that chart review did not adequately capture all pin site infections or subsequent surgical wound infections. However, we used return to the operating room for infection as the outcome for the presence of a deep infection, and all patients had at least 3 months of follow-up to ensure that deep infection did not develop. Development of a postoperative wound infection is influenced by many factors. Of these other factors that may predispose to infection, smoking was significantly more prevalent in those patients who developed a deep infection, which has been demonstrated previously.[17–20] Additional other factors, such as fibular fixation, surgical approach, and the extent of fracture comminution, may also have contributed to the development of infection, and these were not analyzed in this study. The Gustilo–Anderson open fracture type was not available for all patients, and this distribution between groups may have influenced the overall infection rate. Despite this, plate pin site overlap was found to be an independent predictor of deep infection. Additionally, although not statistically significant, there were more overlapping constructs in the higher OTA fracture grades (e.g., C3 vs. C1). This may indicate higher energy injuries in the overlapping group, which may partially account for the higher infection rate. Future prospective studies with larger numbers of patients might more effectively limit any confounding variables and bias and increase the power.

In conclusion, our data have shown that placement of definitive plate fixation overlapping previous external fixator pin sites significantly increases the risk of deep infection in the 2-staged treatment of bicondylar tibial plateau and pilon fractures. Surgeons should make a conscious effort to place external fixator pins outside of future definitive fixation sites to reduce the overall incidence of deep wound infections, particularly in patients with risk factors for infection, such as smoking and severe soft tissue injuries. Although longer plates may provide incremental increases in stability, plate length must be weighed against the risk of infection with overlapping of a previous external fixation pin site. In general, consideration must be given to the relative benefit of a spanning external fixator in light of the potential for infection associated with their use. Additionally, patients who are treated with external fixation at outside institutions and referred for definitive treatment should be evaluated for pin site position relative to joint capsules, planned incisions, and definitive implant overlap and potentially revised when appropriate.

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