Infection After Spanning External Fixation for High-Energy Tibial Plateau Fractures: Is Pin Site–Plate Overlap a Problem?

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Objectives: The purpose of this study was to determine whether overlap between temporary external fixator pins and definitive plate fixation correlates with infection in high-energy tibial plateau fractures.

Design: Retrospective chart and radiographic review.

Setting: Academic medical center.

Patients: Seventy-nine patients with unilateral high-energy tibial plateau fractures formed the basis of this report.

Intervention: Placement of knee-spanning external fixation followed by delayed internal fixation for high-energy tibial plateau fractures treated at our institution between 2000 and 2008.

Methods: Demographic patient information was reviewed. Radiographs were reviewed to assess for the presence of overlap between the temporary external fixator pins and the definitive plate fixation. Fisher exact and *t* test analyses were performed to compare those patients who had overlap and those who did not and were used to determine whether this was a factor in the development of a postoperative infection.

Main Outcome Measurements: Development of infection in those whose external fixation pin sites overlapped with the definitive internal fixation device compared with those whose pin sites did not overlap with definitive plate and screws.

Results: Six knees in six patients developed deep infections requiring serial irrigation and débridement and intravenous antibiotics. Of these six infections, three were in patients with closed fractures and three in patients with open fractures. Two of these six infections followed definitive plate fixation that overlapped the external fixator pin sites with an average of 4.2 cm of overlap. In the four patients who developed an infection and had no overlap, the average distance between the tip of the plate to the first external fixator pin was 6.3 cm. There was no correlation seen between infection and distance from pin to plate, pin–plate overlap distance, time in the external fixator, open fracture, classification of fracture, sex of the patient, age of the patient, or healing status of the fracture.

Conclusion: Fears of definitive fracture fixation site contamination from external fixator pins do not appear to be clinically grounded. When needed, we recommend the use of a temporary external fixation construct with pin placement that provides for the best reduction and stability of the fracture, regardless of plans for future surgery.

Key Words: tibial plateau fracture, spanning external fixation, staged management, infectious complications, pin–plate overlap

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INTRODUCTION

High-energy tibial plateau fractures represent a rare and difficult subset of fractures to treat as a result of the complex nature of the fracture pattern, the damage to the articular surface, the compromised soft tissue envelope as well as concomitant injuries. It has been shown that temporizing treatment with a spanning external fixator can provide stability, help maintain fracture length, and provide increased pain relief while allowing the soft tissues to recover.[1] Concern for pin site colonization over time with knee-spanning external fixation and its potential source for operative wound site infection has led orthopaedic surgeons to advocate caution in the placement of external fixator constructs. It is generally believed that external fixator pins should be placed outside the zone of future internal fixation to prevent potential pin site colonization from interfering with definitive fixation and postoperative wound infection.[2–6] To our knowledge, no prior published report has attempted to validate this association. The purpose of this study was to determine whether overlap between temporary external fixator pins and definitive plate fixation correlate with infection.

PATIENTS AND METHODS

We retrospectively reviewed the trauma database at our institution. Over a 9-year period, 428 patients were treated operatively for a tibial plateau fracture. Of these, 105 patients with 106 tibial plateau fractures that underwent primary temporary knee-spanning external fixation followed by delayed

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open reduction and internal fixation were identified and eligible for review (Fig. 1). All other types of initial fixation or stabilization were excluded. Seventy-nine of these patients had accessible pre- and postoperative radiographic images and chart data related to outcome available for review. These patients form the basis for this study.

There were 60 (76%) male and 19 (24%) female patients. The mean age was 47 years old (range, 19–76 years). Sixty-two (79%) patients sustained closed fractures and 17 (21%) patients presented with open fractures. All fractures were classified as Orthopaedic Trauma Association Type 41C; one (1%) was classified as Schatzker 4, 16 (20%) were Schatzker 5, and 62 (79%) were Schatzker 6 fractures. All 17 open fractures were classified as Gustilo Type 3A. Six patients required fasciotomy for compartment syndrome at initial presentation. Most injuries were the result of high-energy trauma including 33 falls from a height, 18 pedestrians struck by motor vehicles, 17 involved in motor vehicle accidents, six involved in motorcycle accidents, two patients who were struck by a train, two bicyclists struck, and one patient who sustained an equestrian injury.

All 79 patients were treated on presentation by resident staff and an attending orthopaedic surgeon with spanning external fixation and were subsequently definitively fixed with plate and screw fixation by a fellowship-trained trauma surgeon. Spanning external fixation was applied in a consistent manner in all cases. Two 5.0-mm half-pins were drilled and placed in the distal femoral shaft in an anterior–to-posterior direction and two 5.0-mm half-pins were placed in the midshaft tibia in an anterior-to-posterior direction. The two pin clusters were then used to attach an appropriate number of clamps and bars to construct either a single or double-stacked frame. The pins were either predrilled and then inserted by hand or inserted under power without predrilling. Traction was applied to gain generalized fracture and joint reduction with the knee in 10° to 15° of flexion. All connections were then tightened and fluoroscopic images confirmed pin placement and reduction. The mean time from external fixation to internal fixation for all patients was 10 days (range, 2–28 days). Eventually all patients underwent definitive internal fixation for their fractures. The external fixator pins were prepped into the field during each operation and left in place until the final reduction was obtained. In each case, the half-pins were prepped with ethyl alcohol and chlorhexidine followed by our usual protocol of prepping the extremity with a wet prep using an iodine-based scrub solution. Either the external fixator or a femoral distractor was used as a reduction tool intra-operatively. No frames were kept in place postoperatively. Five patients were fixed with dual plates and screws through two incisions and two patients were definitively fixed with only a medial plate. The remaining 72 patients were fixed with only a lateral plate, 51 patients with a locked plate through a single incision and 23 patients with a unilateral nonlocking buttress plate through a single incision.

FIGURE 1. Example of high-energy tibial plateau fracture treated with a spanning external fixator.

Data collected included age, gender, Orthopaedic Trauma Association classification, mechanism of injury, number of surgical procedures performed, and the development of an infectious complication. Radiographs were reviewed for the number of external fixator pins, distance from the proximal pin to the joint line, pin spread, plate measurement, and plate–pin overlap distance if present (Figs. 2 and 3).

Radiographic Analysis

Measurements including distance from the proximal pin site to the joint line, pin spread, plate measurement, and plate–pin overlap distance were recorded. Most x-rays were available through PACS (Centricity; GE, Waukeshaw, WI), the hospital's medical imaging database, in which magnification was accounted for by measurement tools within the software. When x-rays were only available in hard copy (pre-2003), the measurements were made by hand. In these cases, the plates were measured on the x-ray and proportionalized based on known plate and screw lengths. This, in turn, gave us a ratio from which we were able to accurately calculate the distances to be measured.

Statistical Analysis

Fisher exact and *t* test analyses were performed on the data, specifically looking at associations between infection and distance from pin to plate, pin–plate overlap distance, open fracture, classification of fracture, sex of the patient, age of the patient, and healing status of the fracture.

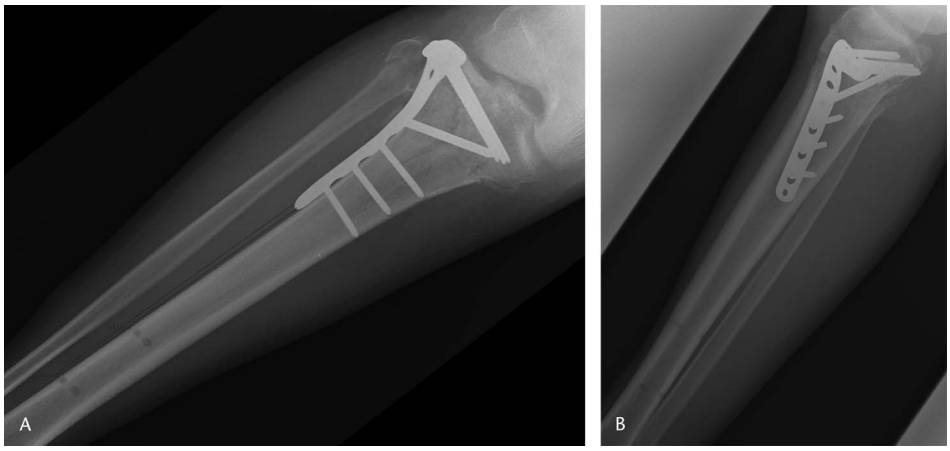

FIGURE 2. Example of no overlap between spanning external fixator pins and definitive plate fixation.

RESULTS

Six of the 79 (7.6%) patients developed a postoperative wound infection; three of these initially were closed injuries and three followed open injuries. Five patients required only a single irrigation and débridement procedure, and one patient required two further surgeries, including irrigation and débridement. Two patients who developed an infection required four-compartment fasciotomy for compartment syndrome at presentation. All six patients received an infectious disease consultation and intravenous antibiotic treatment. There were five unions and one nonunion in the infection group. Three of the 73 patients (4.1%) who did not develop an infection developed a fracture nonunion.

Of the infected patients, five were male and one was female. The average age was 41 years old (range, 19–61 years). Two were falls from a height, two were the result of motor vehicle accidents, one was a pedestrian struck, and one a bicyclist struck (Table 1).

There were 30 patients (38%) with overlap and 49 patients (62%) with no overlap between the external fixator pin sites and the edge of the plate. Only two of the 30 patients (6.7%) with pin–plate overlap developed an infection. Four of the 30 patients (13%) with overlap sustained an open fracture. Four of the 49 patients (8.2%) with no pin–plate overlap developed a postoperative wound infection, whereas 45 (92%) did not. There were 14 open fractures (29%) in patients without pin–plate overlap.

The mean time from external fixation to internal fixation was 13.3 days (range, 4–22 days) in the infected group and 9.8 days (range, 2–28 days) in the noninfected group. Of the patients with overlap, the mean time in the external fixator was 10.9 days. The patients with no overlap had a mean time of 9.3 days in the external fixator. There was no statistically significant difference between these two groups.

Two of the six (33%) extremities that developed infections after definitive plate fixation had overlap with the external fixator pins, whereas four of the six (67%) did not. There was overlap of 20 and 64 mm for an average overlap distance of 42 mm. The patient with 20 mm of overlap was a 51-year-old man with a closed Schatzker V fracture resulting from a fall. He required two surgeries for definitive fixation and went on to union. The patient with 64 mm of overlap was

FIGURE 3. Example of overlap between spanning external fixator pins and definitive plate fixation.

TABLE 1. Patient Characteristics of Those Who Developed a Postoperative Infection

Patient No.	Patient Age (years)/Sex	Schatzker Classification	Mechanism of Injury	Days in External Fixator	Overlap?	Distance From Pin Site to End of Plate	Healed?	Open Fracture (Gustilo type)?
1	51/M	5	Fall	17	Yes	**–20 mm**	Yes	No
2	61/F	6	Pedestrian struck	4	Yes	**–64 mm**	Yes	Yes (type 3A)
3	42/M	6	Fall	22	No	62 mm	Yes	No
4	19/M	5	MVA	14	No	40 mm	No	No
5	36/M	6	MVA	16	No	70 mm	Yes	Yes (type 3A)
6	33/M	6	Bicyclist struck	7	No	105 mm	Yes	Yes (type 3A)

Bold type denotes overlap.
M, male; F, female; MVA, motor vehicle accident.

a 61–year-old female pedestrian struck who required a four-compartment fasciotomy for compartment syndrome after an open Schatzker VI fracture. She also required two procedures for definitive fracture fixation and went on to union.

Of the four infections with no overlap, the average distance between the external fixator pins and the plate was 63 mm. Two of these were open fractures and two were closed. The three Schatzker VI fractures all achieved union, and the one Schatzker V fracture went on to develop a nonunion. Mechanism of injury for these patients included two motor vehicle accidents, one fall from a height, and one bicyclist struck; all were male, ages ranging from 19 to 42 years old.

There were no statistically significant correlations seen between the development of an infection and distance from the external fixation pin site to the end of the plate, pin site–plate overlap distance, time in the external fixator, history of open fracture, fracture classification, patient sex, patient age, or ultimate healing status of the fracture (Table 2).

DISCUSSION

High-energy tibial plateau fractures often present with associated soft tissue trauma and are potentially further complicated by open wounds and compartment syndrome.[7–9] The high complication rate associated with these injuries has led to new techniques for fracture fixation, including limited open reduction internal fixation and delayed fixation. Our protocol is the placement of a temporary knee bridging external fixator in high-energy tibial plateau fractures with staging toward internal fixation. The theoretical risk of pin site colonization as a potential source of infection influences pin placement strategy intraoperatively. Despite the widespread concern for infection regarding the proximity of temporary external fixation pins and the ultimate internal fixation implant in high-energy tibial plateau fractures, we found no correlation between pin site and plate overlap and the development of a postoperative wound infection.

TABLE 2. Comparison of Patient Demographics Between Those Who Did and Did Not Develop an Infection

	Yes Infection	No Infection	*P*
Age (mean years)	40.3	48.5	
Days in external fixator (mean)	13.3	9.8	
Female (no.)	1 (5.3%)	18 (94.7%)	0.553
Male (no.)	5 (8.3%)	55 (91.7%)	0.553
Overlap (no.)	2 (6.7%)	28 (93.3%)	0.535
Union (no.)	5 (6.7%)	70 (93.3%)	0.276
Open fracture (no.)	3 (17.6%)	14 (82.4%)	0.982

By staging treatment with a temporizing spanning external fixator, the soft tissue envelope about the proximal tibia is allowed time to recover. This has been shown to decrease rates of wound infections,[1] and although it may result in a transient increased compartment pressure, has been shown not to lead to compartment syndrome.[10] Attempts to decrease complication rates by minimizing further soft tissue injury have led other authors to advocate circular fixators,[11,12] medial external fixation with lateral plate internal fixation,[13] combination internal fixation and hybrid external fixation,[14–16] indirect reduction and percutaneous screw fixation,[17] and a two-incision approach to the proximal tibia for complex bicondylar tibial plateau plates.[18,19]

Early infectious complications of high-energy tibial plateau fractures are frequent in the setting of treatment by primary osteosynthesis. Wound infection rates have been reported to be between 5% and 10% and appear to correlate with the extent of soft tissue damage and number of metal implants used.[20] Giannoudis et al found a deep infection rate of 11% when primary plating was used for open tibial diaphyseal fractures.[21]

There has been scant literature published regarding the deep infection rates for internal fixation after external fixation in tibial plateau fractures. Barei et al looked at single-incision dual plating after external fixation in 83 high-energy tibial plateau fractures and found an overall infection rate of 8.4%, including six patients with closed fractures and one with an open fracture.[18] Egol et al treated three deep infections in 57 high-energy tibial plateau fractures (one open, two closed) with an overall 5% infection rate.[1] Our data, showing a deep infection rate of 7.6%, are consistent with these published findings.

Published data on other lower extremity long bone fractures treated initially with external fixation may allow for comparison. Deep infection rates for plafond fractures tend to be somewhat higher, in the range of 8% to 11.5%.[22–24] This modest increase is likely the result of the compromised soft tissue envelope about the ankle. Nowotarski et al found an

overall infection rate of 1.7% in femur fractures treated initially with external fixation and followed by conversion to intramedullary nailing. Of the 59 fractures included in this study, 40 were closed and 19 were open. The lone infectious complication was initially an open fracture and was contributed to potential seeding from a nearby contralateral infected above-knee amputation site.[25] This very low infection rate may be the result of the more expansive soft tissue envelope surrounding the femur.

There are little existing data on pin site infections. Superficial infections are common with some reports showing minor infection rates up to 80%.[26] A study by Mahan et al cultured screw tips on the removal of external fixators and found 74.8% to be positive; 90.6% grew *Staphylococcus epidermidis*, 37.5% grew *Staphylococcus aureus*, and 9.4% of the pins grew *Escherichia coli*.[27] Despite this high number, the clinically significant infection rate is known to be much lower. The development of pin site infection is multifactorial, involving the anatomic site, surrounding soft tissue condition, pin placement technique, and postoperative care.[28,29] These factors make it difficult to clearly assess the impact of superficial processes about pins in these various studies.

Mechanically loose pins have been shown to correlate with higher infection rates. Conversely, pin site infections are also known to weaken the bone–pin interface. There are techniques of pin insertion that may theoretically decrease risks of pin site infection. Close attention to the soft tissues is most important, including minimizing thermal necrosis and using sharp drill bits when predrilling holes. Self-cutting pins inserted by hand would theoretically be the most advantageous; however, it has been shown that insertion of pins with power generates the least amount of thermal energy, likely as a result of the decreased time friction is being generated from the contact between the pin and bone.[30]

Of the six deep infections in this series, only two followed definitive plate fixation that overlapped the external fixator pins with an average of 4.2 cm of overlap. In the four patients without overlap, the average distance between the plate and the first external fixator pin was 6.3 cm. We found no correlation between overlap of temporary external fixator pin sites and definitive plate fixation with infection rates. We also found no statistically significant relationships between infection and distance from the pin site to the end of the plate, history of open fracture, time in the external fixator, fracture classification, patient sex, patient age, or ultimate healing status of the fracture.

Limitations to this study include its retrospective design and the lack of complete radiographic studies on all patients included in the initial database. The lack of available x-rays for 27 patients unfortunately decreased the number of subjects and, therefore, the power of the study. Also, some of the x-rays were available on PACS, in which accurate calculations of distances were possible, whereas others were only available in hard copy in which sizing had to be estimated and distances calculated from these estimations, thereby decreasing the precision and increasing the possibility of error. Patients who developed an infection were in the external fixators for an average of 3.5 days longer than those who did not develop an infection, suggesting a possible correlation between fixator duration and infection. Although one can assume more significant soft tissue injuries that required longer time to resolution are more prone to developing infectious complications, the average time in the external fixator was 10 days in this study. We cannot comment on whether extended length of fixator application could contribute to a greater incidence of infection. We also do not have data regarding the condition of the external fixation pins at the time of the secondary surgery. We assume none was acutely infected at the time of removal, because this was not documented in the operative reports.

A post hoc power analysis was conducted to estimate the minimum sample size needed to observe a significant difference in the overlap distance between the infected group and the noninfected group. With regard to the end point of overlap distance, the present study was underpowered to be able to detect a significant difference. To make this comparison, 48 patients would be needed in both the infected and noninfected groups. Based on our rates of infection, close to 600 patients would need to be evaluated and thus a larger, prospective, controlled trial is needed to further evaluate this relationship.

Although it is known that the stability of the external fixator construct is improved with pin placement closer to the fracture site, pins have traditionally been placed away from the field of future internal fixation to prevent possible pin site colonization from interfering with definitive fixation, ultimate fracture healing, and postoperative wound infections. Our data show no correlation between this distance and subsequent infection rates. Based on this, we recommend the use of an external fixation construct with pin placement that provides for the best reduction of the fracture and stability of the construct without regard for ultimate plate placement.

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