Risk Factors for Adverse Outcomes Following Pilon Fracture Fixation: A Multicenter Retrospective Review

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INTRODUCTION: Pilon fractures pose a significant challenge in orthopedics due to soft tissue injuries and potential for poor outcomes. This study aims to identify risk factors for adverse outcomes in the treatment of pilon fracture, specifically regarding the timing of definitive fixation.

METHODS:

A retrospective chart review of adult patients treated for pilon fractures between May 2016 to December 2023 was performed across four US tertiary care centers. Cases were identified using CPT codes. Patients were grouped by fixation strategy, including patients treated with staged fixation (i.e. one or more surgical intervention prior to final definitive fixation, including initial temporization with external fixation, or staged definitive fixation) or unstaged fixation (including single stage primary definitive fixation or definitive fixation with ringed fixator). Descriptive statistics characterized the patient population. Logistic regression with backward stepwise AIC selection identified independent predictors of unplanned return to the OR (uRTOR) and incidence of any postoperative complications, including wound dehiscence, wound drainage, soft tissue breakdown, superficial or deep infection, nonunion, symptomatic hardware, or compartment syndrome. An alpha of 0.05 determined statistical significance, and analyses were performed using R statistical software (R Core Team, 2024).

RESULTS:

1,051 fractures met inclusion criteria (55% male, mean 50 years old). 703 (67%) were treated via primary definitive management, 348 (33%) via staged fixation. 7.9% of patients were treated with definitive external fixation without staged fixation; 6% of patients were treated with staged fixation without initial external fixation (Table 1). Patients treated with staged fixation were more often male (65% vs. 51%, p <0.001), to have sustained their injury via motor vehicle accident (p <0.001), to have more additional fractures (p 0.013), to qualify as polytrauma (30% vs. 22%, p 0.008), and to have open fractures (33% vs. 13%, p <0.001). Staged fixation were more likely to have history of substance use (p 0.002) and to be current or former smokers (p 0.001). Staged fixation were more likely to go onto nonunion (13% vs. 3%, p < 0.001), with increased incidence of any complication (26% vs. 18%, p 0.003). 21% of patients experienced at least one postoperative complication (Table 3). uRTOR was higher in patients treated with staged fixation (21% vs. 14%, p 0.006), including for hardware removal (19% vs. 11%, p 0.013) and revision for malunion/nonunion (13% vs. 2.6%, p <0.001). Mortality within 1 year was 1.3%, and did not vary between groups (p 0.6). Significant factors predictive of postoperative complication overall included external fixator at initial surgery (OR 4.27, 95% CI 2.04, 9.26), osteoporosis (OR 9.93, 95% CI 1.81, 73.5), and former smoking status (OR 3.17, 95% CI 1.55, 6.46). Staged surgery was protective (OR 0.39, 95% CI 0.18, 0.84). Significant predictors of uRTOR included open fracture (OR 4.13, 95% CI 2.31, 7.46), and any complication (OR 9.19, 95% CI 5.40, 16.0). Alcohol abuse was not associated with a higher uRTOR (OR 0.27, 95% CI 0.07, 0.77).

DISCUSSION AND CONCLUSION:

Staged fixation is often necessary for complex cases involving polytrauma, open fractures, and higher-risk patients, but is associated with nonunion and uRTOR compared to primary definitive fixation. Key risk factors for postoperative complications include use of initial external fixation, osteoporosis, and former smoking status, while open fractures significantly predict the need for uRTOR. Interestingly, staged surgery itself appears to be protective against overall complications when controlling for other variables, suggesting that appropriate patient selection and timing of definitive fixation may mitigate some risk. These findings emphasize the importance of careful preoperative planning regarding decisions between immediate vs. delayed definitive fixation.

Table 1: Demographics	Overall N = 1,051	Staged Surgery?		
		No N = 703	Yes N = 348	p-value
Sex				**<0.001**
Male	582 (55%)	357 (51%)	225 (65%)	
Female	468 (45%)	345 (49%)	123 (35%)	
Transgender	1 (<0.1%)	1 (0.1%)	0 (0%)	
Age	50 ± 40	51 ± 20	50 ± 57	**0.032**
Race				**0.017**
American Indian or Alaska Native	5 (0.5%)	4 (0.6%)	1 (0.3%)	
Asian American, Native Hawaiian, or Pacific Islander (AANHPI)	7 (0.7%)	4 (0.6%)	3 (0.9%)	
Black / African American	240 (23%)	140 (20%)	100 (29%)	
White	716 (70%)	500 (73%)	216 (63%)	
Other/Multiple	62 (6.0%)	41 (6.0%)	21 (6.2%)	
Unknown	21	14	7	
Mechanism of injury				**<0.001**
Motor vehicle accident	229 (26%)	130 (22%)	99 (33%)	
Home accident/fall	394 (45%)	265 (46%)	129 (43%)	
Occupational accident/fall	52 (5.9%)	32 (5.5%)	20 (6.7%)	
Other	206 (23%)	155 (27%)	51 (17%)	
Unknown	170	121	49	
Other associated fractures/injuries	992 (94%)	664 (94%)	328 (94%)	>0.9
Number of fractures	2.27 ± 2.30	2.16 ± 1.96	2.49 ± 2.81	**0.013**
Polytrauma patient	249 (24%)	147 (22%)	102 (30%)	**0.008**
Open fracture	204 (20%)	90 (13%)	114 (33%)	**<0.001**
External fixator at initial surgery	378 (38%)	51 (7.9%)	327 (94%)	**<0.001**
Time from consult to definitive fixation (days)	10.25 ± 21.81	5.53 ± 21.01	18.73 ± 20.65	
Time from definitive fixation to most recent follow-up (days)	316.34 ± 393.46	272.62 ± 343.91	401.85 ± 464.60	

Table 2: Comorbidities	Overall N = 1,051	Staged Surgery?		p-value
		No N = 703	Yes N = 348	
BMI	30 ± 7	30 ± 7	30 ± 8	0.3
Osteoporosis	31 (3.1%)	23 (3.4%)	8 (2.5%)	0.5
Cerebrovascular disease (CVD)	35 (3.5%)	23 (3.4%)	12 (3.8%)	>0.9
Asthma (AS)	104 (11%)	66 (9.9%)	38 (12%)	0.4
Cancer (CA)	48 (4.8%)	35 (5.2%)	13 (4.0%)	0.5
Coronary artery disease (CAD)	63 (6.4%)	43 (6.4%)	20 (6.2%)	>0.9
Depression (DEPR)	158 (16%)	101 (15%)	57 (18%)	0.3
Diabetes (DM)	123 (12%)	87 (13%)	36 (11%)	0.5
End Stage Renal Disease (ESRD)	33 (3.3%)	24 (3.6%)	9 (2.8%)	0.7
High Cholesterol (HCL)	145 (14%)	105 (16%)	40 (12%)	0.2
Hypertension (HTN)	312 (31%)	209 (31%)	103 (31%)	>0.9
Obesity	359 (35%)	232 (34%)	127 (37%)	0.3
Substance Use				**0.002**
None	800 (78%)	553 (81%)	247 (72%)	
Alcohol Abuse	106 (10%)	67 (9.9%)	39 (11%)	
Drug Abuse	70 (6.8%)	32 (4.7%)	38 (11%)	
Drug & Alcohol Abuse	26 (2.5%)	15 (2.2%)	11 (3.2%)	
Former Drug OR Alcohol Abuse	20 (2.0%)	13 (1.9%)	7 (2.0%)	
Psychiatric history?	218 (23%)	151 (23%)	67 (24%)	0.7
Smoking Status				**0.001**
Never Smoker	579 (57%)	412 (61%)	167 (49%)	
Current Smoker	337 (33%)	205 (31%)	132 (39%)	
Former smoker	94 (9.3%)	55 (8.2%)	39 (12%)	
Discharged to where?				>0.9
Home	745 (76%)	482 (76%)	263 (77%)	
Rehab	190 (19%)	126 (20%)	64 (19%)	
Other	46 (4.7%)	30 (4.7%)	16 (4.7%)	

Table 3: Complications	Overall N = 1,051	Staged Surgery?		p-value
		No N = 703	Yes N = 348	
Wound dehiscence	5 (0.7%)	4 (0.7%)	1 (0.6%)	>0.9
Wound drainage	11 (1.5%)	7 (1.3%)	4 (2.2%)	0.5
Soft tissue breakdown	6 (0.8%)	5 (0.9%)	1 (0.6%)	>0.9
Superficial infection	14 (1.9%)	7 (1.3%)	7 (3.9%)	0.063
Nonunion	39 (5.4%)	16 (3.0%)	23 (13%)	**<0.001**
Symptomatic hardware	31 (4.3%)	23 (4.3%)	8 (4.4%)	>0.9
Compartment syndrome	0 (0%)	0 (0%)	0 (0%)	>0.9
Deep infection	19 (2.6%)	12 (2.2%)	7 (3.9%)	0.3
Any complication	219 (21%)	128 (18%)	91 (26%)	**0.003**