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Surgical Site Infection in Distal Femur Fractures Following Operative Treatment of Open Fracture: Incidence and Prognostic Risk Factors: A Cohort Study

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ABSTRACT

Introduction: Bimodal distribution of Chinese adults reported an overall 8.7% of all femoral fractures were reported in recent years. The soft tissue dissection during surgery results in impairment in already damaged soft tissue. This impairment leads to postoperative complications.

Aim: To determine the incidence and risk predictors of surgical site infections in distal femur fracture treated by open reduction and internal fixations.

Methodology: We divided all recruited patients into two groups based on the occurrence of SSI. We classified patients with SSI in the case group and without SSI in the control group. Superficial SSI was defined as the infiltration on the skin or subcutaneous tissue of the operation site. The definition of the deep SSI was based on the satisfaction regarding deep fascia infection, persistent wound effusion, local abscess requiring focal debridement, and implant replacements. Wound exudates of all patients were sent for evaluating culture and sensitivity. A cohort study, This study was conducted at Peoples University of Medical & Health Sciences Nawabshah, Pakistan from December 2019 to December 2020.

Results: We observed 22 cases of SSI with a median time duration of 14 ranging from 2 to 106 days. The majority of the SSI cases were reported during hospitalization (81.2%, 18/22). Furthermore, we observed 2.4% superficial SSI and 3.6% deep SSI with an overall prevalence of 6%. The average age of patients was reported as 53.7 ± 17.0 years with three median ages of groups (34, 51, and 68 years respectively).

Conclusion: Our results revealed a high probability of SSI in open fractures, however, the prevalence was 6%. Independent risk factors like A/G levels may play a role as defensive factors. We recommend conducting case-control trials to check the validity of our results.

Key Words: Distal femur fractures, Surgical site infection, Open reduction, Internal fixations, Defensive factors, Bimodal distribution, population

INTRODUCTION

Distal femur fractures are rare but challenging in orthopedics traumas. Bimodal distribution of Chinese adults reported an overall 8.7% of all femoral fractures were reported in recent years.[1] These fractures are usually caused by high energy injuries mostly seen in young patients. These injuries are usually open and comminuted fractures.[2, 3] On contrary in the older population mechanism of injury is low energy injuries with a 13.4% mortality rate reported in one-year follow-

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up.[4] Mostly 50% of distal femur fractures involve articular surface and demand surgical intervention especially open reduction internal fixations (ORIF) and close reduction and internal fixations (CRIF).[1] However, the soft tissue dissection during surgery results in impairment in already damaged soft tissue. This impairment leads to postoperative complications.[5, 6] Surgical site infections are one of the challenging issues for orthopedics and trauma surgeons due to prolonged stay and require high-cost management. The national oral health service of the United Kingdom utilizes £700 million per year to manage SSI.[7] However, 50% of cases of SSI have neglected clinical examinations and are highly seen in these cases.[8] In recent years a variety of literature was produced regarding the examination of SSI of the hip, tibial plateau, and ankle.[9-13] However, very limited literature is available regarding the SSI in distal femur fracture cases treated with ORIF. A single study reported a 0.3 to 11.2% prevalence ratio of SSI in DFF cases.[14] A study by Hoffman presented smoking as a risk factor of SSI whereas another study highlight the link between obesity, diabetes mellitus, and SSI.[15] Our study was designed with a major goal to focus on the incidence of surgical site infections in distal femur fracture treated by open reduction and internal fixations. However, we further aimed to explore the risk predictors which encourage SSI.

METHODOLOGY

This cohort study was conducted at Peoples University of Medical & Health Sciences Nawabshah, Pakistan from December 2019 to December 2020. Permission was taken from the ethical review committee of the institute. All the patients of ORIF aged over 18 years were recruited. Patients with acute distal femur fractures enrolled for ORIF treatment were selected via electronic records. We included open fractures or multiple fractures to evaluate their effect on surgical site infection (SSI). All the patients who visited us after 21 days of initial trauma or having pathological fractures were not entertained in this study. We also excluded all preoperative infections of the open fractures and those who already underwent different surgical procedures like bone grafting etc. All the patients had intraoperative antibiotic prophylaxis. We divided all recruited patients into two groups based on the occurrence of SSI. We classified patients with SSI in the case group and without SSI in the control group. Overall follow-up duration was one year after surgery. We used the definition of CDC as diagnosing criteria of SSI.[8] Superficial SSI was defined as the infiltration on the skin or subcutaneous tissue of the operation site. The definition of the deep SSI was based on the satisfaction regarding deep fascia infection, persistent wound effusion, local abscess requiring focal debridement, and implant replacements. Wound exudates of all patients were sent for evaluating culture and sensitivity. Patients who did not conform to the definition of deep SSI were classified as superficial SSI. Five well-trained physicians were asked to investigate the patient's progress. They followed patients closely in the morning and reviewed the results. All patients were examined from the first day after ORIF until hospital discharge. Patients were followed by telephone at 2, 4, 6, and 12 months after discharge. Suspicious cases of SSI were asked to visit for re-examination and etiological diagnosis. We recalled all patients for radiological evaluation after 6 months of ORIF. We divided our results into 4 main themes including demographic information, fractures related variables, operation-related variables, and laboratory-related variables. The category of demographic variables included age, gender, BMI, the status of comorbidities, etc while fractures related variables hold information related to injury type and mechanisms. Operation-related variables included the history of previous surgery (at any site), pre and postoperative stay, blood loss status during surgery, surgery duration, anesthetic type, ASI classification criteria, intraoperative drainage use, and incision cleanliness. Laboratory-related variables were assessed within 24 hours of injury.

We used SPSS version 23.0 for statistical analysis. Continuous variables were presented in the mean, median, and standard deviations while a comparison between continuous variables was drawn by using a T-test. Normality distribution was analyzed by the Shapiro-Wilk test. We used receiver operating characteristics (ROC) analysis to identify the cut-off values. Categorical variables were compared by using the Chi-square test. Multiple variable analysis was used for analyzing the predicting risk of comorbidities. Odds ratios were used to evaluate the correlation between factors and SSI risk.[16] P-value <0.05 was set as statistically significant.

RESULTS

Overall 461 DFF patients were enrolled for ORIF during the study timeframe. However, 47 were less than 18 years old, 19 had pathological fractures, 5 patients reported old fractures, and 2 had incomplete data. We lost 24 patients during follow up so for the final analysis total of 364 patients were recruited. We observed 22 cases of SSI with a median time duration of 14 ranging from 2 to 106 days. The majority of the SSI cases were reported during hospitalization (81.2%, 18/22). Furthermore, we observed 2.4% superficial SSI and 3.6% deep SSI with an overall prevalence of 6%. The average age of patients was reported as 53.7 ± 17.0 years with three median ages of groups (34, 51, and 68 years respectively). The average BMI was reported as 25.6 ± 4.1 kg. Out of 364 patients, there were 193 males and 171 females. Our study reported more left side fractures than the right side (215 vs 149). Our analysis demonstrates a significant correlation of smoke status, open fractures, injury mechanism, and injury site with SSI. Furthermore, we observed a significant difference in postoperative stay between the two groups. (As shown in Table 1) Moreover, our results revealed a positive correlation between intraoperative drain use and incision cleanliness (0.047 and < 0.001). (As shown in Table 3) In 16 cases of intraoperative drain usage, we observed postoperative SSI. The average duration of drainage was 4.1 ± 2.9 days and the average drainage volume was 173.1 ± 115.6 mL. Surgical debridement was reported in two cases and two cases required reoperation. Interestingly we did not find any case of amputations. There were was significant variations in ALB and A/G levels of both groups. (As shown in Table 2) Furthermore, with the help of ROC, we observed A/G levels ≥ 1.35 as a protective factor against SSI. (As shown in Table 3) In multivariate analysis, we observed incision cleanliness and open fractures as independent risk factors of SSI. (As shown in Table 4) We observed good fitness (X2 = 5.2; p = 0.735) by using the Hosmer-Lemeshow test.

Table 1: Demographic and Surgical outcomes of study participants

Variables	Patients without SSI(n=22)	Patients with SSI (n=342)	All patients (n=364)	p-value
Age (years)				0.186
≥60	143 (41.8%)	5 (22.7%)	148 (40.7%)	
46–59	96 (28.1%)	9 (40.9%)	105 (28.8%)	
18–45	103 (30.1%)	8 (36.4%)	148 (40.7%)	
BMI (kg/m2), mean±SD	25.6±4.2	26.1±4.0	25.6±4.1	0.454
Smoking	42 (12.3%)	8 (36.4%)	50 (13.7%)	0.004
Diabetes mellitus	81 (23.7%)	5 (22.7%)	86 (23.6%)	0.918
History of the previous operation	110 (32.2%)	5 (22.7%)	115 (31.6%)	0.356
Hypertension	89 (26.0%)	6 (27.3%)	95 (26.1%)	0.897
Obesity (BMI≥28)	61 (17.8%)	9 (40.9%)	70 (19.2%)	0.084
Cardiovascular diseases	52 (15.2%)	2 (10.5%)	54 (14.8%)	0.578
Mechanism of injury				0.006
High level energy	212 (62.0%)	20 (90.9%)	232 (63.7%)	
Low-level energy				
Open fractures	69 (20.2%)	17 (77.3%)	86 (23.6%)	<0.0001
Fracture side				0.653
Left	201 (58.8%)	14 (63.6%)	215 (59.1%)	
Right				
Concurrent fractures (≥2 sites)	158 (44.2%)	18 (81.8%)	176 (48.4%)	0.001
Surgery Variables				
Preoperative stay (days), median	6	5	6	0.184b
Preoperative stay (≥7 days), n (%)	165 (48.2%)	11 (50.0%)	176 (48.4%)	0.873c
Postoperative stay (days), median	11	12	36	<0.001b*
American Society of Anesthesiologists (ASA)				0.133c
III-V	117 (34.2%)	11(50%)	128 (35.2%)	
I-II	225 (65.8%)	11(50%)	236 (64.8%)	
Incision cleanliness				<0.001
III	6 (1.8%)	7 (31.8%)	13 (3.5%)	
II	14 (4.1%)	4 (18.2%)	18 (5%)	
I	322 (94.2%)	11 (50%)	333 (91.5%)	
Anesthesia type				0.497c
Combined spinal-epidural	147 (43%)	8 (36.4%)	155 (42.6%)	
Local anesthesia	14 (4.1%)	2 (9.1%)	16 (4.4%)	
General anesthesia	181(52.9%)	193 (53%)	12 (54.5%)	

Table 1: *(Continued)*

Variables	Patients without SSI(n=22)	Patients with SSI (n=342)	All patients (n=364)	p-value
Intraoperative blood loss ≥400 mL	161 (47.1%)	13 (59.1%)	174 (47.8%)	0.274c
Intraoperative blood loss (ml), median	400	550	400	0.151
Plate use (vs. without plate)	263 (76.9%)	19 (86.4%)	282 (77.5%)	0.303c
Use of drain	174 (50.9%)	16 (72.7%)	190 (52.2%)	0.047c
Surgical duration				0.312c
>180	105 (30.7%)	10 (45.5%)	191 (52.5%)	
120–180 min	181 (52.9%)	10 (45.5%)	115 (31.6%)	
<120 min	56 (16.4%)	2 (9.1%)	58 (15.9%)	
Surgical duration (minutes), median	163	180	165	0.136b

Table 2: Univariate analysis of Laboratory variables

Variables	Patients without SSI	Patients with SSI	All patients	P-value
GLU (mmol/L)				
>6.1	191 (55.8%)	13 (51.9%)	204 (56%)	0.766
(3.9–6.1)	151 (44.2%)	9 (40.9%)	160 (44%)	
WBC (10^9/L)				
>10	140 (40.9%)	12 (54.5%)	152 (41.8%)	0.420
4-10%	198 (57.9%)	10 (45.5%)	208 (57.1%)	
A/G				
≥1.35	192 (56%)	4 (18.2%)	196 (53.8%)	0.001
<1.35	150 (44%)	18 (81.8%)	168 (46.2%)	
A/G, mean±SD	1.5±0.4	1.2±0.3	1.5±0.4	<0.001
NEUT (10^9/L)				
>6.3	207 (60.5%)	15 (68.2%)	222 (61%)	0.476
1.8–6.3	135 (39.5%)	7 (31.8%)	142 (39%)	
GLOB (<20 g/L)	71 (20.8%)	2 (9.1%)	73 (20.1%)	0.294
PLT (10^9/L)				
>300	116 (33.9%)	11 (50%)	127 (34.9%)	0.209
<125	20 (5.8%)	2 (9.1%)	22 (6%)	
125–300	206 (60.2%)	9 (40.9%)	215 (59.1%)	
ALB (<30 g/L), n (%)	91 (26.6%)	12 (11.7%)	103 (28.3%)	0.005
ALB(g/L), mean±SD	34.0±5.6	33.8±5.7	33.8±5.7	0.017
LYM (10^9/L)				
<1.1	146 (42.7%)	8 (36.4%)	154 (42.3%)	0.812
1.1–3.2	195 (57%)	14 (63.6%)	209 (57.4%)	
MON (10^9/L)				
>0.6	225 (65.8%)	15 (68.2%)	240 (65.9%)	0.818
0.1–0.6	117 (39.5%)	7 (31.8%)	124 (34.1%)	
RBC (10^{12}/L)				
<Lower limit	244 (68.7%)	19 (86.4%)	263 (72.3%)	0.076
References	107 (31.3%)	3 (13.6%)	110 (30.2%)	

Table 2: *(Continued)*

Variables	Patients without SSI	Patients with SSI	All patients	P-value
BAS (10^9/L)				
>0.06	29 (8.5%)	3 (14%)		0.408
0–0.06	313 (91.5%)	19 (86.4%)	332 (91.2%)	
EOS (10^9/L)				
<0.02	91 (26.6%)	5 (22.7%)	96 (26.4%)	0.829
0.02–0.52	248 (72.5%)	17 (77.3%)	265 (72.8%)	

Table 3: Factors associated with SSI; Multivariate analysis

Variables	95% CI	Odd ratios	p-value
A/G≥1.35	0.1-1.0	0.2	0.042
Open injury	2.0-26.7	7.3	0.003
Incision cleanliness	1.6–7.7	3.5	0.002
Drainage use	1.1–15.5	4.1	0.037

Table 4: ROC curve

Variables	Specificity	Sensitivity	Cut-off value	The area under curve 95% C.I	P-value
A/G	81.9%	56.3%	1.35	71.8%(62.0%-81.6%)	0.001
ALB(g/L)	59.1%	73%	30.3	65.2%(52.9%-77.4%)	0.017

DISCUSSION

This cohort analysis of 364 patients revealed 6% cases of SSI after ORIF in distal femur fractures during a one-year follow-up. These results show consistency with the previous retrospective study of 724 conducted for the two-year timeframe.[15,16] We observed a high ratio of isolated S. aureus pathogen of SSIs. Comparatively, we observed longer prospective stay in patients with SSIs than without SSI. Patients with SSI were examined for 45 days in the hospital while those without SSI were discharged after 15 days. We observed a significant association of incision cleanliness, open fractures with SSIs. After orthopedic surgeries, open fractures are well-known sites for SSI which are the risk factors.[17] In our study, we observed a 7.3 ratio for open fractures. These results are comparable with the previous lower limb studies in which researchers reported 10.0% to 20% SSI prevalence.[6, 12] The study of Lu[15] reported a 10.8% prevalence of SSIs while our prevalence was double their ratio. We observed more blood supply in the intercondylar region than the supracondylar region in patients who sustained an intraarticular fracture. The low blood supply could become a reason for insufficient wound healing. Research Lu observed a 9.5% ratio of open fractures while it was 23.6% in our study. The delayed ORIF reduced the risk of SSI. Damage control orthopedic handled the soft tissue injuries at the initial stage.[18] Aggressive debridement was used for all open fractures and polytrauma cases to perform external fixators. This surgical process was carried out after examination of soft tissue conditions at fracture sites according to Gustilo-Anderson classification.[19]

In orthopedics, the basic purpose of drains is to reduce postoperative seroma. However, no proper criteria are available to describe the proper usage of drains. Anxiousness and pain are the major complaints of drains and drainage sites are more vulnerable to host infection. In recent years some studies observed the association of drains and SSI infections after surgery.[20, 21] Their results are comparable to ours in which we observed 4.1 times high risk of SSI after drain use. For our study, we evaluate the status of incision cleanliness during surgery. We observed that dirty surgical incisions 3.5% times enhanced the risk of surgical site infections. A recent retrospective case-control study revealed a 1.8% ratio of SSI in grade II to IV ankle fractures.[13,22] Another study by Wang also reported the same results.[21] Medical staff worried about the infection in the initial times of surgery.[22] However, the patient's self-monitoring practices also reduced the risk of SSI.[23]

We observed that the increased amount of Albumin/globulin (A/G) levels in adults minimize the risk of SSI after ORIF than the ALB levels. A study by Agarwal[17] reported ALB as a risk factor of SSI after traumatic orthopedic surgeries. We observed that patients with ≥ 1.35 A/G levels had a 77% minimum probability compared to those with <1.35 A/G. A/G helps to maintain the lower levels of protein deficiency or reduces metabolic abnormalities. We suggested that the measurement of A/G levels is meaningful for predicting the probability of SSI. However, the ALB transports the amino acids which help in wound healing. On the other hand, immunoglobulin has an anti-infection effect which lowers the risk of infection after surgery.[24-27]

CONCLUSION

Our results revealed a high probability of SSI in open fractures however there was a 6% prevalence. Independent risk factors like A/G levels may play a role as a defensive factor. We recommend conducting case-control trials to check the validity of our results.

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