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Functional and Radiographic Outcomes of Open Proximal Femoral Fractures Caused by Gunshot Wounds in Yemen

A Prospective Cohort Study

Mohammad Hutaif, MD, Abdullah Al-Moaish, MD, and Anwar Al-fadliy, MD

Investigation performed at Sana'a University School of Medicine, Sana'a, Yemen

Background: Open proximal femoral fractures caused by gunshot wounds are rare but devastating injuries that pose considerable challenges for prognosis and management. The aim of this study was to evaluate the functional and radiographic outcomes of patients with open proximal femoral fractures caused by gunshot wounds treated at 3 Level-I trauma centers in Yemen and to identify the factors that influence them.

Methods: We prospectively enrolled 174 patients with open proximal femoral fractures caused by gunshot wounds. The fractures were classified according to the Gustilo-Anderson and OTA/AO systems. The primary outcome measures were fracture union, infection, and functional outcomes. The secondary outcome measures were the Harris hip score (HHS) and the Short Form-36 (SF-36) health survey score. We performed multivariable logistic regression modeling to identify the predictors of complications and poor functional outcomes.

Results: The overall rate of fracture union was 87%. The complication rates were 18% for infection, 13% for nonunion, 23% for reoperation, 12% for delayed union, 4% for osteonecrosis, 6% for heterotopic ossification, and 2% for amputation. The mean HHS at the final follow-up was 78.4, and the mean SF-36 score was 67.3.

Conclusions: Open proximal femoral fractures caused by gunshot wounds are associated with high rates of complications and poor functional outcomes in Yemen. Early debridement, appropriate fixation, infection control, and adequate soft-tissue coverage are essential for achieving satisfactory results. The type of wound, the type of fracture, and the type of definitive fixation are significant predictors of the outcomes. Future studies should compare different fixation methods and evaluate the long-term outcomes and complications of these injuries.

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

Open proximal femoral fractures are rare injuries, accounting for <1% of all femoral fractures[1]. They typically result from high-energy trauma, such as motor vehicle collisions, falls from a height, or blast injuries[2]. However, regions such as Yemen, afflicted by armed conflicts, witness these fractures frequently due to gunshot wounds[3]. The World Health Organization (WHO)[4] reported Yemen as one of the top nations with respect to firearm-related deaths (6.1 per 100,000 population in 2016) due to the ongoing civil war since 2015, amplifying civilians' exposure to gunshot injuries[5].

Gunshot wounds, based on missile velocity, caliber, trajectory, and fragmentation, create varying injury types[6]. Low-velocity missiles cause localized damage, whereas high-velocity missiles lead to extensive tissue loss and contamination[7]. The management of gunshot-induced open proximal femoral fractures is challenging because of associated complicating factors such as multiple trauma, high infection risk, potential vascular or nerve damage, requirement for complex surgical procedures, and poor functional outcomes[8-13]. Infection risk is linked with the open fracture grade based on the Gustilo-Anderson and modified Rajasekaran classifications[14,15].

Available literature on the outcomes of such injuries, especially in low-resource settings such as Yemen, has been scant and typically comprised small, retrospective studies with

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heterogeneous data[16-20]. Infection rates ranged between 0% and 29%, and nonunion rates ranged between 0% and 25%; functional outcomes usually have been poor, underscoring the need for large, prospective, homogeneous studies[17-20]. This aim of this study was to assess the functional outcomes (the patient's ability to perform daily activities after recovery from the injury) and radiographic outcomes (bone healing and alignment after fracture fixation) of gunshot-induced open proximal femoral fractures treated at 3 Yemeni Level-I trauma centers[21,22]. Additionally, the study sought to identify the factors that influence these outcomes in patients with open proximal femoral fractures caused by gunshot wounds treated at these centers. We hypothesized that patients with these injuries have high rates of complications and poor functional and quality-of-life outcomes (as measured by the Harris hip score [HHS] and the Short Form-36 [SF-36] health survey score), and that these outcomes are influenced by several factors, such as wound type; fracture type; definitive fixation type; Injury Severity Score (ISS); Mangled Extremity Severity Score (MESS); timing of initial antibiotic administration, debridement, and definitive fixation; antibiotic therapy duration; and hospital length of stay. We also aimed to compare our findings with previous reports and discuss their implications for clinical practice and research.

Materials and Methods

Study Design and Setting

This was a prospective cohort study conducted at 3 Level-I trauma centers in Sana'a, Yemen: Al-Thawra Hospital, Al-Jumhori Hospital, and Al-Kuwait Hospital. These hospitals are affiliated with Sana'a University and provide tertiary care for patients with trauma from all over the country. The resources available at these tertiary facilities are limited and insufficient to meet the demands of the population. The trauma team consists of general surgeons, orthopaedic surgeons, neurosurgeons, plastic surgeons, vascular surgeons, and anesthetists, with different levels of experience and training. The types of orthopaedic implants available are mainly intramedullary nails and plates, but there is a lack of variety and quality. The options for soft-tissue coverage are limited to local or free flaps, but there is a lack of plastic surgeons with microvascular facilities. The study was approved by the institutional review board of Sana'a University, and informed consent was obtained from all participants. Participants were both combatants and noncombatants.

Study Population

We enrolled patients with open proximal femoral fractures caused by gunshot wounds between January 2015 and December 2020. Inclusion criteria were patient age of ≥18 years; fracture involving the femoral neck, intertrochanteric, or subtrochanteric region; and a wound classified as Type I, II, IIIA, IIIB, or IIIC according to the Gustilo-Anderson system. Exclusion criteria were patient age of <18 years, fractures involving the femoral head or shaft, presence of concomitant ipsilateral lower-limb amputation, and refusal to participate or loss to follow-up.

TABLE I Baseline Characteristics of the Study Population

Characteristic	Value
No. of patients	174
Age* *(yr)*	31.2 (18 to 65)
Male sex†	172 (99%)
Mechanism of injury†	
High-velocity gunshot wounds from rifles	156 (90%)
Low-velocity gunshot wounds from handguns	18 (10%)
Type of fracture†	
Femoral neck	6 (3%)
Intertrochanteric	35 (20%)
Subtrochanteric	133 (76%)
Type of wound†	
Type I	19 (11%)
Type II	57 (33%)
Type IIIA	67 (39%)
Type IIIB	27 (16%)
Type IIIC	4 (2%)
Associated injuries†	
Chest	28 (16%)
Abdomen	24 (14%)
Head	12 (7%)
Spine	8 (5%)
Pelvis	6 (3%)
Ipsilateral lower limb	14 (8%)
Contralateral lower limb	16 (9%)
ISS*	22.4 (9 to 41)
MESS*	5.6 (2 to 11)
Time*	
From injury to hospital admission *(hr)*	6.4 (1 to 24)
From hospital admission to definitive fixation *(days)*	4.2 (1 to 14)
From injury to initial antibiotic administration *(hr)*	7.2 (2 to 26)
From injury to initial debridement *(hr)*	8.6 (3 to 28)
Duration*	
Antibiotic therapy *(days)*	14.3 (7 to 28)
Hospital stay *(days)*	18.7 (10 to 42)

*The values are given as the mean, with the range in parentheses. †The values are given as the number of patients, with the percentage in parentheses.

Data Collection

Data were collected on demographic characteristics, injury mechanism, fracture and wound types, associated injuries, timelines related to injury and treatment, surgical intervention, antibiotic therapy, length of hospital stay, fracture union, complications, and functional outcomes[14,23-25]. The severity of associated injuries was measured using the Abbreviated Injury Scale

TABLE II The Severity of Associated Injuries and Their Impact on Outcomes

Associated Injury	AIS*	Complications†	Poor Functional Outcome†	Primary Outcomes						
				Infection	Nonunion	Reoperation	Delayed Union	Osteonecrosis	Heterotopic Ossification	Amputation
Chest	3 (2 to 4)	4 (14%)	9 (36%)	32.1%	7.1%	21.4%	7.1%	3.6%	3.6%	0%
Abdomen	3.1 (2 to 4)	6 (25%)	8 (33%)	29.2%	8.3%	20.8%	16.7%	4.2%	0%	0%
Head	3.5 (2 to 4)	2 (17%)	5 (42%)	50%	33.3%	33.3%	50%	33.3%	0%	0%
Spine	3 (2 to 4)	2 (25%)	2 (25%)	62.5%	0%	12.5%	0%	0%	12.5%	0%
Pelvis	3 (2 to 4)	3 (50%)	1 (17%)	83.3%	33.3%	33.3%	16.7%	0%	6.3%	0%
Ipsilateral lower limb	2.7 (2 to 4)	17 (42%)	24 (59%)	46.2%	7.7%	23.1%	15.4%	21.4%	7.7%	0%
Contralateral lower limb	2.5 (2 to 4)	8 (50%)	10 (63%)	56.3%	12.5%	25%	12.5%	25%	6.3%	0%

*The values are given as the median, with the interquartile range in parentheses. †The values are given as the number of patients, with the percentage in parentheses.

(AIS), which assigns a score from 1 (minor) to 6 (unsurvivable) to each of 9 body regions. Data were collected by trained assistants and were verified from medical records. Two experienced surgeons performed wound and fracture classifications, with a third surgeon arbitrating disagreements[14,23]. We defined acceptable outcomes compared with unacceptable outcomes or good outcomes compared with bad outcomes on the HHS and SF-36 based on the established literature. For example, we used a study by Harris[26] that defines a good outcome as an HHS of ≥80, a fair outcome as an HHS of 70 to 79, a poor outcome as an HHS of 60

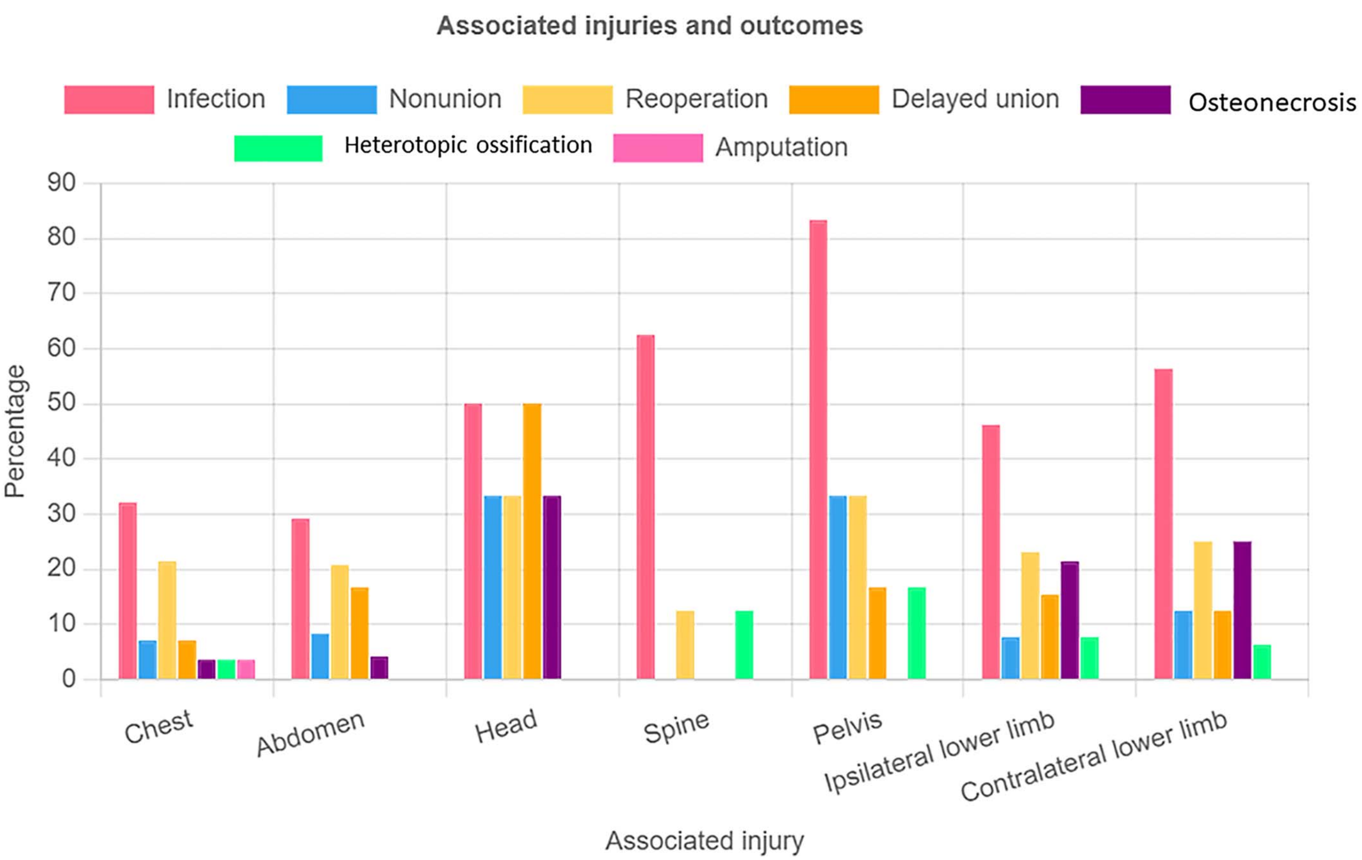

Fig. 1
Associated injuries and outcomes.

TABLE III Primary Outcomes According to the Type of Fracture

	Fracture Type			
Primary Outcome	Femoral Neck (N = 6)	Intertrochanteric (N = 35)	Subtrochanteric (N = 133)	P Value
Fracture union	87%	96%	97%	0.302
Infection	18%	9%	6%	0.057*
Nonunion	13%	5%	3%	<0.001†
Reoperation	23%	9%	10%	<0.001†
Delayed union	12%	5%	3%	<0.001†
Osteonecrosis	4%	0%	0%	<0.001†
Heterotopic ossification	6%	0%	0%	<0.001†
Amputation	2%	0%	0%	<0.001†

*Marginally significant. †Significant.

to 69, and a failure as an HHS of <60. Similarly, we used a study by Ware and Sherbourne[27] that defined a good quality of life as an SF-36 score of ≥75, a moderate quality of life as an SF-36 score of 50 to 74, and a poor quality of life as an SF-36 score of <50.

Wound Management Protocol

The protocol included assessment and resuscitation according to Advanced Trauma Life Support (ATLS) guidelines, administration of antibiotics, irrigation and debridement of the wound, repeat irrigation and debridement if necessary, definitive debridement and fixation, soft-tissue coverage, conversion from external to internal fixation, and delayed primary closure. Antibiotic therapy was continued for specific durations based on wound type[28,29].

Surgical Intervention

The surgical intervention was determined by the type of wound, the type of fracture according to the OTA/AO classification system[30], and availability of resources and surgical time. Patients underwent 1-stage debridement and internal fixation for Type-I and II wounds; 2-stage debridement and internal fixation for Type-IIIA wounds; and 3-stage debridement, external fixation, soft-tissue coverage, and internal fixation for Type-IIIB and IIIC wounds. The type of definitive fixation depended on the fracture type and the surgeon's preference and experience.

Rehabilitation

A standardized protocol including bed exercises, passive range-of-motion exercises, isometric exercises, and weight-bearing exercises was implemented. The protocol was supervised by a physiotherapist and continued until fracture union or the final follow-up.

Outcomes

The primary outcomes of fracture union, infection, nonunion, reoperation, delayed union, osteonecrosis, heterotopic ossification, and amputation were evaluated on the basis of established definitions[31-36]. The secondary outcomes of functional and quality-of-life outcomes were measured using the HHS and the SF-36 score at the final follow-up[26,37-39]. Outcome predictors were identified using multivariable logistic regression models.

Statistical Analysis

We used descriptive statistics to summarize the study population characteristics and outcomes. We used inferential statistics to test the associations between independent variables and

TABLE IV Primary Outcomes According to the Type of Wound

Variable	Type I* (N = 19)	Type II* (N = 57)	Type IIIA* (N = 67)	Type IIIB* (N = 27)	Type IIIC* (N = 4)	P Value
Fracture union	17 (90%)	48 (84%)	64 (96%)	18 (67%)	4 (100%)	0.203
Infection	3 (16%)	6 (11%)	22 (33%)	5 (19%)	0 (0%)	<0.001†
Nonunion	0 (0%)	4 (7%)	17 (25%)	8 (30%)	4 (100%)	<0.001†
Reoperation	2 (11%)	8 (14%)	38 (57%)	7 (26%)	3 (75%)	<0.001†
Delayed union	1 (5%)	3 (5%)	15 (22%)	3 (11%)	0 (0%)	0.112
Osteonecrosis	1 (5%)	1 (2%)	3 (5%)	1 (4%)	0 (0%)	0.887
Heterotopic ossification	0 (0%)	4 (7%)	7 (10%)	4 (15%)	0 (0%)	0.070
Amputation	0 (0%)	0 (0%)	3 (5%)	0 (0%)	1 (25%)	0.034†

*The values are given as the number of patients, with the percentage in parentheses; the percentages are calculated on the basis of the number of patients with a specific type of fracture or wound, rather than the total number of patients. †Significant.

TABLE V Secondary Outcomes According to the Type of Fracture

	Type of Fracture			
Variable	Femoral Neck* (N = 6)	Intertrochanteric* (N = 35)	Subtrochanteric* (N = 133)	P Value
HHS	72.7 (32 to 100)	78.4 (32 to 100)	82.1 (32 to 100)	0.794
SF-36	68.3 (34 to 97)	67.3 (28 to 100)	71.4 (28 to 100)	0.866
PCS	61.8 (30 to 94)	63.2 (25 to 100)	64.8 (30 to 97)	0.854
MCS	74.3 (47 to 95)	73.2 (31 to 100)	71.1 (39 to 98)	0.751

*The values are given as the mean, with the range in parentheses.

outcomes. We used wound type; fracture type; definitive fixation type; ISS; MESS; timing of initial antibiotic administration, debridement, and definitive fixation; antibiotic therapy duration; and hospital length of stay as the independent variables. We used infection, nonunion, reoperation, delayed union, osteonecrosis, heterotopic ossification, amputation, HHS category (poor or fair compared with good or excellent), and SF-36 summary scores (below or above the median) as the dependent variables. We used multivariable logistic regression models to identify the predictors of complications and poor functional outcomes, adjusting for potential confounders. We reported the odds ratios (ORs) and the 95% confidence intervals (CIs) for each predictor variable. We interpreted the ORs as follows: an OR of >1 indicates that the exposure is associated with higher odds of the outcome; an OR of <1 indicates that the exposure is associated with lower odds of the outcome; and OR = 1 indicates that the exposure is not associated with the outcome. For example, an OR of 2.34 for a wound type of III, compared with I and II, as a predictor of infection means that the odds of having an infection are 2.34 times higher for patients with Type-III wounds compared with patients with Type-I or II wounds. We used SPSS software, version 25 (IBM) for data analysis. We considered significance to be $p < 0.05$.

Results

Baseline Characteristics

A total of 174 patients with open proximal femoral fractures caused by gunshot wounds were enrolled. The mean patient age was 31.2 years, and 99% of patients were men. The majority of patients sustained high-velocity gunshot wounds from rifles. Of 88 patients with associated injuries, the most common associated injuries were in the chest (32%), abdomen (25%), and head (22%).

Management of Associated Injuries

The management of the associated injuries varied depending on the type and severity of the injury and the availability of resources and specialists. The most common management modalities were chest tube insertion, laparotomy, craniotomy, spinal fixation, external fixation, debridement and internal fixation, and debridement and external fixation.

Impact of Associated Injuries on Outcomes

The presence and severity of associated injuries were significantly associated with infection, nonunion, reoperation, delayed union, osteonecrosis, heterotopic ossification, amputation, HHS, and SF-36 score. Table I details the baseline characteristics of the study population. Table II and Figure 1 show the severity and management of associated injuries and their impact on outcomes.

Primary Outcomes

The mean follow-up period was 24.6 months (range, 12 to 60 months). The overall rate of fracture union was 87% (151 patients), and the complication rates were 18% for infection, 13% for nonunion, 23% for reoperation, 12% for delayed union, 4% for osteonecrosis, 6% for heterotopic ossification, and 2% for amputation.

The primary outcomes are shown according to the type of fracture in Table III and according to the type of wound in Table IV.

TABLE VI Secondary Outcomes According to the Type of Wound

	Type of Wound*					
Secondary Outcome	Type I (N = 19)	Type II (N = 57)	Type IIIA (N = 67)	Type IIIB (N = 27)	Type IIIC (N = 4)	P Value
HHS	87.1 (64 to 100)	82.6 (43 to 100)	76.9 (32 to 100)	78.7 (45 to 100)	78.8 (40 to 100)	<0.001†
SF-36	76.7 (49 to 100)	67.6 (28 to 100)	65.7 (32 to 99)	67.9 (37 to 100)	69.2 (50 to 90)	<0.001†
SF-36 PCS	73.2 (41 to 99)	64.1 (25 to 100)	61.9 (30 to 97)	64.7 (37 to 99)	67.8 (45 to 85)	<0.001†
SF-36 MCS	81.2 (60 to 98)	75.5 (31 to 100)	72.3 (39 to 98)	72.8 (50 to 98)	73.9 (58 to 85)	<0.001†

*The values are given as the mean, with the range in parentheses. †Significant.

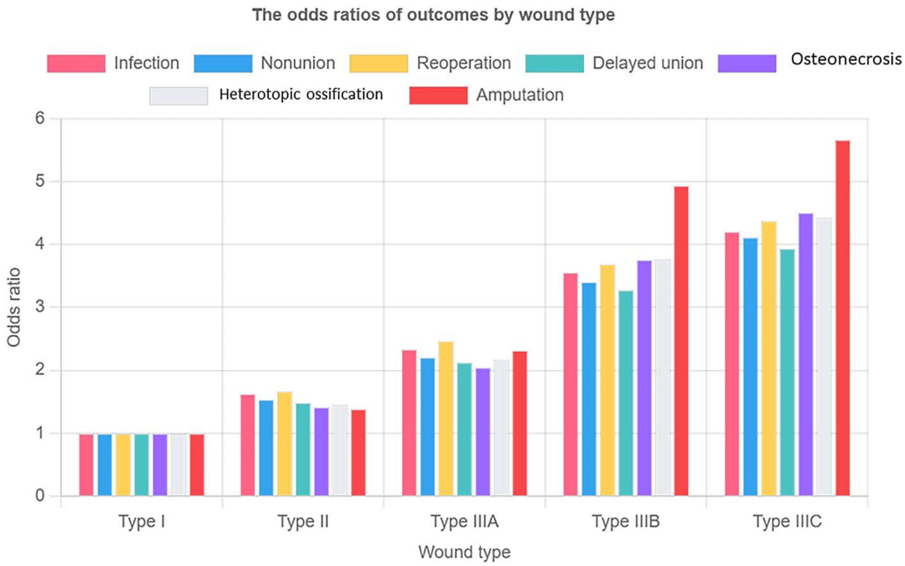

Fig. 2
The ORs of outcomes by wound type.

Secondary Outcomes

The mean HHS at the final follow-up was 78.4 (range, 32 to 100). The mean SF-36 score at the final follow-up was 67.3 (range, 28 to 100). The SF-36 Physical Component Summary (PCS) and Mental Component Summary (MCS), which were also included as secondary outcomes, are shown according to the type of fracture in Table V and according to the type of wound in Table VI.

Predictors of Outcomes

Multivariable logistic regression identified wound type (Fig. 2), fracture type (Fig. 3), and definitive fixation type (Fig. 4) as significant predictors of outcomes ($p < 0.001$), impacting infection, nonunion, reoperation, delayed union, osteonecrosis, heterotopic ossification, and amputation. We report the ORs and the 95% CIs for each predictor variable in our multivariable logistic regression models in Figure 5. The ORs represent the change in the odds of having a certain outcome for a 1-unit increase in a continuous predictor variable or for having a certain category of a categorical predictor variable, compared with a reference category. The 95% CIs represent the range of values that are likely to contain the true OR with a 95% probability.

The ISS, MESS, time to antibiotic administration, and time to debridement were significant infection predictors. The

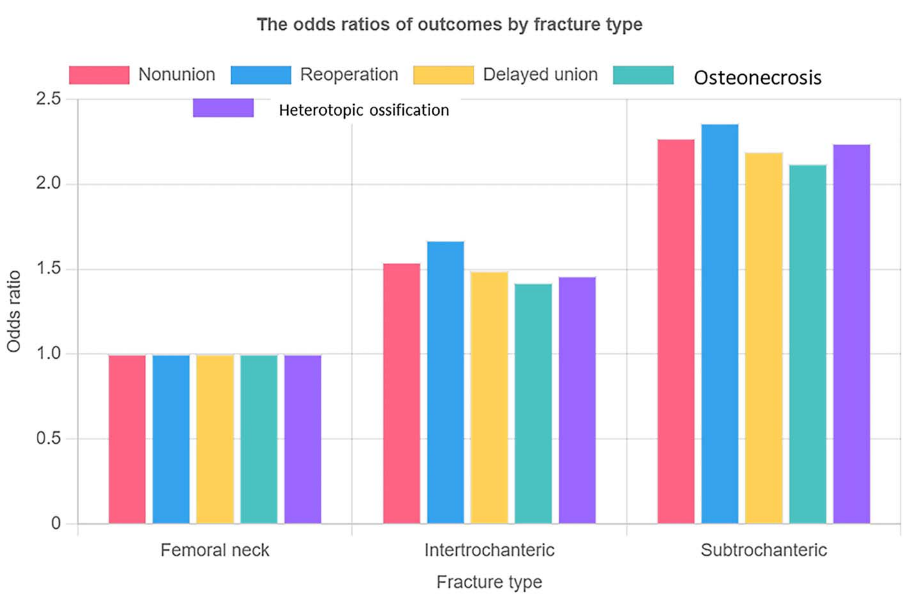

Fig. 3
The ORs of outcomes by fracture type.

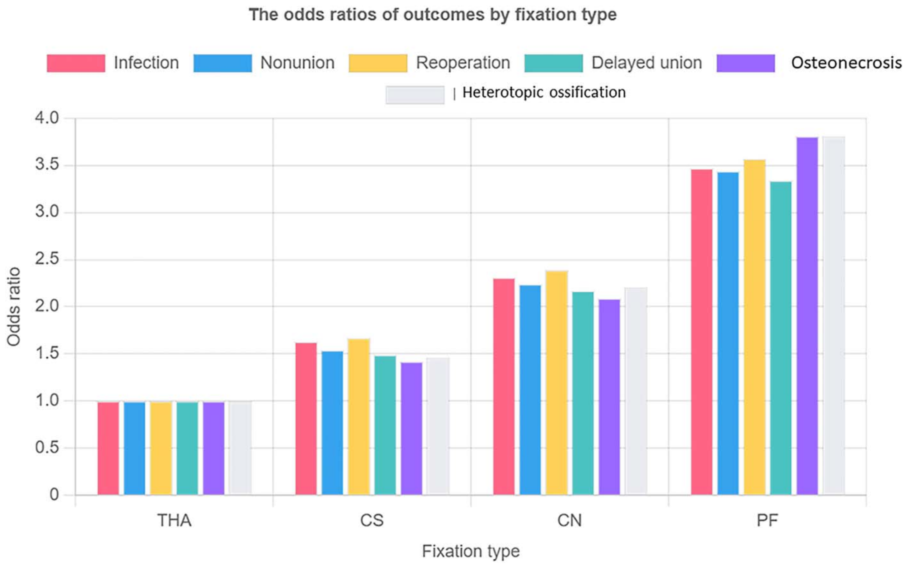

Fig. 4
The ORs of outcomes by fixation type. THA = total hip arthroplasty, CS = cannulated screws, CN = cephalomedullary nail, and PF = plate fixation.

time to definitive fixation significantly predicted nonunion, reoperation, delayed union, osteonecrosis, and heterotopic ossification. The duration of antibiotic therapy and the hospital length of stay were also significant predictors of some outcomes (Table VII).

Discussion

This prospective cohort study conducted at 3 Level-I trauma centers in Yemen evaluated the functional and radiographic outcomes of 174 patients with open proximal femoral fractures caused by gunshot wounds. The findings revealed high rates of complications and poor functional outcomes in these patients. Various factors, including the type of wound, fracture, definitive fixation, ISS, MESS, time to initial antibiotic administration, time to initial debridement, time from hospital admission to definitive fixation, duration of antibiotic therapy, and hospital length of stay, were identified as significant predictors of the outcomes[13].

These results are consistent with previous studies on open proximal femoral fractures caused by gunshot wounds, which have also shown high complication rates, such as infection, nonunion, reoperation, osteonecrosis, heterotopic ossification, and amputation, as well as poor functional outcomes indicated by low HHS and SF-36 scores[17-20]. However, differences in study methods, sample sizes, fracture types, classification systems, fixation techniques, and follow-up periods limit direct comparison or generalization of these findings. Therefore, this study contributes to the existing literature by providing a prospective, large, and homogeneous cohort of patients with standardized outcome measures and multivariable logistic regression models to assess the outcomes of open proximal femoral fractures caused by gunshot wounds and their predictors.

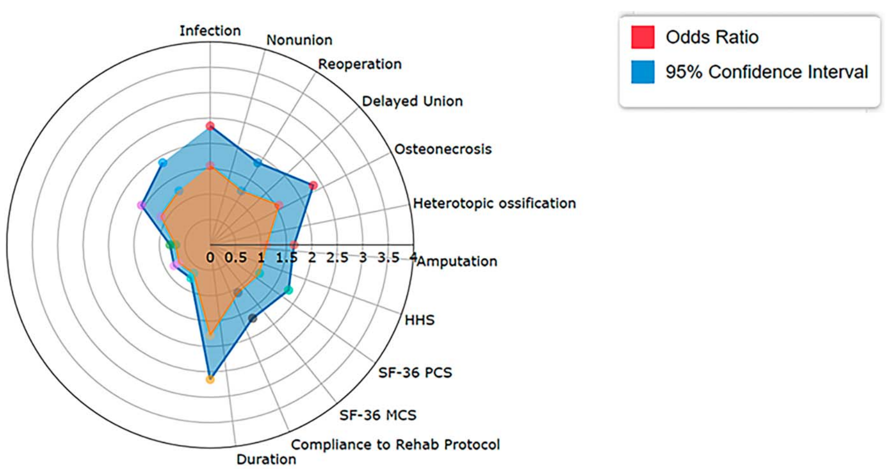

Fig. 5
The ORs and 95% CIs for predictor variables.

TABLE VII Predictors of Complications and Poor Functional Outcomes*

Outcome Variable	Predictor Variable	OR†	P Value‡
Infection	Type of wound	2.34 (1.56 to 3.51)	<0.001
	ISS	1.21 (1.14 to 1.29)	<0.001
	MESS	1.17 (1.11 to 1.24)	<0.001
	Time to initial antibiotic administration	1.19 (1.13 to 1.26)	<0.001
	Time to initial debridement	1.18 (1.12 to 1.25)	<0.001
	Duration of antibiotic therapy	1.11 (1.06 to 1.16)	<0.001
	Hospital length of stay	0.86 (0.82 to 0.91)	<0.001
Nonunion	Type of wound	2.21 (1.43 to 3.41)	<0.001
	Type of fracture	2.27 (1.49 to 3.46)	<0.001
	Time from hospital admission to definitive fixation	1.16 (1.09 to 1.23)	<0.001
	Type of definitive fixation	2.24 (1.46 to 3.44)	<0.001
Reoperation	Type of wound	2.47 (1.65 to 3.69)	<0.001
	Type of fracture	2.36 (1.58 to 3.52)	<0.001
	Time from hospital admission to definitive fixation	1.14 (1.08 to 1.21)	<0.001
	Type of definitive fixation	2.39 (1.60 to 3.57)	<0.001
Delayed union	Type of wound	2.13 (1.38 to 3.28)	<0.001
	Type of fracture	2.19 (1.42 to 3.38)	<0.001
	Time from hospital admission to definitive fixation	1.15 (1.08 to 1.22)	<0.001
	Type of definitive fixation	2.17 (1.41 to 3.34)	<0.001
Osteonecrosis	Type of wound	2.05 (1.12 to 3.76)	<0.001
	Type of fracture	2.12 (1.17 to 3.84)	<0.001
	Time from hospital admission to definitive fixation	1.13 (1.06 to 1.21)	<0.001
	Type of definitive fixation	2.09 (1.15 to 3.81)	<0.001
Heterotopic ossification	Type of wound	2.18 (1.26 to 3.77)	<0.001
	Type of fracture	2.24 (1.31 to 3.83)	<0.001
	Time from hospital admission to definitive fixation	1.12 (1.05 to 1.19)	<0.001
	Type of definitive fixation	2.21 (1.28 to 3.81)	<0.001
Amputation	Type of wound	2.32 (1.09 to 4.94)	<0.001

*The multivariable logistic regression models were adjusted for age, sex, mechanism of injury, associated injuries, ISS, MESS, time to definitive fixation, type of definitive fixation, duration of antibiotic therapy, hospital length of stay, time from injury to initial antibiotic administration, time from injury to initial debridement, and compliance with and adherence to rehabilitation protocol as covariates. †The values are given as the OR, with the 95% CI in parentheses. ‡The p values were all significant.

The high rates of complications and poor functional outcomes observed in this study can be attributed to several factors. First, the high-energy trauma associated with gunshot wounds causes extensive damage to the bone and soft tissues surrounding the hip joint, leading to instability, immobility, or misalignment[9]. Second, these injuries carry a high risk of infection due to foreign bodies, devitalized tissues, and bacterial contamination[10], which can result in septic arthritis, osteomyelitis, or systemic sepsis[11]. Third, the complex nature of these injuries often necessitates multiple surgical procedures involving various stages, implants, and techniques[12], which can contribute to complications such as nonunion, malunion, implant failure or loosening, reoperation, osteonecrosis, heterotopic ossification, or amputation[13]. Fourth, these injuries can impair the function and quality of life of patients due to pain, stiffness, deformity, disability, or psychological distress[16]. Additionally, contextual factors specific to the study setting, such as limited resources, delayed presentation, delayed debridement, delayed fixation, limited options for soft-tissue coverage, lack of trained staff, lack of laboratory facilities, and lack of rehabilitation services, may also impact the outcomes of these injuries[40-47].

The wound, fracture, and definitive fixation types were identified as significant predictors of outcomes in this study. Greater severity, complexity, and invasiveness of these factors were associated with increased odds of complications and poor functional outcomes, aligning with previous literature showing their importance in relation to infection, healing, stability, alignment, function, and quality of life in open proximal femoral fractures[9-12]. However, measuring and classifying these factors present certain limitations and challenges.

The classification of wounds based on the Gustilo-Anderson system may not entirely reflect the true extent of soft-tissue damage and contamination caused by the missile and may be influenced by various factors such as times to presentation and to irrigation and debridement[10]. This system also exhibits limitations in terms of interobserver reliability and validity for open injuries caused by gunshot wounds[48,49]. Similarly, the classification of fractures using the OTA/AO system based on radiographs and operative findings may not capture the full spectrum of fracture patterns and variations caused by gunshot wounds and may be influenced by factors such as image quality, displacement, or reduction[50,51].

The choice of definitive fixation method and technique may not represent the optimal or evidence-based option for these injuries, as it is influenced by factors such as implant availability, surgical skills, or patient compliance[52,53]. Notably, comparing different modalities or techniques of fixation was beyond the scope of this study.

Furthermore, ISS and MESS, time from injury to initial antibiotic administration, and time from injury to initial debridement were also significant predictors of outcomes in this study. The increased severity of these variables was associated with higher odds of complications and poor functional outcomes, in line with previous literature highlighting their importance as measures of injury severity and limb salvageability in patients with trauma[54,55]. These variables reflect the extent and impact of associated injuries caused by the missile, with greater severity of the variables predisposing patients to systemic inflammatory responses, higher infection risks, and lower chances of limb preservation.

This study has several strengths, including a prospective design, large sample size, homogeneous population, standardized protocol, long follow-up period, and comprehensive assessment. However, it also had some limitations, such as potential selection bias and lack of validation of outcome measures in the Yemeni context.

The study findings underscore the need for early and aggressive management of open proximal femoral fractures caused by gunshot wounds in low-resource settings. They also highlight the importance of addressing challenges and barriers to improving the management and outcomes of these injuries.

In conclusion, this study highlights the severity and complexity of open proximal femoral fractures caused by gunshot wounds, which have high rates of complications and poor functional outcomes. Various factors, including the type of wound, fracture, and definitive fixation, as well as the ISS and MESS, the time to initial antibiotic administration and debridement, and the hospital length of stay and antibiotic therapy, significantly impacted outcomes. Although prompt and appropriate management is crucial to optimize outcomes, the prognosis may still be guarded because of the injuries' inherent severity and the presence of associated injuries. Moreover, due to the specific setting in our study, patients may have had limited access to quality care, a situation that affected treatment timing and techniques. Future research should address these limitations and evaluate the effectiveness of interventions to improve outcomes in Yemen. It is also essential to use culturally appropriate and validated outcome measures in future studies. ■

Mohammad Hutaif, MD[1]
Abdullah Al-Moaish, MD[1]
Anwar Al-fadliy, MD[1]

[1]Sana'a University School of Medicine, Sana'a, Yemen

Email for Corresponding author: hutaif8@gmail.com

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