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Original Article

Gender Differences in Postoperative Pain Following Long-Bone Fracture Surgery: A Retrospective Observational Study

Muhammad Shehryar[1], Ali Akhtar[1], Muhammad Mohsin[1], Mutiur Rahman[1], Chandni[1], Dr. Waqas Akram[1]*

[1] Faculty of Pharmaceutical Sciences, University of Central Punjab, Lahore, Pakistan

* Corresponding author: Dr. Waqas Akram, Waqas.akram@ucp.edu.pk

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ABSTRACT

Background: Postoperative pain is common after orthopedic trauma surgery and may delay mobilization, impair rehabilitation, and increase the risk of persistent postsurgical pain. Sex-based differences in pain perception have been reported in several surgical populations, but local evidence among patients undergoing long-bone fracture surgery remains limited. Objective: To evaluate postoperative pain severity after long-bone fracture surgery and determine whether sex and perioperative clinical factors were associated with moderate-to-severe postoperative pain. Methods: This retrospective observational analytical study included 433 adult patients who underwent long-bone fracture surgery at Ghurki Trust Teaching Hospital, Lahore, from May 2025 to December 2025. Data were extracted from medical records, surgical notes, anesthesia records, and postoperative monitoring charts. Postoperative pain was measured using VAS/NRS and categorized as mild pain (0–3) or moderate-to-severe pain (4–10). Demographic, injury-related, surgical, anesthetic, and analgesic variables were analyzed using descriptive statistics, subgroup comparisons, and planned logistic regression. Results: Among 433 patients, 245 (56.6%) were male and 188 (43.4%) were female. Moderate-to-severe postoperative pain was reported by 241 patients (55.7%), while 192 (44.3%) reported mild pain. Female patients had higher median pain scores than male patients (6.0 vs 4.0). Higher median pain scores were also observed among patients with preoperative opioid exposure (7.0 vs 4.0), displaced fractures (6.0 vs 4.0), delayed surgery beyond 24 hours (6.0), and road traffic accident-related injuries (6.0). Conclusion: Moderate-to-severe postoperative pain was frequent after long-bone fracture surgery. Female sex and selected perioperative characteristics showed clinically relevant associations with higher pain burden, supporting early risk stratification and individualized multimodal analgesic planning. Keywords: Postoperative pain; sex differences; long-bone fracture; orthopedic surgery; Visual Analogue Scale; Numeric Rating Scale; opioid exposure.

INTRODUCTION

Postoperative pain remains a major clinical problem after orthopedic trauma surgery because inadequate pain control can delay mobilization, impair participation in rehabilitation, prolong hospital stay, and increase the risk of persistent postsurgical pain. Long-bone fracture surgery is particularly relevant in this context because it involves traumatic tissue injury, fracture manipulation, periosteal irritation, soft-tissue disruption, and variable surgical fixation techniques, all of which may contribute to moderate-to-severe pain in the immediate postoperative period. Early identification of patients at higher risk of clinically important postoperative pain is therefore essential for individualized analgesic planning, timely rehabilitation, and prevention of pain-related functional limitation (1).

Orthopedic procedures are consistently reported among the more painful surgical interventions, and the intensity of acute postoperative pain is influenced by both patient-related and perioperative factors. Previous evidence has shown that severe postoperative pain is associated with preoperative pain characteristics, analgesic exposure, surgical procedure type, and demographic variables, indicating that postoperative pain is not determined by surgical trauma alone (2,3). Among these factors, biological sex has received increasing attention because clinical and experimental pain studies have frequently reported differences in pain perception, pain thresholds, analgesic response, and postoperative pain reporting between males and females (4,5).

Existing literature suggests that females often report higher pain intensity and lower pain tolerance than males across several clinical and experimental pain conditions. These differences may reflect complex interactions among hormonal regulation, inflammatory responses, endogenous opioid mechanisms, psychosocial factors, and differences in pain reporting behavior. In postoperative settings, sex has also been identified as a potential independent predictor of pain intensity, although the magnitude and consistency of this association vary across surgical populations, pain measurement methods, and adjustment strategies (5,6). Therefore, sex-specific analysis is clinically important when evaluating postoperative pain after orthopedic trauma surgery.

Despite growing international evidence on sex-related differences in postoperative pain, limited local data are available from Pakistan regarding pain severity after long-bone fracture surgery. Many previous studies have included heterogeneous surgical populations or specific orthopedic procedures, whereas fewer studies have focused on patients undergoing long-bone fracture fixation using routinely collected hospital data and multivariable adjustment for relevant perioperative predictors. This evidence gap is important because local trauma patterns, surgical timing, analgesic practices, anesthesia approaches, and hospital workflows may influence postoperative pain outcomes.

This study aimed to determine whether biological sex was independently associated with moderate-to-severe postoperative pain following long-bone fracture surgery and to identify additional demographic, injury-related, surgical, anesthetic, and analgesic predictors of postoperative pain severity. The primary research question was whether female patients undergoing long-bone fracture surgery had higher odds of moderate-to-severe postoperative pain than male patients after adjustment for relevant clinical and perioperative factors.

MATERIAL AND METHODS

This retrospective observational analytical study was conducted at Ghurki Trust Teaching Hospital, Lahore, Pakistan, a tertiary-care orthopedic and trauma center providing specialist surgical management for fracture patients. The study used routinely documented hospital records of adult patients who underwent surgery for long-bone fractures from May 2025 to December 2025. The retrospective design was selected to evaluate postoperative pain patterns and associated predictors using available perioperative clinical data without introducing any intervention or alteration in patient management. The study was designed and reported in accordance with the principles of observational clinical research, with attention to transparent eligibility criteria, operational definitions, outcome classification, and adjustment for potential confounding variables (7).

The study population comprised patients aged 18 years or older who underwent surgical treatment for long-bone fractures and had documented postoperative pain assessment using a Visual Analogue Scale or Numeric Rating Scale. Patients were eligible when complete perioperative information was available for the main exposure, outcome, and relevant clinical variables. Patients with multiple major injuries, revision surgery, incomplete records for sex, surgery, or postoperative pain, known chronic pain conditions, or documented opioid addiction were excluded to reduce heterogeneity and minimize bias in pain outcome interpretation. Patients were selected through non-probability consecutive convenience sampling from available hospital records during the defined study period.

The primary exposure variable was biological sex, categorized as male or female according to hospital record documentation. The primary outcome was postoperative pain severity, measured using documented Visual Analogue Scale or Numeric Rating Scale scores during the immediate postoperative period. Pain scores were dichotomized into mild pain and moderate-to-severe pain using the predefined clinical threshold reported in the manuscript, where scores of 0–3 were classified as mild pain and scores of 4–10 were classified as moderate-to-severe pain. This dichotomized outcome was used for logistic regression analysis. Additional variables extracted from the records included age group, smoking status, mechanism of injury, bone involved, fracture displacement, open fracture status, soft-tissue involvement, time from presentation to operation, type of anesthesia, procedure type, and preoperative opioid prescription.

Data were obtained retrospectively from patient medical records, surgical notes, anesthesia records, and postoperative monitoring charts. Pain assessment was based on routinely recorded postoperative pain scores using validated pain intensity scales. The Visual Analogue Scale and Numeric Rating Scale are commonly used tools for clinical pain assessment and allow categorization of pain severity for postoperative monitoring and research analysis (10). Data extraction was performed using available clinical documentation, and records with incomplete key variables were excluded before final analysis. The final analyzed sample included 433 patients with complete eligible records.

Potential sources of bias were addressed through predefined inclusion and exclusion criteria, use of routinely documented perioperative variables, and multivariable adjustment for clinically relevant predictors. Patients with known chronic pain or opioid addiction were excluded because these conditions could independently alter pain perception and postoperative analgesic requirements. Confounding was assessed by including demographic, injury-related, surgical, anesthetic, and analgesic variables in regression analysis. The manuscript reported no significant missing data for the variables included in analysis. Data consistency was maintained by extracting variables from hospital records using the same operational categories used for descriptive and regression analyses.

The sample size was based on the availability of complete eligible records from the hospital database during the study period, yielding 433 patients. This sample provided an adequate number of outcome events for multivariable logistic regression, as 241 patients experienced moderate-to-severe postoperative pain. The adequacy of the sample for regression modeling was considered in relation to the number of candidate predictors and the recommended events-per-variable principles for observational logistic regression analysis (9).

Data were analyzed using the Statistical Package for Social Sciences, version 22. Continuous variables were summarized as mean and standard deviation when normally distributed and as median with interquartile range when distributional assumptions were not met. Categorical variables were summarized as frequencies and percentages. Group comparisons of pain scores across categorical variables were performed using nonparametric tests where pain-score distribution was non-normal. For the primary binary outcome, univariate logistic regression was first used to assess crude associations between each candidate predictor and moderate-to-severe postoperative pain. Multivariable logistic regression was then applied to estimate adjusted associations while controlling for relevant demographic, injury-related, surgical, anesthetic, and analgesic factors. Results were reported as odds ratios with 95% confidence intervals and p-values. A p-value below 0.05 was considered statistically significant. Reference categories and outcome coding were required to remain consistent across descriptive tables, regression tables, and narrative interpretation.

The study was approved by the Institutional Review Board of Ghurki Trust Teaching Hospital, Lahore, under approval number 91/HR/GTTH, dated May 5, 2025. Because the study used retrospective hospital records, patient confidentiality was maintained throughout data extraction, analysis, and reporting. No experimental intervention was performed, and all data were handled in accordance with ethical principles for medical research involving human data (8).

RESULTS

A total of 433 patients who underwent long-bone fracture surgery were included in the analysis. Males represented 245 patients (56.6%), while females represented 188 patients (43.4%). The largest age group was 18–40 years, comprising 222 patients (51.3%). Falls were the most frequent mechanism of injury, reported in 208 patients (48.0%), followed by road traffic accidents in 114 patients (26.3%). The most commonly involved bones were the femur in 114 patients (26.3%) and tibia in 105 patients (24.2%). Fracture displacement was documented in 241 patients (55.4%), while open fractures were present in 169 patients (39.0%). Most patients underwent surgery within 24 hours, with 159 patients (36.7%) operated within 0–7 hours and 155 patients (35.8%) within 8–24 hours. Preoperative opioid prescription was documented in 135 patients (31.2%).

Table 1. Baseline Demographic and Clinical Characteristics of Patients Undergoing Long-Bone Fracture Surgery

Variable	Category	n	%
Total		433	100.0
Sex	Male	245	56.6
	Female	188	43.4
Age group, years	18–40	222	51.3
	41–60	144	33.3
	>60	67	15.5
Smoking	Yes	171	39.5
	No	262	60.5
Mechanism of injury	Fall	208	48.0
	Road traffic accident	114	26.3
	Sports injury	62	14.3
	Assault	49	11.3
Bone involved	Femur	114	26.3
	Tibia	105	24.2
	Radius	79	18.2
	Humerus	76	17.6
	Ulna	59	13.6
Displacement	Yes	241	55.4
	No	192	44.3
Open fracture	Yes	169	39.0
	No	264	61.0
Soft-tissue involvement	Yes	138	31.9
	No	295	68.1
Time to operation, hours	0–7	159	36.7
	8–24	155	35.8
	>24	119	27.5
Anesthesia	Regional	170	39.3
	General	164	37.9
	Combined	99	22.9
Procedure type	Plate fixation	130	30.0
	Intramedullary nail	121	27.9
	External fixation	97	22.4
	Wire fixation	85	19.6
Preoperative opioid prescription	Yes	135	31.2
	No	298	68.8

Postoperative pain was categorized using the predefined threshold of 0–3 for mild pain and 4–10 for moderate-to-severe pain. Overall, 192 patients (44.3%) reported mild postoperative pain, whereas 241 patients (55.7%) reported moderate-to-severe postoperative pain. The mean postoperative pain score in the total sample was 4.79 ± 2.39, with a median score of 5.0 and an interquartile range of 3.0–7.0.

Table 2. Distribution of Postoperative Pain Severity

Pain category	VAS/NRS range	n	%
Mild pain	0–3	192	44.3
Moderate-to-severe pain	4–10	241	55.7

More than half of the patients experienced clinically relevant postoperative pain after long-bone fracture surgery. The observed distribution indicates that moderate-to-severe pain was common in this cohort, affecting 241 of 433 patients. This supports the need for early identification of patients who may require intensified postoperative analgesic planning.

Pain scores differed across several demographic and clinical subgroups. Female patients had higher postoperative pain scores than male patients, with a median VAS/NRS score of 6.0 compared with 4.0 and a mean score of 5.6 compared with 4.1. Pain scores also varied significantly by age group, smoking status, fracture displacement, and preoperative opioid use. Patients with preoperative opioid use had the highest pain scores, with a median VAS/NRS score of 7.0 and mean score of 6.4. Differences by mechanism of injury, bone involved, open fracture status, and time to operation were not statistically significant in the comparative pain-score analysis.

Table 3. Postoperative Pain Scores According to Demographic and Clinical Characteristics

Variable	Category	Median	25th percentile	75th percentile	Mean	SE	p-value
Overall		5.0	3.0	7.0	4.79	0.12	
Sex	Male	4.0	2.0	6.0	4.1	0.21	<0.001
	Female	6.0	4.0	7.0	5.6	0.24	<0.001
Age group, years	18–40	5.0	3.0	7.0	5.2	0.23	0.003
	41–60	5.0	3.0	6.0	4.8	0.26	0.004
	>60	4.0	2.0	6.0	4.1	0.31	
Smoking	Yes	6.0	3.0	7.0	5.3	0.29	0.030
	No	4.0	2.0	6.0	4.5	0.18	0.038
Mechanism of injury	Fall	4.0	2.0	6.0	4.4	0.24	0.093
	Road traffic accident	6.0	4.0	7.0	5.6	0.27	0.081
	Sports injury	5.0	3.0	6.0	4.8	0.33	
	Assault	5.0	3.0	7.0	5.0	0.36	
Bone involved	Femur	6.0	4.0	7.0	5.5	0.31	0.188
	Tibia	5.0	3.0	7.0	5.1	0.28	0.174
	Radius	4.0	2.0	6.0	4.3	0.26	
	Humerus	4.0	2.0	6.0	4.2	0.29	
	Ulna	4.0	2.0	5.0	4.0	0.32	
Displacement	No	4.0	2.0	6.0	4.3	0.19	0.037
	Yes	6.0	4.0	7.0	5.4	0.25	0.041
Open fracture	No	4.0	2.0	6.0	4.5	0.18	0.229
	Yes	5.0	3.0	7.0	5.1	0.24	0.210
Time to operation, hours	0–7	4.0	2.0	6.0	4.4	0.22	0.201
	8–24	5.0	3.0	7.0	4.8	0.25	0.187
	>24	6.0	4.0	7.0	5.5	0.29	
Preoperative opioid use	No	4.0	2.0	6.0	4.2	0.17	0.001
	Yes	7.0	5.0	8.0	6.4	0.33	0.002

VAS/NRS pain scores showed the clearest separation by sex and preoperative opioid use. Female patients had a two-point higher median pain score than male patients, and patients with preoperative opioid use had a three-point higher median pain score than those without preoperative opioid use. Fracture displacement was also associated with higher pain scores, with displaced fractures showing a median score of 6.0 compared with 4.0 for non-displaced fractures. Although road traffic accidents, femur fractures, and delayed surgery beyond 24 hours showed numerically higher pain scores, these comparisons were not statistically significant in the reported pain-score analysis.

The planned logistic regression analysis should be reported after verification of outcome coding, reference categories, and denominators. In the supplied regression table, the pain-category labels overlap at VAS/NRS score 4, displacement counts conflict with the descriptive table, procedure categories are not harmonized with baseline characteristics, and several odds ratios appear directionally inconsistent with the raw percentages. Therefore, the adjusted predictor table should not be finalized until the statistical output is corrected. Once verified, the regression table should report crude and adjusted odds ratios for moderate-to-severe postoperative pain, using mild pain as the reference outcome category and maintaining the threshold of 0–3 versus 4–10 throughout the text, tables, and abstract.

Figure 1 Multidimensional postoperative pain profile after long-bone fracture surgery. Moderate-to-severe postoperative pain was reported by 241 of 433 patients (55.7%), while 192 patients (44.3%) reported mild pain. Female patients showed a higher median VAS/NRS score than male patients (6.0 vs 4.0), and patients with preoperative opioid exposure had the highest pain burden, with a median score of 7.0 compared with 4.0 among those without opioid exposure. Displaced fractures, delayed surgery beyond 24 hours, and road traffic accident-related injuries showed median pain scores reaching 6.0, indicating clinically relevant pain clustering across sex, analgesic exposure, injury severity, and surgical timing.

DISCUSSION

This retrospective observational study evaluated postoperative pain patterns after long-bone fracture surgery and examined whether sex and other perioperative characteristics were associated with moderate-to-severe postoperative pain. More than half of the included patients experienced moderate-to-severe pain, indicating that clinically relevant postoperative pain remained common in this orthopedic trauma cohort. This finding is consistent with previous evidence showing that acute postoperative pain is frequent after surgical procedures and that orthopedic trauma patients are particularly vulnerable because of fracture-related tissue injury, operative manipulation, and early rehabilitation demands (1–3). The observed overall mean pain score of 4.79 ± 2.39 and the predominance of moderate-to-severe pain emphasize the need for structured postoperative pain surveillance rather than relying only on routine analgesic prescription.

Female patients showed higher postoperative pain scores than male patients, with a median VAS/NRS score of 6.0 compared with 4.0 in males. This finding supports the central hypothesis of the study and aligns with previous orthopedic and perioperative pain literature reporting higher postoperative pain intensity among females (4,6). Storesund et al. reported higher postoperative pain scores among females after ankle surgery, suggesting that sex-related pain differences may remain relevant even within specific orthopedic populations (4). Similarly, broader pain literature indicates that females often demonstrate lower pain thresholds, lower pain tolerance, and greater pain sensitivity across several experimental and clinical pain conditions (5). These differences may reflect biological mechanisms such as hormonal modulation, inflammatory responses, endogenous opioid system variation, and psychosocial factors influencing pain perception and reporting (5,6). In the present cohort, the two-point median difference between females and males is clinically meaningful because it crosses the threshold for moderate pain and may influence early mobilization, rehabilitation participation, and analgesic requirements.

Preoperative opioid exposure was associated with the highest postoperative pain burden in the subgroup pain-score analysis, with a median VAS/NRS score of 7.0 among patients with preoperative opioid prescription compared with 4.0 among those without opioid exposure. This finding is clinically important because previous research has shown that preoperative pain intensity and analgesic use may predict more severe postoperative pain and higher postoperative analgesic consumption (1,3). Mechanistically, preoperative opioid exposure may be associated with opioid tolerance, opioid-induced hyperalgesia, altered central pain processing, or greater preoperative injury-related pain severity. However, the adjusted regression estimate for opioid exposure should be interpreted only after verification of outcome coding and reference categories, because the supplied regression table showed a direction of association that did not align with the raw pain-category distribution. Therefore, the descriptive finding supports the clinical relevance of opioid exposure, but the final independent effect should be confirmed through corrected multivariable analysis.

Fracture displacement was associated with higher pain scores, with displaced fractures showing a median VAS/NRS score of 6.0 compared with 4.0 for non-displaced fractures. This pattern is clinically plausible because displaced fractures may involve greater periosteal irritation, soft-tissue traction, instability, and operative manipulation. Although open fracture status and bone involved were not statistically significant in the reported pain-score comparisons, femur and tibia fractures showed numerically higher mean pain scores than upper-limb fractures. This trend may reflect the functional and mechanical relevance of weight-bearing bones, greater soft-tissue trauma, and the complexity of fixation procedures. Similar orthopedic literature has emphasized that surgical extent, tissue handling, and trauma severity may influence postoperative pain intensity and recovery trajectories (11,12).

Timing of surgery showed a clinically relevant gradient, with patients operated after more than 24 hours having a median pain score of 6.0 compared with 4.0 among those operated within 0–7 hours, although the reported comparative analysis did not reach statistical significance. Delayed surgery may prolong preoperative nociceptive input, immobilization-related discomfort, inflammatory sensitization, and anxiety related to trauma and pending surgery. These findings suggest that surgical timing may still be clinically relevant even when statistical significance is not demonstrated in subgroup comparisons. Similarly, road traffic accident-related injuries showed higher median pain scores than falls, which may reflect higher-energy trauma and greater tissue involvement, although interpretation should remain cautious because the supplied regression table requires verification before firm adjusted conclusions are drawn.

The findings have practical implications for postoperative pain management in orthopedic trauma settings. Female patients, patients with preoperative opioid exposure, displaced fractures, delayed surgery, and high-energy injury mechanisms may benefit from early pain risk stratification, scheduled multimodal analgesia, closer pain reassessment, and coordinated rehabilitation planning. Pharmacist-led analgesic review and opioid stewardship may also be valuable, particularly for patients with preoperative opioid exposure or high immediate postoperative pain scores. However, because this was a retrospective observational study, these findings should be interpreted as associations rather than causal relationships.

The study has several strengths. It included a relatively large local orthopedic trauma cohort of 433 patients, used routinely documented clinical data from a tertiary-care orthopedic hospital, and assessed multiple demographic, injury-related, surgical, anesthetic, and analgesic variables. The use of VAS/NRS pain scoring allowed clinically interpretable pain classification, and the sample contained an adequate number of moderate-to-severe pain events for multivariable modeling after correction of coding and reference-category issues (9,10). These features strengthen the study's relevance for local postoperative pain planning in fracture surgery.

Several limitations should be acknowledged. First, the retrospective design limits causal inference and depends on the completeness and accuracy of hospital records. Second, the exact timing and operational definition of the primary postoperative pain score should be standardized in the final manuscript, because pain may differ between PACU, ward-based assessment, and the first 24-hour postoperative period. Third, psychological factors, baseline pain intensity, analgesic dose, intraoperative analgesia, and postoperative analgesic protocols were not fully captured, although these factors may influence pain reporting. Fourth, this was a single-center study from a tertiary orthopedic hospital, which may limit generalizability to other trauma-care settings. Finally, the regression table requires verification for outcome coding, reference categories, and internal consistency before adjusted predictor claims are finalized.

CONCLUSION

In conclusion, moderate-to-severe postoperative pain was common after long-bone fracture surgery in this retrospective orthopedic trauma cohort. Female patients had higher postoperative pain scores than male patients, and higher pain burden was also observed among patients with preoperative opioid exposure, displaced fractures, delayed surgery beyond 24 hours, and road traffic accident-related injuries. These findings support the need for early postoperative pain risk stratification, sex-sensitive analgesic planning, structured reassessment, and individualized multimodal pain management in patients undergoing long-bone fracture surgery. Corrected multivariable analysis is required to confirm the independent contribution of each predictor before final adjusted conclusions are reported.

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