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Outcome of management of gunshot injury following the July revolution in Bangladesh by the Ilizarov method

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ABSTRACT

Background: Gunshot injuries (GSIs) are a major contributor to the global burden of injury, frequently resulting in severe fractures, extensive soft tissue damage and long-term disability, particularly among young adult males in both civilian and military settings. The purpose of this study is to evaluate the clinical and functional outcomes of patients with extremity gunshot injuries sustained during the July revolution in Bangladesh who were managed using the Ilizarov method.
Methods: This prospective observational study at the Department of Orthopedics, National institute of traumatology and orthopaedic rehabilitation (NITOR), Dhaka, Bangladesh, from July 2024 to December 2025 included 30 patients with gunshot-induced extremity fractures from the July revolution, all managed with the Ilizarov external fixator and followed for at least 18 months. Outcomes assessed were fracture union, anatomical and functional results (ASAMI criteria), and treatment-related complications, analyzed using descriptive statistics.
Results: In 30 patients (mean age 25.0±10.4 years, 96.7% male), 66.7% had high-velocity injuries and 70.0% were potentially lethal. Tibial fractures predominated (60.0%) with 86.7% open fractures. Primary fixation was done in 73.3%. At 18 months, 90.0% achieved union, 70.0% had minimal deformity, 60.0% had no shortening, and 80.0% had satisfactory or good functional outcomes, with manageable complications.
Conclusions: The Ilizarov method provides effective anatomical restoration and functional recovery in complex gunshot injuries sustained during the July revolution in Bangladesh.

Keywords: Gunshot injuries, Ilizarov method, July revolution

INTRODUCTION

Gunshot injuries (GSIs) represent a significant contributor to the global burden of injury. Overall, injuries account for 12% of worldwide disease burden and rank as the third leading cause of death globally.[1,2] The incidence of GSIs has been steadily increasing across both military and civilian populations. Penetrating gunshot injuries, perforating gunshot injuries, high-velocity injuries and polytraumatic gunshot injuries are among the most severe

types of traumatic injury, often linked with high mortality rates and long-term disability. Among them, penetrating gunshot wounds are particularly severe, often resulting in high mortality and long-term disability. The majority of affected individuals are young adult males, who form the most active and economically productive segment of society, amplifying the public health and socio-economic impact.[3,4] Recent studies indicate that over half of gunshot injuries treated in civilian trauma centers in developing countries involve the extremities, which frequently present with complex fractures and extensive soft tissue damage.[5,6]

In 2024, Bangladesh witnessed one of its most notable civil movements, the students–people's uprising, also known as the July revolution, which faced violent suppression by state authorities.[7,8] The movement escalated into a widespread uprising after government forces used force against protesters, culminating in what is now called the July Massacre. During the July–August protests, more than 22,000 individuals sustained injuries, with 587 left permanently disabled and 21 suffering amputations.[9] The HRSS assessed the causes of death of 772 individuals and found that at least 599 confirmed gunshot deaths accounted for 77% of the deaths.[10] Over 30,000 people were injured during this period, many sustaining gunshot wounds including severe cranial trauma.[10] Public and private hospitals in Dhaka were overwhelmed with patients requiring urgent, complex trauma care.[11,12] The NITOR played a key role in providing specialized orthopedic and rehabilitation care for the large influx of patients with gunshot-related extremity injuries during this crisis.

Managing gunshot injuries continues to be a major challenge for trauma surgeons worldwide. Gunshot injuries range from low-velocity (≈380 m/s) to high-velocity (≈1200 m/s) bullets, with high-velocity injuries often causing extensive tissue and skeletal damage and presenting significant management challenges. In developing countries with underdeveloped trauma systems and limited access to care, treating extremity GSIs is especially demanding. Gustilo-Anderson type III open fractures caused by high-velocity firearms present some of the most complex challenges in orthopedic surgery.[13,14] Open tibial fractures are frequently complicated by non-union, infection and potential limb loss.[15] While the Ilizarov method may not be considered the optimal long-term solution compared to internal fixation or nailing in well-resourced settings, it offers significant advantages for immediate stabilization and management of complex extremity fractures in high-volume, resource-limited trauma settings like Bangladesh during the July Revolution. Evidence shows that the Ilizarov method for managing segmental lower limb defects can achieve union rates as high as 95%, while being cost-effective and suitable for use in resource-limited settings like Bangladesh.[17] Despite the increasing prevalence of civilian gunshot injuries in regions affected by political instability, research from low-resource settings remains limited. The association between clinical predictors and outcomes of GSIs in developing countries is still poorly understood.[18] Differences in injury patterns and outcomes highlighted in prior studies underscore the need for prospective data in local settings to inform preventive strategies and improve patient care. This evidence gap emphasizes the importance of focused research on the management and outcomes of extremity gunshot injuries sustained during periods of civil unrest, such as the July revolution, particularly when utilizing advanced reconstructive techniques like the Ilizarov method. The purpose of the study is to assess the clinical and functional outcomes of patients with gunshot injuries sustained during the July revolution in Bangladesh managed using the Ilizarov method.

METHODS

This prospective observational study was conducted at the Department of Orthopaedics, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, from July 2024 to December 2025. During this period, NITOR served as the central referral center for high-energy orthopaedic trauma resulting from civil unrest during the July revolution. The study was performed in accordance with the ethical principles outlined in the Declaration of Helsinki. Consecutive patients with gunshot-induced extremity fractures treated using the Ilizarov external fixation method were identified from the institutional orthopaedic trauma registry and operative records. A total of 30 patients with gunshot injuries sustained during the July revolution in Bangladesh were included.

Inclusion criteria

Patients of any age or sex who sustained gunshot-induced fractures of the extremities, including the humerus, femur, and tibia, during the civil unrest of July 2024 were included in the study. Eligible patients were those whose fractures required surgical stabilization and were managed definitively using the Ilizarov external fixator. In addition, only patients who had a minimum postoperative follow-up period of 18 months were considered for inclusion.

Exclusion criteria

Patients with isolated soft tissue gunshot wounds without associated fractures were excluded from the study. Patients whose fractures were managed primarily with internal fixation rather than the Ilizarov external fixator were also excluded. Additionally, patients who were lost to follow-up before the 18-months outcome assessment and those with incomplete medical or radiographic records were not included in the analysis.

Data collection and injury assessment

Data were systematically collected using a standardized proforma. Recorded variables included patient demographics (age and sex), injury characteristics (date of injury, bone involved and fracture classification according

to the Gustilo–Anderson system) and ballistic profile. Bullet velocity was categorized as low-velocity (approximately 380 m/s) or high-velocity (approximately 1200 m/s) based on clinical history, wound morphology, and the extent of radiographic comminution. Injury lethality was classified as potentially lethal or non-lethal according to hemodynamic status at presentation and overall injury severity.

Management protocol

All patients underwent Advanced trauma life support–guided resuscitation followed by urgent surgical debridement. Definitive fixation using the Ilizarov external fixator was performed either as primary fixation within 72 hours or as staged fixation, depending on the extent of soft-tissue injury and patient stability. Bone transport was employed in cases with segmental bone defects exceeding 2 cm. The Ilizarov configuration was individualized based on fracture pattern and soft-tissue condition, and the duration of fixation was recorded for each patient. The Ilizarov external fixator was selected due to its versatility in managing complex open fractures with severe soft tissue damage, its suitability for staged reconstruction, and its ability to provide immediate stabilization in an overwhelmed trauma setting.

Follow-up and outcome measures

Patients were followed prospectively for a minimum period of 18 months. The primary outcome measure was fracture union. Secondary outcomes included radiographic union, defined as the presence of bridging callus across at least three cortices; anatomic outcomes assessed by residual deformity (measured in degrees) and limb shortening (measured in centimeters); functional outcome evaluated using the ASAMI criteria; and treatment-related complications, including pin-tract infection, joint stiffness, limb length discrepancy and re-fracture.

Statistical analysis

Statistical analysis was performed using SPSS version 27.0. Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequencies and percentages.

RESULTS

Most patients were young adults aged 18-30 years (n=22, 73.3%), with a mean age of 25.0±10.4 years. The cohort was predominantly male (n=29, 96.7%).

Regarding the mechanism of injury, 20 patients (66.7%) sustained high-velocity gunshot injuries, while 10 patients (33.3%) had low-velocity injuries.

Lethality assessment showed that 21 patients (70.0%) had potentially lethal injuries, whereas 9 patients (30.0%) sustained non-lethal injuries.

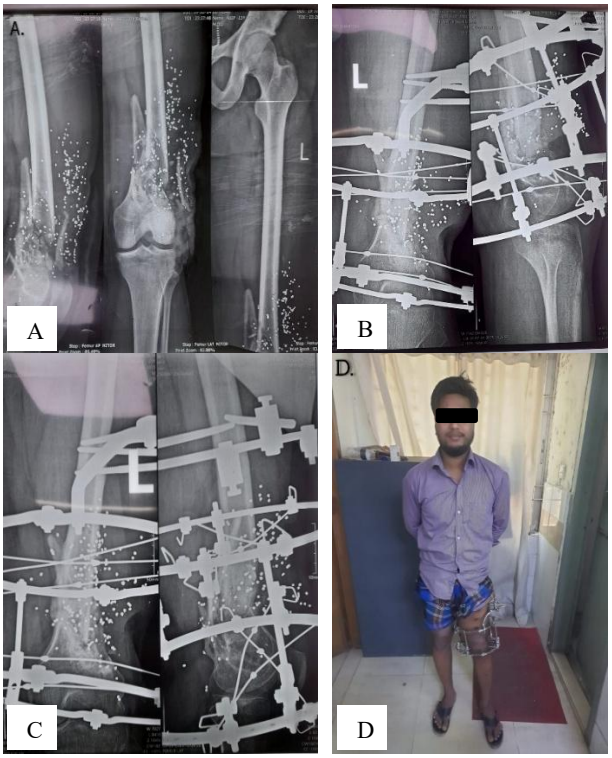


Figure 1: Radiographic and clinical progression of femoral gunshot injuries managed by the Ilizarov method: (A) preoperative radiographs of a left femoral comminuted fracture with retained pellets, (B) postoperative radiographs of a left femoral gunshot injury showing union, (C) radiographs showing Ilizarov fixation before removal of fixation of a femoral fracture and (D) clinical picture of a patient treated with Ilizarov fixator.

The tibia was the most commonly involved bone (n=18, 60.0%), followed by the femur (n=8, 26.7%) and humerus (n=4, 13.3%). Open fractures were predominant (n=26, 86.7%). Soft tissue injury was severe in 12 patients (40.0%), moderate in 10 (33.3%) and mild in 8 (26.7%). Regarding management, 22 patients (73.3%) underwent primary fixation within 72 hours, 8 (26.7%) underwent staged fixation and bone transport was required in 9 patients (30.0%).

The mean duration of fixation was 6.5±1.3 months. Figure 1 illustrates the fracture union status at 18 months of follow-up. Bone union was achieved in 27 patients (90.0%), delayed union was observed in 2 patients (6.7%) and non-union occurred in 1 patient (3.3%).

Deformity was within 0–<5° in 21 patients (70.0%), 5-10° in 6 patients (20.0%) and >10° in 3 patients (10.0%). Limb shortening of 0-<2 cm was observed in 18 patients (60.0%), 2-5 cm in 8 patients (26.7%) and >5 cm in 4 patients (13.3%).

Overall, most patients achieved satisfactory anatomical alignment and acceptable limb length restoration following treatment.



Figure 2: (A) Pre-operative X-ray of shaft of the left humerus with external fixator showing comminuted fracture and bullet in situ; (B) post-operative X-ray of the left humerus with Ilizarov fixator; (C) clinical picture of the patient with ilizarov fixator in the left arm and (D) X-ray of the left arm showing unity in the fracture site.

Table 1: Demographic and injury characteristics of the study population (n=30).

Variables		Frequency (N)	Percentage (%)
Age (years)	18-30	22	73.3
	31-45	6	20.0
	>45	2	6.7
	Mean±SD	25.0±10.4	
Sex	Male	29	96.7
	Female	1	3.3
Bullet velocity	High-velocity (≈1200 m/s)	20	66.7
	Low-velocity (≈380 m/s)	10	33.3
Lethality assessment	Potentially lethal injury	21	70.0
	Non-lethal injury	9	30.0

Functional recovery was satisfactory in 14 patients (46.7%), good in 10 (33.3%), fair in 5 (16.7%) and poor in 1 (3.3%).

Table 2: Injury pattern and management characteristics of gunshot injuries (n=30).

Variables		Frequency (N)	Percentage (%)
Bone involved	Tibia	18	60.0
	Femur	8	26.7
	Humerus	4	13.3
Fracture type	Open fracture (Gustilo type III)	26	86.7
	Closed fracture	4	13.3
Soft tissue injury severity	Severe	12	40.0
	Moderate	10	33.3
	Mild	8	26.7
Management	Primary fixation (<72 h)	22	73.3
	Staged fixation	8	26.7
	Bone transport required	9	30.0
	Mean duration of fixation	6.5±1.3 months	

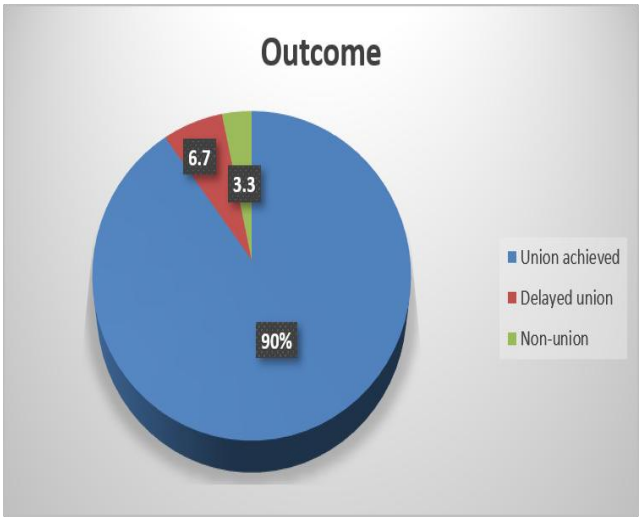


Figure 3: Fracture union status at 18-months follow-up (n=30).

Table 3: Post-treatment deformity and limb shortening (n=30).

Variables		Frequency (N)	Percentage (%)
Deformity (°)	0-<5	21	70.0
	5-10	6	20.0
	>10	3	10.0
Limb shortening (cm)	0-<2	18	60.0
	2-5	8	26.7
	>5	4	13.3

Table 4: Functional outcome and secondary/tertiary complications (n=30).

Variables		Frequency (N)	Percentage (%)
Functional outcome (ASAMI)	Satisfactory	14	46.7
	Good	10	33.3
	Fair	5	16.7
	Poor	1	3.3
Secondary complications	Pin-tract infection	8	26.7
	Joint stiffness	5	16.7
	Limb length discrepancy requiring shoe raise	4	13.3
	Re-fracture	1	3.3

Secondary complications included pin-tract infection in 8 patients (26.7%), joint stiffness in 5 (16.7%), limb length discrepancy in 4 (13.3%) and re-fracture in 1 (3.3%).

DISCUSSION

This prospective observational study was conducted at the NITOR, Dhaka, Bangladesh, from July 2024 to December 2025 to evaluate the outcomes of gunshot-induced extremity fractures managed using the Ilizarov external fixator following the July revolution. A total of 30 patients with gunshot injuries sustained during this period were enrolled. The study systematically assessed fracture union, anatomical alignment, limb length, functional recovery using ASAMI criteria and treatment-related complications over a minimum follow-up of 18 months.

The demographic profile of our study population aligns with trends reported in previous gunshot injury research, showing a marked predominance of young adult males—73.3% aged 18-30 years and 96.7% male. This is consistent with Congiusta et al, who found that orthopaedic fractures from gunshot wounds most commonly occur in individuals aged 19-29 years with over 90% male and Muss et al, who observed that the average age of patients was under 30 years, with males accounting for 94.2% of the cohort.[19,20] These findings underscore the increased susceptibility of young men to high-energy extremity trauma, particularly during periods of conflict or civil unrest, such as the July revolution. In our cohort, a significant portion of injuries resulted from high-velocity projectiles (66.7%) and were deemed potentially lethal (70%), highlighting both the severity and complexity of these fractures and the necessity for specialized treatment approaches like the Ilizarov method. Overall, these results emphasize the importance of focused surgical strategies for managing high-energy gunshot injuries in young male populations affected by post-conflict trauma.

The injury pattern and management characteristics observed in this study reflect the high-energy nature of civilian gunshot wounds sustained during the July revolution. The tibia was the most commonly involved bone (60.0%), followed by the femur (26.7%) and humerus (13.3%), a distribution comparable to that reported by Yeganeh et al, who also identified the tibia, femur and humerus as the predominant long bones affected by gunshot injuries.[21] In line with their findings, the vast majority of fractures in the present cohort were severe open injuries, with Gustilo type III fractures accounting for 86.7%, underscoring the extensive osseous and soft-tissue damage typical of ballistic trauma and the need for complex reconstructive strategies. The significant extent of soft-tissue injury in our cohort, with 40.0% of patients exhibiting severe involvement, aligns with findings by Metcalf et al, who reported that civilian gunshot-induced open fractures of the tibia and femur often involve extensive soft-tissue damage, requiring individualized and sometimes staged management strategies.[22] Accordingly, although most patients in the present study underwent early definitive fixation within 72 hours, over one-quarter required staged fixation, and nearly one-third required bone transport, reflecting the complexity of these injuries. The mean duration of fixation of 6.5±1.3 months further illustrates the prolonged and resource-intensive nature of managing high-energy gunshot fractures, consistent with patterns reported in the existing literature. Collectively, these findings reinforce that high-energy gunshot fractures sustained during periods of civil unrest are characterized by severe osseous and soft-tissue damage and require individualized, often prolonged, reconstructive management strategies, for which the Ilizarov method remains an effective option.

At 18 months post-treatment, the majority of patients achieved fracture union, with an overall union rate of 90.0% and a minimal non-union rate of 3.3%. This aligns with the findings of Riehl et al, who reported that most gunshot-related fractures ultimately united, with only a small fraction progressing to non-union despite a considerable incidence of delayed healing, highlighting the inherently challenging biology of gunshot fractures yet demonstrating favorable long-term outcomes when appropriately stabilized.[23] Similarly, Gerafa et al observed an overall union rate of around 91% in civilian gunshot-induced tibial fractures, closely reflecting the union rate in the present cohort.[24] The low incidence of non-union in this study reinforces existing evidence that stable fixation paired with careful soft-tissue management can consistently achieve successful fracture union in high-energy gunshot injuries, even with complex fracture patterns.

In the present study, the majority of patients achieved satisfactory post-treatment anatomical outcomes, with 70.0% demonstrating minimal angular deformity within 0-<5° and only 10.0% exhibiting deformity greater than 10°, indicating generally acceptable alignment correction. Limb length outcomes were similarly favorable, as 60.0% of patients had limb shortening within 0-<2 cm, while most of the remaining patients showed mild shortening of 2-5 cm, and only a small proportion demonstrated shortening

exceeding 5 cm. These findings are consistent with previous literature, including Abramson et al, who reported residual limb shortening in approximately one-third of patients with gunshot-related fractures managed with intramedullary fixation, suggesting that minor shortening is a relatively common but clinically acceptable outcome in such high-energy injuries.[25] Comparable results have also been reported in retrospective studies of tibial gunshot fractures, where most patients achieved satisfactory alignment with limited residual deformity and minimal limb length discrepancy following appropriate fixation strategies.[26] Overall, these results demonstrate that the Ilizarov method effectively preserves limb alignment and length in complex gunshot injuries sustained during the July revolution in Bangladesh, supporting its role as a reliable reconstructive option in high-energy conflict-related extremity trauma.

Functional outcomes following Ilizarov fixation were predominantly favorable, with satisfactory results achieved in 46.7% of patients and good results in 33.3%, while only a minority had fair (16.7%) or poor (3.3%) outcomes. This distribution closely mirrors the findings of Zargar et al, who reported that most patients treated with Ilizarov external fixation attained satisfactory or good ASAMI functional scores, with fewer patients falling into the fair or poor categories.[27] Similar patterns were also observed by Ansari et al, who noted that satisfactory and good functional outcomes constituted the majority in firearm-related open fractures managed with Ilizarov techniques, despite the presence of manageable complications.[28] In the current series, pin-tract infection was the most frequent complication, occurring in 26.7% of cases, followed by joint stiffness (16.7%), limb length discrepancy requiring shoe raise (13.3%), and re-fracture (3.3%). These findings are consistent with the report by Erdem et al, who identified pin-tract infection as a common but generally minor complication in high-velocity ballistic injuries treated with Ilizarov fixation.[29] Collectively, these comparable results reinforce that Ilizarov external fixation provides satisfactory functional outcomes in gunshot-related fractures, with complications that are well recognized and typically manageable within standard postoperative care.

Limitations

This study has several limitations. First, the relatively small sample size (n=30) may limit the generalizability of the findings and restrict the ability to perform meaningful subgroup or comparative statistical analyses. Second, the single-center design, conducted at a tertiary referral institution during a specific period of civil unrest, may reduce the representativeness of the results for other healthcare settings and populations. Finally, the study population consisted exclusively of patients with gunshot injuries sustained during the July revolution, a context that may involve unique injury patterns, treatment delays, and resource constraints. Consequently, the findings may not be fully applicable to routine civilian trauma care or peacetime settings.

CONCLUSION

Gunshot injuries sustained during the July revolution in Bangladesh are often severe and pose significant challenges due to extensive bone and soft tissue damage. Management using the Ilizarov method provided effective fracture healing, restored limb alignment and length, achieved satisfactory functional recovery and minimized complications, demonstrating its value in the comprehensive management of complex gunshot injuries. Although the Ilizarov method may not represent the definitive gold standard for all gunshot-induced fractures, it proved highly effective for immediate stabilization and functional recovery in complex extremity injuries during mass casualty events, highlighting its utility in resource-limited and high-demand settings.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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