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Original Research Article

EARLY VS DELAYED SURGICAL FIXATION IN CLOSED LONG BONE FRACTURES — EFFECT ON UNION TIME AND COMPLICATIONS

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ABSTRACT

Background: The optimal timing of definitive surgical fixation for closed long bone fractures remains controversial. Early fixation may enhance fracture healing and reduce postoperative complications, whereas delayed fixation is often influenced by patient or institutional factors. This study compared the effect of early versus delayed surgical fixation on fracture union and clinical outcomes.

Materials and Methods: A prospective comparative observational study was conducted on 100 adult patients with closed long bone fractures requiring definitive surgical fixation. Patients were divided into an early fixation group (≤48 hours; n=50) and a delayed fixation group (>48 hours; n=50). The primary outcome was radiological fracture union, while secondary outcomes included postoperative complications, hospital stay, and overall clinical outcome. Statistical analysis was performed using IBM SPSS Statistics, with $p<0.05$ considered statistically significant.

Results: Baseline demographic and fracture characteristics were comparable between the groups. The early fixation group demonstrated significantly shorter mean radiological union time than the delayed fixation group (16.7 ± 2.8 vs. 19.6 ± 3.4 weeks; $p<0.0001$). Delayed union was significantly less frequent following early fixation (8.0% vs. 28.0%; $p=0.0096$). Patients treated early also had significantly lower rates of surgical site infection, implant failure, and revision surgery, along with shorter hospital stay, earlier mobilization, and superior overall clinical outcomes.

Conclusion: Early definitive surgical fixation within 48 hours was associated with faster fracture union, fewer postoperative complications, and improved functional recovery compared with delayed fixation. Whenever clinically feasible in physiologically stable patients, early fixation should be considered the preferred treatment strategy for closed long bone fractures.

Keywords: Closed long bone fractures, Early surgical fixation, Fracture union, Postoperative complications, Clinical outcome.

INTRODUCTION

Long bone fractures are among the most common orthopedic injuries and are associated with significant morbidity, prolonged disability, and socioeconomic burden. Successful fracture healing depends on the interaction between biological factors and mechanical stability, with repair occurring through inflammatory, reparative, and remodeling phases.[1,2] Definitive surgical fixation of displaced closed long bone fractures restores alignment, provides stability, facilitates early mobilization, and helps create a favorable mechanical environment for union.[3]

The timing of fracture fixation remains an important consideration in orthopedic trauma care. Early definitive fixation, commonly described under the concept of Early Total Care, has been advocated in physiologically stable patients because it allows early mobilization and may reduce complications related to prolonged immobilization.[4] In contrast, Damage Control Orthopaedics recommends temporary

stabilization followed by delayed definitive fixation in physiologically unstable or severely injured patients to avoid the adverse effects of prolonged surgery during the acute inflammatory phase.[5,6] More recent approaches emphasize individualized timing based on patient physiology, soft-tissue status, and response to resuscitation rather than a fixed time threshold.[7]

Although the concepts of early fixation and delayed fixation have been widely discussed in polytrauma, evidence specifically addressing isolated closed long bone fractures remains limited. Previous studies have reported that early surgical intervention may reduce union time, hospital stay, and complication rates, whereas delayed fixation may be associated with prolonged healing and poorer recovery.[8,9] Therefore, the present prospective comparative observational study was undertaken to evaluate the effect of early versus delayed definitive surgical fixation on fracture union, postoperative complications, and overall clinical outcomes in adult patients with closed long bone fractures.

MATERIALS AND METHODS

This prospective comparative observational study was conducted in the Department of Orthopaedics at Parbhani Medical Colleg, Parbhani, Maharashtra a tertiary care teaching hospital, after approval from the Institutional Ethics Committee. Adult patients (≥18 years) presenting with closed long bone fractures requiring definitive surgical fixation were enrolled after obtaining written informed consent. Patients with open or pathological fractures, polytrauma requiring damage control orthopaedics, previous fractures at the same site, associated neurovascular injuries, or severe systemic illness were excluded. Based on the timing of definitive surgery, patients were categorized into an early fixation group (≤48 hours after injury) and a delayed fixation group (>48 hours after injury). The choice of implant and fixation technique was based on fracture configuration and standard institutional protocols.

Baseline demographic, clinical, and operative data were prospectively recorded. Patients were followed at 6 weeks, 3 months, 6 months, and 12 months or until fracture union. The primary outcome was time to radiological fracture union, defined as bridging callus across at least three of four cortices on standard radiographs with corresponding clinical union. Secondary outcomes included surgical site infection, delayed union, non-union, malunion, implant failure, revision surgery, hospital stay, and overall clinical outcome.

Statistical analysis was performed using IBM SPSS Statistics version [25]. Continuous variables were expressed as mean ± standard deviation and compared using the independent Student's t-test or Mann–Whitney U test, as appropriate. Categorical variables were presented as frequencies and percentages and analyzed using the Chi-square test or Fisher's exact test. A two-tailed p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (N = 100)

Characteristic	Category	Early Fixation (n=50) n (%)	Delayed Fixation (n=50) n (%)	Total (N=100) n (%)	*p* value
Age (years)	Mean ± SD	39.8 ± 12.4	41.6 ± 13.1	40.7 ± 12.7	0.4821
Age Group (years)	18–30	16 (32.0)	13 (26.0)	29 (29.0)	0.8015
	31–45	18 (36.0)	19 (38.0)	37 (37.0)	
	46–60	11 (22.0)	12 (24.0)	23 (23.0)	
	>60	5 (10.0)	6 (12.0)	11 (11.0)	
Gender	Male	36 (72.0)	34 (68.0)	70 (70.0)	0.6639
	Female	14 (28.0)	16 (32.0)	30 (30.0)	
Body Mass Index	Underweight (<18.5 kg/m²)	2 (4.0)	3 (6.0)	5 (5.0)	0.7814
	Normal (18.5–24.9 kg/m²)	28 (56.0)	26 (52.0)	54 (54.0)	
	Overweight (25–29.9 kg/m²)	15 (30.0)	16 (32.0)	31 (31.0)	
	Obese (≥30 kg/m²)	5 (10.0)	5 (10.0)	10 (10.0)	
Smoking Status	Smoker	12 (24.0)	14 (28.0)	26 (26.0)	0.6487
	Non-smoker	38 (76.0)	36 (72.0)	74 (74.0)	
Diabetes Mellitus	Present	8 (16.0)	10 (20.0)	18 (18.0)	0.6028
	Absent	42 (84.0)	40 (80.0)	82 (82.0)	
Hypertension	Present	11 (22.0)	13 (26.0)	24 (24.0)	0.6417
	Absent	39 (78.0)	37 (74.0)	76 (76.0)	
Mechanism of Injury	Road Traffic Accident	32 (64.0)	34 (68.0)	66 (66.0)	0.8316
	Fall from Height	10 (20.0)	9 (18.0)	19 (19.0)	
	Slip/Fall	6 (12.0)	5 (10.0)	11 (11.0)	
	Sports Injury	2 (4.0)	2 (4.0)	4 (4.0)	
Side of Injury	Right	27 (54.0)	29 (58.0)	56 (56.0)	0.6885
	Left	23 (46.0)	21 (42.0)	44 (44.0)	
Bone Involved	Femur	18 (36.0)	17 (34.0)	35 (35.0)	0.9542
	Tibia	20 (40.0)	22 (44.0)	42 (42.0)	
	Humerus	7 (14.0)	6 (12.0)	13 (13.0)	
	Radius/Ulna	5 (10.0)	5 (10.0)	10 (10.0)	

AO/OTA Fracture Type	Type A	22 (44.0)	21 (42.0)	43 (43.0)	0.9178
	Type B	18 (36.0)	20 (40.0)	38 (38.0)	
	Type C	10 (20.0)	9 (18.0)	19 (19.0)	

A total of 100 patients were included in the study, with 50 patients each in the early fixation and delayed fixation groups. The mean age of the study population was 40.7 ± 12.7 years, with no significant difference between the groups (39.8 ± 12.4 vs. 41.6 ± 13.1 years, p=0.4821). Most patients were males (70.0%), and the distribution of age groups, gender, body mass index, smoking status, diabetes mellitus, hypertension, mechanism of injury, side of injury, bone involved, and AO/OTA fracture classification was comparable between the two groups (all p>0.05). Road traffic accidents were the most common mechanism of injury (66.0%), while tibial fractures constituted the largest proportion of injuries (42.0%).

Table 2: Injury Characteristics and Operative Details of the Study Population

Characteristic	Category	Early Fixation (n=50) n (%)	Delayed Fixation (n=50) n (%)	Total (N=100) n (%)	*p* value
Time from injury to surgery	≤24 hours	24 (48.0)	0 (0.0)	24 (24.0)	<0.0001
	25–48 hours	26 (52.0)	0 (0.0)	26 (26.0)	
	49–72 hours	0 (0.0)	18 (36.0)	18 (18.0)	
	>72 hours	0 (0.0)	32 (64.0)	32 (32.0)	
Fracture pattern	Transverse	16 (32.0)	15 (30.0)	31 (31.0)	0.9286
	Oblique	14 (28.0)	16 (32.0)	30 (30.0)	
	Spiral	10 (20.0)	9 (18.0)	19 (19.0)	
	Comminuted	10 (20.0)	10 (20.0)	20 (20.0)	
Definitive fixation method	Intramedullary Nail	28 (56.0)	30 (60.0)	58 (58.0)	0.8734
	Plate Osteosynthesis	18 (36.0)	17 (34.0)	35 (35.0)	
	Cannulated Screws	4 (8.0)	3 (6.0)	7 (7.0)	
Duration of surgery (minutes)	<90	21 (42.0)	19 (38.0)	40 (40.0)	0.7548
	90–120	22 (44.0)	23 (46.0)	45 (45.0)	
	>120	7 (14.0)	8 (16.0)	15 (15.0)	
Estimated blood loss (mL)	<200	31 (62.0)	28 (56.0)	59 (59.0)	0.6892
	200–400	15 (30.0)	17 (34.0)	32 (32.0)	
	>400	4 (8.0)	5 (10.0)	9 (9.0)	
Duration of hospital stay	≤5 days	29 (58.0)	13 (26.0)	42 (42.0)	0.0016
	6–10 days	18 (36.0)	25 (50.0)	43 (43.0)	
	>10 days	3 (6.0)	12 (24.0)	15 (15.0)	
Initiation of mobilization	Within 48 hours	34 (68.0)	17 (34.0)	51 (51.0)	0.0007
	3–5 days	14 (28.0)	23 (46.0)	37 (37.0)	
	>5 days	2 (4.0)	10 (20.0)	12 (12.0)	
Weight bearing (lower limb fractures)†	≤6 weeks	24 (64.9)	11 (30.6)	35 (47.9)	0.0038
	7–8 weeks	11 (29.7)	17 (47.2)	28 (38.4)	
	>8 weeks	2 (5.4)	8 (22.2)	10 (13.7)	

The timing of definitive fixation differed significantly between the study groups by design (p<0.0001). Patients in the early fixation group underwent surgery within 48 hours of injury, whereas all patients in the delayed fixation group underwent surgery after 48 hours. No significant differences were observed in fracture pattern, definitive fixation method, duration of surgery, or estimated intraoperative blood loss between the groups (all p>0.05). However, patients treated with early fixation had a significantly shorter hospital stay, with 58.0% discharged within five days compared with 26.0% in the delayed fixation group (p=0.0016). Early mobilization within 48 hours was achieved in 68.0% of the early fixation group versus 34.0% of the delayed fixation group (p=0.0007). Similarly, initiation of weight-bearing occurred significantly earlier among patients undergoing early fixation (p=0.0038).

Table 3: Comparison of Fracture Union Outcomes Between Early and Delayed Surgical Fixation Groups

Outcome	Category	Early Fixation (n=50) n (%)	Delayed Fixation (n=50) n (%)	Total (N=100) n (%)	*p* value
Radiological union time (weeks)	Mean ± SD	16.7 ± 2.8	19.6 ± 3.4	18.2 ± 3.3	<0.0001
Time to radiological union	≤16 weeks	24 (48.0)	8 (16.0)	32 (32.0)	0.0012
	17–20 weeks	21 (42.0)	20 (40.0)	41 (41.0)	
	>20 weeks	5 (10.0)	22 (44.0)	27 (27.0)	
Clinical union	Achieved	49 (98.0)	46 (92.0)	95 (95.0)	0.1675
	Not achieved	1 (2.0)	4 (8.0)	5 (5.0)	
Delayed union	Present	4 (8.0)	14 (28.0)	18 (18.0)	0.0096
	Absent	46 (92.0)	36 (72.0)	82 (82.0)	
Non-union	Present	1 (2.0)	5 (10.0)	6 (6.0)	0.0914
	Absent	49 (98.0)	45 (90.0)	94 (94.0)	
Need for secondary	Bone grafting	2 (4.0)	7 (14.0)	9 (9.0)	0.0816

procedure	Revision fixation	1 (2.0)	4 (8.0)	5 (5.0)	
	None	47 (94.0)	39 (78.0)	86 (86.0)	
Overall fracture healing outcome	Excellent (Union ≤16 weeks)	24 (48.0)	8 (16.0)	32 (32.0)	0.0023
	Satisfactory (17–20 weeks)	21 (42.0)	20 (40.0)	41 (41.0)	
	Poor (>20 weeks/Non-union)	5 (10.0)	22 (44.0)	27 (27.0)	

Patients who underwent early surgical fixation demonstrated a significantly shorter mean radiological union time than those who underwent delayed fixation (16.7 ± 2.8 weeks vs. 19.6 ± 3.4 weeks, p<0.0001). Radiological union within 16 weeks was achieved in 48.0% of patients in the early fixation group compared with 16.0% in the delayed fixation group, whereas union beyond 20 weeks was observed more frequently following delayed fixation (44.0% vs. 10.0%; p=0.0012). Delayed union occurred significantly more often in the delayed fixation group (28.0% vs. 8.0%; p=0.0096). Although non-union and the requirement for secondary surgical procedures were more frequent among patients undergoing delayed fixation, these differences did not reach statistical significance (p=0.0914 and p=0.0816, respectively). Overall fracture healing outcomes were significantly more favorable in the early fixation group (p=0.0023).

Table 4: Comparison of Postoperative Complications Between Early and Delayed Surgical Fixation Groups

Complication	Category	Early Fixation (n=50) n (%)	Delayed Fixation (n=50) n (%)	Total (N=100) n (%)	*p* value
Surgical site infection	None	47 (94.0)	41 (82.0)	88 (88.0)	0.0428
	Superficial	3 (6.0)	6 (12.0)	9 (9.0)	
	Deep	0 (0.0)	3 (6.0)	3 (3.0)	
Delayed union	Present	4 (8.0)	14 (28.0)	18 (18.0)	0.0096
	Absent	46 (92.0)	36 (72.0)	82 (82.0)	
Non-union	Present	1 (2.0)	5 (10.0)	6 (6.0)	0.0914
	Absent	49 (98.0)	45 (90.0)	94 (94.0)	
Malunion	Present	2 (4.0)	7 (14.0)	9 (9.0)	0.0816
	Absent	48 (96.0)	43 (86.0)	91 (91.0)	
Implant failure	Present	1 (2.0)	6 (12.0)	7 (7.0)	0.0493
	Absent	49 (98.0)	44 (88.0)	93 (93.0)	
Revision surgery	Required	2 (4.0)	8 (16.0)	10 (10.0)	0.0457
	Not required	48 (96.0)	42 (84.0)	90 (90.0)	
Joint stiffness requiring physiotherapy	Present	6 (12.0)	13 (26.0)	19 (19.0)	0.0748
	Absent	44 (88.0)	37 (74.0)	81 (81.0)	
Overall postoperative complications	≥1 complication	10 (20.0)	24 (48.0)	34 (34.0)	0.0031
	No complication	40 (80.0)	26 (52.0)	66 (66.0)	

Postoperative complications were observed more frequently in patients who underwent delayed surgical fixation. Surgical site infection occurred in 18.0% of patients in the delayed fixation group compared with 6.0% in the early fixation group, including three cases of deep infection following delayed fixation (p=0.0428). Delayed union remained significantly more common in the delayed fixation group (28.0% vs. 8.0%; p=0.0096). Implant failure and the requirement for revision surgery were also significantly higher following delayed fixation (p=0.0493 and p=0.0457, respectively). Although malunion, non-union, and joint stiffness occurred more frequently in the delayed fixation group, these differences were not statistically significant. Overall, at least one postoperative complication was documented in 48.0% of patients undergoing delayed fixation compared with 20.0% of those treated with early fixation (p=0.0031).

Table 5: Overall Clinical Outcomes Following Early and Delayed Surgical Fixation

Clinical Outcome	Category	Early Fixation (n=50) n (%)	Delayed Fixation (n=50) n (%)	Total (N=100) n (%)	*p* value
Time to independent ambulation	≤6 weeks	28 (56.0)	14 (28.0)	42 (42.0)	0.0042
	7–12 weeks	18 (36.0)	24 (48.0)	42 (42.0)	
	>12 weeks	4 (8.0)	12 (24.0)	16 (16.0)	
Return to pre-injury daily activities	≤12 weeks	34 (68.0)	20 (40.0)	54 (54.0)	0.0057
	13–20 weeks	13 (26.0)	20 (40.0)	33 (33.0)	
	>20 weeks	3 (6.0)	10 (20.0)	13 (13.0)	
Pain at final follow-up	None	39 (78.0)	28 (56.0)	67 (67.0)	0.0198
	Mild	9 (18.0)	16 (32.0)	25 (25.0)	
	Moderate/Severe	2 (4.0)	6 (12.0)	8 (8.0)	
Range of motion	Full	41 (82.0)	31 (62.0)	72 (72.0)	0.0256
	Mild restriction	7 (14.0)	13 (26.0)	20 (20.0)	
	Moderate/Severe restriction	2 (4.0)	6 (12.0)	8 (8.0)	

Patient satisfaction	Very satisfied	30 (60.0)	18 (36.0)	48 (48.0)	0.0187
	Satisfied	17 (34.0)	22 (44.0)	39 (39.0)	
	Unsatisfied	3 (6.0)	10 (20.0)	13 (13.0)	
Overall clinical outcome	Excellent	29 (58.0)	16 (32.0)	45 (45.0)	0.0063
	Good	16 (32.0)	20 (40.0)	36 (36.0)	
	Fair	4 (8.0)	10 (20.0)	14 (14.0)	
	Poor	1 (2.0)	4 (8.0)	5 (5.0)	

Patients treated with early surgical fixation achieved significantly better overall clinical outcomes than those undergoing delayed fixation. Independent ambulation within six weeks was achieved in 56.0% of patients in the early fixation group compared with 28.0% in the delayed fixation group (p=0.0042). Return to pre-injury daily activities within 12 weeks was significantly more frequent following early fixation (68.0% vs. 40.0%; p=0.0057). At the final follow-up, patients in the early fixation group more commonly reported complete pain relief and full range of motion than those in the delayed fixation group (p=0.0198 and p=0.0256, respectively). Patient satisfaction was significantly higher after early fixation (p=0.0187). Overall, excellent or good clinical outcomes were achieved in 90.0% of patients treated with early fixation compared with 72.0% of those treated with delayed fixation, while fair and poor outcomes were more frequent among patients who underwent delayed fixation (p=0.0063).

DISCUSSION

This prospective comparative study assessed the impact of timing of definitive fixation on outcomes in adult patients with closed long bone fractures. Patients undergoing early fixation (≤48 hours) showed significantly faster union, fewer complications, shorter hospital stay, earlier mobilization, and better overall outcomes than those treated later. These findings align with current orthopedic trauma principles emphasizing early stable fixation in optimized patients to enhance recovery and reduce morbidity.[4-7]

Radiological union occurred earlier in the early fixation group (16.7 ± 2.8 weeks vs. 19.6 ± 3.4 weeks, p<0.0001), with significantly fewer cases of delayed union (8.0% vs. 28.0%, p=0.0096). Similar results were reported by Hofman et al., who highlighted delayed stabilization as a risk factor for non-union.[8] Von Lübken et al. also supported timely fixation for improved healing without increased complications.[9] Experimental evidence suggests early stabilization preserves fracture biology, promotes angiogenesis, and accelerates repair.[10]

Postoperative complications were lower with early fixation, reducing overall rates from 48.0% to 20.0%. Surgical site infection, implant failure, and revision surgery were less frequent. Vallier et al. similarly showed reduced complications with physiologically guided early fixation.[11] Makridis et al. noted that delayed healing and repeated surgeries increase infection risk.[12] These findings support minimizing delays in definitive fixation.

Functional outcomes also favored early fixation, with earlier ambulation, quicker return to daily activities, and better pain relief and mobility. This aligns with Early Total Care principles promoting early rehabilitation and reduced immobilization-related complications.[4,5] While Damage Control Orthopaedics remains essential for unstable patients, stable individuals benefit from early fixation.[6,11,13]

Biologically, fracture healing depends on vascularity, stability, and preservation of hematoma.[1,2] Delayed fixation may prolong inflammation and impair healing, whereas early stabilization restores alignment and supports callus formation.[10] These mechanisms explain improved outcomes with early fixation.[14,15]

Strengths of this study include its prospective design and comprehensive outcome assessment. Limitations include single-center setting, modest sample size, heterogeneity of fractures and fixation methods, and lack of multivariable analysis.[16]

Overall, early definitive fixation within 48 hours is recommended for physiologically stable patients, as it leads to faster union, fewer complications, shorter hospitalization, and better functional recovery, supporting current evidence for timely individualized management.[5,7,9,13]

CONCLUSION

The findings of the present prospective comparative study demonstrate that early definitive surgical fixation (within 48 hours) of closed long bone fractures is associated with significantly faster radiological fracture union, lower rates of delayed union and postoperative complications, shorter hospital stay, earlier mobilization, and superior overall clinical outcomes compared with delayed fixation. These results support the practice of early fixation in hemodynamically stable patients whenever feasible, as it facilitates biological fracture healing and functional recovery while minimizing treatment-related morbidity. However, the timing of surgery should be individualized after careful assessment of the patient's physiological status, associated injuries, soft-tissue condition, and available institutional resources. The present study is limited by its single-center design, relatively small sample size, inclusion of different long bones with varying fixation techniques, and the absence of multivariable analysis to adjust for potential confounders, which may limit the generalizability of the findings. Future multicenter studies with larger sample sizes, fracture-specific subgroup analyses, longer follow-up, and multivariate regression models

are recommended to further validate these findings and establish evidence-based guidelines for the optimal timing of definitive fixation in closed long bone fractures.

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