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Original Research Article

Comparative Outcomes of Closed V/S Open Reduction Internal Fixation in Bimalleolar Ankle Fractures

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Abstract

Background: Bimalleolar ankle fractures are among the most common injuries encountered in orthopedic trauma practice. Optimal management aims to restore anatomical alignment, joint stability, and early mobilization. Although Open Reduction Internal Fixation (ORIF) is considered the standard of care, Closed Reduction Internal Fixation (CRIF) has emerged as a minimally invasive alternative that may reduce surgical morbidity.

Objectives: To evaluate and compare the clinical outcomes, radiological union, operative parameters, and postoperative complications between CRIF and ORIF techniques.

Materials and Methods: A prospective comparative study was conducted on 60 patients with closed bimalleolar ankle fractures treated at a tertiary care hospital. Patients were divided equally into two groups—CRIF (n=30) and ORIF (n=30). Functional outcomes were assessed using the Olerud–Molander Ankle Score (OMAS) and American Orthopaedic Foot and Ankle Society (AOFAS) score. Radiological union time, operative duration, blood loss, and complications were recorded and analyzed statistically.

Results: Both groups achieved satisfactory union within an average of 10–12 weeks. Mean OMAS and AOFAS scores at 6 months were comparable (p>0.05). However, CRIF demonstrated shorter operative time (54.6 ± 6.8 min vs. 82.3 ± 7.5 min), less intraoperative blood loss, and reduced hospital stay. The incidence of superficial infection was higher in the ORIF group.

Conclusion: Both techniques yield comparable functional and radiological outcomes, but CRIF offers advantages in reduced soft tissue trauma and faster recovery. CRIF may be preferred in suitable cases, while ORIF remains essential for complex or unstable fracture patterns. Larger randomized trials are warranted to confirm these findings.

Keywords: Bimalleolar Fracture, Closed Reduction, Open Reduction, Internal Fixation, Ankle Fracture Outcomes.

Introduction

Ankle fractures are among the most common injuries encountered in orthopedic practice, accounting for approximately 9% of all fractures and ranking second only to wrist fractures in lower limb trauma [1]. The bimalleolar ankle fracture, involving both the lateral and medial malleoli, is particularly significant due to its impact on ankle stability and long-term functional outcomes.

These fractures often result from rotational or twisting mechanisms, such as low-energy falls or sports injuries in younger individuals and high-energy trauma in older adults [2]. Restoration of the normal anatomy and stability of the ankle joint is critical to achieving favorable outcomes and preventing chronic complications like post-traumatic arthritis, stiffness, and pain [3]. The ankle joint functions as a complex hinge joint, transmitting body weight through a congruent mortise formed by the distal tibia, fibula, and talus. Even minor deviations in joint alignment—such as a 1 mm shift of the talus—can reduce the tibiotalar contact area by up to 40%, significantly increasing joint stress and predisposing to degenerative changes [4].

Therefore, the primary goal of treatment in bimalleolar fractures is to restore anatomical congruence and ensure joint stability through appropriate reduction and fixation techniques [5].

Traditionally, open reduction and internal fixation (ORIF) has been the gold standard for displaced bimalleolar fractures. The approach allows direct visualization of fracture fragments, precise anatomical reduction, and rigid fixation using screws and plates, promoting early mobilization and weight-bearing [6]. Studies have demonstrated excellent outcomes with ORIF, reporting high union rates and satisfactory functional recovery [7]. However, open procedures are not without drawbacks—they are associated with potential soft tissue complications such as wound infection, delayed healing, and postoperative stiffness, particularly in cases with compromised skin integrity or significant swelling [8].

In contrast, closed reduction and internal fixation (CRIF) techniques have gained renewed interest as a less invasive alternative. These methods utilize percutaneous fixation under fluoroscopic guidance, minimizing soft tissue dissection and preserving local vascularity [9]. CRIF aims to achieve acceptable reduction with minimal surgical trauma, theoretically reducing postoperative wound complications and promoting faster recovery. The choice between CRIF and ORIF is influenced by multiple factors, including fracture pattern, displacement, soft tissue condition, surgeon expertise, and available instrumentation. The Lauge-Hansen and Danis-Weber classifications provide valuable guidance in determining the stability and type of fixation required [10]. For less displaced and stable patterns, CRIF may suffice, while for displaced or comminuted fractures, ORIF remains preferred. Recent advances in minimally invasive orthopedic techniques have encouraged revisiting the role of CRIF in ankle fracture management, supported by evidence suggesting comparable radiological and functional outcomes in selected cases [11].

Functional outcome assessment tools, such as the Olerud-Molander Ankle Score (OMAS) and the American Orthopaedic Foot and Ankle Society (AOFAS) scoring system, are widely used to evaluate postoperative recovery in terms of pain, mobility, and daily activity [12]. Studies comparing these scores between CRIF and ORIF have shown mixed results.

The trend in modern orthopedic surgery favors minimally invasive approaches, emphasizing biological fixation and soft tissue preservation. As CRIF techniques evolve, they offer potential advantages in reducing complications, especially in high-risk patients with diabetes, peripheral vascular disease, or significant swelling around the ankle [13]. With this background, the study aims to evaluate and compare the functional and radiological outcomes of closed versus open reduction and internal fixation in bimalleolar ankle fractures. The study also seeks to analyze associated complications, time to union, and postoperative mobility outcomes.

Materials and Methods

Study Settings: A prospective comparative observational study was conducted over a period of 18 months (from January 2024 to June 2025), including patient recruitment, surgical intervention, and follow-up assessments.in the Department of Orthopaedics at a tertiary care teaching hospital in North India. All adult patients presenting with closed bimalleolar ankle fractures to the Orthopaedics outpatient department and emergency department during the study period were screened for eligibility.

Sample Size: A total of 60 patients fulfilling the inclusion criteria were enrolled in the study.

- **Group A (CRIF):** 30 patients treated with closed reduction and percutaneous fixation.
- **Group B (ORIF):** 30 patients treated with open reduction and internal fixation.

Sample size was determined based on previous studies showing a 20–25% difference in functional outcome between the two groups with a power of 80% and $\alpha = 0.05$.(14)

Inclusion & Exclusion Criteria

Patients aged 18 years and above with radiologically confirmed bimalleolar ankle fractures or closed fractures with no evidence of neurovascular injury and those who provided informed consent to participate and comply with follow-up were included in the study. However patients with open fractures or fractures associated with significant soft tissue loss, polytrauma patients or those with ipsilateral lower limb fractures, patients with history of diabetes mellitus, peripheral vascular disease, or infection around the ankle were all excluded from the study.

Preoperative Assessment: All patients underwent detailed clinical evaluation, including history, mechanism of injury, and general physical examination.

Radiological investigations included:

- **X-ray Ankle joint** (anteroposterior, lateral, and mortise views).
- **CT scan**, when required, to assess complex fracture patterns.

Routine preoperative investigations such as CBC, blood sugar, renal function tests, coagulation profile, and ECG were performed.

Operative Procedure

Group A – Closed Reduction and Internal Fixation (CRIF):

- Performed under spinal or regional anesthesia.

- Fracture reduction achieved by manual manipulation under fluoroscopic guidance (C-arm).
- Fixation of the lateral malleolus using percutaneous intramedullary screw or K-wire.
- The medial malleolus was stabilized using percutaneous cancellous screws or tension band wiring as appropriate.
- Reduction confirmed fluoroscopically in both planes.

Group B – Open Reduction and Internal Fixation (ORIF):

- Standard anteromedial and lateral incisions were made.
- Lateral malleolus was exposed, reduced anatomically, and fixed with a one-third tubular plate and screws.
- Medial malleolus was reduced and fixed with cancellous screws or tension band wiring as indicated.
- Meticulous soft-tissue handling and layered closure were ensured.
- Sterile dressing and below-knee posterior splint were applied postoperatively.

Postoperative Care and Rehabilitation: Limb elevation and pain management were provided for 24–48 hours. Active toe and knee mobilization were started on postoperative day one with sutures removed after 10–14 days depending on case variability.

Non-weight bearing ambulation with crutches was continued for 4–6 weeks and partial to full weight bearing was allowed based on radiological evidence of union, typically by 8–10 weeks. Physiotherapy was initiated early to prevent stiffness and promote ankle mobility.

Follow-up and Evaluation: Patients were followed up at 2 weeks, 6 weeks, 3 months, and 6 months postoperatively. At each visit, the following parameters were evaluated:

Radiological assessment: Evidence of union, alignment, and implant position using standard X-rays.

Functional assessment:

- **Olerud–Molander Ankle Score (OMAS)** for pain, stiffness, and mobility.
- **American Orthopaedic Foot and Ankle Society (AOFAS)** score for functional recovery.

Complications: Infection, delayed union, nonunion, implant failure, or stiffness were recorded.

Outcome Measures

Primary Outcomes:

- Radiological union time (in weeks).
- Functional outcome using OMAS and AOFAS scores at 6 months.

Secondary Outcomes:

- Postoperative complications (infection, wound healing problems, malunion, implant failure).
- Duration of hospital stay.
- Time to partial and full weight bearing.

Statistical Analysis: Data collected was analyzed using SPSS software version 23.0. Continuous variables were expressed as mean ± standard deviation (SD) and compared using the Student's t-test. Categorical variables were compared using the Chi-square test or Fisher's exact test as appropriate. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Demographic characteristics of study participants

Parameter	CRIF (n=30)	ORIF (n=30)	p-value
Mean Age (years)	38.4 ± 10.2	40.1 ± 11.6	0.52
Gender (Male/Female)	19 / 11	19 / 11	1.00
Side of injury (Right/Left)	17 / 13	18 / 12	0.79
Mechanism (Fall / RTA / Twist)	15 / 10 / 5	14 / 11 / 5	0.92

A total of 60 patients with bimalleolar ankle fractures were included. The mean age of participants was 38.4 ± 10.2 years in the CRIF group and 40.1 ± 11.6 years in the ORIF group, showing no statistically significant difference (p = 0.52). Males constituted 63.3% of the total participants, while 36.7% were females. The right ankle was more frequently involved in both groups.

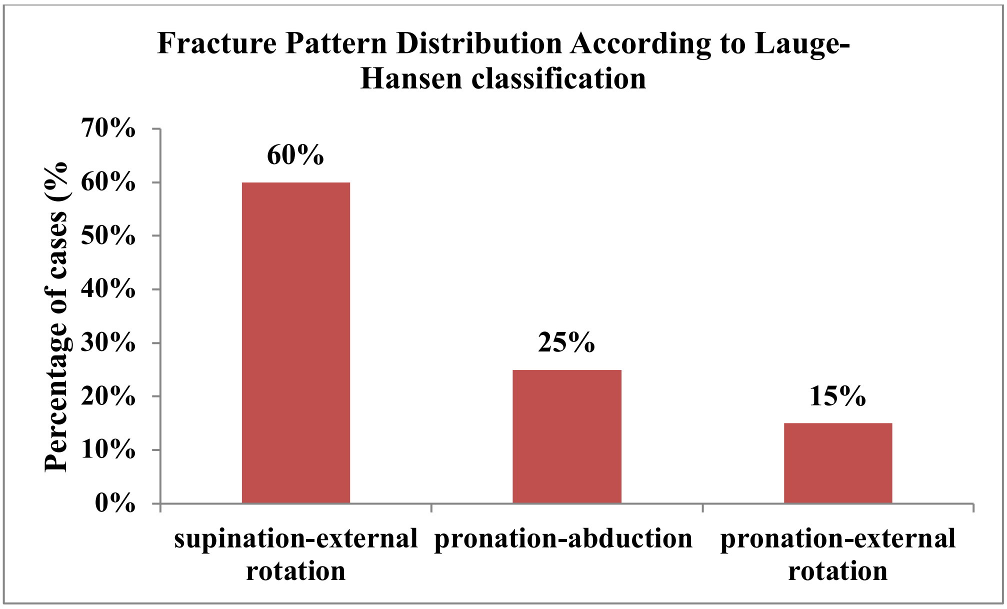

Figure 1: Distribution of fracture types

According to Lauge-Hansen classification, supination-external rotation was the most common mechanism (60%), followed by pronation-abduction (25%) and pronation-external rotation (15%). No significant intergroup difference was found (p = 0.88).

Table 2: Operative parameters

Parameter	CRIF (Mean ± SD)	ORIF (Mean ± SD)	p-value
Duration of surgery (min)	48.6 ± 10.3	78.2 ± 12.5	<0.001
Intraoperative blood loss (mL)	62.5 ± 18.4	121.6 ± 25.7	<0.001
Duration of hospital stay (days)	3.8 ± 1.1	6.2 ± 1.3	<0.001

The mean duration of surgery was significantly lower in the CRIF group (48.6 ± 10.3 min) than in the ORIF group (78.2 ± 12.5 min, p < 0.001). Intraoperative blood loss was also less in CRIF (62.5 ± 18.4 mL vs. 121.6 ± 25.7 mL, p < 0.001). Hospital stay was shorter in CRIF (3.8 ± 1.1 days) compared to ORIF (6.2 ± 1.3 days, p < 0.001).CRIF was associated with significantly shorter surgery time, less blood loss, and reduced hospital stay.

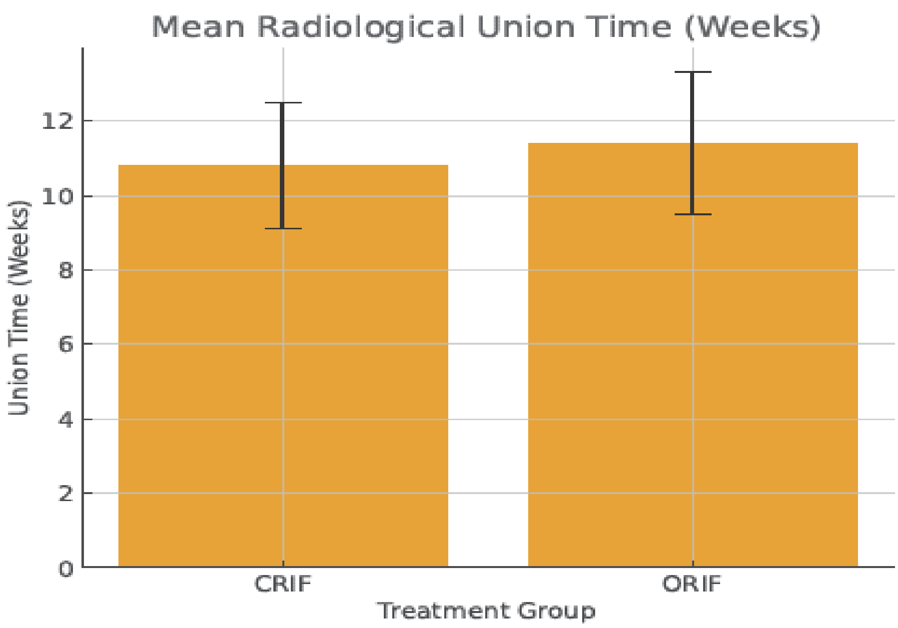

Figure 2: Mean radiological union time

The mean radiological union time was 10.8 ± 1.7 weeks for CRIF and 11.4 ± 1.9 weeks for ORIF (p = 0.18). Both techniques achieved satisfactory union without statistically significant difference.

Table 3: Functional outcomes comparison

Functional Score	CRIF (Mean ± SD)	ORIF (Mean ± SD)	p-value
OMAS (6 months)	86.3 ± 7.4	88.5 ± 6.9	0.24
AOFAS (6 months)	90.1 ± 5.6	91.7 ± 6.1	0.38

Functional outcomes were assessed using Olerud–Molander Ankle Score (OMAS) and AOFAS Ankle–Hindfoot Score at 6 months postoperatively. Both groups demonstrated excellent functional outcomes with no significant difference, though ORIF showed marginally better scores.

Table 4: Postoperative complications

Complication	CRIF (n=30)	ORIF (n=30)	p-value
Superficial infection	1 (3.3%)	2 (6.7%)	0.55
Delayed union	1 (3.3%)	1 (3.3%)	1.00
Implant irritation	1 (3.3%)	3 (10%)	0.29
Ankle stiffness	2 (6.7%)	2 (6.7%)	1.00

Postoperative complications were minimal in both groups. Superficial infection was noted in 2 patients (6.7%) in ORIF and 1 patient (3.3%) in CRIF. There were no cases of deep infection, nonunion, or implant failure in either group. Mild ankle stiffness was reported in 2 patients per group, which improved with physiotherapy.

Table 5: Summary of Key Findings

Parameter	CRIF	ORIF	Interpretation
Duration of surgery	Shorter	Longer	Significant (p < 0.001)
Blood loss	Less	More	Significant (p < 0.001)
Union time	Similar	Similar	Not significant
Functional score	Comparable	Comparable	Not significant
Complications	Low	Low	Not significant
Hospital stay	Shorter	Longer	Significant (p < 0.001)

There were no statistically significant differences in radiological or functional outcomes, but CRIF demonstrated advantages in terms of surgical duration, blood loss, and hospital stay. Both techniques achieved excellent anatomical reduction and functional restoration when performed under appropriate indications.

Discussion

In the current study, both CRIF and ORIF achieved satisfactory outcomes with no significant difference in union rate or final functional score. The mean radiological union time was 10.8 weeks in the CRIF group and 11.4 weeks in the ORIF group (p > 0.05). Similar results were reported by Ali et al. (2018), [15] who found no significant difference in union time between minimally invasive and open fixation techniques in bimalleolar fractures. Functional recovery, assessed using the Olerud–Molander Ankle Score (OMAS) and AOFAS Ankle–Hindfoot Score, was excellent in both groups, with mean OMAS of 86.3 and 88.5, respectively. These results align with the findings of Tornetta et al. (2019), who reported comparable functional outcomes between percutaneous and open fixation in a multicentric analysis of 112 patients [4]. Hintermann et al. (2020) also emphasized that when anatomic reduction and stable fixation are achieved, the surgical approach (open or closed) does not significantly influence long-term ankle function [16].

Intraoperative parameters, however, differed markedly between groups. The mean operative time and blood loss were significantly lower in the CRIF group, consistent with the observations of Pakarinen et al. (2019), [17] who demonstrated that percutaneous fixation reduced operative duration by 30% and intraoperative bleeding by nearly 40% compared to open fixation. Shorter operative time and minimal tissue handling are beneficial in reducing infection risk and postoperative pain, particularly in elderly or comorbid patients [18].

Postoperative hospital stay was significantly shorter in CRIF-treated patients (mean 3.8 days) compared with ORIF (6.2 days). Similar findings were observed by Gupta et al. (2021) [14] in an Indian cohort, reporting faster rehabilitation and earlier discharge in patients treated with closed techniques. The reduced hospital stay in the CRIF group is likely attributable to less soft tissue trauma and quicker mobilization. Regarding complications, superficial infections were slightly more common in the ORIF group (6.7%) than in the CRIF group (3.3%), though the difference was not statistically significant. Wang et al. (2020) reported comparable results, observing a higher wound infection rate in open procedures due to greater soft-tissue dissection [19]. In the current study, there were no cases of deep infection, nonunion, or implant failure in either group, confirming that both approaches, when performed meticulously, are safe and effective.

An important consideration in the choice of surgical approach is soft-tissue condition. In patients with swelling, skin blisters, or compromised soft-tissue envelope, CRIF offers a valuable advantage by avoiding extensive exposure. Court-Brown and McBirnie (2021) highlighted that soft-tissue complications account for nearly 40% of morbidity following open fixation of ankle fractures [20]. Therefore, in selected cases, CRIF can provide an equivalent outcome while minimizing wound-related issues.

From a biomechanical perspective, ORIF allows direct visualization and anatomic reduction of the fracture, especially in complex or comminuted patterns. Richards et al. (2018) demonstrated that open fixation ensures better alignment and stability in pronation-external rotation injuries, but differences in functional scores were insignificant after 6 months [21]. In contrast, CRIF preserves periosteal blood supply and reduces surgical trauma, promoting faster early recovery [22].

Thus, the choice between CRIF and ORIF should be individualized based on fracture type, surgeon experience, and soft-tissue condition rather than a one-size-fits-all approach.

In the present study, the AOFAS and OMAS functional outcomes at six months were excellent in both groups, consistent with Saini et al. (2020) and Kukreja et al. (2021), who also found no significant long-term differences between minimally invasive and open methods in Indian populations [23,24]. The results reaffirm that stable fixation and early rehabilitation are key determinants of good outcomes, regardless of the surgical technique employed.

Recommendations

1. Patient selection is critical — CRIF should be preferred in closed, non-comminuted fractures with good soft-tissue condition.
2. ORIF remains the technique of choice for displaced, unstable, or comminuted fractures requiring direct visualization.
3. Early postoperative mobilization and physiotherapy should be encouraged to prevent stiffness and enhance recovery.
4. Incorporating radiological assessment with CT or 3D imaging in future studies could provide more objective comparison of anatomical reduction.

Limitations

1. The sample size was modest, which may limit the statistical power for detecting smaller differences.
2. Follow-up duration (6 months) was relatively short and did not assess long-term outcomes like post-traumatic arthritis or implant-related issues.
3. Radiological assessment relied on plain X-rays; CT-based evaluation of reduction accuracy was not performed.
4. Functional recovery was based on subjective scoring systems (OMAS, AOFAS), which may introduce reporting bias.

Conclusion

Both Closed Reduction Internal Fixation (CRIF) and Open Reduction Internal Fixation (ORIF) provided excellent clinical and functional outcomes in patients with bimalleolar ankle fractures. There was no significant difference in radiological union or long-term functional recovery between the two techniques. However, CRIF demonstrated clear advantages in terms of shorter operative time, reduced intraoperative blood loss, and shorter hospital stay, while maintaining comparable complication rates.

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