

Functional Assessment of Percutaneous Medial and Lateral Malleoli Fractures' Fixation by K-wires on October 6th Hospital: Interventional Study

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ABSTRACT

Background: Ankle fractures are common orthopedic injuries, and minimally invasive fixation may limit soft-tissue disruption. This study aimed to assess functional outcomes after percutaneous Kirschner wire (K-wire) fixation of ankle fractures.

Methods: This interventional study included 37 adults with unimalleolar or bimalleolar ankle fractures who underwent percutaneous K-wire fixation. The primary outcome was functional recovery assessed at 2, 4, and 6 months using the Olerud–Molander Ankle Score (OMAS), Functional Symmetry Test, Four-Stage Balance Test, and posture grading. Secondary outcomes included fracture union, postoperative complications, pain intensity, and emotional acceptance.

Results: Mean operative time was 23.4 ± 11.9 min, and mean fracture union time was 1.5 ± 0.5 months. OMAS increased from 24.2 ± 10.6 at 2 months to 64.1 ± 19.2 at 4 months and 85.4 ± 17.7 at 6 months. At functional assessment, 54.1% achieved Grade 2 symmetry, 91.9% had moderate balance impairment, and 51.4% had moderate postural deviation. Favorable emotional acceptance increased from 5.4% at 2 months to 70.2% at 6 months. Postoperative complications occurred in 6 patients (16.2%). Patients with complications were older (72 vs. 50 years, $P=0.013$) and more frequently had hypertension ($P=0.012$) and ischemic heart disease ($P<0.012$), with longer fracture union time (2 vs. 1 month, $P=0.013$).

Conclusion: Percutaneous K-wire fixation was associated with progressive functional improvement and fracture healing over 6 months. Older age, hypertension, ischemic heart disease, and longer union time were associated with postoperative complications.

Keywords: Ankle Fractures, Kirschner Wires, Percutaneous Fixation, Functional Outcome, Olerud–Molander Ankle Score.

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INTRODUCTION

Ankle fractures are among the most common injuries encountered in orthopedic practice 1. They range from isolated unimalleolar injuries to bimalleolar and trimalleolar patterns. Early classifications were based mainly on the number of malleoli involved, but this approach did not reliably distinguish stable from unstable injuries, an important consideration when selecting treatment and determining the need for operative stabilization 2. The clinical importance of this distinction relates to maintaining ankle stability and joint congruity, as these factors guide the choice between conservative and operative.

Patients typically present with acute pain, inability to bear weight, swelling, bruising, tenderness, and deformity. Diagnosis is based on clinical assessment supported by imaging. Plain radiography remains the main initial investigation, while computed tomography (CT) and magnetic resonance imaging (MRI) may be used when fracture configuration or associated soft-tissue injury requires further evaluation 3, 4. Careful assessment of the surrounding soft tissues is essential because swelling,

ecchymosis, degloving injury, and fracture blisters may influence the timing and method of fixation 5.

Open reduction and internal fixation (ORIF) with plates and screws is commonly used for unstable ankle fractures; however, wound-related complications, including infection and impaired wound healing, remain an important concern, particularly in older patients and those with peripheral neuropathy or open fractures 6. Delays in definitive fixation may negatively influence postoperative recovery, potentially contributing to prolonged pain, slower functional improvement, and less favorable patient-reported outcomes 7.

These concerns have encouraged the use of less invasive fixation methods. Percutaneous fixation aims to achieve adequate fracture reduction and stability while minimizing soft-tissue dissection. Such an approach may be particularly useful when preservation of the soft-tissue envelope is important and can support functional rehabilitation. Kirschner wires (K-wires) provide a simple method of percutaneous fixation for selected ankle fractures, allowing fracture stabilization with limited surgical exposure and minimal disruption of the surrounding soft tissues 8.

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Accordingly, this study aimed to assess the functional outcome of percutaneous K-wire fixation in patients with ankle fractures during postoperative follow-up.

PATIENTS AND METHODS

Study design and setting

This interventional study was carried out on 37 adult patients with unimalleolar or bimalleolar ankle fractures who underwent percutaneous fixation using K-wires at the Orthopedic Surgery Department, Faculty of Medicine, October 6 University, in collaboration with Beni-Suef University Hospital, from June 2024 to June 2025. The study was approved by the Research Ethics Committee of the Faculty of Medicine, October 6 University and registered on ClinicalTrials.gov. Written informed consent was secured from all participants or their first-degree relatives before enrollment.

Eligibility Criteria

Patients aged ≥ 18 years of both sexes with fresh, radiographically confirmed unimalleolar or bimalleolar ankle fractures were eligible for inclusion. Eligible patients had closed fractures amenable to closed reduction, were medically fit for surgery under spinal or general anesthesia, provided informed consent, and agreed to attend scheduled postoperative follow-up. Exclusion criteria were pilon fractures, high-energy fractures with comminution, old, neglected, or malunited fractures, ankle fracture-dislocation, diabetic neuropathy, severe peripheral vascular disease, other neuropathic conditions, pathological fractures, systemic bone disease, refusal to participate, and loss to follow-up.

Preoperative Evaluation

All patients underwent standardized preoperative assessment including demographic and clinical characteristics, injury-related history, relevant medical and surgical history, medication use, and comorbidities. Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg and/or pharmacologically treated hypertension 9. Diabetes mellitus was defined as fasting blood glucose >126 mg/dL, 2-hour postprandial blood glucose ≥ 200 mg/dL, glycated hemoglobin $\geq 6.5\%$, and/or pharmacologically treated hyperglycemia 10. Active smoking was defined as smoking within the preceding six months. Clinical examination included general assessment of vital signs, body mass index, overall medical fitness, and associated injuries, together with detailed local examination of the affected ankle covering soft-tissue condition, deformity, tenderness, range of motion, and neurovascular status. The Kleiger external rotation test and squeeze test were performed when tolerated to assess possible syndesmotic injury, while fracture laterality, morphology, and suspected associated ligamentous or bony injuries were also documented 4.

Radiological and Laboratory Evaluation

All patients underwent imaging assessment with plain ankle radiographs in anteroposterior, lateral, and mortise views to evaluate fracture morphology, displacement, and joint congruity. Computed tomography (CT) was performed selectively when fracture lines were unclear or intra-articular extension was suspected, to further define fracture

geometry and assist procedural planning. Routine preoperative laboratory evaluation included hematological, glycemic, renal, hepatic, coagulation, and serological assessments according to hospital policy.

Operative Technique

All procedures were performed under spinal or general anesthesia with the patient in the supine position on a radiolucent operating table. A pneumatic thigh tourniquet was applied, and the operative limb was prepared and draped under sterile conditions. Closed reduction was performed under fluoroscopic guidance using gentle traction and manipulation. Lateral malleolar fractures were reduced by inversion and internal rotation of the foot, whereas medial malleolar fractures were reduced using eversion and external rotation. Reduction was confirmed in anteroposterior, lateral, and mortise fluoroscopic views.

After satisfactory reduction, percutaneous fixation was performed using K-wires. Medial malleolar fractures were stabilized with two parallel smooth K-wires measuring 1.6–2.0 mm, inserted from the tip of the medial malleolus and directed proximolaterally across the fracture into the tibial metaphysis. Lateral malleolar fractures were stabilized with two oblique K-wires directed superiorly and posteriorly from the distal fragment into the fibular shaft. In bimalleolar fractures, both malleoli were fixed sequentially. Final fluoroscopic views were obtained to confirm fracture alignment, wire position, and restoration of the ankle mortise. The wires were bent and cut externally, sterile dressings were applied, and operative time was recorded.

Postoperative Management and Follow-Up

Postoperatively, patients received intravenous antibiotics for 24–48 hours followed by oral antibiotics for five days. Analgesic and anti-inflammatory medications were prescribed, and low-molecular-weight heparin was administered for deep vein thrombosis prophylaxis according to individual risk. The operated limb was immobilized in a below-knee posterior slab or circumferential cast according to intraoperative stability. Immediate postoperative anteroposterior and lateral radiographs were obtained to confirm fixation and maintenance of reduction. Patients were discharged after adequate pain control with instructions regarding limb elevation and non-weight-bearing ambulation using crutches. Follow-up was performed every two weeks during the first two postoperative months and monthly during the subsequent four months. At each visit, clinical and radiological assessments were performed to evaluate fracture union, pin-site condition, rehabilitation progress, and complications, including pin tract infection, wire loosening, malunion, and delayed or non-union.

Outcome Measures

The primary outcome was postoperative functional recovery, assessed at 2, 4, and 6 months using the Olerud–Molander Ankle Score (OMAS), Functional Symmetry Test, Four-Stage Balance Test, and posture grading. The OMAS ranged from 0 to 100, with higher scores indicating better ankle function 11. Functional symmetry was graded from Grade 0, indicating inability to perform the task, to Grade III, indicating full symmetry without compensation. Balance was assessed from Stage I, indicating high fall risk,

to Stage IV, indicating normal balance, while posture was graded from Grade 0, indicating inability to maintain posture, to Grade IV, indicating excellent posture without deviation.

Secondary outcomes included fracture union, postoperative complications, pain intensity, and emotional acceptance. Fracture union was assessed clinically and radiographically during follow-up, while complications included pin tract infection, wire loosening, malunion, and delayed or non-union. Pain was assessed using the Numerical Rating Scale (NRS), ranging from 0 to 10, and emotional adaptation was evaluated using the Emotional Acceptance Questionnaire (EAQ).

Statistical Methods

Data management and statistical analysis were performed using SPSS version 27 (IBM, Armonk, New York, United States). Quantitative variables were assessed for normality using the Shapiro–Wilk test and direct data visualization. Normally distributed data were summarized as mean and standard deviation, while non-normally distributed data were summarized as median and range. Categorical variables were presented as numbers and percentages. Repeated-measures analysis of variance and the Friedman test were used to compare normally distributed and non-

normally distributed or ordinal variables, respectively, across different follow-up points. Quantitative variables were compared between unimalleolar and bimalleolar fracture groups using the independent-samples t-test or Mann–Whitney U test, as appropriate. Categorical variables were compared using the chi-square test or Fisher's exact test. All statistical tests were two-sided, and P-values <0.05 were considered statistically significant.

RESULTS

In this study, 37 patients with unimalleolar or bimalleolar ankle fractures who underwent percutaneous K-wire fixation were included in the final analysis.

The median age of the studied patients was 55 years (IQR: 12), and 78.4% were males, with a mean body weight of 77.8 kg. Hypertension was present in 35.1%, diabetes mellitus in 10.8%, ischemic heart disease in 8.1%, and active smoking in 45.9%. Ankle twisting was the most frequent mechanism of injury (54.1%), and fractures were nearly equally distributed between the left and right sides. Lateral malleolar fractures were the most common pattern (43.2%), followed by bimalleolar (29.7%) and medial malleolar fractures (27.0%). Associated Lisfranc injury was detected in 5.4%, while 13.5% of fractures were open.

Table 1

Table 1: Baseline demographic and injury characteristics of the studied patients (n=37)

Baseline characteristics		
Age (years)	Median (IQR)	55 (12)
Sex		
Male	n (%)	29 (78.4)
Female	n (%)	8 (21.6)
Weight (kg)	Mean ±SD	77.8
Hypertension	n (%)	13 (35.1)
Diabetes mellitus	n (%)	4 (10.8)
Ischemic heart disease	n (%)	3 (8.1)
Active smoker	n (%)	17 (45.9)
Mechanism of injury		
Ankle twist	n (%)	20 (54.1)
Road traffic accident	n (%)	17 (45.9)
Side of fracture		
Left	n (%)	19 (51.4)
Right	n (%)	18 (48.6)
Fracture pattern		
Lateral malleolar	n (%)	16 (43.2)
Bimalleolar	n (%)	11 (29.7)
Medial malleolar	n (%)	10 (27.0)
Associated lisfranc injury	n (%)	2 (5.4)
Type of fracture		
Open fracture	n (%)	5 (13.5)
Closed fracture	n (%)	32 (86.0)

n: number, IQR: Interquartile range, SD: Standard deviation.

The mean operative time was 23.4 ± 11.9 min, ranging from 15 to 60 min. Postoperative immobilization was performed using a below-knee slab in 67.6% of patients and a circumferential cast in 32.4%. The mean fracture union time

was 1.5 ± 0.5 months, with mal-union and delayed or non-union each occurring in 8.1% of patients. No cases of Sudeck's atrophy or wire loosening were recorded. Table 2

Table 2: Operative, postoperative, radiographic, and hardware-related outcomes of the studied patients (n=37)

Operative and postoperative outcomes		
Operative time (min)	Mean $\pm$ SD	23.4 $\pm$ 11.9
Operative time range (min)	Range	15 – 60
Postoperative immobilization		
Below-knee slab	n (%)	25 (67.6)
Circumferential cast	n (%)	12 (32.4)
Outcome		
Fracture union time (months)	Mean $\pm$ SD	1.5 $\pm$ 0.5
Fracture union time range (months)	Range	1.0 – 2.0
Mal-union	n (%)	3 (8.1)
Delayed or non-union	n (%)	3 (8.1)
Sudeck's atrophy	n (%)	0 (0)
Wire loosening	n (%)	0 (0)

n: number, SD: Standard deviation.

The mean OMAS progressively increased from 24.2 $\pm$ 10.6 at 2 months to 64.1 $\pm$ 19.2 at 4 months and 85.4 $\pm$ 17.7 at 6 months, representing an overall increase of 61.2 points during follow-up. By 6 months, the mean OMAS exceeded the threshold of 80. Figure 1

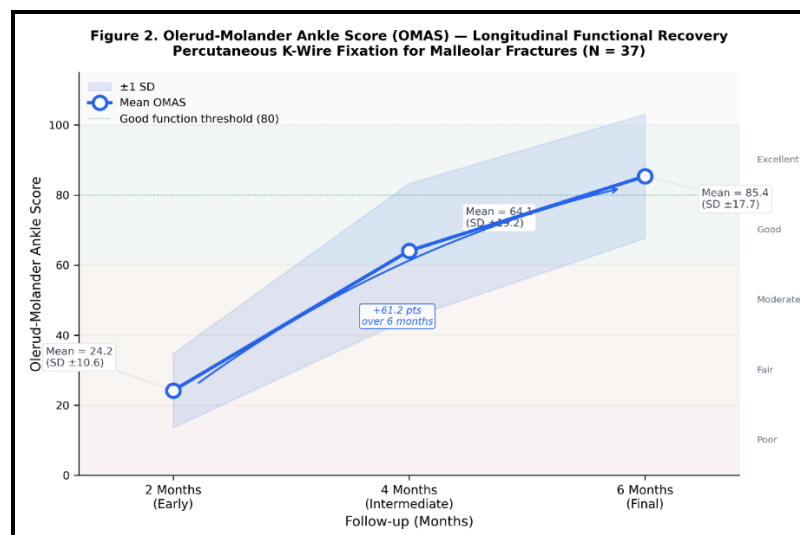


Figure 1: Changes in OMAS at 2, 4, and 6 months following percutaneous K-wire fixation

At functional assessment, 54.1% of patients achieved Grade 2 functional symmetry, while 40.5% had mild asymmetry and 5.4% had marked asymmetry. Moderate balance impairment was observed in 91.9% of patients, while 8.1% were classified as having a high fall risk. Regarding posture, 51.4% showed moderate deviation while remaining independent, 43.2% had poor posture requiring assistance, and 5.4% were unable to maintain posture. Table 3, Figure 2

Table 3: Functional symmetry, balance, and posture assessment of the studied patients (n=37)

Functional assessment	n (%)
Functional Symmetry Test	
Grade 2 (symmetric)	20 (54.1)
Grade 1 (mild asymmetry)	15 (40.5)
Grade 0 (marked asymmetry)	2 (5.4)
Four-Stage Balance Test	
Moderate impairment	34 (91.9)
High fall risk	3 (8.1)
Posture Grading	
Moderate deviation, independent	19 (51.4)
Poor posture, needs assistance	16 (43.2)
Unable to maintain posture	2 (5.4)

n: number.

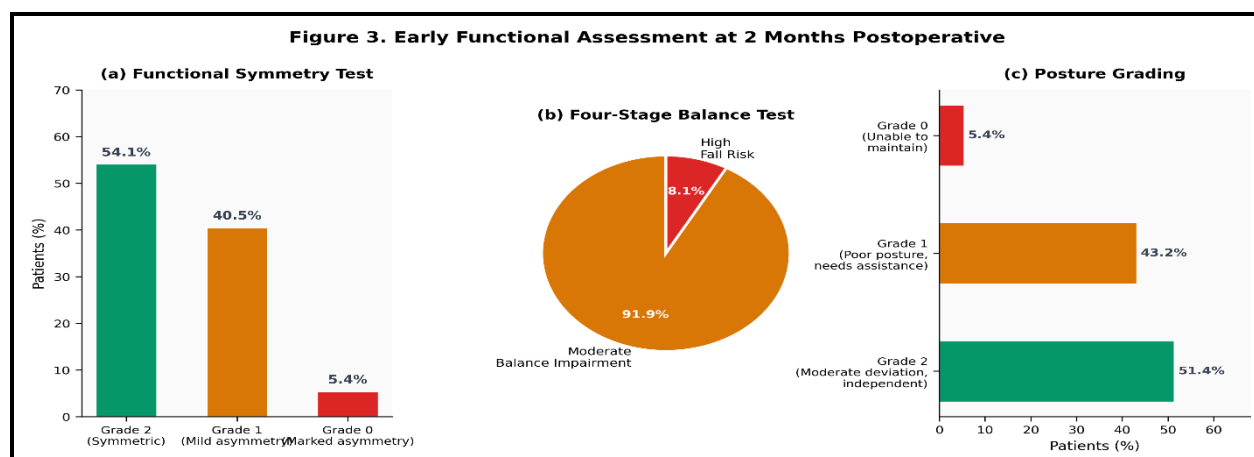


Figure 2: Functional symmetry, balance, and posture assessment at 2 months postoperatively

Emotional acceptance progressively improved throughout follow-up. Low acceptance decreased from 73.0% at 2 months to 40.5% at 4 months and 10.8% at 6 months, while good acceptance increased from 2.7% to 24.3% and 40.5%, respectively. Full acceptance increased from 2.7% at both 2

and 4 months to 29.7% at 6 months. Consequently, favorable emotional acceptance increased from 5.4% at 2 months to 27.0% at 4 months and 70.2% at 6 months. Table 4

Table 4: Emotional acceptance at sequential postoperative follow-up intervals (n=37)

Acceptance Category	2 Months n (%)	4 Months n (%)	6 Months n (%)
Low	27 (73.0)	15 (40.5)	4 (10.8)
Moderate	8 (21.6)	12 (32.4)	7 (18.9)
Good	1 (2.7)	9 (24.3)	15 (40.5)
Full	1 (2.7)	1 (2.7)	11 (29.7)
Favorable total (Good + Full)	2 (5.4)	10 (27.0)	26 (70.2)
Unfavorable total (Low + Moderate)	35 (94.6)	27 (73.0)	11 (29.7)

n: number.

Patients who developed postoperative complications were significantly older than those without complications (72 vs. 50 years, $P=0.013$). Hypertension and ischemic heart disease were significantly more frequent among patients with complications ($P=0.012$ and $P<0.012$, respectively).

Fracture union time was also significantly longer in patients with complications (2 vs. 1 month, $P=0.013$). In contrast, sex, body weight, diabetes mellitus, active smoking, open fracture, and operative time did not differ significantly according to complication status. Table 5

Table 5: Demographic, clinical, and operative characteristics according to postoperative complications

		Complications		P value
		Yes (n = 6)	No (n = 31)	
Age (years)	Median	72	50	0.013*
Female sex	n (%)	1 (16.7)	7 (22.6)	0.752
Weight (kg)	Median	77.5	80	0.923
Hypertension (No)	n (%)	1 (16.7)	23 (74.2)	0.012*
Diabetes mellitus (No)	n (%)	4 (66.7)	29 (93.5)	0.052
Ischemic heart disease (No)	n (%)	3 (50.0)	31 (100.0)	<0.012*
Active smoking (Yes)	n (%)	3 (50.0)	14 (45.2)	0.832
Open fracture	n (%)	1 (16.7)	4 (12.9)	0.812
Fracture union time (months)	Median	2	1	0.013*
Operative time (min)	Median	30	15	0.343

n: number, *: Significant P-value.

Cases

Case 1

A medically free patient presented after a right ankle twisting injury with an isolated right lateral malleolus

fracture. The fracture was treated by closed reduction and percutaneous K-wire fixation, followed by postoperative immobilization and serial radiographic follow-up at 2, 4, and 8 weeks. Figures 3-8



Figure 3: Preoperative radiographs of the right lateral malleolus fracture

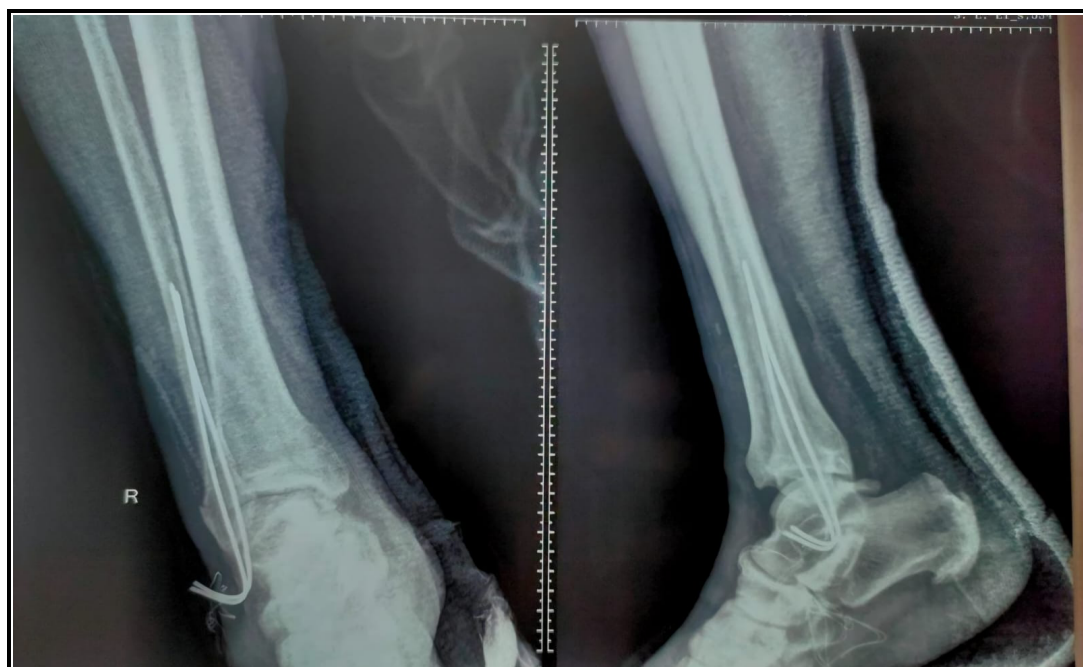


Figure 4: Postoperative radiographs after percutaneous K-wire fixation



Figure 5: Percutaneous K-wire fixation of the right lateral malleolus

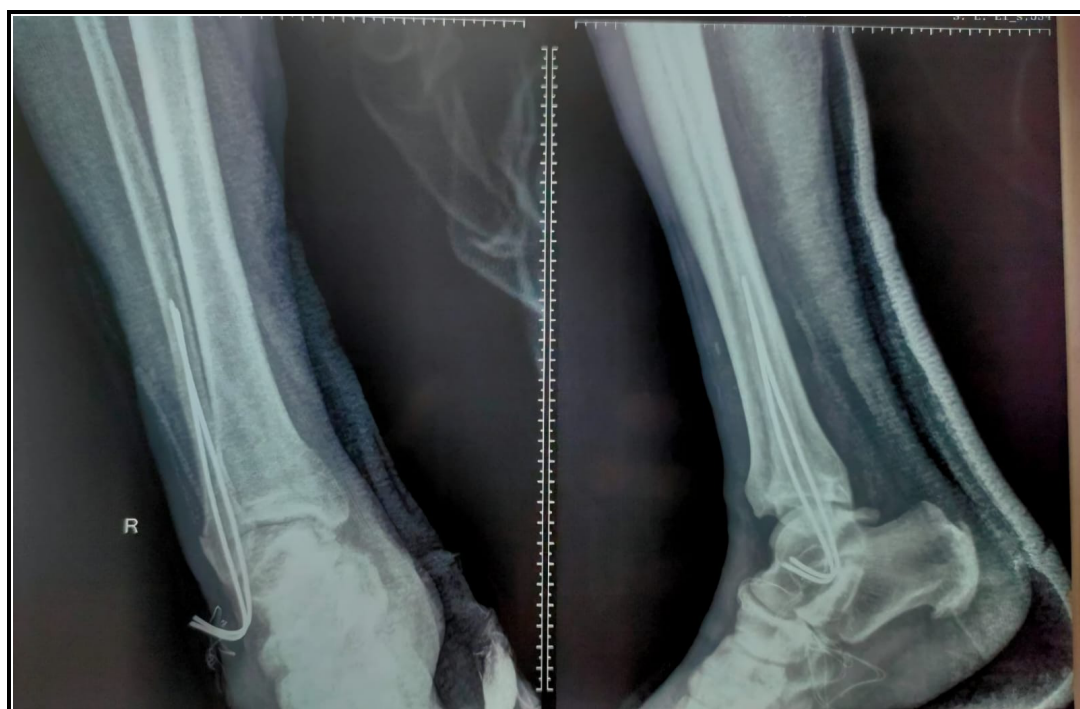


Figure 6: Radiographs at 2 weeks postoperatively



Figure 7: Radiographs at 4 weeks postoperatively



Figure 8: Radiographs at 8 weeks postoperatively

Case 2

A 50-year-old male with a medical history of hypertension and diabetes mellitus, presented with a left ankle injury and was diagnosed radiographically with a left medial malleolus fracture. The patient underwent operative management with fracture reduction and internal fixation. Immediate postoperative radiographs were obtained to assess the

adequacy of reduction, implant position, and ankle alignment. Serial radiographic follow-up was subsequently performed at 2, 4, and 8 weeks postoperatively to evaluate maintenance of reduction, stability of fixation, and progression of fracture healing.



Figure 9: Preoperative radiographs of the left medial malleolus fracture



Figure 10: Postoperative radiographs

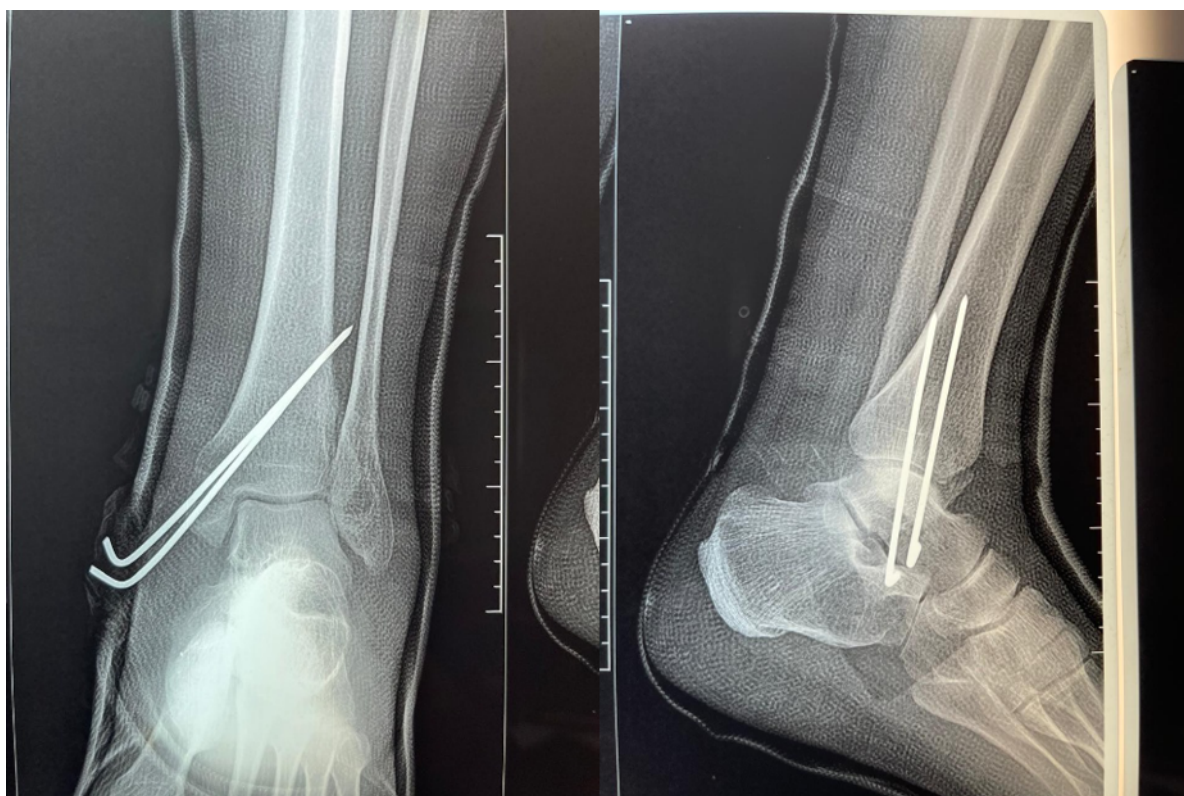


Figure 11: Radiographs at 2 weeks postoperatively

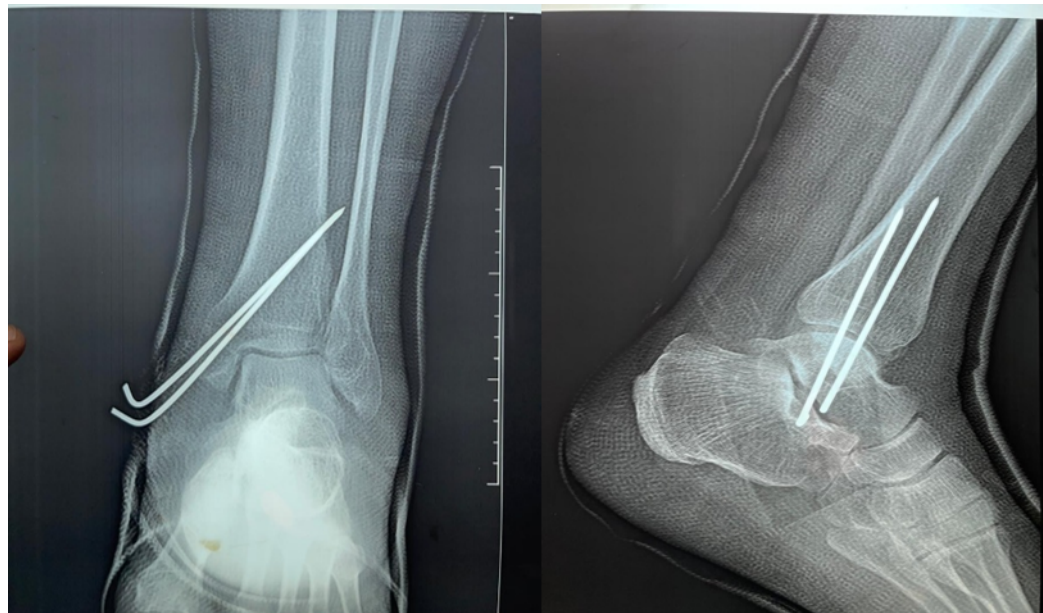


Figure 12: Radiographs at 4 weeks postoperatively



Figure 13: Radiographs at 8 weeks postoperatively

DISCUSSION

This study evaluated functional outcomes after percutaneous K-wire fixation of unimalleolar and bimalleolar ankle fractures. The results showed progressive improvement in ankle function during follow-up, relatively early fracture union, and a short operative time. Postoperative complications were mainly related to pin tract infection, while emotional acceptance improved over time. No demographic, clinical, fracture-related, or operative variable was associated with emotional acceptance at six months. In contrast, postoperative complications were more frequent among older patients and those with hypertension or ischemic heart disease and were accompanied by longer fracture union time.

Functional recovery was reflected by the progressive rise in OMAS from 24.2 at two months to 64.1 at four months and 85.4 at six months. Egol et al. 13 reported OMAS values of approximately 74–83 at 12 months after ankle fracture surgery using plate and lag-screw fixation, while Ponzer et al. 14 documented values of 77–82 during follow-up of surgically treated ankle fractures. Similarly, Belcher et al. 15 found a mean OMAS of 72 during follow-up of operatively treated malleolar fractures, with persistent functional impairment in some patients. These findings are in agreement with the favorable six-month OMAS observed in the present cohort. The low score at two months also agrees with the expected early functional limitation after ankle fracture surgery, followed by a marked gain in function during the subsequent months. The broad variation in OMAS at six months, with scores ranging from 30 to 100, shows that recovery was not uniform across all patients, with some remaining within moderate or poor functional ranges. This variability may be related to malunion, delayed union, or comorbidity-related complications.

The relatively short operative time and early fracture union observed in the present study support the practical feasibility of percutaneous K-wire fixation. Mean operative time was 23.4 minutes, while fracture union occurred after a mean of 1.5 months. This finding is in agreement with Court-Brown and Caesar 16, who reported a typical union period of approximately 6–8 weeks for malleolar fractures treated surgically. Malunion occurred in 8.1% of patients, and delayed or non-union was recorded in another 8.1%. Herscovici et al. 17 discussed the limited rotational control of smooth K-wires compared with compression screws, which may be relevant in less stable fracture configurations. Postoperative complications occurred in 16.2% of patients, with pin tract infection being the most frequent event, affecting 13.5%. Kazmers et al. 18 reported pin-site infection rates ranging from approximately 6% to 18% across fixation settings, depending on pin-care practice, wire characteristics, and duration of retention. The infection rate observed in the present series falls within this reported range. No wire loosening or Sudeck's atrophy was recorded. The absence of documented timing of K-wire removal, however, limits comparison of infection occurrence with the duration of wire retention.

The complication analysis showed differences according to age and cardiovascular comorbidity. Patients who developed complications had a median age of 72 years compared with 50 years among those without complications. Hypertension was present in 83.3% of patients with complications compared with 25.8% of those without complications, while ischemic heart disease was present in 50% of the complication group and in none of the patients without complications. SooHoo et al. 19 showed the importance of patient-related factors in complications after ankle fracture fixation. Similarly, Wukich et al. 20 described higher postoperative complication rates in foot

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and ankle surgery among patients with systemic comorbidity and vascular compromise. These observations are in agreement with the complication profile found in the present study.

Fracture union time was also longer among patients who developed complications, with a median of two months compared with one month in those without complications. Ovaska et al. 21 likewise described the association between patient-related factors and poorer outcomes after operative treatment of ankle fractures. In the present cohort, this difference accompanied the greater burden of hypertension and ischemic heart disease among patients with complications. Diabetes, smoking, fracture type, operative time, and postoperative immobilization did not differ according to complication status.

At two months, 54.1% of patients achieved Grade 2 functional symmetry, while most patients still had moderate balance impairment (91.9%). Posture assessment showed moderate deviation with preserved independence in 51.4%, while 43.2% required assistance. Riemann and Lephart 22 showed the role of proprioception and sensorimotor control in functional joint stability. The remaining 45.9% of patients with mild or marked asymmetry may represent those with more complex fracture patterns, greater initial displacement, or comorbidity-related limitations in healing. The marked balance impairment at this stage is consistent with persistent proprioceptive and functional deficits during early rehabilitation.

Pain at two months had a mean NRS score of 4.4. Williamson and Hoggart 23 described the usefulness of NRS for monitoring pain intensity during recovery. In the current series, this pain level accompanied the functional limitations seen at the same stage, whereas the subsequent OMAS course showed continued improvement over four and six months.

Emotional acceptance changed progressively during follow-up. Favorable acceptance increased from 5.4% at two months to 27.0% at four months and 70.2% at six months, while unfavorable acceptance decreased from 94.6% to 29.7%. Vissers et al. 24 emphasized the importance of psychological factors during recovery from musculoskeletal conditions, while Linton and Shaw 25 showed the close relationship between physical recovery, pain, and psychological responses. The parallel improvement in OMAS and emotional acceptance across follow-up is consistent with this general pattern. However, the present analysis did not identify any demographic, clinical, fracture-related, or operative factor associated with emotional acceptance at six months. Low emotional acceptance remained in about 11% of patients at six months. This proportion was close to the rates of malunion and delayed or non-union, each occurring in 8.1%, suggesting that persistent physical problems may accompany less favorable emotional recovery. However, this relationship could not be formally tested in the present analysis.

The absence of significant associations with six-month emotional acceptance should be considered in relation to the small sizes of the four acceptance categories, particularly the low-acceptance group. Vranceanu et al. 26 reported that psychological factors may influence disability

and pain after skeletal trauma, supporting continued attention to psychosocial recovery after orthopedic injury. In the present study, age, sex, body weight, comorbidities, injury mechanism, fracture morphology, operative time, immobilization type, and union time did not differ across emotional acceptance categories. Accordingly, the observed improvement in acceptance was a follow-up pattern rather than one linked to a specific baseline characteristic in this cohort.

This study has several limitations. First, the relatively small sample size and single-arm design limited statistical power and direct comparison with other treatment methods. Second, the six-month follow-up did not capture long-term outcomes. Third, K-wire removal timing was not systematically documented, and fracture union lacked a prespecified standardized radiographic definition. Fourth, different fracture patterns were analyzed together despite their biomechanical differences. Finally, the emotional acceptance tool was not validated specifically for ankle-fracture populations.

CONCLUSIONS

Percutaneous K-wire fixation of unimalleolar and bimalleolar ankle fractures was associated with progressive functional recovery, early fracture union, and a short operative time during six months of follow-up. Pin tract infection was the most frequent complication, while older age, hypertension, ischemic heart disease, and longer union time were associated with postoperative complications. Emotional acceptance improved progressively during follow-up.

REFERENCES

1. Olías-López B, Boluda-Mengod J, Rendón-Díaz D, et al. Fractures of the peroneal malleolus: Current concepts. *Rev Esp Cir Ortop Traumatol*. Sep–Oct 2024;68(5):502–512. Fracturas del maléolo peroneo: conceptos actuales. doi: 10.1016/j.recot.2024.06.008
2. Patel S, Dionisopoulos SB. Current Concepts in Ankle Fracture Management. *Clin Podiatr Med Surg*. Jul 2024;41(3):519–534. doi: 10.1016/j.cpm.2024.01.008
3. Ghosh A. Diagnostic and Surgical Planning Value of Computed Tomography (CT) in Adult Ankle Fractures: A Narrative Review. *Cureus*. Dec 2025;17(12): e98749. doi:10.7759/cureus.98749
4. Kyriacou H, Mostafa A, Davies BM, Khan WS. Principles and guidelines in the management of ankle fractures in adults. *J Perioper Pract*. Nov 2021;31(11):427–434. doi:10.1177/1750458920969029
5. Redman I, Sugand K, Daruwalla A, Clark A. Pre-operative management of fracture blisters: a systematic review. *EFORT Open Rev*. Mar 1, 2025;10(3):166–171. doi:10.1530/eor-2024-0074
6. Han X, Chu F, Jia D, et al. Wound complication risk factors following open reduction and internal fixation of ankle fractures. *Int Wound J*. Apr 2024;21(4): e14581. doi:10.1111/iwj.14581
7. Hawkins J, Andrews NA, Sankey MT, et al. The Impact

- of Surgical Timing After Ankle Fracture on Clinical and Long-Term Patient Reported Outcomes. *J Foot Ankle Surg.* Jul–Aug 2023;62(4):701–706. doi: 10.1053/j.jfas.2023.02.011
8. Arceri A, Mazzotti A, Zielli SO, et al. The Role of Kirschner Wires in Foot and Ankle Surgery: A Comprehensive Review and Practical Appraisal of Applications, Benefits, and Challenges. *Medicina (Kaunas).* Oct 14 2025;61(10):1836. doi:10.3390/medicina61101836
 9. Unger T, Borghi C, Charchar F, et al. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. *Hypertension.* Jun 2020;75(6):1334–1357. doi:10.1161/hypertensionaha.120.15026
 10. ElSayed NA, Aleppo G, Aroda VR, et al. 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes Care.* Jan 1 2023;46(Suppl 1): S19–s40. doi:10.2337/dc23-S002
 11. Nilsson GM, Eneroth M, Ekdahl CS. The Swedish version of OMAS is a reliable and valid outcome measure for patients with ankle fractures. *BMC Musculoskelet Disord.* Mar 25 2013; 14:109. doi:10.1186/1471-2474-14-109
 12. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res (Hoboken).* Nov 2011;63 Suppl 11: S240–52. doi:10.1002/acr.20543
 13. Egol KA, Tejwani NC, Walsh MG, Capla EL, Koval KJ. Predictors of short-term functional outcome following ankle fracture surgery. *J Bone Joint Surg Am.* May 2006;88(5):974–9. doi:10.2106/jbjs.E.00343
 14. Ponzer S, Näsell H, Bergman B, Törnkvist H. Functional outcome and quality of life in patients with Type B ankle fractures: a two-year follow-up study. *J Orthop Trauma.* Jun–Jul 1999;13(5):363–8. doi:10.1097/00005131-199906000-00007
 15. Belcher GL, Radomisli TE, Abate JA, Stabile LA, Trafton PG. Functional outcome analysis of operatively treated malleolar fractures. *J Orthop Trauma.* Feb–Mar 1997;11(2):106–9. doi:10.1097/00005131-199702000-00007
 16. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury.* Aug 2006;37(8):691–7. doi: 10.1016/j.injury.2006.04.130
 17. Herscovici D, Jr., Scaduto JM, Infante A. Conservative treatment of isolated fractures of the medial malleolus. *J Bone Joint Surg Br.* Jan 2007;89(1):89–93. doi:10.1302/0301-620x.89b1.18349
 18. Kazmers NH, Fragomen AT, Rozbruch SR. Prevention of pin site infection in external fixation: a review of the literature. *Strategies Trauma Limb Reconstr.* Aug 2016;11(2):75–85. doi:10.1007/s11751-016-0256-4
 19. SooHoo NF, Krenke L, Eagan MJ, Gurbani B, Ko CY, Zingmond DS. Complication rates following open reduction and internal fixation of ankle fractures. *J Bone Joint Surg Am.* May 2009;91(5):1042–9. doi:10.2106/jbjs.H.00653
 20. Wukich DK, Lowery NJ, McMillen RL, Frykberg RG. Postoperative infection rates in foot and ankle surgery: a comparison of patients with and without diabetes mellitus. *J Bone Joint Surg Am.* Feb 2010;92(2):287–95. doi:10.2106/jbjs.I.00080
 21. Ovaska MT, Mäkinen TJ, Madanat R, Vahlberg T, Hirvensalo E, Lindahl J. Predictors of poor outcomes following deep infection after internal fixation of ankle fractures. *Injury.* Jul 2013;44(7):1002–6. doi: 10.1016/j.injury.2013.02.027
 22. Riemann BL, Lephart SM. The Sensorimotor System, Part II: The Role of Proprioception in Motor Control and Functional Joint Stability. *J Athl Train.* Jan 2002;37(1):80–4.
 23. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. *J Clin Nurs.* Aug 2005;14(7):798–804. doi:10.1111/j.1365-2702.2005.01121.x
 24. Vissers MM, Bussmann JB, Verhaar JA, Busschbach JJ, Bierma-Zeinstra SM, Reijman M. Psychological factors affecting the outcome of total hip and knee arthroplasty: a systematic review. *Semin Arthritis Rheum.* Feb 2012;41(4):576–88. doi: 10.1016/j.semarthrit.2011.07.003
 25. Linton SJ, Shaw WS. Impact of psychological factors in the experience of pain. *Phys Ther.* May 2011;91(5):700–11. doi:10.2522/ptj.20100330
 26. Vranceanu AM, Bachoura A, Weening A, Vrahas M, Smith RM, Ring D. Psychological factors predict disability and pain intensity after skeletal trauma. *J Bone Joint Surg Am.* Feb 5 2014;96(3): e20. doi:10.2106/jbjs.L.00479