Journal of Research in
Orthopedic Science
2026. Volume 13. Issue 2

Research Paper

Mid-term Outcomes of Lateral Opening-wedge Distal Femoral Osteotomy for Valgus Knees

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Citation Askari A, Jabalameli M, Moghtadaei M, Yahyazadeh H, Gholami E, Zareie B, et al. Mid-term Outcomes of Lateral Opening-wedge Distal Femoral Osteotomy for Valgus Knees. Journal of Research in Orthopedic Science. 2026; 13(2):49-56. http://dx.doi.org/10.32598/JROSJ.13.2.2745.1

http://dx.doi.org/10.32598/JROSJ.13.2.2745.1

Article info:
Received: 22 Aug 2025
Revised: 14 Jan 2026
Accepted: 01 Feb 2026

Keywords:
Distal femoral osteotomy (DFO), Valgus knee, Lateral opening wedge, Alignment correction, Nonunion, 36-item short form health survey (SF-36)

ABSTRACT

Background: Distal femoral osteotomy (DFO) is a joint-preserving procedure for symptomatic valgus knees.

Objectives: This study aimed to evaluate radiographic correction, final patient-reported outcomes at mid-term follow-up, complications, and associated factors after lateral opening-wedge DFO fixed with a locking compression plate.

Methods: A retrospective cohort of 46 patients (46 knees) undergoing lateral opening-wedge DFO was reviewed. Mechanical alignment was assessed using the hip–knee–ankle (HKA) angle on standing long-leg radiographs. Pain and health-related quality of life at the final follow-up were measured using a visual analogue scale (VAS, 0–10) and the 36-item short form health survey (SF-36, 0–100). Complications and conversion to total knee arthroplasty (TKA) were recorded. Associations between baseline variables and outcomes were analyzed using correlation and group comparisons.

Results: Mean age was 38.30±10.14 years, and mean follow-up was 4.85±1.67 years. Mean HKA improved from 194.91±1.53° preoperatively to 180.33±0.87° at final follow-up (P<0.001). Final VAS was 2.11±1.10 and final SF-36 was 81.59±9.07. Complications occurred in 7 patients (15.22%), including nonunion in 6(13.04%) and conversion to TKA in 1(2.17%). Older age correlated with lower SF-36 (r=−0.36, P=0.01). Higher Kellgren–Lawrence (KL) grade was associated with worse SF-36 (P<0.001) and higher VAS (P=0.007).

Conclusion: Lateral opening-wedge DFO achieved consistent correction to near-neutral alignment with favorable outcomes. Nonunion was the most frequent complication, while TKA conversion was uncommon. Older age and greater osteoarthritis severity were associated with worse outcomes and increased risk of complications.

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Introduction

Valgus malalignment shifts the mechanical axis laterally and increases the contact pressure in the lateral compartment, contributing to pain and progressive degeneration of the lateral compartment. In young and active patients, arthroplasty may be less desirable due to activity restrictions and the risk of future revision. Distal femoral osteotomy (DFO) is a joint-preserving realignment procedure that aims to unload the lateral compartment by restoring a more neutral mechanical axis in knees with primarily femoral deformity [1–5].

DFO can be performed using a medial closing wedge or a lateral opening wedge technique. Systematic reviews suggest both approaches can achieve reliable correction and comparable outcomes when performed with careful preoperative planning and stable fixation; however, complication profiles differ, and delayed union/nonunion has been highlighted as a particular concern after lateral opening-wedge techniques [3–6]. Mid- to long-term series report that DFO can delay conversion to arthroplasty in appropriately selected patients, but survivorship and complication rates vary with age, baseline osteoarthritis severity, and treatment of the osteotomy gap [7, 8].

The purposes of this study were (1) to report radiographic correction, final pain and health-related quality of life, and complications after lateral opening-wedge DFO fixed with a locking compression plate (LCP); and (2) to assess factors associated with outcomes and complications. We hypothesized that DFO would restore near-neutral alignment with acceptable final visual analogue scale (VAS) and SF-36 scores, and that older age and higher K grade would be associated with worse outcomes and an increased risk of complications.

Methods

Study design and setting

This retrospective cohort study was conducted at three tertiary referral hospitals. Data were extracted from institutional medical records between October 2016 and October 2024. The study was reported in accordance with the strengthening the reporting of observational studies in epidemiology (STROBE) statement for observational studies (Figure 1) [9].

Participants

Consecutive patients who underwent lateral opening-wedge DFO for symptomatic valgus malalignment were screened. The primary indication was symptomatic valgus alignment on standing long-leg radiographs (hip–knee–ankle [HKA]>180° as measured in our institution) with clinical and/or radiographic evidence of lateral compartment overload. Patients were included if a complete radiographic dataset (pre- and postoperative long-leg radiographs) and final follow-up clinical assessment were available. Patients with inflammatory arthropathy or advanced tricompartmental degeneration were not considered candidates for osteotomy [1, 2].

Surgical technique

All procedures were performed using a lateral opening-wedge DFO via a direct lateral approach, and the DFO was fixed with a lateral LCP. The goal was to restore near-neutral mechanical alignment based on preoperative planning and intraoperative fluoroscopic confirmation.

Postoperative rehabilitation

Range-of-motion exercises were started immediately after surgery as tolerated. Patients remained non-weight-bearing for approximately 6 weeks (1.5 months), followed by progressive loading. Full weight bearing was permitted after approximately 12 weeks (3 months), based on clinical assessment and radiographic review.

Radiographic assessment

Long-leg anteroposterior radiographs were used to evaluate lower-limb alignment. The HKA angle was measured preoperatively and at final follow-up. In this study, values greater than 180 degrees indicated valgus alignment [10]. Preoperative osteoarthritis severity was classified using the Kellgren–Lawrence (KL) grading system on weight-bearing radiographs [11].

Clinical outcomes

Pain at final follow-up was assessed using a VAS, 0–10 [12]. Health-related quality of life at final follow-up was assessed using the 36-item short form health survey (SF-36, 0–100) [13]. Preoperative VAS and SF-36 scores were unavailable in the medical records and were not analyzed.

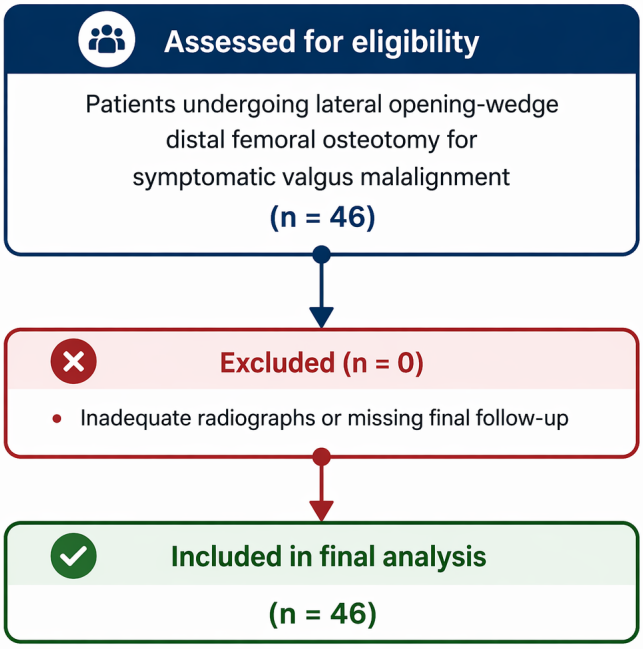

Figure 1. Study flow diagram showing patient selection and final cohort included in the analysis

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Complications and failure

Postoperative complications were identified by chart review. In this cohort, complications comprised non-union and conversion to total knee arthroplasty (TKA). Failure was defined a priori as conversion to arthroplasty (TKA) during follow-up [6].

Statistical analysis

Continuous variables are reported as Mean±SD and range, and categorical variables as counts and percentages. Pre- versus postoperative HKA was compared using a paired t-test. Correlations were assessed using Pearson correlation (age vs SF-36) and Spearman correlation (KL grade vs SF-36). Differences in VAS across KL grades were tested using one-way analysis of variance (ANOVA). Comparisons between patients with and without complications were performed using independent-samples t-tests for continuous variables and Fisher exact tests for categorical variables. Statistical significance was set at $P<0.05$. Analyses were performed using IBM SPSS software, version 16 (IBM Corp., Armonk, NY, USA).

Use of generative AI tools

Generative AI tools were used only for language refinement during manuscript preparation. All scientific content, analysis, and interpretations were developed and verified by the authors, who take full responsibility for the manuscript.

Results

Cohort characteristics

Forty-six patients (46 knees) were included. The mean age was 38.3±10.14 years (range 18–54), and the mean follow-up was 4.85±1.67 years (range 2–8). Thirty-five patients were female (76.09%), and 24 procedures were performed on the right knee (52.17%). Preoperative KL grade was 0 in 7 knees (15.22%), 1 in 28 (60.87%), 2 in 10 (21.74%), and 3 in 1 (2.17%) (Table 1).

Radiographic outcomes

Mean preoperative HKA was 194.91±1.53°, consistent with valgus malalignment. At final follow-up, mean HKA was corrected to 180.33±0.87°, representing a mean correction of 14.59±1.51° ($P<0.001$) (Table 2, Figure 2).

Clinical outcomes

At final follow-up, the mean VAS pain score was 2.11±1.1, and the mean SF-36 score was 81.59±9.07 (Table 3). Preoperative patient-reported outcome measures (PROMs) were unavailable, and changes from baseline could not be calculated.

Predictors of outcome

Age correlated negatively with SF-36 ($r=-0.36$, $P=0.01$). Higher KL grade was associated with lower SF-36 (Spearman's rho=-0.50, $P<0.001$). VAS differed

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Figure 2. Representative radiographs

A) Preoperative long-standing anteroposterior radiograph showing valgus malalignment, B) Postoperative anteroposterior radiograph demonstrating lateral opening-wedge DFO fixed with a lateral locking plate

significantly across KL grades (ANOVA, P=0.007) (Figure 3).

Complications and failure

Complications occurred in seven patients (15.22%). Nonunion occurred in six patients (13.04%). One patient (2.17%) underwent conversion to TKA due to persistent pain; this patient had preoperative KL grade 3. Patients with complications were significantly older (P=0.028) and more likely to have KL grade 2 or greater (P=0.046) (Table 4).

Discussion

The principal findings of this retrospective cohort study were that lateral opening-wedge DFO fixed with a locking plate restored near-neutral mechanical alignment with consistent correction and yielded favorable final pain and SF-36 scores at a mean follow-up of 4.85 years. Conversion to TKA occurred in one patient (2.17%), while nonunion was the predominant complication (13.04%). Older age and more advanced radiographic osteoarthritis (KL grade) were associated with worse outcomes and an increased risk of complications.

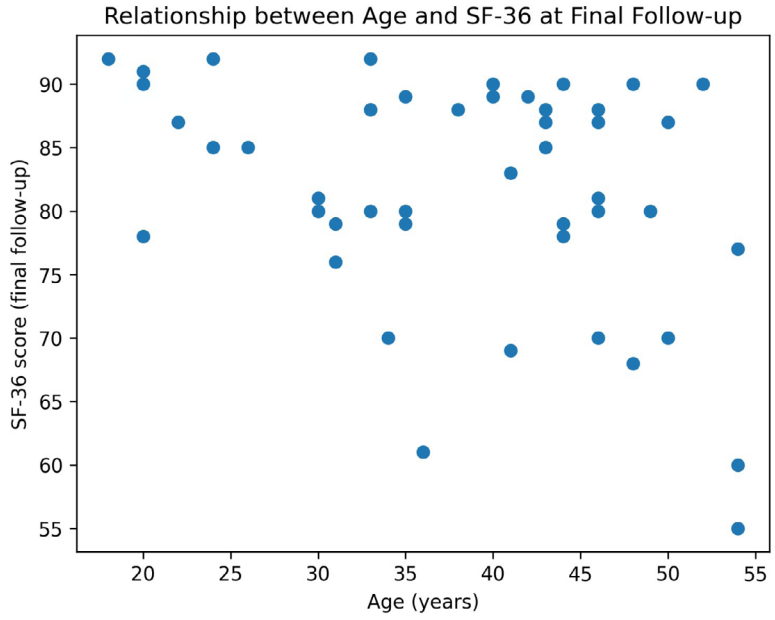

Figure 3. Representative radiographs

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A) Preoperative long-standing anteroposterior radiograph showing valgus malalignment, B) Postoperative anteroposterior radiograph demonstrating lateral opening-wedge dfo fixed with a lateral locking plate

Radiographic correction is central to the rationale of DFO because shifting the mechanical axis toward neutral unloads the lateral compartment and is the core premise of joint-preserving treatment. In our cohort, mean HKA improved from 194.91° to 180.33°, with a postoperative SD of 0.87°, suggesting a high degree of correction consistency. Systematic reviews and meta-analyses have similarly shown that both opening- and closing-wedge DFO can achieve correction to neutral or slight varus when deformity correction is performed at the origin, and stable fixation is used [3–5]. Studies evaluating correction accuracy after lateral opening-wedge DFO with locking plate constructs have also reported high accuracy, supporting the reliability of contemporary fixation [14].

Table 1. Baseline characteristics (n=46)

Variables			Mean±SD/No. (%)
Age (y)		18–54	38.30±10.14
Female sex	BMI (kg/m²)	19–34	27.41±3.26
	Follow-up (y)	2–8	4.85±1.67
Operated side (right)			24(52.17)
Preoperative KL grade	KL 0		7(15.22)
	KL 1		28(60.87)
	KL 2		10(21.74)
	KL 3		1(2.17)
Preoperative HKA (°)			194.91±1.53

HKA: Hip–knee–ankle; BMI: Body mass index.

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Table 2. Radiographic outcomes

Parameter	Mean±SD
Preoperative HKA (°)	194.91±1.53
Postoperative HKA (°)	180.33±0.87
Correction (°)	14.59±1.51
P	<0.001

HKA: Hip–knee–ankle.
*Paired t-test.

Table 3. Clinical outcomes at final follow-up

Outcome	Mean±SD
	Final Follow-up
VAS pain (0–10)	2.11±1.10
SF-36 (0–100)	81.59±9.07

VAS: Visual analogue scale; SF-36: 36-item short form health survey.

The final PROMs in this series were favorable (VAS 2.11; SF-36 81.59). Baseline PROMs were not available, so improvement from preoperative status could not be quantified. Nevertheless, these final values compare well with other opening-wedge DFO cohorts that report meaningful symptom relief and functional improvement at mid-term follow-up (often using different instruments, such as KOOS) [15–17]. Return to activity is an important patient-centered endpoint, and prior cohorts have reported that most patients resume physical activity and/or return to work and sports after DFO, although participation in high-impact activity may decrease compared with pre-symptomatic levels [18, 19]. Long-term survivorship remains a key outcome for joint-preserving pro-

Table 4. Baseline characteristics and final outcomes in patients with and without complications

Variables	Mean±SD/No. (%)		P
	Complications (n=7)	No Complications (n=39)	
Age (y)	46.00±8.08	36.92±9.93	0.027
Female sex	5(71.43)	30(76.92)	1.000
BMI (kg/m²)	26.57±4.28	27.56±3.08	0.464
Right side	5(71.43)	19(48.72)	0.418
KL grade ≥2	4(57.14)	7(17.95)	0.046
Follow-up (y)	5.29±1.50	4.77±1.71	0.458
Preop HKA (°)	194.71±1.89	194.95±1.49	0.714
Postop HKA (°)	180.57±0.98	180.28±0.86	0.424
Correction (°)	14.14±2.04	14.67±1.42	0.405
Final VAS	3.57±0.98	1.85±0.90	<0.001
Final SF-36	64.86±6.12	84.59±5.55	<0.001

Abbreviations: VAS: Visual analogue scale; SF-36: 36-item short form health survey; HKA: Hip–knee–ankle; BMI: Body mass index.

cedures; published series indicate that DFO can delay conversion to arthroplasty in selected patients at 5–10 years, but results vary with age, baseline arthritis severity, and follow-up duration [7, 8, 20, 21].

Complication rates after DFO vary across the literature and depend on technique, fixation, and definitions used. In the present cohort, nonunion was the dominant complication. Nonunion and delayed union have been emphasized as specific concerns after lateral opening-wedge DFO, reinforcing the need for careful technique, risk-factor management, and patient counseling regarding potential reoperation and radiographic union monitoring [6]. Published technical and clinical series have described strategies to support healing, including stable fixation and, in selected cases, the use of grafts or substitutes to manage the osteotomy gap [22].

We observed clinically intuitive predictors: higher KL grade was associated with worse SF-36 and greater pain, and older age was associated with lower SF-36. These results support emphasizing careful patient selection for joint-preserving surgery, particularly in knees with more advanced radiographic osteoarthritis, and align with prior DFO series and syntheses that baseline disease stage and patient factors influence outcomes [1, 5, 7, 8].

This study has limitations. Its retrospective design may introduce selection and information bias. Baseline PROMs were not available, preventing assessment of improvement and limiting direct comparison with prospective series. The cohort size was modest, and included few patients with advanced radiographic osteoarthritis, limiting conclusions regarding KL grade 3 disease. Finally, we did not analyze additional knee-specific functional scores or activity-level outcomes. Strengths include a homogeneous technique (lateral opening-wedge DFO with locking plate fixation), mid-term follow-up, and complete radiographic alignment data for all included patients.

Conclusion

Lateral opening-wedge DFO fixed with a LCP achieved accurate correction to near-neutral mechanical alignment and favorable final patient-reported outcomes at a mean follow-up of 4.85 years. Conversion to TKA is uncommon, while nonunion remains the most frequent complication. Older age and higher KL grade were associated with worse outcomes and an increased risk of complications.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Ethics Committee of Iran University of Medical Sciences, Tehran, Iran (Code: IR.IUMS.REC.1403.1056).

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interpretation of the results, and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflict of interest.

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