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Research Paper

Origin-specific Osteotomy for the Correction of Genu Valgum Deformity of the Knee: A Retrospective Study

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ABSTRACT

Background: Valgus deformity in adults may originate from the distal femur, proximal tibia, or a combined pattern. Correcting a deformity at the wrong anatomical level may improve the mechanical axis but leave the joint line oblique, potentially affecting load distribution and symptoms.

Objectives: This study evaluated an origin-directed osteotomy strategy using long-leg radiographic measurements.

Methods: Thirty-one patients (34 knees) with symptomatic genu valgum underwent deformity analysis based on the lateral distal femoral angle (LDFA), medial proximal tibial angle (MPTA), and joint-line convergence angle (JLCA). According to the dominant radiographic deviation, patients were treated with distal femoral osteotomy (DFO), proximal tibial osteotomy (PTO), or double-level correction. Radiographic outcomes, knee range of motion (ROM), KOOS, WOMAC, and complications were assessed at a mean follow-up of 4.2 years.

Results: Most deformities were femoral-based (76.5%), followed by combined (17.6%) and tibial-based (5.9%) patterns. LDFA improved from 80.5° to 86.8° (P<0.001), JLCA from −3.44° to 3.2° (P<0.001), and the valgus angle from 14° to 6.5° (P<0.001). MPTA did not change significantly (90.4° to 89.8°, P=0.10). At final follow-up, mean KOOS was 79.6 and mean WOMAC was 23.5. Seven knees (20.6%) underwent elective plate removal, and one nonunion (2.9%) occurred. No postoperative joint-line obliquity or recurrent valgus was observed.

Conclusion: Assigning correction to the anatomical origin of valgus deformity resulted in accurate coronal realignment, preservation of joint-line orientation, and satisfactory mid-term outcomes. Origin-specific planning based on long-leg radiographs is a practical and reproducible strategy for adult valgus correction.

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Introduction

Valgus malalignment alters coronal-plane mechanics by shifting the mechanical axis laterally, increasing load across the lateral tibiofemoral compartment. In physiologically young adults with persistent symptoms, realignment osteotomy remains a dependable joint-preserving option. Its effectiveness, however, depends on correcting the deformity at the anatomical level responsible for the deviation. When correction is performed at the wrong segment, the mechanical axis may be restored, but the joint line can remain oblique, creating abnormal shear forces and compromising load distribution [1-3].

Distal femoral varus osteotomy (DFO) has historically been the standard treatment for symptomatic valgus deformity. Closing-wedge and, more recently, lateral opening-wedge techniques have produced reliable correction, solid union, and durable pain relief in several series, particularly when deformity originates in the distal femur [4-8]. However, detailed long-leg radiographic analysis has shown that valgus deformity does not always arise from the femur alone. Some patients demonstrate proximal tibial involvement, and others exhibit combined femoral, tibial, and intra-articular contributions [3, 9-11]. In such cases, a femur-only osteotomy may normalize the mechanical axis yet leave the joint line tilted.

Objective radiographic measures—the lateral distal femoral angle (LDFA), medial proximal tibial angle (MPTA), and joint-line convergence angle (JLCA)—provide a structured framework for identifying the anatomical source of deformity [1-3]. An origin-directed approach assigns the osteotomy to the segment demonstrating the primary deviation and uses double-level correction when both segments contribute substantially or when JLCA suggests an intra-articular component [12]. Although widely acknowledged conceptually, few clinical series have applied this strategy as a systematic decision algorithm.

The purpose of the present study was to evaluate an origin-specific approach to valgus realignment in adults. Deformities were classified by their anatomical origin using standardized long-leg radiographs, and patients underwent distal femoral, proximal tibial, or Double-level osteotomy (DLO) accordingly. We aimed to determine whether this strategy yields accurate coronal correction, preserves joint-line orientation, and produces satisfactory mid-term clinical outcomes.

Methods

Study design and ethical approval

This retrospective study was conducted at a tertiary orthopedic referral center. All adult patients who underwent realignment surgery for symptomatic valgus knee deformity between 2011 and 2018 were screened. The study protocol was approved by the institutional review board, and all participants provided informed consent.

Patient selection

Inclusion criteria were symptomatic coronal-plane valgus deformity confirmed on standing long-leg radiographs, age appropriate for joint-preserving surgery, and a minimum of two years of radiographic and clinical follow-up. Indications included lateral compartment pain related to valgus overload, progressive deformity, post-traumatic malalignment, ligamentous insufficiency with valgus thrust, neuromuscular sequelae, or early osteoarthritis in physiologically young adults.

Exclusion criteria were previous realignment surgery around the knee, metabolic bone disease, incomplete imaging, or inability to complete follow-up. Thirty-one patients (34 knees) met the criteria and were included.

Radiographic assessment

Standardized standing long-leg anteroposterior radiographs were obtained with the patella directed forward and both hips and ankles included. Imaging was performed under full weight-bearing. Measurements were performed digitally on PACS by the operating surgeon or a senior fellow.

Three parameters were assessed: LDFA, defined as the angle between the femoral mechanical axis and distal femoral joint line; MPTA, defined as the angle between the tibial mechanical axis and proximal tibial joint line; and JLCA, defined as the angle between the distal femoral and proximal tibial joint lines. Normal reference values (LDFA ≈ 87°, MPTA ≈ 87°, JLCA ≈ 0–2°) were used to determine deformity origin [1-3].

Classification of deformity origin

Deformities were classified as femoral-based, tibial-based, or combined deformities. This algorithm guided the selection of DFO, PTO, or DLO [1-3, 12].

Surgical techniques

Distal femoral osteotomy (DFO) was used for femoral-based deformity, typically employing a lateral opening-wedge technique. Through a lateral approach, the distal femur was exposed and a biplanar osteotomy created under fluoroscopic guidance, preserving a medial cortical hinge. The wedge was opened to the planned correction and fixed with a locking compression plate [4-8, 13-15].

Proximal tibial osteotomy (PTO) was used for tibial-based deformity. A medial approach was used to perform a medial opening- or closing-wedge osteotomy according to anatomy and surgeon preference, with careful preservation of posterior tibial slope [16, 17]. Fixation was achieved with a locking plate.

DLO was used for combined deformity or markedly increased JLCA. The correction magnitude was divided between distal femur and proximal tibia to maintain joint-line orientation while restoring the mechanical axis [3, 12].

Postoperative management

Passive and active-assisted motion began on the first postoperative day. The goal was to reach at least 90° of flexion by four weeks and a functional range of motion (ROM) by six weeks. Partial weight-bearing was initiated after early callus formation, typically at eight weeks, and progressed to full weight-bearing by ten to twelve weeks based on radiographic union and clinical tolerance.

Outcome measures

Radiographic outcomes included LDFA, MPTA, JLCA, and mechanical valgus angle, recorded preoperatively and at final follow-up. Clinical outcomes included knee ROM, Western Ontario and McMaster universities osteoarthritis index (WOMAC), and knee injury and osteoarthritis outcome score (KOOS). Validated Persian versions of WOMAC and KOOS were used when applicable [18-20]. Complications, such as nonunion, hardware irritation requiring removal, loss of correction, and recurrent valgus were recorded.

Statistical analysis

Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Preoperative and final follow-up values were compared using paired t-tests when normally distributed and non-parametric tests when appropriate. Categorical variables were compared using chi-square tests. Statistical significance was set at $P<0.05$.

Results

Thirty-one patients (34 knees) met the inclusion criteria. The cohort included 26 women (83.9%) and 5 men (16.1%), with a mean age of 34.8±9.9 years and a mean body mass index (BMI) of 23.3±2.9 kg/m². Mean follow-up duration was 4.2±2.7 years. Laterality was evenly distributed (14 right, 14 left), and three patients (9.6%) had bilateral procedures. Indications included valgus overload pain, progressive deformity, post-traumatic malalignment, ligamentous insufficiency with valgus

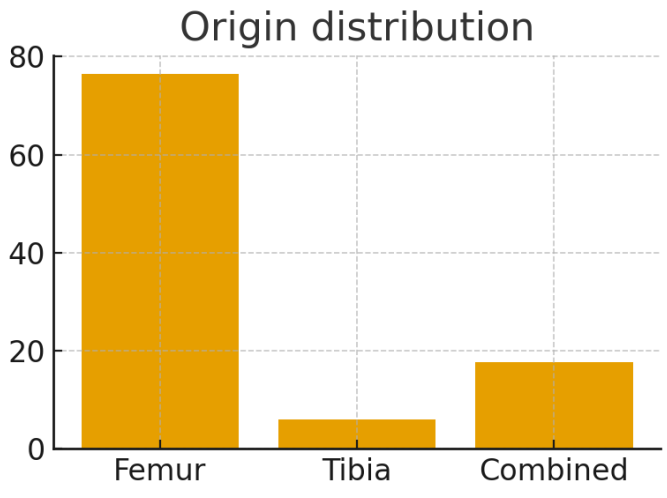

Figure 1. Origin distribution of valgus deformity
Note: Most deformities were femoral-based (76.5%), with smaller tibial-based and combined subsets.

Table 1. Baseline characteristics of participants

Variables	Value
Number of patients	31
Number of knees	34
Age (y), Mean±SD	34.8±9.9
Sex	83.9% female (n=26); 16.1% male (n=5)
BMI (kg/m²), Mean±SD	23.3±2.9
Follow-up duration (y), Mean±SD	4.2±2.7
Laterality	Right 14; Left 14; Bilateral 3
Indications	Valgus overload pain; progressive deformity; post-traumatic malalignment; ligamentous insufficiency; neuromuscular deformity; early osteoarthritis

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thrust, neuromuscular conditions, and early osteoarthritis. Baseline characteristics are summarized in Table 1.

Radiographically, 26 knees (76.5%) showed femoral-based deformity, 2 knees (5.9%) had tibial-based deformity, and 6 knees (17.6%) had combined deformity or marked JLCA. The distribution of deformity origin is shown in Table 2 and Figure 1.

Table 2. Distribution of deformity origin

Origin of Deformity	No. (%)
	Knees
Distal femur	26(76.5)
Proximal tibia	2(5.9)
Combined	6(17.6)

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Table 3. Radiographic outcomes

Outcome Measure	Mean±SD		P
	After Surgery	Final Follow-up	
LDFA (°)	80.5±2.5	86.8±1.3	<0.001
MPTA (°)	90.4±2.8	89.8±0.7	0.10
JLCA (°)	3.44±1	3.2±0.9	<0.001
Valgus angle (°)	14±2.5	6.5±1.9	<0.001

Outcome Measure	After Surgery	Final Follow-up	P
ROM (°)	127.9	121.8	–
KOOS	–	79.6 (66–99)	–
WOMAC	–	23.5 (17–29)	–

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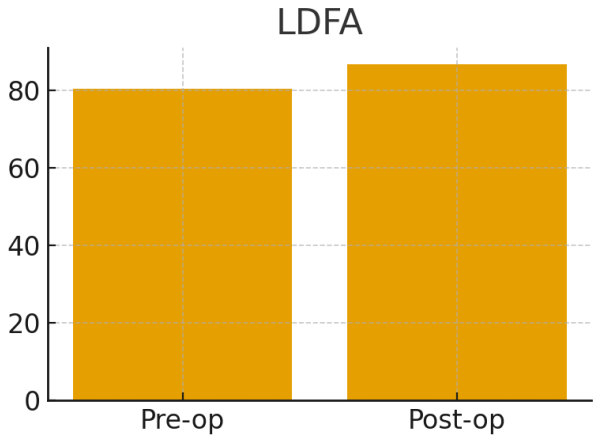

Figure 2. LDFA

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LDFA increased from 80.5° to 86.8° (P<0.001). JLCA improved from −3.44° to 3.2° (P<0.001). The mechanical valgus angle decreased from 14° to 6.5° (P<0.001). MPTA changed from 90.4° to 89.8° and this difference was not statistically significant (P=0.10). Radiographic outcomes are presented in Table 3 and Figures 2, 3, 4 and 5.

MPTA showed no significant change (P=0.10). Mean knee ROM decreased from 127.9° preoperatively to 121.8° at final follow-up. No patient required further intervention for stiffness. Mean KOOS at final follow-up was 79.6 (range 66–99), and mean WOMAC was 23.5 (range 17–29), indicating satisfactory mid-term functional outcomes (Figures 6, 7, and 8).

Final WOMAC scores (mean 23.5, range 17–29) reflect acceptable symptom levels. Seven knees (20.6%) underwent elective plate removal due to hardware irritation after union. One nonunion (2.9%) occurred and required revision. No cases of loss of correction, progressive joint-line obliquity, or recurrent valgus deformity were observed.

Discussion

The principal finding of this study is that assigning osteotomy to the anatomical source of valgus deformity resulted in reliable coronal correction and preservation of joint-line orientation. Most deformities in this cohort were femoral-based, in agreement with previous work that identified the distal femur as the dominant contributor in many adult valgus knees [4-8]. In such cases, DFO remains an appropriate and effective solution. The presence of tibial-based and combined deformities, however, confirms that valgus malalignment is not uniformly femoral and highlights the need for systematic radiographic analysis rather than a one-size-fits-all approach [3, 9-11].

The changes observed in LDFA, JLCA, and overall valgus angle are comparable to those reported in earlier

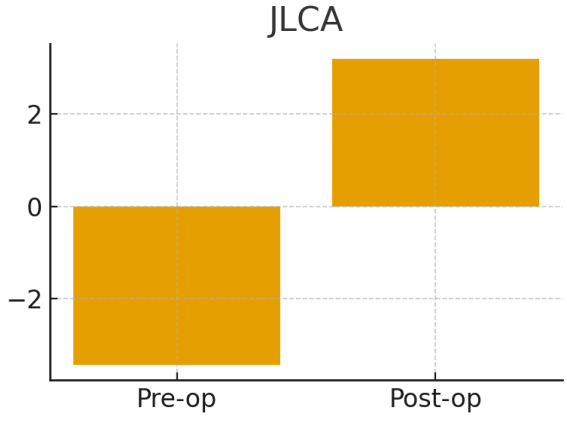

Figure 3. JLCA

Note: LDFA improved from 80.5° to 86.8° (P<0.001).

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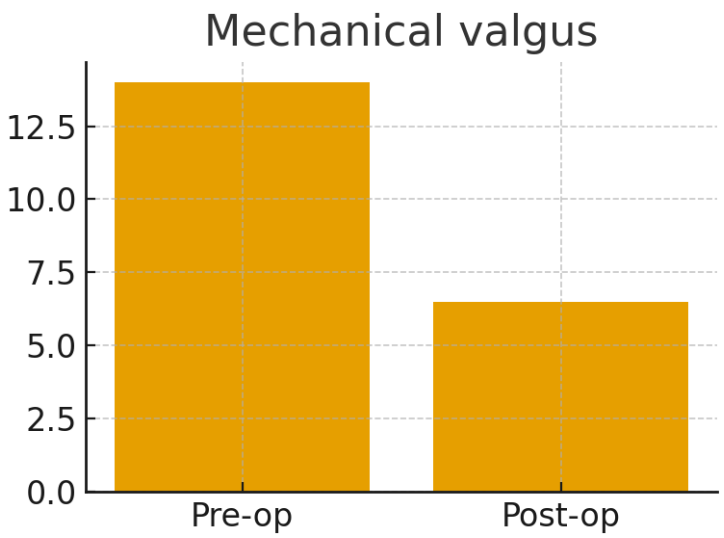

Figure 4 Mechanical valgus angle
Note: JLCA corrected from −3.44° to 3.2° (P<0.001).

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DFO series using both closing- and opening-wedge techniques [4-8, 13-15]. Our data support the concept that matching the correction site to the origin of deformity improves joint-line orientation. In combined deformities, distributing correction through DLO avoids excessive wedge magnitude at a single site and helps maintain a horizontal joint line, in line with the rationale described by Backstein et al. [3] and Babis et al. [12].

Tibial-based deformity was uncommon in this cohort, but targeted PTO achieved acceptable alignment in these cases. Although the small number precludes detailed statistical analysis, the results align with established experience in valgus tibial osteotomy [16, 17] and emphasize that femur-only correction is not appropriate when the primary deviation lies in the tibia.

Functional outcomes in this series were satisfactory and comparable to prior reports of DFO in relatively young patients with valgus deformity [1, 7-9]. The modest reduction in flexion range did not translate into clinically relevant stiffness, and the rate of hardware-related symptoms requiring plate removal was consistent with other plate-fixed osteotomy series. The single nonunion observed was in line with reported nonunion rates for opening-wedge DFO [7, 8, 13-15].

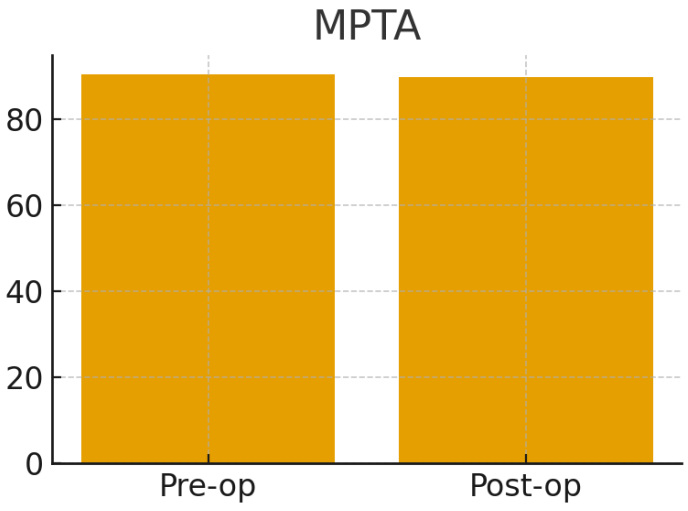

Figure 5. MPTA
Note: The mechanical valgus angle decreased from 14° to 6.5° (P<0.001).

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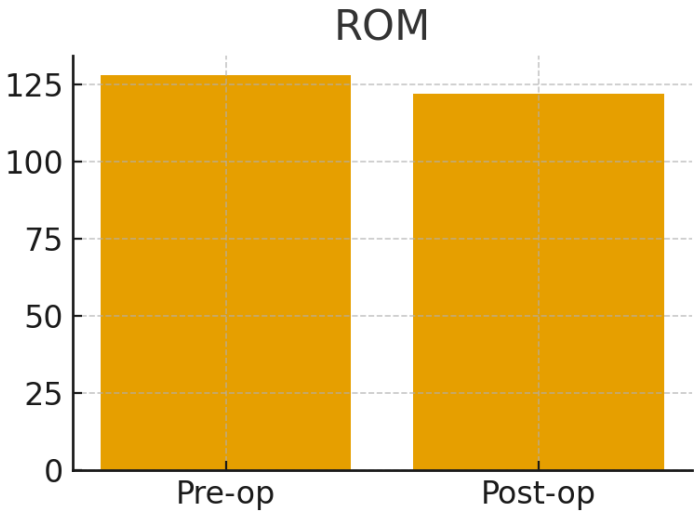

Figure 6. Knee ROM

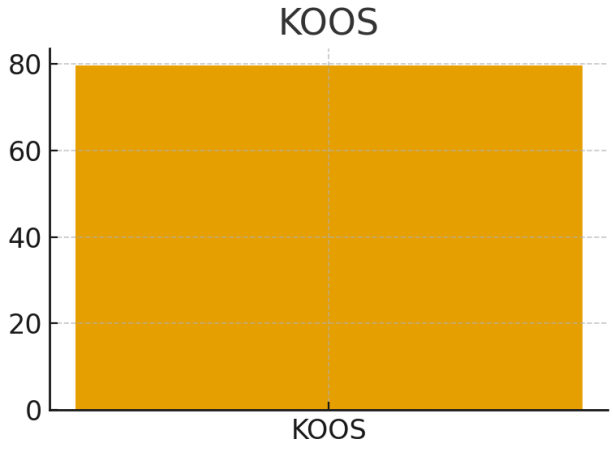

Figure 7. KOOS score at final follow-up

Note: Knee ROM decreased slightly but remained functional (127.9° to 121.8°).

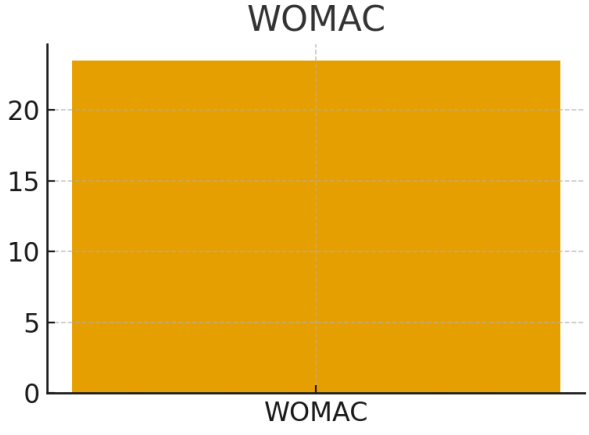

Figure 8. WOMAC score at final follow-up

Note: Final KOOS scores (mean: 79.6, range: 66–99) indicated satisfactory function.

This study has limitations. The retrospective design introduces potential selection bias, and the number of tibial-based and combined deformities was small, limiting subgroup analysis. Preoperative patient-reported outcome data were incomplete in some patients, which restricts analysis of change over time. The follow-up period, while adequate to confirm union and early stability of correction, did not allow conclusions about long-term survivorship or conversion to arthroplasty.

Despite these limitations, the findings support a practical, reproducible algorithm based on standardized long-leg radiographs. Identifying the anatomical origin of deformity and tailoring the correction accordingly appears to yield reliable alignment, preserves joint-line orientation, and produces functional outcomes that are consistent with established series.

Conclusion

In this cohort of adults with symptomatic valgus knee deformity, directing osteotomy to the anatomical source of malalignment produced reliable correction and preserved joint-line orientation. Most deformities were femoral-based and were effectively treated with DFO. Tibial-based and combined deformities were less common, but when present, proximal tibial or DLO restored alignment without inducing postoperative joint-line tilt. Functional outcomes were satisfactory, and serious complications were uncommon. Origin-specific planning based on standardized long-leg radiographs is a practical and reproducible strategy for valgus realignment in physiologically young adults.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Research Ethics Committee of School of Medicine, Iran University of Medical Sciences, Tehran, Iran (Code: IR.IUMS.FMD.REC.1399.387).

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Authors' contributions

Conceptualization and supervision: Behnam Sour; Data collection: Bushra Zareie, Mohammadreza Heidarikhoo, and Behnam Sour; Data analysis: Bushra Zareie; Investigation: Abolfazl Bagherifard and Mahmoud Jabalameli; Writing: All authors.

Conflict of interest

The authors declared no conflict of interest.

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