RESEARCH PAPER

Incidence And Predictors Of Lateral Hinge Fractures Following Medial Opening-Wedge High Tibial Osteotomy Using Locking Plate System

Kashif Anwar[1], Muhammad Faisal Iqbal[2], Shohab Hyder Shaikh[3], Ali Raza[4], Bakhat Hussain[5]*

[1] Consultant Orthopedic Surgeon, Department of Orthopedics, Jinnah Postgraduate Medical Centre (JPMC), Karachi, Pakistan.
Email: dr.kashif.anwar@gmail.com
[2] Assistant Professor, Department of Orthopedics, Amna Inayat Medical College, Faisal Chaudhary Hospital, Lahore, Pakistan.
[3] Consultant Trauma & Orthopaedic Surgeon, Department of Trauma & Orthopaedics, South City Hospital, Karachi, Pakistan.
[4] Senior RMO, Orthopedic Unit-I, Dr. Ruth K. M. Pfau Civil Hospital, Karachi, Pakistan.
[5] Orthopedic Surgeon, Orthopedic Unit-I, Dr. Ruth K. M. Pfau Civil Hospital, Karachi, Pakistan.

Corresponding Author:
*Kashif Anwar[1]**
Consultant Orthopedic Surgeon, Department of Orthopedics, Jinnah Postgraduate Medical Centre (JPMC), Karachi, Pakistan.
Email: dr.kashif.anwar@gmail.com

ABSTRACT
Background: Lateral hinge fracture is a recognized complication of medial opening-wedge high tibial osteotomy and may affect correction stability, union, and postoperative recovery. Objective: To determine the incidence and predictors of lateral hinge fractures following medial opening-wedge high tibial osteotomy using a locking plate system. Methods: This cross-sectional analytical study was conducted at Jinnah Postgraduate Medical Centre (JPMC), Karachi from March 2025 to March 2026 including 190 patients undergoing medial opening-wedge high tibial osteotomy with locking plate fixation. Results: Lateral hinge fracture occurred in 42 (22.1%) patients. Type I fracture was most common, seen in 23 (54.8%) cases. Patients with hinge fracture had significantly higher BMI, larger correction angle, greater wedge opening height, and longer operative time. Correction angle >12° was the strongest predictor of lateral hinge fracture (aOR 4.38; p<0.001), followed by wedge opening height >12 mm (aOR 3.91; p=0.001), operative time >100 minutes (aOR 2.88; p=0.009), smoking history (aOR 2.61; p=0.02), and BMI ≥30 kg/m² (aOR 2.34; p=0.03). Conclusion: Lateral hinge fracture occurred in a considerable proportion of patients after medial opening-wedge high tibial osteotomy. Larger correction angle, greater wedge opening height, obesity, smoking, and prolonged operative time were significant predictors.

Keywords: High tibial osteotomy; lateral hinge fracture; locking plate; medial opening wedge; predictors; knee osteoarthritis...
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INTRODUCTION

Medial opening-wedge high tibial osteotomy (MOWHTO) is a well-established surgical procedure that is used for the treatment of medial compartment osteoarthritis of the knee, especially in younger and active patients who have a varus malalignment [1]. The goal of MOWHTO is to eliminate pain, restore function and prevent the need for total knee arthroplasty (TKA) by correcting the mechanical alignment of the lower extremity and redistribute weight from the diseased medial compartment to the healthier lateral compartment [2]. Locking plate systems have significantly advanced the stability of procedures and outcomes of rehabilitation after surgery thanks to technological developments in fixation [3]. Although effective, MOWHTO has a number of intraoperative and postoperative complications, one of which is the lateral hinge fracture, which is one of the most common technical complications [4]. The lateral cortical hinge is not only a biomechanical advantage during osteotomy but also functions as a pivot which helps to ensure stability during correction and allows for controlled opening of the medial wedge [5]. An alteration of this hinge may lead to a loss of integrity of the fixation and to a negative effect on the healing process. Lateral hinge fractures can be caused during the osteotomy preparation, during the opening of a wedge, or when applying the fixation, and are more likely to occur if the osteotomy is too far into the lateral cortex or if the hinge is too weak anatomically [6]. The incidence rate can differ significantly from one study to another,

**Author for Correspondence: dr.kashif.anwar@gmail.com*

depending on the surgical procedure used, the type of imaging modality employed, the type of fracture, and the patient population [7]. There are reports on the incidence of 10-30% or even more, which makes this a clinically relevant complication [8].

Lateral hinge fractures can result in failure to correct, instability, delay in union, nonunion, implant failure, greater postoperative pain, longer recovery periods and revision surgery [9]. While some hinge fracture patterns may heal without any problems, the unstable patterns can significantly affect the surgical results [10]. Early recognition and prevention are thus crucial. Many factors have been suggested for the etiology of lateral hinge fractures, including technical and patient factors. These consist of osteotomy height, hinge position, correction angle, wedge opening size, hinge width, surgeon skills/knowledge, bone mineral density, obesity, and specific anatomical differences [11]. The lateral cortical stress and fracture risk may be greatly increased by inappropriate positioning of the osteotomy cut or by overcorrection [12]. Locking plate fixation systems offer better biomechanics than traditional fixation techniques and have made MOWHTO a more common method of fixation [13]. Despite today's fixation constructs, however, lateral hinge fractures are possible, suggesting that the technical risk of the implants is not limited to implant technology per se [14]. Factors predictive of this complication could be of benefit to better guide the operative management and reduce the patients' morbidity. As the use of MOWHTO has increased, and lateral hinge fractures have become clinically significant, it is still pertinent to understand the incidence and associated risk factors for this fracture type for optimisation of orthopaedic surgery [15]. There is limited local outcome data in many contexts.

Objective

To determine the incidence and predictors of lateral hinge fractures following medial opening-wedge high tibial osteotomy using a locking plate system.

Methodology

This was a cross-sectional analytical study conducted at Jinnah Postgraduate Medical Centre (JPMC), Karachi from March 2025 to March 2026 including 190 patients undergoing medial opening-wedge high tibial osteotomy (MOWHTO) using a locking plate fixation system to determine the incidence and predictors of lateral hinge fractures.

Inclusion Criteria

Adult patients aged 18–70 years undergoing medial opening-wedge high tibial osteotomy for symptomatic medial compartment knee osteoarthritis with varus deformity were included. Patients treated using a standardized locking plate fixation system with complete perioperative radiographic documentation and postoperative follow-up were included. Patients willing to participate and providing informed consent were considered eligible.

Exclusion Criteria

Patients with prior knee osteotomy, revision high tibial osteotomy, traumatic proximal tibial deformity, inflammatory arthritis, severe osteoporosis, pathological bone disease, concurrent ligament reconstruction procedures significantly altering biomechanics, incomplete imaging records, or inadequate postoperative follow-up were excluded.

Data Collection

After obtaining ethical approval, data were collected using a structured proforma. Baseline demographic and clinical variables included age, gender, body mass index, smoking history, comorbidities, severity of osteoarthritis, and preoperative mechanical axis alignment. Operative variables included correction angle, wedge opening height, osteotomy level, hinge position, plate type, surgical duration, and surgeon experience. Immediate postoperative radiographs and relevant imaging were reviewed to identify lateral hinge fractures using standard radiological classification criteria. Fractures were categorized according to recognized hinge fracture classification systems where applicable. Postoperative outcomes including loss of correction, delayed union, nonunion, implant-related complications, pain scores, and rehabilitation progression were recorded. Comparative analysis was performed between patients with and without lateral hinge fractures to identify associated predictors.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Independent t-tests and chi-square tests were used to compare patients with and without lateral hinge fractures. Multivariable logistic regression analysis was performed to identify independent predictors of lateral hinge fracture occurrence. A p-value ≤ 0.05 was considered statistically significant.

Results

The study included 190 patients with a mean age of 52.6 ± 8.9 years, and most were aged 50–59 years (94; 49.5%). Males were predominant, 118 (62.1%), and the mean BMI was 29.8 ± 4.7 kg/m². The mean preoperative varus angle was 8.7 ± 3.1°, the correction angle was 10.9 ± 3.8°, wedge opening height was 11.8 ± 3.4 mm, and mean operative time was 96.4 ± 18.7 minutes.

Table 1: Baseline Demographic, Clinical, and Operative Characteristics of Patients Undergoing MOWHTO (n = 190)

Variable	Total (n = 190)
Age (years), mean ± SD	52.6 ± 8.9
40–49 years, n (%)	48 (25.3%)
50–59 years, n (%)	94 (49.5%)
≥60 years, n (%)	48 (25.3%)

Male, n (%)	118 (62.1%)
Female, n (%)	72 (37.9%)
BMI (kg/m²), mean ± SD	29.8 ± 4.7
BMI ≥30 kg/m², n (%)	86 (45.3%)
Smokers, n (%)	41 (21.6%)
Diabetes Mellitus, n (%)	38 (20.0%)
Preoperative Varus Angle (degrees), mean ± SD	8.7 ± 3.1
Correction Angle (degrees), mean ± SD	10.9 ± 3.8
Wedge Opening Height (mm), mean ± SD	11.8 ± 3.4
Operative Time (minutes), mean ± SD	96.4 ± 18.7

Lateral hinge fracture occurred in 42 (22.1%) patients, while 148 (77.9%) had no fracture. Among fracture cases, Type I was most common, seen in 23 (54.8%), followed by Type II in 13 (31.0%) and Type III in 6 (14.3%). Clinical consequences included increased postoperative pain in 17 (40.5%), loss of correction in 11 (26.2%), delayed union in 9 (21.4%), and implant irritation in 8 (19.0%).

Table 2: Incidence and Characteristics of Lateral Hinge Fractures Following MOWHTO

Variable	**Frequency (n)**	**Percentage (%)**
Lateral Hinge Fracture Present	42	22.1
No Lateral Hinge Fracture	148	77.9
Fracture Type		
Type I	23	54.8
Type II	13	31.0
Type III	6	14.3
Loss of Correction	11	26.2
Delayed Union	9	21.4
Increased Postoperative Pain	17	40.5
Implant-related Irritation	8	19.0

Patients with lateral hinge fractures had higher BMI (31.6 ± 4.9 vs. 29.2 ± 4.4 kg/m²; p=0.004), larger correction angle (14.2 ± 3.6° vs. 10.0 ± 2.9°; p<0.001), greater wedge opening height (14.7 ± 3.2 vs. 10.9 ± 2.8 mm; p<0.001), and longer operative time (109.3 ± 19.6 vs. 92.8 ± 16.9 minutes; p<0.001).

Table 3: Comparative Analysis Between Patients with and Without Lateral Hinge Fractures

Variable	**Lateral Hinge Fracture Present (n=42)**	**No Fracture (n=148)**	**p-value**
Age (years), mean ± SD	54.8 ± 9.1	51.9 ± 8.7	0.06
BMI (kg/m²), mean ± SD	31.6 ± 4.9	29.2 ± 4.4	0.004
Correction Angle (degrees), mean ± SD	14.2 ± 3.6	10.0 ± 2.9	<0.001
Wedge Opening Height (mm), mean ± SD	14.7 ± 3.2	10.9 ± 2.8	<0.001
Smokers, n (%)	15 (35.7%)	26 (17.6%)	0.01
BMI ≥30 kg/m², n (%)	26 (61.9%)	60 (40.5%)	0.02
Diabetes Mellitus, n (%)	12 (28.6%)	26 (17.6%)	0.11
Operative Time (minutes), mean ± SD	109.3 ± 19.6	92.8 ± 16.9	<0.001

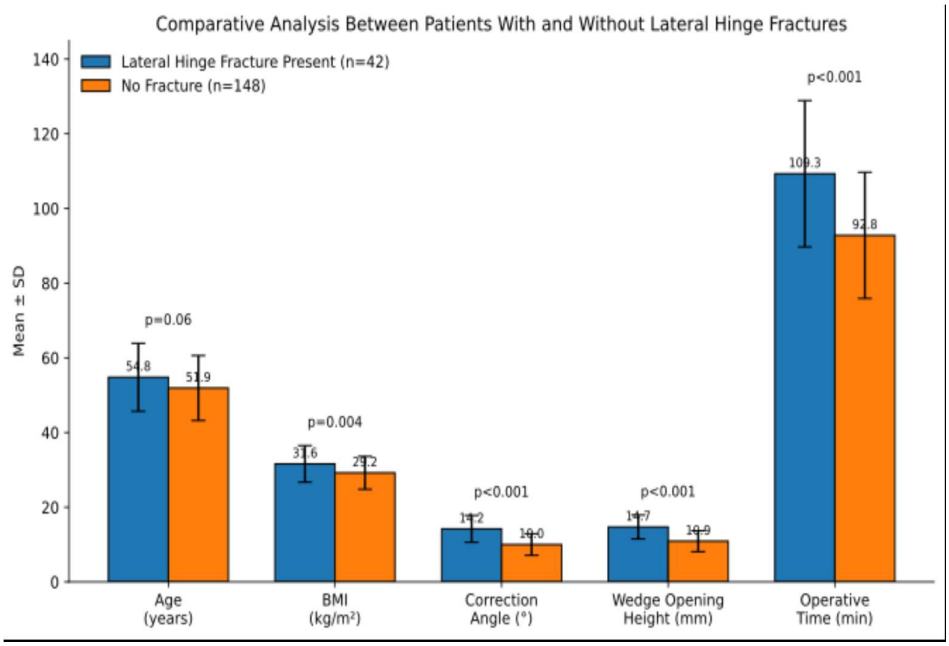

Figure 1: Comparative Analysis of Continuous Clinical and Operative Variables Between Patients with and Without Lateral Hinge Fractures Following MOWHTO

Logistic regression showed that correction angle >12° was the strongest predictor of lateral hinge fracture (aOR 4.38; 95% CI: 1.98–9.67; p<0.001). Other significant predictors included wedge opening height >12 mm (aOR 3.91; p=0.001), operative time >100 minutes (aOR 2.88; p=0.009), smoking history (aOR 2.61; p=0.02), and BMI ≥30 kg/m² (aOR 2.34; p=0.03).

Table 4: Multivariable Logistic Regression Analysis for Predictors of Lateral Hinge Fracture

Variable	Adjusted OR	95% CI	p-value
Correction Angle >12°	4.38	1.98–9.67	<0.001
Wedge Opening Height >12 mm	3.91	1.76–8.68	0.001
BMI ≥30 kg/m²	2.34	1.08–5.08	0.03
Smoking History	2.61	1.14–5.94	0.02
Operative Time >100 Minutes	2.88	1.29–6.41	0.009

Discussion

This study assessed the incidence and risk factors of lateral hinge fractures after an MWEHTOS performed using a locking plate and identified that 42 (22.1%) of 190 patients had lateral hinge fractures. This suggests that even with contemporary fixation systems, lateral hinge fracture is not uncommon. Clinically, this complication has been reported at around 15% to 30% in a previous research, which is in line with our findings [16]. The most prevalent type of fracture was found to be Type I (23, 54.8%) followed by Type II (13, 31.0%) and Type III (6, 14.3%). Usually considered biomechanically more stable, a lateral hinge disruption has clinical implications with a type I fracture. This study revealed that 8 (40.5%) fracture patients had increased postoperative pain, 8 (26.2%) had loss of correction, 9 (21.4%) had delayed union, and 8 (19.0%) had implant irritation. A previous study also reported that delayed rehabilitation, loss of correction and poor osteotomy stability were related to lateral hinge fractures [17]. One conclusion was that there was a strong relationship between technical surgical factors and a fracture. Patients with lateral hinge fractures had significantly larger correction angles (14.2 ± 3.6° vs. 10.0 ± 2.9°; p<0.001) and greater wedge opening heights (14.7 ± 3.2 mm vs. 10.9 ± 2.8 mm; p<0.001). Too much correction will generally lead to an increase in lateral cortical stress and will increase the chance that hinges will fail during wedge opening. Further, regression analysis confirmed that correction angle >12° is the strongest predictor (aOR 4.38; p<0.001) and that, fracture risk almost quadruples and increases (aOR 3.91; p=0.001) with wedge opening >12 mm. A previous study also showed that over opening the wedge and having a greater amount of correction is a significant factor in inducing hinge fracture laterally [18].

Other factors that seemed significant were operative complexity and the amount of space available. Patients with fractures had significantly longer mean operative time than non-fracture patients (109.3 ± 19.6 vs. 92.8 ± 16.9 minutes; p<0.001) and operative time >100 minutes was an independent predictor of fracture (aOR 2.88; p=0.009).

More lengthy procedures are likely to be indicative of complexity of deformity correction, technical difficulty or other intraoperative issues that may result in unstable hinges. Another study has found higher complication rates in more complicated osteotomy techniques [19]. Risk factors that were patient related were also significant. Patients with fractures had higher BMI (31.6 ± 4.9 vs. 29.2 ± 4.4 kg/m²; p=0.004), and obesity independently increased fracture risk (aOR 2.34; p=0.03). Biomechanical stresses may be higher on the osteotomy construct and lateral hinge during correction with increased body mass. Fracture patients also had a higher prevalence of smoking (35.7% vs 17.6%, p=0.01) and smoking history was an independent risk factor for fracture (aOR 2.61, p=0.02). In a previous study, other factors associated with decreased bone quality and greater orthopedic complication risk included obesity and smoking [20].

Limitations

This study has several limitations. Being a single-center cross-sectional study, the findings may not be generalizable to all surgical settings. The sample size was moderate, which may limit subgroup analysis according to fracture type. Lateral hinge fractures were assessed mainly through postoperative imaging, and minor occult fractures may have been missed without routine CT evaluation. Surgical technique, surgeon experience, hinge position, and intraoperative correction control may have influenced outcomes. Long-term follow-up was also limited, so late complications such as progressive correction loss, delayed functional recovery, or implant failure could not be fully assessed.

Conclusion

It is concluded that lateral hinge fracture is a relatively common complication following medial opening-wedge high tibial osteotomy using a locking plate system, occurring in 22.1% of patients in this study. Larger correction angles, greater wedge opening height, prolonged operative time, obesity, and smoking were identified as significant independent predictors. Lateral hinge fractures were associated with adverse clinical consequences including increased postoperative pain, delayed union, and loss of correction. Careful surgical planning, precise osteotomy technique, controlled correction, and preoperative identification of high-risk patients may help reduce the incidence of this complication and improve overall surgical outcomes.

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