Joint Diseases and Related Surgery

Jt Dis Relat Surg
2025;36(2):266-271

ORIGINAL ARTICLE

Proximal partial fibular resection versus high tibial osteotomy: Comparative outcomes in early-stage knee osteoarthritis

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ABSTRACT

Objectives: This study aims to compare the clinical and radiographic outcomes of proximal partial fibular resection (PPFR) and opening-wedge high tibial osteotomy (OWHTO) in middle-aged patients with early-stage medial compartment knee osteoarthritis (OA).

Patients and methods: Between January 2017 and January 2023, a total of 90 patients (47 males, 43 females; mean age: 50.9±5.8 years; range, 40 to 59 years) who underwent PPFR or OWHTO for early-stage medial compartment knee OA were retrospectively analyzed. The patients were divided into two groups based on the surgical technique: Group 1 (n=48) included those who underwent PPFR, while Group 2 (n=42) comprised those treated with OWHTO. Clinical outcomes were evaluated using the Visual Analog Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Radiographic measurements included femorotibial angle (FTA) and lateral joint space (LJS).

Results: Both procedures demonstrated a significant improvement in function and pain. The mean postoperative FTA change was greater in the OWHTO group (7.69±1.35°) compared to the PPFR group (2.87±1.24°, p=0.001). The mean LJS changes were not statistically significant between the groups. Postoperative WOMAC and VAS scores improved in both groups, indicating no significant difference. Minor complications included transient peroneal nerve symptoms in the PPFR group, which resolved spontaneously at three months postoperatively.

Conclusion: Both PPFR and OWHTO are effective surgical options for early-stage medial compartment knee OA. While OWHTO offers superior mechanical correction, PPFR provides a less invasive alternative with similar functional outcomes.

Keywords: Functional outcomes, high tibial osteotomy, knee osteoarthritis, partial fibular resection.

Osteoarthritis (OA) is a prevalent degenerative joint disorder characterized by pain, stiffness, and structural deterioration of the joints.[1] Globally, approximately 250 million individuals are affected by symptomatic OA, with its prevalence significantly higher among older adults and individuals with obesity.[2]

Among the joints affected by OA, the knee is the most commonly involved, followed by the hand and hip. Symptomatic knee OA is more frequent in women than in men.[2] Radiographic assessments, such as standing anteroposterior (AP) X-rays, reveal varus deformity-a hallmark of reduced medial joint space-in approximately 74% of patients with knee OA.[3]

Surgical intervention is often considered for patients presenting with medial knee compartment OA and varus deformity. Options such as unicompartmental knee arthroplasty (UKA), high tibial osteotomy (HTO), and total knee arthroplasty (TKA) are selected based on factors including patient age, activity level, severity of medial joint degeneration, condition of the lateral compartment, and surgeon expertise. While UKA and TKA can

Received: December 13, 2024
Accepted: December 21, 2024
Published online: February 07, 2025

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Doi: 10.52312/jdrs.2025.2107

Citation: Gultac E, Can Fİ, Hürriyet Aydoğan N. Proximal partial fibular resection versus high tibial osteotomy: Comparative outcomes in early-stage knee osteoarthritis. Jt Dis Relat Surg 2025;36(2):266-271. doi: 10.52312/jdrs.2025.2107.

improve alignment, relieve pain, and restore joint function, they are not without complications. Unicompartmental knee arthroplasty carries risks of component dislocation, implant loosening, polyethylene wear, periprosthetic fractures, infection, and progression of arthritis to other compartments. On the other hand, TKA is usually less favorable for younger, more active patients or those with moderate OA.[4]

For younger patients, HTO remains a preferred choice, although it poses certain risks such as neurovascular injury, fractures, and delayed bone healing.[5,6] Proximal fibular osteotomy (PFO) or proximal partial fibular resection (PPFR) has recently emerged as a minimally invasive alternative, particularly in East Asian countries. This approach is simpler and less invasive compared to HTO and TKA, offering promise in the management of knee OA.[7]

In the present study, we aimed to evaluate and compare the outcomes of PPFR with opening-wedge HTO and to determine the most optimal surgical intervention for middle-aged individuals with early-stage knee OA.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Muğla Sıtkı Koçman University Faculty of Medicine, Department of Orthopedics and Traumatology between January 2017 and January 2023. The data of patients underwent PPFR or opening-wedge HTO (OWHTO) were analyzed. In our clinic, only OWHTO was applied to patients with early-stage knee OA until a certain period, but later PPFR started to be preferred instead of OWHTO. Inclusion criteria were age between 40 and 60 years, having surgery for medial compartment OA and completion of minimum 12-month follow-up. Exclusion criteria were as follows: age under 40 years; a body mass index (BMI) of higher than 30 kg/m^2 (n=34), inflammatory or post-traumatic arthritis (n=7), significant valgus deformities or flexion contractures (n=3), previous knee surgeries (n=6), bilateral procedures (n=2), peripheral neuropathy (n=1), incomplete medical records (n=2), or inability and non-compliance to complete follow-up evaluations (n=23). Of a total of 168 patients initially screened, 90 (47 males, 43 females; mean age: 50.9±5.8 years; range, 40 to 59 years). The patients were divided into two groups based on the surgical technique: Group 1 (n=48) included those who underwent PPFR, while Group 2 (n=42) comprised those treated with OWHTO.

A written informed consent was obtained from each patient. The study protocol was approved by the Mugla Sıtkı Koçman University Health Sciences Ethics Committee (date: 07.09.2019, no: 165). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical techniques

Proximal Partial Fibular Resection

All PPFR procedures were performed under regional anesthesia with patients in the supine position. The fibular head was identified and marked, followed by a posterolateral incision of 6 to 10 cm, adjusted to patient height, below the fibular head. The peroneal nerve was exposed and protected throughout the procedure. A segment of the proximal fibula, measuring 1 to 1.5 cm, was resected using a chainsaw. Postoperatively, patients were encouraged to perform isometric and range of motion (ROM) exercises immediately and allowed weight-bearing mobilization from the first postoperative day without movement restrictions.

Opening-Wedge High Tibial Osteotomy

For OWHTO, a vertical incision of approximately 5 cm was made from the tibial tuberosity to the posteromedial proximal tibia. The pes anserinus and the distal segment of the superficial layer of the medial collateral ligament were detached from the tibia, followed by subperiosteal dissection to the posteromedial tibial region. A guidewire was inserted approximately 4 cm below the medial joint line, extending obliquely toward the fibular head. Tibial osteotomy was performed along the guidewire, and the osteotomy was opened using a calibrated wedge to achieve the desired alignment correction. The osteotomy was stabilized with a Puddu plate. A drain was applied at the end of the procedure and removed on postoperative Day 2. Patients began isometric and ROM exercises after drain removal, while weight-bearing mobilization was delayed until 45 days after surgery.

Radiographic and clinical evaluation

Alignment was assessed on full-length weight-bearing radiographs taken preoperatively and at 12 months postoperatively. The femorotibial angle (FTA), which is defined as the lateral angle between the anatomical axes of the tibia and femur; and the lateral joint space (LJS), which is defined as the distance between the lateral femoral condyle and lateral tibial plateau, were measured preoperatively and at 12 months postoperatively using weight-bearing radiographs (Figures 1, 2).

The preoperative and postoperative 12-month clinical and functional results were evaluated using the data gathered from the patient files with the Visual Analog Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scoring systems.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). The distribution of the variables was checked using the Shapiro-Wilk test. Continuous data were presented in mean ± standard deviation (SD) or median (min-max), while categorical data were presented in number and frequency. Independent t-test was employed to compare continuous variables. A p value of <0.05 was considered statistically significant.

RESULTS

The mean BMI was 26.88±2.26 kg/m² in Group 1 and 27.05±3.06 kg/m² in Group 2. There was no statistically significant difference in the demographic data between the two groups (p>0.05).

In Group 1, the mean pre- and postoperative 12-month FTA was measured as 183.02±2.03° and 180.20±2.72°, respectively. In Group 2, the mean pre- and postoperative 12-month FTA was measured as 182.97±2.05° and 175.38±2.41°, respectively. The mean FTA change was 2.87±1.24° in Group 1 and 7.69±1.35° in Group 2, indicating a statistically significant difference (p=0.001). In Group 1, the mean pre- and postoperative LJS was 8.98±0.44 mm and 7.40±0.37 mm, respectively. In Group 2, the mean pre- and postoperative LJS was 8.95±0.4 mm and 7.58±0.43 mm, respectively. The mean LJS change was 1.57±0.59° in Group 1 and 1.37±0.47° in Group 2, indicating no statistically significant difference (p=0.089).

In Group 1, the mean pre- and postoperative VAS scores were 6.56±0.61 and 2.95±0.87, respectively, while in Group 2, these scores were 6.66±0.78 and 3.07±0.8, respectively. The mean VAS change was 3.60±0.93 in Group 1 and 3.59±0.7 in Group 2, indicating no statistically significant difference (p=0.96).

In Group 1, the mean pre- and postoperative WOMAC scores were 62.89±7.39 and 37.31±8.07, respectively, while in Group 2, these scores were

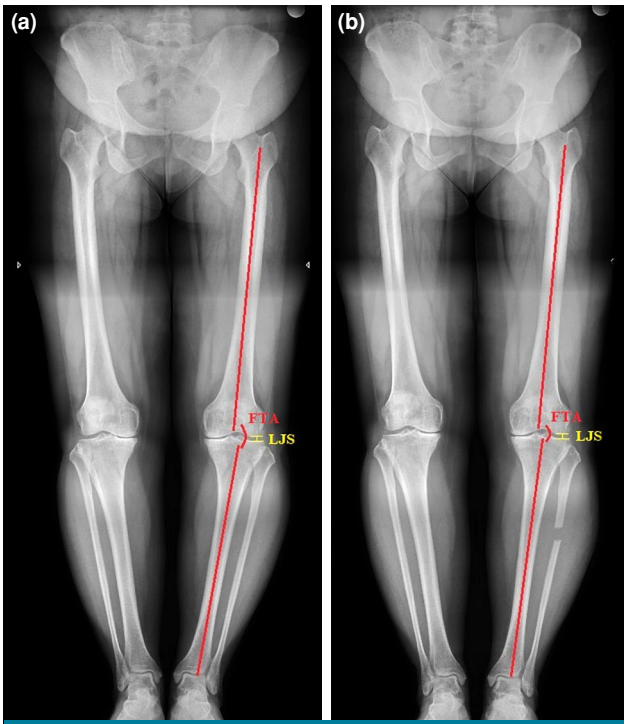

FIGURE 1. (a) Preoperative orthoroentgenogram of a PPFR procedure. **(b)** Postoperative orthoroentgenogram of a PPFR procedure.

Red lines: FTA; Yellow lines: LJS measurements; PPFR: Proximal partial fibular resection; FTA: Femorotibial angle; LJS: Lateral joint space.

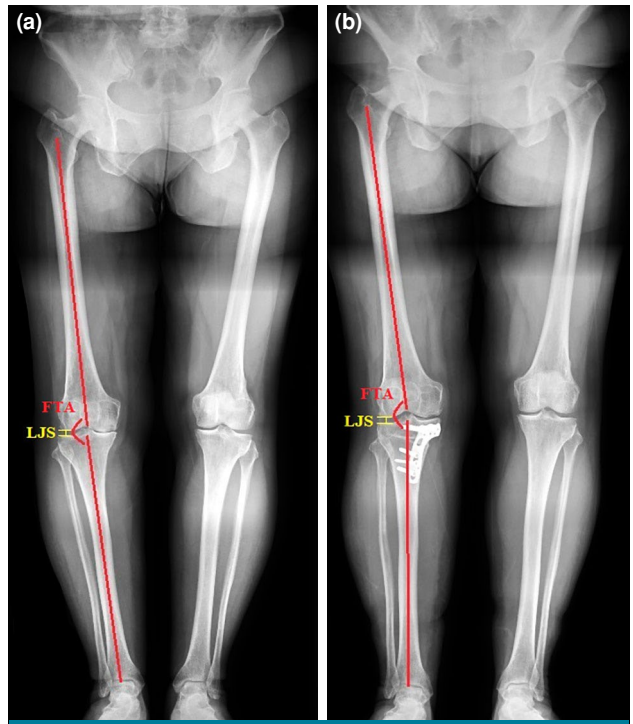

FIGURE 2. (a) Preoperative orthoroentgenogram of a OWHTO procedure. **(b)** Postoperative orthoroentgenogram of a OWHTO procedure.

Red lines: FTA; Yellow lines: LJS measurements; OWHTO: Opening-wedge high tibial osteotomy; FTA: Femorotibial angle; LJS: Lateral joint space.

TABLE I
Summary table of preoperative and postoperative parameters

	Group 1	Group 2	
	Mean±SD	Mean±SD	
FTA preoperative (°)	183.02±2.03	182.97±2.05	-
FTA postoperative (°)	180.20±2.72	175.38±2.41	-
FTA change (°)	2.87±1.24	7.69±1.35	**0.001**
LJS preoperative (mm)	8.98±0.44	8.95±0.40	-
LJS postoperative (mm)	7.40±0.37	7.58±0.43	-
LJS change (mm)	1.57±0.59	1.37±0.47	0.089
VAS preoperative	6.56±0.61	6.66±0.78	-
VAS postoperative	2.95±0.87	3.07±0.80	-
VAS change	3.60±0.93	3.59±0.70	0.960
WOMAC preoperative	62.89±7.39	61.57±7.38	-
WOMAC postoperative	37.31±8.07	37.11±7.33	-
WOMAC change	25.58±8.82	24.45±5.59	0.477

SD: Standard deviation; FTA: Femorotibial angle; LJS: Lateral joint space; VAS: Visual Analog Scale; WOMAC: Western Ontario and McMaster Universities Arthritis Index.

61.57±7.38 and 37.11±7.33, respectively. The mean WOMAC change was 25.58±8.82 in Group 1 and 24.45±5.59 in Group 2, indicating no statistically significant difference (p=0.477). The radiological and functional assessment measurements are presented in Table I.

Three patients had symptoms compatible with postoperative possible superficial peroneal nerve area in Group 1, while there was no such complication in Group 2. The numbness symptoms in the dorsal foot described by the patients resolved at three months postoperatively. Nonunion was not observed in any of the patients in Group 2.

DISCUSSION

In the present study, we compared PPFR and OWHTO in treating early-stage medial compartment knee OA. Our study results revealed certain advantages for each technique. The OWHTO achieved superior mechanical realignment, as indicated by a greater mean change in FTA, emphasizing its effectiveness in correcting varus deformity. In contrast, PPFR provided comparable improvements in functional outcomes, as evidenced by similar postoperative VAS and WOMAC scores, despite less significant FTA correction. These findings align with prior research showing that OWHTO can effectively correct varus deformity by shifting the mechanical axis.[8,9] The outcomes of PPFR were also found to be consistent with similar studies.[10,11] The absence of significant LJS differences between groups suggests similar cartilage preservation capabilities, consistent with findings from Sánchez-Soler et al.[12]

The OWHTO has a well-documented capacity for precise mechanical axis realignment by shifting the weight-bearing axis laterally, reducing medial compartment loading.[8,9] This effect leads to significant correction of varus deformity, as reflected in our study's findings of a greater change in FTA in the OWHTO group. However, this biomechanical advantage comes at the cost of increased surgical complexity and a longer recovery period due to delayed weight-bearing protocols. On the other hand, PPFR achieves biomechanical improvement through an indirect mechanism. By resecting a portion of the fibula, PPFR induces a redistribution of compressive forces across the knee joint, particularly through a non-uniform settlement of the tibial plateau.[13] This approach offers a less invasive medium of reducing medial compartment stress without directly altering the mechanical axis. Although the FTA correction was less pronounced in the PPFR group, the comparable improvements in functional scores suggest that its indirect biomechanical effects provide meaningful clinical benefits.[11]

Furthermore, both procedures resulted in significant improvements in WOMAC and VAS scores in our study. This supports previous findings

that PFO and OWHTO both reduce pain and improve function.[14,15] Studies also indicate that while OWHTO has a more substantial effect on long-term joint realignment, PFO provides faster pain relief and functional recovery.[16,17]

In the current study, postoperative complications were minimal, with transient peroneal nerve symptoms reported only in the PPFR group, resolving within three months. Postoperative peroneal nerve palsy was encountered in three patients in Group 1. This finding is consistent with documented minor neurovascular complications in PFO.[11,18] A systematic review reported a 2.25% incidence of peroneal nerve palsy after PFO, making it a relatively rare but notable complication.[19] Of note, OWHTO is technically demanding and carries risks such as proximal tibiofibular joint pain, lateral instability, nonunion and even conversion to total knee replacement.[8,12] Nonetheless, no infections or nonunion cases were observed in our study, supporting the procedures' overall safety, when performed with proper techniques. Review of the literature reveals that complications related to union and implants have been reported due to osteotomy in the OWHTO procedure.[20] Since there is no implant in the PPFR procedure, complications related to the implant are not expected. Also, since there is no need for union, complications related to bone union are not expected. In our study, complications mentioned in the literature were not seen in patients who underwent OWHTO, and only temporary peroneal nerve complications which resolved spontaneously within three months were observed in the PPFR group.

Research on the biomechanics of PFO highlights theories such as non-uniform tibial plateau settlement and ground reaction vector readjustment as potential mechanisms for pain relief and joint stabilization.[7,13] These mechanisms may explain why PFO provides significant symptom relief despite less mechanical correction compared to OWHTO.

Patient selection should consider age, activity level, and the severity of the deformity. Younger, active patients requiring substantial realignment may benefit more from OWHTO, while those seeking a less invasive, cost-effective option with faster recovery could consider PFO. This tailored approach aligns with current clinical recommendations.[21,22]

The single-center, retrospective design is the main limitation to this study. In addition, we were only able to evaluate mid-term results. Further multi-center, large-scale, prospective studies with a longer follow-up are necessary to confirm these findings.

In conclusion, both PPFR and OWHTO are effective surgical options for early-stage medial compartment knee OA. While OWHTO offers superior mechanical correction, PPFR provides a less invasive alternative with similar functional outcomes. Future studies are warranted to better elucidate the long-term benefits of each technique.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Concept, design, literature rewiew, writing the article: E.G.; Data collection, analysis, writing the article: F.İ.C.; Idea/concept, control/supervision, critical review: N.H.A.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

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