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Original Research Article

A Study on the Efficacy of Proximal Fibular Osteotomy for Medial Compartment Osteoarthrosis of the Knee

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Abstract:

Background: Medial compartment osteoarthrosis (OA) of the knee is a significant contributor to disability in the aging population. Although traditional surgical options, including high tibial osteotomy and arthroplasty, are effective, they are typically more invasive and costly. Proximal fibular osteotomy (PFO) has recently been sought as a simpler and minimally invasive treatment for pain relief and functional improvement.

Aim: The aim of the study was to examine the clinical and radiological outcomes of PFO in patients with medial compartment osteoarthrosis of the knee at one-year post-operation.

Methodology: In this prospective cohort study, the outcomes of 18 patients (18 knees) with medial compartment knee OA were studied. All patients underwent PFO using a consistent approach. Pain was assessed using the Visual Analogue Scale (VAS), function was examined using the American Knee Society Score (AKSS), and alignment was assessed radiologically through the medial -to- lateral (ML) joint space ratio at baseline, three months, and one year.

Results: Statistically significant improvements were noted for all variables ($p < 0.001$). The mean VAS decreased from 7.72 ± 0.71 to 3.81 ± 1.24, clinical AKSS improved from 57.18 ± 7.14 to 72.38 ± 9.41, and functional AKSS improved from 47.92 ± 13.78 to 70.92 ± 14.87. The ML ratio also improved from 0.32 ± 0.18 to 0.50 ± 0.21.

Conclusion: PFO provides substantial pain relief, improvement of function, and biomechanical realignment making it a safe, cost effective, and minimally invasive option to treat medial compartment knee OA.

Keywords: Proximal fibular osteotomy, medial compartment osteoarthritis, knee pain, osteoarthrosis, knee alignment, functional outcome.

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Introduction

Osteoarthritis (OA) is a degenerative disease, chronic and progressive disorder that presents itself in more than one joint causing pain, stiffness, functional limitation and reduced life quality. It is a multifactorial etiological polyarticular disorder, which entails mechanical, biological, and biochemical mechanisms, which cumulatively lead to the destruction of articular cartilage, subchondral bone remodeling, and the presence of different levels of synovial inflammation. Out of the many affected joints, the knee joint is the most commonly affected and causes most disability in the world [1].

OA of the knee in India has become one of the most common causes of chronic morbidity particularly in the aging population. A high prevalence of knee OA was found in a large community-based study on persons over the age of 40 years residing in five states of India where the prevalence was 28.7%. Such great prevalence highlights the scale of the issue and the increased people health issue that comes with it. It has been noted that a number of risk factors have led to the occurrence and the progression of knee OA, such as old age, increased body mass index (BMI), female gender, genetic predisposition, past knee traumas, and lack of physical exercise. On the same note, according to the United States data, the predominance of radiographic knee OA in persons over 60 years is about 37%, and 12% of the older population has symptomatic OA [2]. In addition, the risk of developing symptomatic knee OA throughout the lifetime has been calculated as 44.7 per cent, which means that almost half of adult population is susceptible to developing a clinically significant disease in their lifetime [3].

Kellgren-Lawrence (KL) grading system is widely used in the diagnosis and grading of knee OA that includes five grades of disease severity depending on radiographic evidence [4]. Such parameters are included under this classification, and they are joint space narrowing, osteophyte formation, subchondral sclerosis and bone end deformity. Compartmental nature of the joint space narrowing, which may be medial, lateral or patellofemoral, is one of the typical characteristics of OA of the knee. However, of them all medial compartment involvement is, by far, the most common, and is linked to the varus malalignment of the lower limb, which results in higher load and stress being exerted upon the medial tibiofemoral compartment. This augmented biomechanical stressor aids in the gradual rupture of the medial joint space causing pain, deformity and functional deficiency [5].

Medial compartment osteoarthrosis (OA) of the knee is a disease that is managed based on the level of severity and the functional needs of the patient. Conservative therapies involve loss of weight, modification of activities, physical therapy, orthotic aids and pharmacologic interventions like non-steroidal anti-inflammatory medications (NSAIDs) and intra-articular injections. Nevertheless, they are just short-term symptomatic treatment that does not help the disease change. Surgical intervention is regarded as a means of correcting deformity, restoring joint position and relieving pain in instances when the state is not able to be cured through conservative treatment.

High tibial osteotomy (HTO), unicompartmental knee arthroplasty (UKA) and total knee arthroplasty (TKA) are the established treatment options of medial compartment OA of the knee. High tibial osteotomy is actually used when the patient is younger and active with isolated medial compartment disease and is expected to shift load-bearing forces on the diseased medial compartment to the lateral compartment that is still relatively intact. Nevertheless, HTO is a technically challenging procedure, which carries the risk of complications including nonunion, neurovascular damage, and long-term re-hospitalization, and outcomes might worsen over time. Unicompartmental knee arthroplasty is a more physiological option that replaces only the diseased compartment; however, it needs a specific selection of patients and surgical skills, and leads to the risks of aseptic loosening, polyethylene wear, and disease progression in the uninvolved compartments. Total knee arthroplasty is the most concluding option in the treatment of end-stage OA because it is an effective treatment with good pain relief and restoration of normal functions but is a very expensive procedure, which requires bone resection and long-term issues in arthroplasty especially in children and active people.

Over the last few years, proximal fibular osteotomy (PFO) has become one of the potentials, minimally invasive, and less expensive surgical procedures in the treatment of medial compartment osteoarthrosis of the knee. The concept of the procedure is grounded in the biomechanical principle that the resection of a part of the proximal fibula means the decrease in the lateral cortical support of the tibia, which permits progressive redistribution of the load-bearing forces between the medial and the lateral compartment. This change of load decreases the stress on the medial compartment, and the pain disappears and the joint becomes functional. The method needs minimal incision, minimal soft-tissue resection, and does not imply any internal fixation or bone replacement, which is especially important in resource-constrained environments and in older patients who might not respond to more intense surgical procedures.

Preliminary investigations have documented positive effects after PFO with a high degree of pain, functional capacity and radiographic outcome such as joint space enlargement and varus deformity correction. It is also a good alternative because of its simplicity of the process and less time of rehabilitation since the patient might not be the right candidate to undergo arthroplasty owing to their age, finances, or comorbidities. Nevertheless, in spite of these encouraging results, the existing literature on PFO is insufficient as the majority of the studies are small in size, have limited follow up times and have no standardized outcomes.

Considering such gaps, the evaluation of the clinical effectiveness and radiological outcomes of proximal fibular osteotomy needs to be done in a bigger group with extended follow-up. Knowledge on its role in the larger treatment algorithm of medial compartment OA will assist in the narrowing down of patient selection criteria and establish the long-term advantages and limitations of medial compartment OA in comparison to traditional surgical intervention.

This study was to analyze the functional and radiological outcomes of proximal fibular osteotomy on patients with medial compartment osteoarthrosis of the knee using a one-year period of follow-ups. We hope that with the current study, we can add to the existing body of evidence on the effectiveness of this simple, less invasive and cost-effective form of surgery as a management of medial knee OA.

Methodology

Study Design: It was a prospective cohort study, which was to assess the effectiveness of Proximal Fibular Osteotomy (PFO) in patients with medial compartment osteoarthrosis (OA) of the knee joint.

Study Area: It was conducted at the Orthopaedics department, Indira Gandhi Institute of Medical Sciences (IGIMS), Patna, Bihar, India.

Study Duration: The research was carried out in a span of one year.

Sample Size: The sample size was 18 Patients (18 Knees), calculated using the following formula:

$$N = (Z_\alpha + Z_\beta)^2(s_1^2 + s_2^2)/d^2$$

Where

- $s_1 = 1.5$and $s_2 = 2.34$ are the standard deviations of preoperative and postoperative VAS scores, respectively (as reported by Wang et al.),
- Type I error (α) = 5%,
- Type II error (β) = 10%, and
- Power = 90%.

The required sample size was determined to be 18 patients. However, an additional few patients were considered to account for potential loss to follow-up.

The expected mean difference used in the calculation was 2.5 points on the VAS scale, based on previous studies reporting clinically significant pain reduction after PFO.

Study Population: Patients admitted to the Department of Orthopaedics, IGIMS, with a clinical diagnosis of medial compartment osteoarthritis of the knee were enrolled in the study after obtaining informed consent.

Inclusion Criteria

- Patients diagnosed with medial compartment osteoarthritis according to the American College of Rheumatology (ACR) clinical criteria:
    - Knee pain plus at least three of the following:
- Age > 50 years
- Morning stiffness < 30 minutes
- Crepitus
- Bony tenderness
- Bony enlargement
- Absence of palpable warmth
- Patients are willing to participate and provide written informed consent.

Exclusion Criteria

- Incomplete medical records.
- Concomitant arthritis due to other causes (e.g., rheumatoid arthritis, seronegative OA).
- Post-traumatic arthritis of the knee.
- History of ligament or meniscal injury.
- Clinical valgus deformity of the knee (as measured with a goniometer).

Data Collection: Each registered patient received an assessment protocol based on standard clinical and radiological evaluation before surgery. The demographic variables that were collected included age, sex, body mass index (BMI), years of the disease, comorbidities, and history of intra-articular injections. The Kellgren-Lawrence (KL) grading of the severity of osteoarthritis and medial-to-lateral (ML) joint space ratio on full weight bearing anteroposterior knee radiographies were performed as the radiographic evaluation. The outcomes in terms of functional and clinical outcomes were measured with the help of Visual Analogue Scale (VAS) of pain and American Knee Society Score (AKSS) which consists of clinical and functional sub-elements (pain, stability, and range of motion) and walking distance and stairs climbing ability (functional component). Three-month and one-year postoperative assessments of the patients were conducted on the same parameters to identify the changes in the pain, function, and joint space ratio.

Procedure: Each surgery was done by the same orthopedic surgeon with the same method of the operation. They were placed in the supine position with spinal anesthesia; the field of operation was prepared and covered (mid-thigh to foot). A longitudinal proximal fibula incision of 5-6 cm was done on the lateral side. The intermuscular space between peroneal muscles and soleus was well developed to reveal the fibula. Transverse osteotomies were then done with several holes of drills to excise a 2-3 cm portion of the fibula of about 7-10 cm below the fibular head. Hemostasis was ensured and the wound was closed in layers. Knee and ankle mobilization and full weight bearing were introduced within 24 hours after surgery. Patients were followed up clinically and radiologically at three months and one year post-operatively.

Statistical Analysis: All the data gathered were tabulated and analyzed by use of IBM SPSS Statistics version 25.0 (Armonk, NY, USA). The continuous variables were represented as mean +- standard deviation (SD) or median, whereas the categorical variables were represented as numbers and percentages. The normality of the data was measured through the Kolmogorov-Smirnov test. When paired data was non-normally distributed, a comparison was made between preoperative and postoperative value using the Wilcoxon signed-rank test. Qualitative variables were analyzed using the Chi-square test or fisher exact test, as the case was. All comparisons have a p-value below 0.05 as statistically significant."

Result

Table 1 reveals the allocation of the knees based on the Kellgren-Lawrence (KL) grading system. Out of all the 18 knees considered, most of them were Grade 2 (55.6%), which shows moderate osteoarthritic changes. Grade 3 changes were seen in 33.3% of knees and Grade 1 and Grade 4 had changes of 5.6% and 5.6% cases which are mild and severe, respectively. This distribution indicates that a majority of patients were mild to moderately impacted with osteoarthritis at the baseline.

Table 1: Distribution of knees as per Kellgren–Lawrence (KL) grade		
KL Grade	**Number of knees**	**%**
1	1	5.6
2	10	55.6
3	6	33.3
4	1	5.6
Total knees	**18**	**100**

Table 2 compares the clinical and radiological parameters at baseline and at three months among 18 knees. There was a statistically significant improvement in all evaluated measures following intervention. The mean VAS score decreased from 7.72 ± 0.71 at baseline to 5.28 ± 1.09 at three months ($p < 0.001$), indicating notable pain relief. The clinical AKSS increased from 57.18 ± 7.14 to 63.67 ± 6.32 ($p < 0.001$), and the functional AKSS improved from 47.92 ± 13.78 to 59.33 ± 13.56 ($p < 0.001$), reflecting better knee function and mobility. Radiologically, the ML ratio rose from 0.32 ± 0.18 to 0.40 ± 0.19 ($p < 0.01$), suggesting early structural improvement within three months of follow-up.

Table 2: Comparison of the means of clinical and radiological parameters at baseline and at three months (n = 18 knees)			
Variable	**At baseline, mean ± SD**	**At three months, mean ± SD**	**p-value**
VAS score	7.72 ± 0.71	5.28 ± 1.09	< 0.001
Clinical AKSS	57.18 ± 7.14	63.67 ± 6.32	< 0.001
Functional AKSS	47.92 ± 13.78	59.33 ± 13.56	< 0.001
ML ratio	0.32 ± 0.18	0.40 ± 0.19	< 0.01

Table 3 focuses on clinical and radiological outcomes comparison at three months and one year after the intervention in 18 knees. There was a substantial increase in all parameters over time. The average score of VAS was reduced by 5.28 +- 1.09 at the third month to 3.81 +- 1.24 at the first year ($p < 0.001$), which also showed additional pain reduction. The clinical AKSS results improved to 72.38 +- 9.41 ($p < 0.001$) and functional AKSS to 70.92 +- 14.87 ($p < 0.001$), indicating the improved functioning and activity level of the knee. Moreover, the increase in ML ratio was observed (0.40 +- 0.19 to 0.50 +- 0.21, $p < 0.001$), which indicated gradual radiological progress and a more proper joint positioning at one year.

Table 3: Comparison of the means of clinical and radiological parameters at three months and at one year (n = 18 knees)			
Variable	**At three months, mean ± SD**	**At one year, mean ± SD**	**p-value**
VAS score	5.28 ± 1.09	3.81 ± 1.24	< 0.001
Clinical AKSS	63.67 ± 6.32	72.38 ± 9.41	< 0.001
Functional AKSS	59.33 ± 13.56	70.92 ± 14.87	< 0.001

Table 4 shows comparison between the clinical and radiological outcomes at one year and baseline on 18 knees. All the parameters were improved significantly. The average of VAS score came down significantly 7.72 +- 0.71 to 3.81 +- 1.24 ($p < 0.001$), which means that the pain level was decreased. Likewise, clinical AKSS rose to 57.18 +- 7.14 to 72.38 +- 9.41 ($p < 0.001$), and functional AKSS rose to 47.92 +- 13.78 to 70.92 +- 14.87 ($p < 0.001$), which was an improvement of knee functionality and mobility. The ML ratio also increased significantly (0.32 +- 0.18 to 0.50 +- 0.21 $p < 0.001$), indicating increased radiological alignment and stability of the joint after one-year.

Table 4: Comparison of the means of clinical and radiological parameters at baseline and at one year (n = 18 knees)			
Variable	**At baseline, mean ± SD**	**At one year, mean ± SD**	**p-value**
VAS score	7.72 ± 0.71	3.81 ± 1.24	< 0.001
Clinical AKSS	57.18 ± 7.14	72.38 ± 9.41	< 0.001
Functional AKSS	47.92 ± 13.78	70.92 ± 14.87	< 0.001
ML ratio	0.32 ± 0.18	0.50 ± 0.21	< 0.001

Discussion

The current study shows that proximal fibular osteotomy (PFO) had favorable clinical and radiological outcomes in patients with knee medial compartment osteoarthritis (OA). The mean VAS decreased significantly from baseline (7.72 ± 0.71) to one year post-operatively (3.81 ± 1.24). This signals long-term analgesia and is consistent with previous studies, including Wang et al. (2017) [6], which reported improvement at 12 months post-operation with a VAS decreases from 7.4 ± 1.2 to 3.1 ± 1.5, suggesting that PFO effectively reduces pain from knee OA over time. Rai et al. (2019) [7] also published a similar reduction in VAS from 8.1 +- 0.9 to 3.7 +- 1.0 over one year stating an overall reduction in knee pain in the long term. It is noted that all of these studies are uniform in the results. It is significant for supporting the hypothesis that PFO was effective in redistribution of load-bearing forces and that decompression of the medial compartment resulted in a significant reduction in knee OA pain in the long term."

Regarding knee performance, we found that both clinical and functional American Knee Society Scores (AKSS) improved significantly with the clinical score changing by 57.18 +- 7.14 to 72.38 +- 9.41 and by functional score by 47.92 +- 13.78 to 70.92 +- 14.87 at one year. Similar results were obtained by Liu et al. (2018) [8] who have found that the average AKSS clinical scores have increased to 71.3 +- 7.9 +- 9.8 and so did the functional scores (46.7 +- 10.1 +- 9.8) in 12 months. These findings show that PFO results in a significant improvement of knee mechanics and mobility. Similarly, Subash and Naidu (2018) [9] observed an increase of AKSS by 55.1-73.5 in one year, pointing out the need to maintain the functional restoration of studies. Nevertheless, our postoperative functional recovery was a little below that of Prakash (2019) [10] who scored postoperative functional recovery of AKSS above 85. This distinction can be explained by the differences in the level of preoperative functioning since our patients scored relatively lower in their initial AKSS scores.

The fact that the results have shown progressive improvement between three months and one year shows that PFO is not only effective in terms of symptomatic relief in the short term but can also offer functional benefits in the long term. Yang et al. (2015) [11] reported similar longitudinal outcomes, revealing that pain and function improved up to 18 months following the surgery. In contrast, Huda et al. (2020) [12] found that significant improvement in VAS and WOMAC scores was seen at the three-month time point, but not at six or twelve months, suggesting that any apparent early improvement occurred prior to six months and plateaued. Factors that could delineate the differences between their results and ours involve variance in patient population, surgical variables, and duration of follow-up.

Radiologically, the median medial-lateral (ML) ratio in our study, 0.32 +- 0.18 at baseline, improved to 0.50 +- 0.21 by one year, suggesting a positive change in the distribution of loads and positioning of the joint. This radiographic change is comparable to that of Wang et al. (2017) [6] and Sukumaran et al. (2019) [13], both of whom demonstrated a significant postoperative increase in ML ratio post-surgery, further indicating that load redistribution toward the lateral compartment, and the effect of decompression of the medial compartment are important in the relief of symptoms. Moreover, Dong et al. (2016) [14] also presented radiographic data to prove the non-uniform settlement hypothesis, showing a reduction in the medial joint space constriction after PFO. Likewise, Yang et al. (2015) [9] demonstrated improvements in radiological data on the femorotibial angle and condyle-plateau angle one year and supported our results on increased alignment and medial compartment unloading.

Several complementary biomechanical explanations clarify why PFO improves pain and alignment in medial compartment knee OA. First, the non-uniform settlement concept proposes that the fibula acts as a lateral strut for the tibial plateau; this asymmetric support allows greater load to concentrate medially over time. By removing a short segment of the proximal fibula, lateral support is reduced, which facilitates a more even redistribution of load across the tibiofemoral joint and lowers medial contact stress. Radiographically, this mechanism aligns with the increase in medial-to-lateral (ML) joint space ratio observed post-operatively and with prior reports documenting reduced medial narrowing after PFO [14].

Second, the lateral cortical–fibular stiffness hypothesis suggests that the combined stiffness of the lateral tibial cortex plus the fibula forms a rigid arch that channels stress medially. Releasing the fibula reduces this lateral rigidity, rebalances the mechanical environment, and supports gradual correction of varus alignment, thereby reducing nociceptive input from the overloaded medial compartment [10].

Third, ground-reaction vector (GRV) readjustment after high/proximal fibular osteotomy shifts the stance-phase GRV laterally relative to the knee center, diminishing the adduction (varus) moment and lowering medial compartment load. This dynamic change explains sustained pain relief and the functional gains seen over a year in multiple series [15].

These mechanisms are also consistent with post-operative changes in femorotibial and condyle-plateau angles reported in pilot work, which reflect improved alignment and unloading of the medial compartment following PFO [11]. Taken together, these converging models—settlement correction, stiffness modulation, and GRV shift—provide a coherent explanation for the clinical analgesia, functional improvement (AKSS), and radiological ML ratio

changes observed at three months and one year in our cohort.

Although our analysis has shown some positive results within one year, we are yet to know the results of the long-term outcomes. Yang et al. (2015) also found a sustained benefit in clinical functioning and radiological outcomes over a year long, which indicated that PFO might have a time-related cumulative effect. Our study, however, does not provide long-term follow-up hence we cannot verify this long-term efficacy. Moreover, despite the peroneal nerve injury being an acknowledged complication of PFO, we have only experienced temporary paresthesia, which is in line with the low rates of complication peroneal and superficial peroneal nerve injury, reported by Yang et al. (2015) 1.8% each [11].

All in all, the results of the current study are in line with the accumulating amount of data that proves PFO to be a safe and efficient surgical procedure in the treatment of medial compartment knee osteoarthritis. The operation provides significant analgesia, better functional outcome, and quantitative radiological reposition, especially in patients of moderate varus deformity. In comparison to high tibial osteotomy and noncompartmental knee arthroplasty, PFO offers an easy, less invasive, and less expensive option that has fewer complications (Utomo et al., 2018) [16]. It is effective in the short to mid-term, PFO could be used as an intermediate line of treatment in patients who are not eligible to undergo arthroplasty or delay joint replacement surgery.

Conclusion

The research showed that proximal fibular osteotomy (PFO) is an effective surgical procedure for treating medial compartment osteoarthritis of the knee, especially within patients with moderate radiographic degeneration grades. Clinical results showed consistent and statistically significant improvements in pain level, the function of the knee and alignment over time. Pain scores demonstrated a decreased pattern from baseline to 12 months, while both clinical and functional American Knee Society Scores (AKSS) also highlighted a significant increase in improvements, demonstrating improved performance of the joint and better mobility for the patient. The medial to lateral (ML) ratio showed significant radiographic improvement, demonstrating a favorable load shift from the medial to lateral compartment, decreasing loading of the affected compartment. These improvements were not only seen at 3 and 12 months but were maintained throughout the entire follow-up period, demonstrating that proximal fibular osteotomy (PFO) provided early symptom improvement and also transformed into improved function and mechanical alignment of the knee joint over time. In conclusion, the research supports the use of proximal fibular osteotomy (PFO) as an easy, low-cost and low-invasive intervention in a selected group of patients with medial compartment osteoarthritis of the knee who are not yet candidates for total knee arthroplasty.

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