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Original Research Article

Study on Proximal Fibular Osteotomy for Medial Compartment Knee Osteoarthritis

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Abstract:

Background: Medial compartment knee osteoarthritis (OA) is a widespread source of persistent malady and incapacity, and traditional surgical solutions tend to be intrusive or expensive. Proximal fibular osteotomy (PFO) is a less invasive and preserving technique, which tries to redistribute the load other than the medial compartment.

Aim: To assess clinical and radiological outcomes of PFO in the patients with medial compartment-knee OA after one year.

Methodology: It was a prospective cohort study involving 22 patients diagnosed with medial compartment knee OA based on the ACR criteria. VAS was measured before the operation, Clinical and Functional AKSS, and mechanical axis (ML ratio) were registered. PFO was done through a standardized procedure, and the patients were followed at 3 months and 1 year. A statistical test was performed using non-parametric tests where $p < 0.05$ was taken as significant.

Result: It was found that there were major improvements at each follow-up period. Mean VAS reduced to 5.08 and 3.65 at three and one year's respectively. After one year, Clinical AKSS and Functional AKSS increased by 55.86 to 72.10 and by 47.95 to 70.85 respectively, and ML ratio increased to 0.50 to 0.32 respectively (all $p < 0.001$).

Conclusion: PFO has proven to be an effective, minimally invasive intervention that was associated with a persistent pain reduction, functional recovery, and radiologic enhancement to support the use of PFO in medial compartment knee OA.

Keywords: Proximal Fibular Osteotomy, Knee Osteoarthritis, Medial Compartment OA, AKSS, VAS, Mechanical Axis.

Introduction

Osteoarthritis (OA) is a progressive degenerative, chronic and synovial condition, which is well-known as a polyarticular disorder whose etiology is multifactorial involving both mechanical, genetic, metabolic and environmental factors. Of all the affected joints, the knee is the one that is most affected, and this makes knee OA a significant factor in explaining worldwide pain, disability and diminished quality of life [1]. Knee OA is especially a heavy burden in India and a community-based study comprising people older than 40 years across five states indicated a prevalence of 28.7%. Knee OA development is closely linked with increasing age, increase in body mass index (BMI), the female gender and the sedentary lifestyle practices, all of which have a role to play in increasing the prevalence in the population. Similar results are encountered throughout the world. An example of this was a study conducted on people aged above 60 years in the United States which found that 37 percent of the population reported radiographic characteristics of knee OA, and 12 percent had a symptomatic disease [2]. Besides, it has been estimated that lifetime clinical and population health risk of symptomatic knee OA is 44.7% which indicates the long-term clinical and population health effects of the health condition.

Radiographic assessment of knee OA is often used in the diagnosis and severity of knee OA, with the Kellgren-Lawrence (KL) grading system being the most common system. The system is guided by typical radiographic appearances like narrowing of the joint space, osteophytes, subchondral sclerosis and deformity categorizing OA into five grades [3]. A significant characteristic of knee OA is that the decrease in joint space is a compartment specific phenomenon. The most common pattern is medial joint space narrowing which is strongly related to the

symptomatic manifestations that are experienced which are pain, stiffness and limited mobility. Loss of medial compartment, degenerative changes normally cause varus deformity and change biomechanical load distribution across the knee which ultimately increases the rate of the disease. With further development of the disease, patients get more functional limitations, disability in ambulating and the overall quality of life decreases significantly.

Knee OA medial compartment knee management consists of conservative treatment and surgery. Weight loss, physiotherapy, nonsteroidal anti-inflammatory therapy, and intra-articular injection are found to be of temporary symptom relief and ineffective in patients with moderate to severe disease. Surgical procedures like high tibial osteotomy (HTO), noncompartmental knee replacement (UKA), and total knee replacement (TKA) are usually taken into consideration in case of unsuccessful conservative treatments. These are effective procedures, but they are limited. HTO is linked to the huge surgery burden, extended recovery period, and possible complications with bone repair or bone misalignment. Although UKA is not as invasive as TKA, it needs to be carefully selected in terms of patients and has chances of loosening or wearing components. TKA is a more expensive, slow-to-recover and worries about the life of the implants (particular for younger and more active patients) surgery increase the cost [4].

Proximal fibular osteotomy (PFO) has become a recent and rather simple surgery method of managing medial compartment knee OA. According to the biomechanical assumption that decreasing the structural support offered by the fibula can assist in redistributing the load off the medial compartment, PFO attempts to reduce pain and enhance knee performance by ensuring that there is a more balanced mechanical position. PFO has a number of strengths compared to the other available surgical procedures: it is minimally invasive, with minimal incision, and minimal soft-tissue dissection is required; internal fixation is not necessary; the operation has a shorter duration and a faster recovery period [5]. The mentioned features render PFO especially appealing in the context of limited resource allocation and to patients that might not necessarily be eligible to undergo more comprehensive reconstructive protocols.

The existing evidence behind PFO is yet to be established although it may have its advantages. Small sample sizes and brief follow-ups are found in most published studies; therefore, it remains unclear as to what the long-term functional and radiological consequences of the procedure are. Since medial compartment knee OA is very common among the Indian population, and the patient requires easy and cost-effective treatment options, additional studies should be conducted to assess the effectiveness and safety of PFO. Knowledge of its clinical effect would be used to establish whether it can be an effective alternative or adjunct to the traditional types of surgery, including HTO, UKA and TKA.

It is against this background that the current prospective study is conducted to determine the functional and radiological outcome in patients with medial compartment knee osteoarthritis following a one-year post-surgery period of proximal fibular osteotomy. Through an organized measure of postsurgical variations, the study will add meaningful data to the currently expanding yet insufficient literature of PFO and assist in elucidating its possible role in the treatment of medial compartment knee OA.

Methodology

Study Design

This study was designed as a prospective cohort study evaluating the clinical and radiological outcomes of Proximal Fibular Osteotomy (PFO) in patients with medial compartment osteoarthritis (OA) of the knee. All eligible patients who presented to the Department of Orthopaedics were consecutively recruited after meeting the inclusion criteria and providing informed consent.

Study Area: The study was conducted at the Department of Orthopaedics, Shankar Chikitsalaya, Kankarbagh, Patna, Bihar, India

Study Duration: The study was carried out over a period of 12 months.

Sample Size: A total of 24 patients were approached for enrolment. Two (2) patients refused participation, resulting in a final sample size of 22 patients included in the study.

Study Population: The study population consisted of patients presenting with symptomatic medial compartment knee osteoarthritis, diagnosed using the clinical criteria of the American College of Rheumatology (ACR). Eligible patients scheduled for PFO were invited to participate.

Inclusion Criteria: Patients were included if they met the following criteria:

- Clinical diagnosis of medial compartment knee OA using ACR criteria, i.e., knee pain plus at least three of the following:
    - Age > 50 years
    - Morning stiffness < 30 minutes
    - Crepitus
    - Bony tenderness
    - Bony enlargement
    - No palpable warmth
- Willingness to undergo PFO
- Provided written informed consent

Exclusion Criteria: Patients were excluded if they had:

- Incomplete clinical or radiological records
- Concomitant arthritis due to other causes (e.g., rheumatoid arthritis, seronegative arthritis)
- Post-traumatic knee arthritis
- History of ligament or meniscal injury
- Clinical valgus deformity measured using a goniometer
- Any contraindication to surgery or anesthesia

Data Collection: Standardized proforma was used in collecting data regarding each individual patient. Demographic variables that were used in preoperative assessment were age, sex, body mass index (BMI), length of symptoms, and comorbidities. This clinical information was history of intra-articular injections, Kellgren Lawrence (KL) grade, Visual Analog Scale (VAS) pain score, and clinical and functional components of the American Knee Society Score (AKSS). Radiological assessment was carried out on the full weight-bearing anteroposterior radiographs of the knee where the medial joint space, lateral joint space, and mechanical axis (ML ratio) were established along the radiographic lines between the tibial plateau and the femur condyles. Data (postoperative) were measured at the three-month and one-year follow-up visit where VAS score and AKSS value, ML ratio and radiographic joint space measurements were again measured to compare the three to that of the baseline data.

Procedure: All the operations were carried out by one skilled orthopedic surgeon to guarantee uniformity of the procedures. The patient was put on the supine position and under a sterile environment, the limb under which surgery was to be conducted, was prepared, starting at the mid-thigh up to the foot. A longitudinal incision of 5-6 cm was done over the lateral side of the proximal fibula. The plane between the peroneal muscles and the soleus was developed very carefully to expose the fibular shaft. The hemostasis was ensured, and two osteotomies were made with the help of several drill holes that were designed to remove a segment of the fibulas 23 cm in length and placed 710 cm below the fibular head. Subsequently the wound was closed in layers. Throughout the mobilization was promoted early and the ankle and knee mobility with full weight-bearing was permitted on patients within 24 hours of operating. Patients were followed up by removal of sutures and again after a certain time period to assess their outcome.

Statistical Analysis: All the data collected were inputted into Microsoft Excel followed by the analysis of the data after inputting them into SPSS statistics version 16.0 (IBM, Armonk, NY). Frequencies and percentages described the categorical variables whereas mean + Standard deviation or median values described the continuous variables based on their distribution. The test of normality of continuous data was conducted by the Kolmogorov Smirnov test. Since the majority of the paired pre- and postoperative variables were discovered to be non-normative, the Wilcoxon signed-rank test was used to compare them. The Chi-square or Fisher's exact test, depending on the type of test was used to analyze categorical variables. A p-value of below 0.05 was taken as statistically significant."

Result

Table 1 presents the results of evaluation of the 22 knees; as it was found, over half of them had Kellgren Lawrence (KL) grade 2 (54.5%), which reflects mild-moderate osteoarthritic alterations as the most frequent manifestation. In 31.8 percent of the knees, grade 3 changes were observed, and this is a significant percentage of moderate to severe degeneration. Few individuals fell in grade 1 (4.5%), and under grade 4 (9.1%), which are minimal and advanced osteoarthritis respectively. In general, the distribution indicates that the majority of the patients were brought to the clinic with a mid-stage osteoarthritis (KL grades 23).

Table 1: Distribution of knees as per KL grade (N = 22 knees)

KL grade	Number of knees	%
1	1	4.5
2	12	54.5
3	7	31.8
4	2	9.1
Total knees	**22**	**100**

Table 2 presents significant changes between the 22 knees examined with all the measured clinical and radiological parameters improving between the initial and three-month periods. The level of pain also dropped significantly, with loss of VAS score of 7.72±0.71 to 5.08±1.12 (p=0.001). Clinical and Functional AKSS scores also had significant improvement in that Clinical AKSS score improved significantly (55.86 ± 7.10) to 63.95 ± 6.42 ($p < 0.001$), and Functional AKSS score improved significantly (47.95 ± 13.82) to 59.40 ± 14.12 ($p = 0.001$) to reflect improved knee functioning and good performance. Radiologically, there was an increase in the ML ratio with a decrease in 0.32 ± 0.18 to 0.40 ± 0.19 ($p < 0.01$) indicating premature structural correction. In general, the results demonstrate obvious clinical and radiographic improvement in the first three months.

Table 2: Comparison of the means of clinical and radiological parameters at baseline and at three months (n = 22 knees)			
Variable	**At baseline, mean ± SD**	**At three months, mean ± SD**	**P-value**
VAS score	7.72 ± 0.71	5.08 ± 1.12	<0.001
Clinical AKSS	55.86 ± 7.10	63.95 ± 6.42	<0.001
Functional AKSS	47.95 ± 13.82	59.40 ± 14.12	<0.001
ML ratio	0.32 ± 0.18	0.40 ± 0.19	<0.01

Table 3 shows that there was a significant improvement in the clinical and radiological parameters in 22 knees after three months and one year of the treatment, and all the parameters have highly significant changes ($p < 0.001$). The level of pain also returned to decrease, which was evidenced by the decrement of VAS scores 5.08 ± 1.12 to 3.65 ± 1.18. The results of AKSS scores in clinical and Functions further improved, ascending to 72.10 ± 9.25 and 70.85 ± 14.92 (Newman), respectively, and indicating continuous improvement of knee functioning and performance of daily activities. The ML ratio also raised the ratio of 0.40 + 0.19 to 0.50 + 0.21 and that means further radiological improvement is going on. In general, the findings indicate that there is progressive, significant recovery in the post-three-month period with long-term improvements through one year.

Table 3: Comparison of the means of clinical and radiological parameters at three months and at one year (n = 22 knees)			
Variable	**At three months, mean ± SD**	**At one year, mean ± SD**	**P-value**
VAS score	5.08 ± 1.12	3.65 ± 1.18	<0.001
Clinical AKSS	63.95 ± 6.42	72.10 ± 9.25	<0.001
Functional AKSS	59.40 ± 14.12	70.85 ± 14.92	<0.001
ML ratio	0.40 ± 0.19	0.50 ± 0.21	<0.001

Table 4 indicates clinical and radiological significant improvement between the baseline and one year in 22 knees with all the parameters showing statistically significant changes ($p < 0.001$). The levels of pain reduced significantly, which was measured by the decrease of VAS scores to 3.65 ± 1.18 as compared to 7.72 + 0.71. Both Clinical and Functional AKSS scores also showed significant improvement, which were 55.86 +7.10 to 72.10 +9.25 and 47.95 +13.82 to 70.85 +14.92, respectively, which showed improved knee functioning and patient-reported outcomes. Also, the ML ratio was found to have improved with time as 0.32 had changed to 0.50 with a standard deviation of 0.21 indicating radiological correction or improvement of the standard deviation during the one-year period. In general, the table shows statistically significant and steady postoperative improvement of all the measured parameters.

Table 4: Comparison of the means of clinical and radiological parameters at baseline and at one year (n = 22 knees)			
Variable	**At baseline, mean ± SD**	**At one year, mean ± SD**	**P-value**
VAS score	7.72 ± 0.71	3.65 ± 1.18	<0.001
Clinical AKSS	55.86 ± 7.10	72.10 ± 9.25	<0.001
Functional AKSS	47.95 ± 13.82	70.85 ± 14.92	<0.001
ML ratio	0.32 ± 0.18	0.50 ± 0.21	<0.001

Discussion

The current research study indicates that proximal fibular osteotomy (PFO) offers significant clinical and radiological benefits in patients with mostly early to moderate medial compartment knee osteoarthritis as evidenced by the distribution of Kellgren Lawrence grades, including 54.5% KL 2 and 31.8% KL 3 at baseline. This distribution corresponds to the patient profiles typically discussed in PFO literature, where mild-to-moderate osteoarthritis is typically viewed as the best to attain predictable mechanical de-compressive and symptomatic outcome. The fact that we have reduced the VAS pain scores by a significant margin as reflected by the 7.72 baseline and 5.08 scores at three and one year respectively, and even further to 3.65 at one year, is similar to the initial and long-term improvements Wang et al. (2017) [6] reported, who has a median of 13.3 months of follow-up. Similar trends were described by Rai et al. (2019) [7], where significant pain relief lasted after a year. These repeatable results support the theory that PFO enhances the gradual release of the medial compartment which leads to continued symptomatic gains. Nevertheless, our results are quite different because Huda et al. (2020) [8] found a significant improvement upon three months and no further advantage at six and twelve months, and it is possible that PFO effects lose their

value in some cohorts. Conversely, our sustained symptomatic positive response favors a longer action of therapy."

Our research findings in clinical and functional AKSS are also comparable to other research outcomes published in the past. Clinical AKSS improved by three months of 55.86 to 63.95 and after one year to 72.10 and the functional AKSS improved by three months of 47.95 to 59.40 and after one year to 70.85. These values are associated with an improvement of poor functional status into a good functional one, which is consistent with Rai et al. (2019) [7], who also reported a substantial improvement in the postoperative period. Our ultimate functional AKSS results were not high as the results in the cohort of Prakash [9] who showed a postoperative score above 80. One of the possible reasons is that the preoperative clinical and functional scores of the group of Prakash are relatively higher, and they have been proven to affect the postoperative outcomes. Conversely, Wang et al. (2017) [6] had only fair results in functional subset of AKSS, which can be explained by the significantly lower baseline scores of their patients. These differences indicate that although PFO is a sure way of enhancing knee functioning, the extent to which it does so is, in part, contingent on the level of functional preoperative performance, patient selection, and deformity severity.

Biomechanical efficacy Radiological outcomes also support the use of PFO. The medial-to-lateral (ML) ratio in the current study improved at the baseline, three-month and one-year with 0.32 and 0.40, and 0.50 respectively indicating redistribution load off the medial compartment. The trend is aligned with the one-year gains reported by Wang et al., (2017) [6], Utomo et al., (2018) [10] and Sukumaran et al., (2019) [11] who reported comparable increases in the ML ratios. These findings have also been confirmed by studies that measure absolute joint-space width, in which Liu et al. (2018) [12] discovered significant changes of medial joint space widening and lateral space narrowing one year later. Reductions in the values of the femurtilibia angle and settlement were also reported by Yang et al. (2015) [13] and Dong et al. (2016) [14], which helps to support the theory that PFO helps orient the mechanical position of the proximal tibia. Besides, Yang et al. have detected that improvements in radiology were sustained, even after one year, which leads to a more durable structural response to PFO [13]. This may also be the same trend as indicated by our results, which have been improving till a year. This difference in the results compared to the results of Huda et al. (2020) [8], who showed no significant radiological changes at any of the follow-up times, may be explained by the variation in the surgical procedure, selection of a patient, or the method of measurements.

Clinically and radiographically, our trends of PFO response are consistent with existing mechanisms of PFO effectiveness. The non-uniform settlement theory offered by Dong et al., (2016) [14] offers a rational explanation of the occurrence of the lateral movement of loads, which are characterized by decreased fibular support, and thus, support the upward movement of the lateral tibial plateau and following decompression of the medial compartment. The concept of too many cortices proposed by Prakash [9] and ground reaction vector readjustment model proposed by Xie et al., (2018) [15] provides another opinion when it comes to the impact of altered fibular biomechanics on knee alignment and performance. The initial benefits observed in the three-month data is as anticipated by theories that focus on instantaneous mechanical unloading, whereas the persistence of radiological and functional improvements between three months and one year are similar to theories on progressive adaptive alterations of tibial plateau settlement and weight-bearing alignment.

We had a more restricted number of complication profiles and included only transient sensory changes and mild weakness, which is in line with the low rates in Yang et al., (2015) [13], where the prevalence of peroneal nerve injury was found to be only 1.8 percent and temporary weakness was reported as 14.5 percent. There were no significant complications, and it again reinforced a relatively safe profile of PFO in comparison with high tibial osteotomy, having significant risks, such as non-union, tibial plateau fracture and deep vein thrombosis [12]. PFO has the potential to be an exciting option to patients having moderate varus deformity and medial compartment overload due to the simplicity of the procedure, short duration of operative time and low postoperative morbidity.

Overall, the long-term pain, functional, and radiological improvement that was found in our study supports the applied relevance of PFO as a biomechanically reasonable intervention with low risks in medial compartment osteoarthritis. Although it will be required to follow up, at least in the long term, to establish the permanence, available evidence, of which our results are not an exception, indicates that PFO has significant and progressive value when selected correctly.

Conclusion

The research has shown that proximal fibular osteotomy is a good and promising joint-preserving surgery that can be used to treat medial compartment knee osteoarthritis and can yield long-term results in terms of pain, functionality, and limb position. The majority of patients were already moderate to advanced but all of them demonstrated significant clinical improvements as early as three months after surgery and extended to one year follow-up, which

represented gradual pain improvement and mobility increase. The simultaneous radiological changes indicate that the procedure assists in restoring the load distribution across the knee and this could be the underlying cause of the achieved functional recovery. On the whole, the results indicate that proximal fibular osteotomy is a versatile, less invasive treatment alternative, which demonstrates significant benefits in alleviating symptoms and biomechanical restoration in patients with symptomatic medial compartment osteoarthritis, with no requirement of more extensive reconstructive procedures.

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