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Impact of posterior femoral condylar offset restoration on knee range of motion in total knee arthroplasty patients. A retrospective case series study

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Abstract

Background

Total knee replacement (TKR) is a proven intervention for alleviating pain and restoring function in patients with advanced knee osteoarthritis. Accurate radiographic assessment of femoral posterior condylar offset (PFCO) and its restoration is vital for optimizing surgical outcomes and enhancing patient satisfaction. However the extent of this relationship remains unclear.

Objectives

This study aims to compare preoperative and postoperative radiographic measurements of PFCO in patients underwent TKR, evaluating their influence on postoperative range of motion (ROM)

Health Affairs ISSN - 0278-2715 Volume 13 ISSUE 10 page 4694-4704
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and clinical outcomes.

Methods

This retrospective case series study was performed on patients aged 55 to 80 who underwent primary TKR and had complete preoperative and postoperative imaging and follow up data for 6 months at Lady Reading Hospital. Preoperative and postoperative lateral knee radiographs were evaluated to measure PFCO and knee ROM was assed preoperatively and at 1, 3, and 6 months postoperatively. Statistical analyses were conducted to determine correlations between these measurements and postoperative ROM.

Results

The study included 50 patients. Postoperative assessments showed significant changes in PFCO compared to preoperative measurements. The mean preoperative PFCO was 33.05 mm and increased to 35.67mm postoperatively ($p< 0.0001$). Mean preoperative flexion angle was 115.1^0, improving to 126.6^0 postoperatively ($p <0.001$). The mean gain in PFCO was +2.38 mm and in flexion angle was $+10.16^0$. A moderate positive correlation was found between PFCO restoration and postoperative flexion improvement ($r= 0.138$, $p= 0.34$)

Conclusion

Although PFCO restoration significantly improved post TKR flexion, its direct relationship with flexion gain was modest, indicating that multiple surgical and rehabilitative factors influence functional recovery. So a comprehensive approach is essential to optimize ROM outcome.

Key words. TKR (total knee replacement), OA (osteoarthritis), PFCO (posterior femoral condylar offset), ROM, (range of motion)

Introduction

Knee Osteoarthritis is a leading cause of disability in the elderly population with significant effect on their life[1]. Total knee replacement surgery has become a standard treatment for

Health Affairs ISSN - 0278-2715 Volume 13 ISSUE 10 page 4694-4704
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advanced OA, offering substantial pain relief and functional improvement[2]. It has been shown to contribute to a greater improvement in the pains, knee function, and quality of life in patients with late-stage knee OA[2,3]. Postoperative painless maximum knee flexion is a primary goal of every knee arthroplasty surgeon. One key goal in TKR is restoring native knee kinematics, where posterior femoral condylar offset (PFCO) plays a crucial biomechanical role[4,5] . PFCO is defined as the sagittal distance between the posterior femoral cortex and the posterior condylar surface[6]. The ability to achieve sufficient postoperative flexion is crucial for daily activities like ascending stairs and sitting, with a minimum flexion of approximately 90° necessary for basic tasks such as climbing stairs and sitting, while more deeper flexion of 120º -150º is necessary for more demanding practices such as cross-legged sitting and squatting especially in Asian population[7,8]. Despite the need for enhanced knee flexion, achieving greater than 120° postoperatively remains infrequent and can negatively impact patient-reported outcome scores[9,10].

Achieving maximum postoperative knee flexion is challenging due the interplay of multiple modifiable and non-modifiable factors[10]. Among the modifiable surgical factors, posterior femoral condylar offset (PFCO) plays a crucial role in enhancing femoral rollback during flexion[11, 12, 13,14]. PFCO is measured as the distance between the posterior femoral condyle and the posterior cortex on true lateral knee radiograph[15]. Inadequate restoration of PFCO can lead to anterior impingement, reduced posterior clearance and limited flexion[16,17]. Conversely increasing PFCO can enhance the flexion arc and improve knee kinematics there by maximizing ROM and flexion instability[18].

Several studies have emphasized the importance of restoring PFCO for improving functional outcomes following total knee replacemen[19,20]. Many clinical and cadaveric experimental studies have sought to determine the restoration of PFCO in TKR[21]. Despite its importance the impact of PFCO restoration on postoperative range of motion is not fully understood and remains debated with some investigations reporting weak correlations[21,22]. Some studies has suggested a link between reduced PFCO and limited postoperative flexion, while others report inconclusive findings[23, 24].

This study seeks to clarify the relationship between PFCO restoration in TKR and their effects on postoperative ROM in a local patient population through a retrospective case series design.

Objectives of the Study

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1. To compare preoperative and postoperative measurements of PFCO in patients underwent TKR.
2. To evaluate the impact of these measurements on postoperative range of motion and clinical outcomes.

Methodology

Study Design and setting

This retrospective case series study was conducted at Lady Reading Hospital Peshawar, a public tertiary health care center, including patients who underwent primary total knee replacement surgery between Jan 2023 and Feb 2024. The analysis focused on preoperative and postoperative knee radiographs to measure PFCO, and pre-operative and postoperative knee range of motion at 1st, 3rd and 6th months.

Inclusion Criteria

- Patients aged 55 to 80 years.
- Diagnosed with advanced primary knee osteoarthritis.
- Underwent primary TKR.
- Availability of preoperative and postoperative radiographic data.
- Complete follow up record for 6 months.

Exclusion Criteria

- History of previous knee surgeries on the affected joint.
- Significant deformities unrelated to osteoarthritis.
- Incomplete radiographic data.
- Previous surgeries such as ligament reconstruction or partial knee replacement.
- Inflammatory arthritis, joint infection or malignancy around knee joint.

Data collection

Measurement Techniques

1. Demographics: Age, gender, involved knee, grade of arthritis and whether unilateral or bilateral replacement was performed were recorded.
2. Knee ROM. Pre-operative active and passive ROM of affected knee measured with a goniometer

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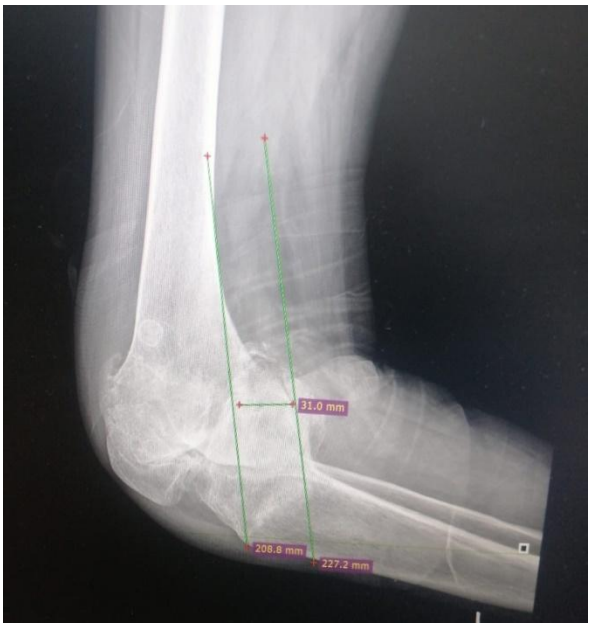
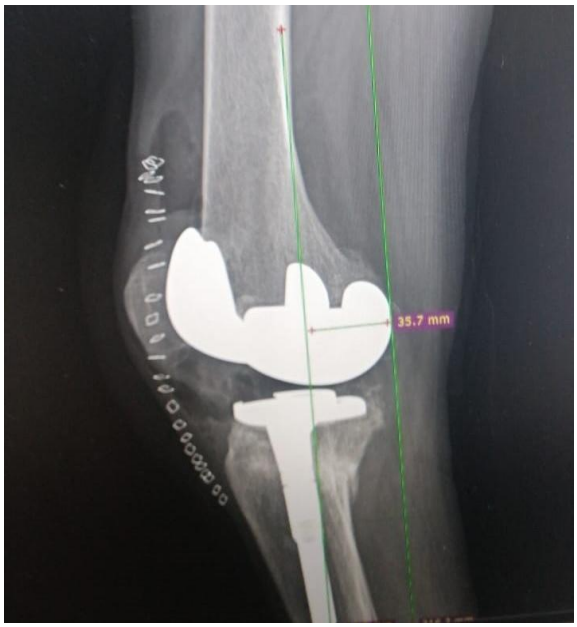
3. Post-operative ROM measured on 1st, 3rd, and 6th follow up month.
4. **Posterior Femoral Condylar Offset (PFCO):**
    - **Preoperative Assessment:** Measured from lateral radiographs, capturing the distance between posterior condylar margins and the tangent of the femoral diaphysis.
    - **Postoperative Assessment:** Similar measurement technique applied to assess the alignment of the prosthetic component. For measurement of PCO we did not add cartilage thickness of posterior femoral condyle either pre-operative or postoperative so that the change in PCO would remain the same. Figure 1 : (A,B).

A. Pre-op PFCO measurement	B. Post-op PFCO measurement
	

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All patients' surgeries were performed by experienced arthroplasty surgeon with aim to restore PFCO along with addressing the surgical modifiable factors such as soft tissues balancing, posterior tibial slope, implant design and component alignment. Standardized TKA technique used in all cases. All knee replaced with cruciate sacrificing, posteriorly stabilized, fixed bearing designs. Descriptive statistics used to summarize base line characteristics, pre-op and post-op ROM, and OA severity. Paired t-test used to compare preoperative versus postoperative ROM. Pearson correlation coefficient applied to examine the relationship between PFCO and ROM change. Multivariate regression analysis used to identify PFCO as an independent predictor of ROM, adjusting for confounders like age, gender, BMI, and pre-operative ROM. A p value <0.05 was considered statically significant.

Results

A total of 50 patients (54 knees) underwent total knee replacement (TKR) for grade 4 osteoarthritis. The mean age was 66 years (55 -80 years), with a female predominance. Among them 58% (29) were female and 42% (21) were male. Of the 54 knees replaced 29 were right knees and 25 were left knees, with 4 patients having both knees replaced (table 1). The mean preoperative PFCO was 33.05mm, which increased to 35.67mm postoperatively, resulting in a mean gain of 2.38 mm, this increase was statistically significant. Paired t-test: t= 6.36, p < 0.00001). The mean preoperative flexion was 115.1^{o}, improving to 126.6^{o} postoperatively. The average gain in flexion was 9.66^{o}, which was highly significant (paired t-test: t= 15.28, p <0.00001) (table 2). Pearson correlation analysis demonstrated a moderate positive correlation between PFCO gain and postoperative flexion gain (r = 0.307, p=0.03). Bivariate linear regression analysis demonstrated that for each 1 mm increase in PFCO, there was an associated 0.52^{0} increase in flexion (P= 0.03, R^2 =0.0940 · Multivariate regression confirmed that postoperative PFCO was a significant positive predictor of flexion gain (p = 0.033). A moderate positive correlation was identified between the restoration of PFCO and postoperative ROM, indicating that greater restoration of PFCO is associated with improved knee flexion outcomes.

Health Affairs ISSN - 0278-2715 Volume 13 ISSUE 10 page 4694-4704
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Table 1: patient demographics and procedural data

Variable	value
Total patients	50
Knee replaced	54
Mean age (range)	66 years (55-80)
Gender (male/female)	21/29
Unilateral/bilateral TKR	46/4
Side of replacement (R/L)	29/25

Table 2: Preoperative and Postoperative Radiographic and Clinical findings

Parameter	Preoperative	postoperative	change
PFCO	33.05 mm	36.67 mm	+2.38mm
Knee flexion angle	115.1^0	126.6^0	$+9.66^0$

Discussion

ROM after total knee arthroplasty is a very important factor in determining the functional outcome of the procedure, especially in a country like Pakistan where activities of daily living require more amount of flexion.This study aimed to assess the possible influence of posterior femoral condylar offset (PFCO) reconstruction on flexion (weight bearing and non-weight bearing) in posterior stabilized total knee arthroplasty.

This study highlights the importance of posterior femoral condylar offset restoration in improving postoperative knee flexion. Restoration of posterior femoral condylar offset was achieved in nearly all patients; with an average of 2.38 mm. This anatomical correction was associated with a clinically meaningful improvement in knee flexion, with an average gain of nearly 10^o. The findings suggest that achieving optimal PFCO restoration is vital for maximizing postoperative ROM. Ours findings are in line with previous studies that emphasized PFCO restoration as a biomechanical contributor to optimizing knee kinematics[25].

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Bellemanns et al. reported that the reduction in postoperative PCO correlated with significant decrease in final maximum angle of flexion[20]. For every 3 mm decrease in PCO, the maximal obtainable flexion was reduced by a mean of 29.7° in comparison to those knees in which the PCO had been restored within 3 mm. Similarly Massinet al showed that a 3-mm decrease of the PCO could reduce knee flexion by 10° before the occurrence of tibio femoral impingement[17].

We noticed that post-operative ROM in CS knees was proportionately better in cases with better preoperative ROM similar to previously reported[26].

While the correlation between PFCO restoration and flexion gain was statistically significant, the modest R^2 value (9.4%) suggests that PFCO alone cannot fully predict postoperative ROM. This supports the notion that functional recovery is multifactorial, influenced by factors such as preoperative ROM, implant design, surgical precision, and rehabilitation adherence[26,27].

Biomechanically, restoration of PCO prevents the tibio femoral impingement during flexion and there by improves the maximum range of flexion after TKR[27]. When PCO is decreased mechanical block is caused by the impingement of the femur sliding forwards on the tibia during flexion, resulting in limitation of flexion after CR TKA[17].

Interestingly, patients with lower preoperative PFCO experienced greater flexion gains postoperatively , underscoring the value of targeted anatomical restoration in these cases possibly due to a greater potential for posterior clearance and flexion arc recovery. Our findings highlight the importance of combining PFCO optimization with soft tissues balancing, proper component alignment, and patient adherence to physiotherapy protocol are critical to achieve the best outcomes.

Conclusion

Restoring posterior femoral condylar offset significantly enhances postoperative knee flexion following primary TKR. However, its independent contribution to ROM is modest, emphasizing the need for a comprehensive approach involving precise surgical techniques and structured rehabilitation. Future research should continue to explore the relationships between these anatomical parameters and clinical outcomes to further refine surgical techniques and protocols.

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