

## Patellar Tracking in Total Knee Replacement (Review Article)

### Abstract

One of the common complications after total knee replacement surgery is pain and instability in the patellofemoral joint, which significantly impacts patients' quality of life. Statistics show that 8–12% of revision knee replacement surgeries are due to issues related to the patellofemoral joint. A critical concern during surgery is patellar maltracking, which is frequently observed. This condition occurs when the patella does not move along its proper path, leading to functional problems and pain. Various methods have been introduced to evaluate and correct patellar maltracking. This review article addresses different aspects of this issue, including: Definition of patellofemoral maltracking, factors affecting patellar tracking, intraoperative evaluation of patellar tracking, the concept of Perfect Patellar Tracking, Surgical methods to correct patellar maltracking. This article aims to provide a comprehensive perspective on the importance of proper correction of patellar tracking to improve surgical outcomes and patients' satisfaction.

**Keywords:** Patella, Knee replacement arthroplasty, Patellofemoral joint.

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### Introduction

One of the common complications after total knee arthroplasty (TKA) is pain and/or instability of the patellofemoral joint (PFJ). Currently, 8-12% of TKA revision procedures are performed due to PFJ-related problems<sup>(1-3)</sup>. Even mild degrees of patellar maltracking can result in PFJ pain, while more severe cases may lead to patellar subluxation (Sx) or complete dislocation (Dx)<sup>(4,5)</sup>.

Approximately 5–52% of patients undergoing primary TKA require a corrective surgical procedure for patellofemoral maltracking (PFM)<sup>(6)</sup>, the most frequent cause of which is surgical error. Therefore, prevention of this complication is of critical importance.

### Definition of Patellofemoral Maltracking (PFM)

PFM can present in four different forms<sup>(4-7)</sup>:

#### I. Lateral patellar tilt greater than 5

On an axial view or patellar radiograph, one line is drawn tangent to the most anterior points of the lateral and medial femoral condyles, and another line is drawn across the widest portion of the patella. The angle between these two lines is defined as the *patellar tilt*. If the intersection point of these lines lies lateral to the PF joint, it indicates *lateral patellar tilt*; if it lies medially, *medial patellar tilt* is present (Figure 1).

#### II. Patellar shift or translation greater than 5 mm

On an axial view, a line is drawn tangent to the posterior aspects of both femoral condyles, known as the posterior condylar axis (PCA). A perpendicular line to the PCA is then drawn through the apex of the patellar articular surface. Another perpendicular line to the PCA is drawn through the deepest point of the trochlea. The horizontal distance between these two perpendicular lines represents the patellar shift or translation (Figure 2).

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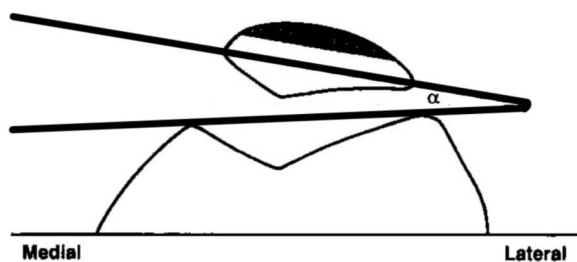


Figure 1: Lateral patellar tilt angle

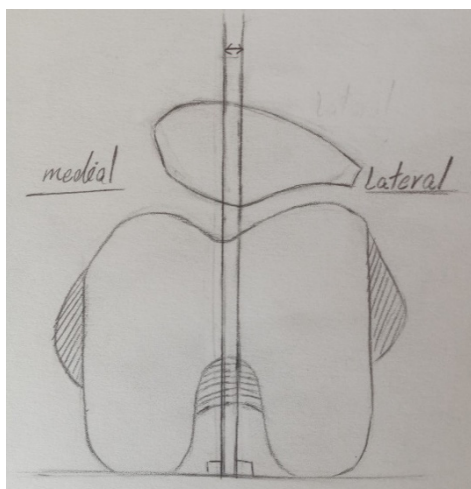


Figure 2: Patellar shift or translation

### III. Patellar subluxation (Sx)

Partial displacement of the patella.

### IV. Patellar dislocation (Dx)

Complete displacement of the patella.

## Factors Influencing Patellar Tracking

A variety of factors can affect patellar tracking, which can be categorized into 3 groups:

1. Patient-related factors
2. Prosthesis design-related factors
3. Surgical technique-related factors

Among patient-related factors, preoperative limb alignment (valgus deformity), pre-existing patellar Sx or Dx, and advanced PFJ osteoarthritis are particularly important. These conditions increase the likelihood of requiring corrective procedures for PFM and also predispose patients to PFJ complications after surgery. Therefore, in such cases, the surgeon must plan carefully preoperatively and adopt intraoperative strategies to correct these deformities.

Another critical factor influencing patellar tracking is the design of trochlear groove in femoral component. Modern femoral components are referred to as patella-friendly, as their groove design is more

anatomical, allowing better articulation with the native patella and thereby reducing the need for patellar reshaping. In patella-friendly prosthesis designs, the following features are incorporated:

1. The anterior flange of the femoral component extends proximally, allowing the patella to engage the trochlear groove at lower degrees of knee flexion.
2. The trochlear groove is asymmetric, with the lateral ridge higher than the medial ridge, which facilitates smoother patellar engagement in early knee flexion.
3. The groove is wider, deeper, and extends further distally.
4. The groove orientation is directed laterally, running from distal-central to proximal-lateral.
5. The anterior flange thickness is minimized to prevent patellofemoral overstuffing.

In a randomized clinical trial (RCT), two types of prostheses were compared: modern patella-friendly designs versus older designs lacking these anatomical considerations<sup>(8)</sup>. At final follow-up, anterior knee pain was reported in 21% of cases with patella-friendly prostheses versus 31% in the older design group. Similarly, the need for revision surgery due to PFJ complications was 1.2% in the modern group and 12% in the older group.

Surgical errors represent another major cause of PFM and, in fact, are the most common. These include residual valgus alignment, patella alta, internal rotation of the femoral or tibial components, inadequate gap balancing, and failure to perform lateral retinacular release (LRR) when indicated<sup>(4,9,10)</sup>. Another intraoperative factor that can influence patellar tracking is whether the tourniquet is active or inactive at the time of assessment, as well as the degree of knee flexion when it is inflated. Studies have shown that inflating the tourniquet in full knee extension can cause lateral patellar tilt and falsely increase the perceived need for lateral retinacular release<sup>(11,12)</sup>.

Husted et al., inflated the tourniquet in full extension. After placement of the trial components, patellar tracking was assessed. When PFM was noted, the tourniquet was deflated, and patellar tracking was reassessed. It was found that in 31% of patients, PFM resolved simply by deflating the tourniquet<sup>(11)</sup>. Importantly, if the tourniquet in full flexion of knee is turned on, it does not adversely affect the extensor

mechanism, and therefore does not require deflation to assess patellar tracking<sup>(6,13)</sup>.

One of the most frequent surgical errors leading to PFJ instability is internal rotation of the femoral or tibial component, or both<sup>(4,14)</sup>. After placing the trial components and the tourniquet is deflated, patellar tracking should be reassessed. If PFM is present, internal rotation of the components should be carefully evaluated. There is no single absolute threshold value for internal rotation of each component; rather, the combined internal rotation of both femoral and tibial components is critical<sup>(4,14)</sup>. Berger et al. demonstrated a direct relationship between the magnitude of combined internal rotation and the severity of PFJ problems: combined internal rotation of 1–4° resulted in lateral patellar tilting, 3–8° in patellar subluxation, and 7–17° in patellar dislocation with subsequent patellar prosthesis failure<sup>(4)</sup>.

### Proper Patellar Tracking

During TKA, after completing the final tibial and femoral cuts and inserting the trial components, the patella is repositioned and engaged within the trochlear groove. Then check the patellar movement in fully flexion and extension of knee without applying manual force. The medial facet of the patella should remain parallel to and in direct contact with the medial facet of the trochlear groove, while the apex of the patellar articular surface should track centrally and within the deepest portion of the groove<sup>(14)</sup>.

### Intraoperative Assessment of Patellofemoral Tracking in TKA

One commonly used method for evaluating patellar tracking is the *No Thumb technique*, in which the surgeon does not apply thumb pressure to guide the patella. After placement of the trial components and reduction of the patella into the trochlear groove, the knee is taken through full flexion and extension, and patellar tracking is observed without manipulation. However, the reliability of this technique has been questioned in several studies.

Archibeck et al.<sup>(12)</sup>, reported about the 200 knees, inflated the tourniquet in full knee flexion and, after placement of the trial components and patellar reduction, initially assessed tracking using the No Thumb technique without deflating the tourniquet. With this method, PFM was observed in 39% of cases. For patients with a positive No Thumb test, two towel

clips were used to approximate the capsule temporarily—one at the superolateral corner of the patella and another at the mid-patellar region. Patellar tracking was reassessed, and PFM was then noted in only 6.5% of patients. LRR was performed exclusively in those with a positive towel clip test. At 6-month follow-up, none of the patients demonstrated PFM on patellar view radiographs. The authors concluded that the No Thumb test has a high false-positive rate, approximately 32.5%.

Other studies have also shown that the No Thumb technique tends to overestimate the presence of PFM when the knee is approached through a medial parapatellar arthrotomy<sup>(16,17)</sup>.

### Common Surgical Interventions for Correcting Patellar Maltracking and Their Outcomes

The first surgical procedure introduced for correcting intraoperative PFM was the classic lateral retinacular release (LRR). In this technique, 1 cm lateral to the patella, longitudinal incision is made, extended distally from the fibers of the vastus lateralis to the tibial tubercle, performed either inside-out or outside-in. Although this method often corrects PFM, it carries a high complication rate, including avascular necrosis and possible fracture of the patella, anterior knee pain, wound healing problems, increasing the risk of lessening of patellar component, prolonged hospitalization, increased transfusion requirements, painful clicking during flexion-extension, and restricted joint motion<sup>(18,19)</sup>.

Due to these high complication rates, alternative methods for correcting PFM have been introduced over time.

One of the simplest and most effective techniques is lateral patellar facetectomy. In this procedure, approximately 7–9 mm of the most lateral part of the patella is resected with a saw and removed subperiosteally<sup>(20)</sup>. This lengthens the lateral retinaculum and reduces the lateralizing force on the patella (Figure 3). Lakstein et al.<sup>(21)</sup> was proposed lateral facetectomy as an appropriate substitute for classic LRR. After insertion of trial components and reduction of the patella into the trochlear groove, patellar tracking was assessed. If PFM was observed, lateral facetectomy was performed. Outcomes in this group were comparable to those of patients without intraoperative PFM. The authors therefore recommended lateral facetectomy as their first-line intervention for PFM correction, but advised against

resecting more than 50% of the lateral facet, as this may itself induce lateral patellar tilt. If PFM persisted after lateral facetectomy, they proceeded to staged LRR. Some authors have even advocated performing lateral facetectomy in all cases of primary TKA<sup>(20)</sup>.

In an interesting study published by Strachan et al. in the Journal of Arthroplasty in 2009, a novel staged LRR technique was introduced<sup>(6)</sup>. The tourniquet was inflated in full flexion and was not deflated during intraoperative patellar tracking assessment. After placement of the trial components, patellar tracking was first evaluated using the No Thumb test. If the No Thumb test was positive, they proceeded to the two-stitch technique, in which the capsule was temporarily closed with two sutures—one at the superolateral corner of the patella and the other at the mid-patellar region, similar to the towel clip method. Patellar tracking was then reassessed.

They proposed a six-step staged LRR protocol. If only the No Thumb test was positive (and the two-stitch test was negative), stage one was performed. If both the No Thumb and two-stitch tests were positive,

stages one and two were performed, followed by reassessment.

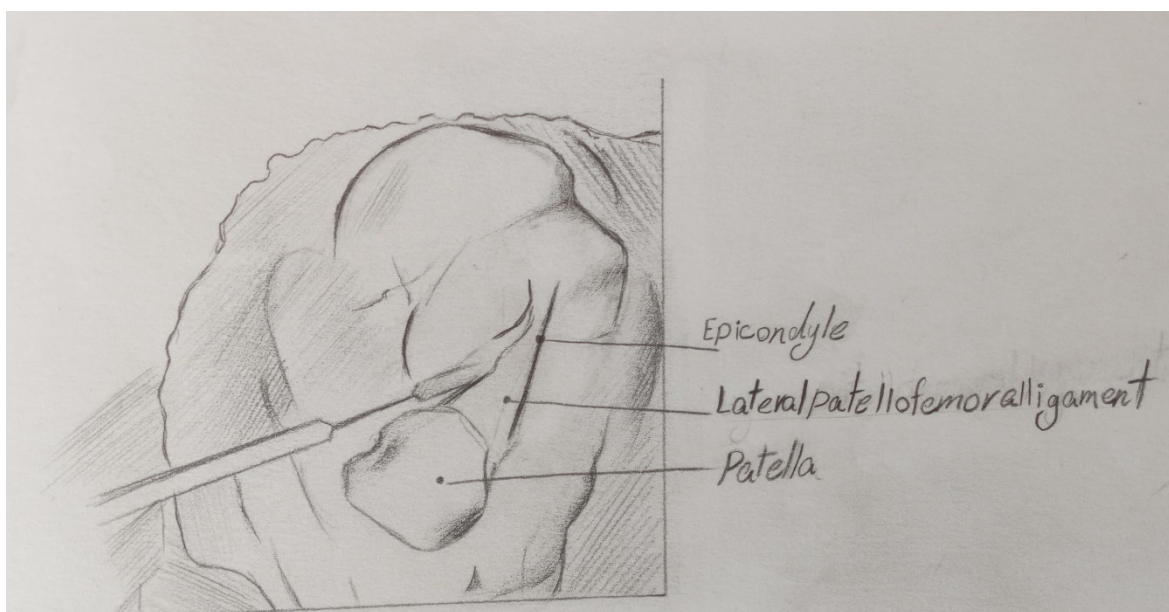
If PFM persisted, subsequent stages were undertaken sequentially up to stage six. At each step, patellar tracking was rechecked, and progression occurred only if maltracking remained.

In this series, 52% of patients exhibited PFM and required some degree of LRR. Among 50 patients with PFM, 9 (18%) were corrected at stage one, 10 (20%) at stage two, 16 (32%) at stage three, 13 (26%) at stage four, and 2 (4%) at stage five. None required stage six. Postoperative evaluation of patellar position using patellar radiographs at 45° knee flexion revealed that out of 96 operated patients, 13 demonstrated lateral patellar tilt of 5–10°, and 3 had tilt greater than 10°. One patient showed lateral patellar translation >10 mm, and 5 had medial patellar translation >5 mm. No cases of patellar subluxation or dislocation were observed.

The six stages of this staged LRR technique are detailed in Table 1, with illustrations of the procedure provided in Figure 3-5.

**Table 1: Staged Lateral Retinacular Release (LRR) Technique**

Stage	Surgical Step
Stage 1	Release of the lateral patellofemoral ligament (LPFL) from within the joint
Stage 2	Release of the lateral retinaculum from 25 mm above the patella down to the superior border of the patella
Stage 3	Release of the lateral retinaculum down to the mid-patellar level
Stage 4	Release of the lateral retinaculum down to the inferior pole of the patella
Stage 5	Release of the lateral retinaculum from the inferior pole of the patella down to the level of the knee joint line
Stage 6	Release of the lateral retinaculum extending to the level of the tibial tubercle



**Figure 3: Stage 1 of lateral retinacular release.**

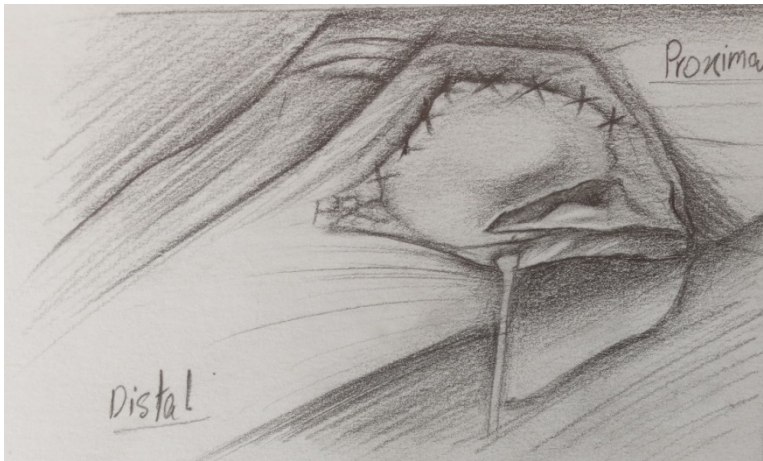


Figure 4: Final view of lateral retinacular release, which in this patient was carried out up to Stage 5.

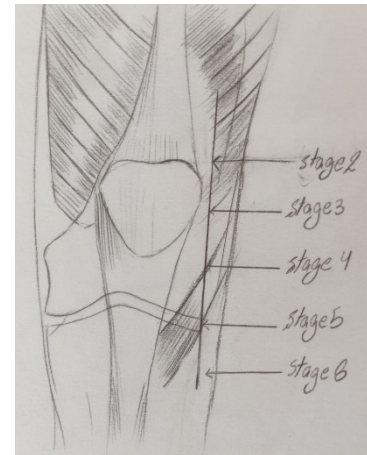


Figure 5: Sequential stages of lateral retinacular release.

A longitudinal incision is made, outside-in, around 2 cm lateral to the edge of the patella. The capsular and synovial layers should remain intact, and the joint should not be opened to prevent postoperative subcutaneous hematoma. Prior to performing stage two of the release, it is recommended to explore and identify the superior lateral genicular artery. This artery can typically be found immediately distal to the vastus lateralis fibers, and 2–2.5 cm from the superolateral corner of the patella. However, some studies have questioned the necessity of preserving this artery.

Ritter<sup>(22,23)</sup> argued that maintaining this artery does not reduce PF complications because the artery is very small and may rupture or thrombose during medialization of the patella, rendering it functionally insignificant.

## Conclusion

Patellofemoral (PF) complications are among the most common issues following total knee arthroplasty (TKA). The primary causes can be grouped into three categories:

1. Patient-related factors
2. Prosthesis design-related factors
3. Surgical technique-related factors

Therefore, careful preoperative patient preparation, appropriate prosthesis selection, and meticulous surgical technique are essential for the prevention of PF complications.

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