FACTORS AFFECTING PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY

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Abstract

Background: Optimizing patellar tracking in total knee arthroplasty is a surgical priority. Our objective was to compare the impact of the major controllable femoral, tibial and patellar component positions on patellar kinematics during both passive and loaded flexion.

Findings: The major determinants of patellar tilt and shift were patellar component medialization, patellar resection angle and femoral component rotation. The relative order of these variables depended on the structure (bone or component), kinematic parameter (tilt or shift) and flexion angle (early or late flexion). Effects of component changes were consistent between the intraoperative and weightbearing rigs.

Interpretation: To improve patellar tracking, and clinical outcome, surgeons should focus on patellar component medialization, patellar resection angle and femoral component rotation. These have been linked with anterior knee pain as well. Neither tibial component rotation nor patellar thickness should be adjusted to improve patellar tracking.

Keywords: Total knee replacement; Total knee arthroplasty; Patellar tracking; Patella; Femur; Tibia; Kinematics; Surgical technique; Component rotation; Patellar component medialization; Patellar resection; Patellar thickness.
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Introduction

Patellar instability after total knee arthroplasty (TKA) is a serious complication that impairs functional outcome and may lead to revision surgery.

Despite advances in surgical technique and implant design, complications involving the extensor mechanism and patellofemoral joint after total knee arthroplasty (TKA) continue to be the most common cause of pain and the most common reason for revision TKA surgery.

A thorough understanding of the etiologies of patellofemoral instability, careful preoperative planning, and meticulous surgical techniques will optimize clinical outcome. Evaluation of patellofemoral stability should begin in the operating room.

Postoperatively, thorough history, physical examination, and dedicated radiographic studies should be obtained. Computed tomography scan is the most accurate and reliable way to assess component positioning.

Treatment of patellofemoral instability is directed by its etiology. Revision of one or both components is indicated if malpositioning is present. If the components are determined to be in satisfactory positions, soft tissue procedures can be pursued.

Future advancements in prosthetic design and the routine use of computer-assisted navigation systems will minimize patellofemoral instability.
AIM OF THE WORK

The aim of this study is to assess the impact of the femoral, tibial and patellar component positions on patellar tracking in total knee arthroplasty.
I. Anatomy of patellofemoral joint

**Osseous Structures:**

The main components of the patellofemoral joint are the patella and the femoral trochlea.

1. The patella:

The patella is the central component of the patellofemoral joint. It is roughly an oval bone with a rounded point inferiorly and has a transverse diameter slightly longer than the longitudinal.

The anterior surface is convex in both proximodistal and mediolateral directions. The upper two thirds receive the insertion of the quadriceps tendon and the lower third receives the insertion of the patellar tendon.

The articular surface is oval with the longest diameter in the transverse plane. The articular cartilage is the thickest in the body and can measure up to 5.5 mm especially at the median ridge.

The median ridge or crest divides the patella into medial and lateral facets. The respective sizes of the facets are variable. The medial facet is smaller and slightly convex, while the lateral facet is larger and constitutes about two third of the articular surface, has a sagittal convexity and coronal concavity. The medial facet varies from person to person, it is divided by a medial ridge into the medial facet proper and the odd facet. (fig. 1) (1)
The odd facet is purely cartilaginous and is felt to develop due to forces between the lateral aspect of the medial condyle of the femur and the medial facet and contacts the medial femoral condyle at full flexion. \(^{(1-4)}\)

Fig. 1: Patella, anterior surface and articular (posterior) surface \(^{(1)}\)

2. The femoral trochlea:

The articular portion of the anterior aspect of the distal femur constitutes the sulcus with lateral and medial facets. The sulcus continues distally with the intercondylar notch. The medial and lateral facets continue distally with the medial and lateral femoral condyles.

These facets are asymmetrical where the lateral facet is few millimeters more prominent than the medial and extends more proximally.

The articular cartilage measures approximately 2 to 3 mm in thickness. The greater height of the lateral facet and the congruence between the sulcus and the median ridge of the patella constitute the osseous stabilizer of the patellofemoral joint.
Anatomy

A ridge may be present between the trochlea and the anterior cortex of the femur and is more prominent medially. This ridge was assumed to be a cause of chondromalacia of the patella due to frequent friction with the medial patellar facet but this is refused on the basis that the patella enters the sulcus from the lateral side. (fig.2,3) (1-3)

**Fig 2:** Left femur, E from below, articulated with the patella in the extended position 1. Medial condyle 2. Lateral condyle. (2)

**Fig 3:** F from below and behind articulated with the patella in the flexed position 1. Medial condyle 2. Lateral condyle. The most medial facet of the patella only comes into contact with the medial condyle in extreme flexion. (2)
3. **Supratrochlear fossa:**

It is situated on the anterior surface of the femur immediately proximal to the trochlear facet. It is slightly depressed and triangle in shape. It is covered with patellofemoral fat pad.

At the lateral margin of the upper trochlea, there is an area marked by thickened, fibrotic synovia, which appear as fibro cartilaginous extension of the lateral facet. This is the site of contact with the patella under full forced extension.

The cartilaginous border of the lateral facet terminates subtly, which perhaps favors lateral displacement of the patella at the end of extension.¹⁻⁵

**Stability of the patellofemoral joint:**

- The stability of the patellofemoral joint is achieved through bony and soft tissue stabilizers.

  **I.** The bony stabilizer is achieved through the shape of the lateral trochlear facet and the congruency between the central ridge of the patella and the trochlear sulcus.

  **II.** The soft tissue stabilizers of the patellofemoral joint are either static or dynamic.
- **Soft tissue structures:**

1- **Quadriceps muscle (Extensor mechanism): Dynamic stabilizer**

Anatomy of the extensor mechanism consists of the tibial tubercle, the patellar tendon, the patella, the quadriceps tendon and the quadriceps muscle.

The quadriceps muscle attaches to the quadriceps tendon which attaches to the patella. At the bottom of the patella is the patellar tendon. It runs from the inferior pole of the patella to the tibial tubercle just below the front of the knee.

As the quadriceps muscle contracts, it pulls on the quadriceps tendon, the patella, the patellar tendon, the tibial tubercle and the tibia to extend the knee \(^{(6)}\) (Fig 8).

![Fig. 8: The extensor mechanism\(^{(6)}\)](image-url)
Anatomy

The quadriceps muscle is formed of four main components that join to form the quadriceps tendon. The components are monoarticular, the vastus medialis, lateralis and vastus intermedius, while the rectus femoris component is biarticular.

The quadriceps tendon is composed of three layers. The most superficial fibers of the rectus femoris run over the surface of the patella and the patellar tendon, while the deep portion inserts into the base of the patella.

The vastus medialis and the vastus lateralis join to form the middle layer and insert into the base of the patella as the middle layer. They send fibers to the corresponding retinaculae.

The vastus intermedius forms the deep layer that inserts into the base of the patella, and is the chief knee extensor muscle. (6)

The vastus medialis is composed of two parts, the vastus medialis longus, and the vastus medialis obliquus (VMO). The vastus medialis obliquus does nothing with knee extension but its fibers insert at an angle of 55-70 degrees to the longitudinal axis of the quadriceps tendon and acts to limit the lateral displacement of the patella.

The vastus lateralis approaches the patella at a more acute angle than the medialis, at an angle of 27-45 degrees. The most distal fibers are most distinct and form the vastus lateralis obliquus muscle (VLO). These fibers apply a lateral displacing force on the patella.
The entire knee joint is covered by a thick, fibrous capsule. This capsule contains a lining synovium that produces fluid to lubricate the joint and reduce friction and wear.

The muscles and ligaments must work together in a balanced fashion to maintain normal patellar motion as the knee flexes and extends. The patellar tendon is an extension of the extensor mechanism and connects the patella to the upper end of the tibia.

A fat pad located behind the patellar tendon helps to reduce friction between the patellar tendon and the tibia (fig.9).^6^

Fig. 9: Anatomical structures of the anterior aspect of the extended knee^4^
2-Patellar tendon: (static stabilizer)

The patellar tendon determines the proximodistal position of the patella in relation to the joint line (height of the patella), and limits patellar displacement proximally to less than 10mm.

It is obliquely oriented distally and laterally contributing to overall valgus alignment of the extensor mechanism. The oblique orientation is increased in patellar instability.\(^{(4)}\)

3-Lateral retinaculum: (static stabilizer)

The lateral retinaculum is composed of two layers. The superficial oblique retinaculum connects the lateral patella to iliotibial tract and is less significant. The deep portion is more important and is composed of three distinct portions.

The mid portion (the deep transverse retinaculum) runs from the deep surface of the iliotibial band to the lateral border of the patella. Superior to this is the epicondylarpatellar ligament, and inferior is the patellotibial or patellomeniscal ligament that runs from near Gerdy’s tubercle to inferolateral aspect of patella.

The lateral retinaculum passes from the lateral border of the patella and patellar ligament to the anterior aspect of the iliotibial tract, so with knee flexion, the tract is displaced posteriorly increasing the lateral pull on the patella. If the medial restraints are weak or weakened by trauma or surgery, then lateral patellar tilt or subluxation can occur.\(^{(3,6)}\)
4-Medial retinaculum: (static stabilizer)

The medial retinaculum inserts into the upper two thirds of the patellar medial border. It is composed of two main ligaments, the medial patellofemoral ligament, which inserts into the medial femoral epicondyle,

and the medial patellotibial ligament, which inserts into the medial meniscus and adjacent tibia. (3,6)
• **Vascular anatomy of the patella**

1. **Arterial supply:**

   **A-The extra-osseous arterial pattern:** \(^{(3, 7)}\)

   The patella is surrounded by a vascular anastomotic ring lying in thin layer of loose connective tissue which covers the dense fibrous rectus expansion.

   The main vessels that contribute to this anastomotic circle are:
   1. The superior genicular artery (branch of profunda femoris artery).
   2. The lateral superior genicular artery (branch of popliteal artery).
   3. The medial superior genicular artery (branch of popliteal artery).
   4. The medial inferior genicular artery (branch of popliteal artery).
   5. The medial tibial recurrent artery (branch of popliteal artery).
   6. The lateral inferior genicular artery (branch of popliteal artery).
   7. The anterior tibial recurrent artery (branch of anterior tibial artery).

   The posterior or the femoral component of the patellofemoral joint, that is, the synovium and femoral epiphyses, is supplied by two deep anastomotic systems coming from the same superior and inferior genicular arteries (fig.4)

   **B-The intraosseous arterial pattern:** \(^{(3, 7)}\)

   The intraosseous arterial pattern can be grouped into two main systems:
   1. Mid patellar vessels:
   The mid patellar vessels enter the vascular foramina situated on the middle third of the anterior surface. These foramina open at the bottom of longitudinal fissures and vary in number from ten to twelve.
2. The arteries that arise from the polar vessels which come from the infrapatellar anastomosis behind the patellar ligament.

2. **Venous drainage:**

The venous drainage follows the general prepatellar arterial framework. The two principal drainage routes consist of:

1. The popliteal vein
2. The internal saphenous vein.\(^6\)

![Anatomy of the arterial supply of the patellofemoral joint](image)