The goal of total knee arthroplasty is to relieve pain and to improve function by creating a knee with adequate range of motion as well as osseous and ligamentous stability. Axial alignment is achieved with resections of the distal femur and proximal tibia. The tibial cut, with the aid of either intramedullary or extramedullary alignment guides, is generally made perpendicular to its long axis. A perpendicular cut is preferred because it is easier to reproduce and, when performed properly, helps to recreate the mechanical axis of the limb and thus improve the clinical outcome.1–4 Axial alignment of the femur is generally made by resecting the distal femur in 5 to 7 degrees of valgus. Rotational alignment of the femur is achieved with the anterior and posterior distal femoral resections. The mechanics of the patellofemoral joint are heavily dependent on this rotational alignment. Improper rotational alignment may cause patellofemoral problems or gross changes in the foot progression angle during the gait cycle.

This chapter addresses the various methods used to achieve proper axial and rotational alignment of the femur in total knee arthroplasty. The influence of femoral alignment on patellofemoral mechanics and how it relates to achieving balanced flexion and extension gaps is also discussed. Particular attention is given to the current technique for achieving proper alignment in the revision setting.

ANATOMY

A tremendous amount of variation occurs in normal limb alignment. Static alignment is affected by height, weight, and bony morphology. Knee kinematics are influenced by the degenerative changes found in arthritic knees. The geometry of the human femur has been well described,6 and several studies examine the specific sizes and shapes of the femur.6,7

In the coronal plane, the anatomic axis is defined as a line drawn down the centers of the femur and tibia (Figure 11-1). On average, this creates an angle of 5 to 7 degrees of valgus at the knee joint. The tibiofemoral angle results from a combination of the varus tilt of the tibial plateau (3 degrees) and the valgus alignment of the femoral condyles, on average 7 degrees.8 The mechanical axis is defined as a line drawn from the center of the femoral head, through the center of the knee, and ending in the center of the ankle joint. In general, the mechanical axis lies 3 degrees off the vertical axis.

The flexion axis of rotation of the knee is thought to transect a line drawn between the medial and lateral epicondyles at the origins of the medial and collateral ligaments. This axis should lie transverse to the long axis of the tibia. At 90 degrees of flexion, the medial condyle extends 1–6 mm more posterior than the lateral condyle6 (Figure 11-2). This axis undoubtedly has wide variation, and the amount of the condyles that fall below the transepicondylar axis varies as well.

BIOMECHANICS

The lower extremity goes through 2 stages during the gait cycle. It bears weight in the stance phase and is advanced in the swing phase. Stance phase can be divided into a period of double-limb support followed by a time of single-limb support. The single-limb support segment is further divided into multiple parts: heel strike, foot flat, heel off, and toe off. The contralateral foot enters heel strike shortly after the initial foot passes through heel rise. Stance phase comprises 62% of the gait cycle while swing phase accounts for 38%.10
In stance phase of the gait cycle, the medial compartment of the knee experiences approximately 60% to 70% of the weightbearing forces in a lower extremity with 7 degrees of anatomic valgus or a neutral mechanical axis. Any perturbation in the alignment will likely lead to changes in this distribution, and even small changes may predispose the joint to degenerative arthritis. Establishing the correct axial and rotational alignment during total knee arthroplasty should serve to reproduce, as closely as possible, the normal distribution of forces seen across the knee joint during gait. This in turn should lead to an overall better clinical result and improve the survivorship of the components. It has been shown that even a 5-degree axial malalignment can change the load seen across the knee joint by up to 40%. This work was supported by the study of Ritter et al., who concluded that early failures in total knee arthroplasty were correlated with tibial varus of greater than 5 degrees. Further, Berger and Rubash, in comparing 30 patients with isolated patellofemoral complications after total knee arthroplasty to 20 patients with well-functioning total knee arthroplasties, found that patellofemoral complications were directly correlated with combined internal rotation of the femur and tibia. They noted that internal rotation of 1 to 4 degrees produced lateral tracking and patellar tilt. Patellar subluxation was seen with 3 to 8 degrees of internal rotation. As the internal rotation increased to 7 to 17 degrees, they reported patellar dislocation and early patellar component failure.

**AXIAL ALIGNMENT**

The mechanical axis of the lower extremity must be restored to neutral for a revision total knee arthroplasty to be successful. Most surgeons will perform the distal femoral resection by aligning it in 5 to 7 degrees of valgus. It is commonly believed that the tibiofemoral angle should be restored to 6 degrees (±1 to 2 degrees).