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Imaging of knee arthroplasty

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Abstract

Knee replacement surgery, either with unicompartmental or total systems, is common. The purpose of this manuscript is to review the appearance of normal knee arthroplasty and the appearances of complications such as infection, polyethylene wear, aseptic loosening and particle-induced osteolysis, patellofemoral abnormalities, axial instability, and periprosthetic and component fracture. Knowledge of the potential complications and their imaging appearances will help the radiologist in the diagnostic evaluation of the patient with a painful knee arthroplasty.

Keywords: Knee; Joint replacement; Total arthroplasty; Unicompartmental arthroplasty; Imaging; Infection; Polyethylene; Osteolysis; Malrotation

1. Introduction

The knee is second only to the hip as the most commonly replaced joint, with approximately 250,000 primary and revision arthroplasties performed each year [1]. Osteoarthritis and rheumatoid arthritis, with their associated pain, limitation of motion, and/or deformity, are the most common reasons for arthroplasty.

Unlike hip arthroplasty, in which the entire femoral head and neck are replaced, knee arthroplasty involves resurfacing of the condylar and tibial surfaces, with the surgeon taking just enough bone to allow placement of the prosthetic components. If the arthritis or other abnormal condition (such as avascular necrosis or fracture) affects only the medial or lateral compartment of the knee, a unicompartmental arthroplasty may be performed, in which only the condylar and tibial surfaces of that particular compartment are replaced. If both the medial and lateral compartment are involved, a total knee arthroplasty is performed, which may or may not involve resurfacing of the patella [2–4].

While radiographs are the requisite of any imaging evaluation, other imaging modalities such as fluoroscopy, CT, MR, nuclear scintigraphy and sonography also have roles in the evaluation of specific complications of knee arthroplasty and will be discussed with such. The purpose of this manuscript is to review the appearance of normal knee arthroplasty and the appearances of complications.

2. Normal

2.1. Total joint replacement

There is a dizzying array of total knee arthroplasty (TKA) designs available for the surgeon to implant, depending on the age and expected activity level of the patient, and on the preoperative deformity and stability of the knee. All total knee prostheses sacrifice the anterior cruciate ligament; some also sacrifice or substitute for the posterior cruciate ligament while others retain the PCL. All of these devices are considered unconstrained or partially constrained, depending on the degree of stability they provide to the knee joint. Fully constrained devices act like simple hinges and provide complete stabilization to a knee that no longer has any inherent stability, but are used in less than 5% of cases [5].

Common to all designs is a metal condylar component that is either cemented or ingrowth, and a metal tibial component

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which is usually cemented. A slab of polyethylene is attached to the metal tibial plateau and articulates with the condylar component. The attachment of the polyethylene to the tibial tray may be fixed, or may allow some motion between the polyethylene and the tray (called meniscal-bearing and mobile-platform designs) [5]. The posterior cruciate-substituting designs have a central tibial post that is located between the femoral condyles and a cross-bar across the posterior aspect of the intercondylar space, providing a cam mechanism that controls posterior tibial subluxation during flexion. The patella may be resurfaced too, consisting of a cemented polyethylene component usually without a metal backing.

The arthroplasty must be implanted in such a way as to reproduce the normal anatomic alignment of the joint and maintain proper tension and balancing of the surrounding collateral ligamentous structures. Thus, on a weight-bearing AP view of the entire lower extremity, a line drawn from the center of the femoral head to the center of the tibiotalar joint (called the mechanical axis) should intercept the middle of the knee joint, and the femoral and tibial components should be perpendicular to this line [6,7]; a line drawn along the femoral shaft (called the anatomic axis) should form an angle of approximately 5–8° with the mechanical axis, thereby creating approximately 5–8° of valgus at the knee joint [6,7] (Fig. 1). The tibial plateau should be perpendicular to the shaft of the tibia on the frontal radiograph, and should have approximately 10° of postero-inferior tilt on the lateral view. This latter orientation is accomplished either by tilting the tibial tray itself or by having the tibial polyethelene component thinner posteriorly [8]. Lack of postero-inferior tilt will block full flexion of the knee. On a lateral view, the patella should have the same height from the prosthetic polyethylene surface as is did from the native tibial plateau, and the combined anteroposterior thickness of the patella and patellar polyethylene should not exceed that of the native patella [7] in order to avoid pain due to tension stress on the extensor mechanism.

The size of the tibial component should match the size of the native plateau because component overhang may irritate the adjacent ligaments and tendons and because component undersizing leads to increased subsidence [8]. The anterior flange of a properly sized condylar component should fit flush against and be parallel to the anterior cortex of the distal femur. A condylar component that is too big may block full range of motion and leaves a gap between the flange and anterior cortex of the femur which may lead to painful lack of fixation. A condylar component that is too small may lead to instability and its anterior flange will cause notching of the anterior femoral cortex which predisposes the femoral shaft to fracture [9].

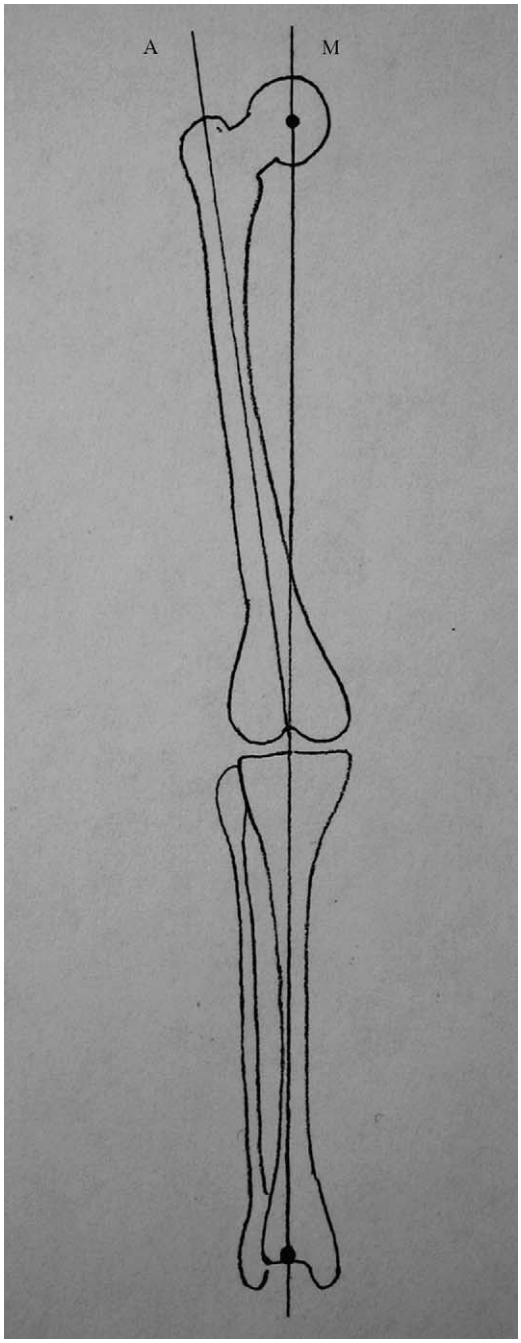

Fig. 1. Diagram showing normal axial alignment. The mechanical axis (line M) connects the center of the femoral head to the center of the tibial plafond, and should intersect the middle of the knee joint. The anatomic axis (line A) is parallel to the long axis of the femoral shaft. The angle between the mechanical axis and anatomic axis is normally 5–8°.

2.2. Unicompartmental

Unicompartmental knee arthroplasty (UKA) is most commonly performed for degenerative arthritis involving only the medial or lateral compartment, and was developed as an alternative both to high tibial osteotomy (which merely unloads the degenerated side and which makes future TKA technically more difficult) and to total knee arthroplasty (which replaces the entire knee joint even though the arthritis is unicompartmental) [10]. UKA requires the patient to have an intact anterior cruciate ligament and to have correctable knee