Radiographic Film Critique of the Lower Extremity:

Part 2: Knee

Written by Nicholas Joseph Jr. RT(R)(CT) B.S. M.S

Anatomy of the Femur and Knee

Injury to the knee is not limited to bone only, soft tissues can also be injured, and structures within the knee joint too. Soft tissue injury can manifest as swelling about the knee, inability to bear weight, loss of function such as bending or straightening of the joint, or other clinical indicators. Radiographically, soft tissue surrounding the knee must be demonstrated when imaging for trauma. Fractures that involve the upper fourth of the tibia, may or may not involve the knee joint, and may be limited to ligaments supporting the joint. Fractures that enter the knee joint often render the joint defective and the once smooth joint surface made irregular. Additionally, fractures resulting in improper limb alignment may contribute to long-term morbidity like arthritis, instability, and functional loss of motion. Consider that the knee joint is the largest weight-bearing joint of the body. For many years anatomist classified it as a simple hinge joint however, its motions are more complex occurring in several planes. Complex motions of the knee joint render the stability of the joint dependent on soft tissues (muscles and ligaments), and on the alignment of the joint surfaces that oppose each other. The proximal fibula also contributes to lateral stability of the knee joint by providing supportive attachment for the lateral collateral ligament of the knee. Ligaments within the knee joint also support the knee. These ligaments may be injured with trauma sparing bone. Therefore, it is important that
the radiographer understand the basic soft tissues of the knee and their relationships to knee stability.

The stabilizing ligaments of the knee include the medial collateral ligament (MCL) and lateral collateral ligament (LCL), and are located outside the knee joint proper; the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) are stabilizer ligaments located within the knee joint. The patellar ligament is located outside the knee joint; it also provides support for the knee by shielding it, and strengthening the actions of the quadriceps femoris muscle. Because the patella is integrated into the extensor knee apparatus it contains both passive and active elements. The patellar ligament is one of the passive elements of the knee. It originates at the apex of the patella and extends to the tibial tuberosity. The role of the patellar ligament is to limit proximal patellar ascent.

This schematic drawing of the knee in a slightly bent position demonstrates some of the soft tissue structures of the knee joint. The patella (B) is shown suspended in the tendon of the quadriceps femoris muscle (A) and attached to the tibial tuberosity by the patellar ligament (C). The articular surface of the femoral condyle (D) will articulate on the tibia through shock absorbing cushions called the meniscus. The knee joint is stabilized by internal ligaments like the anterior cruciate (E) and externally by the lateral collateral ligament (F), and other structures not labeled on this drawing.

The space between the condyles of the femur and the tibial plateaus is small. This space contains the menisci, articular cartilage, and the anterior and posterior cruciate ligaments. The bent knee drawing above is exaggerated to demonstrate these important structures within this space. The knee contains two semi-lunar C-shaped menisci composed of fibrocartilage. The two menisci lie on the tibial plateaus along the lateral peripheries of the joint. The function of the meniscus is to provide shock absorption to the knee during the stress of weight-bearing and movement. The youthful healthy meniscus is only partially supplied with blood and is stronger than older cartilage. With age the meniscus deteriorates and can easily tear. A damaged torn meniscus can seed torn pieces into the joint (meniscal fragment) causing pain, swelling, and loss of function. The reason meniscal fragments are released is that the majority of the meniscus has no blood supply and does not properly heal when damaged. Instead, deteriorated portions of the meniscus tend to tear off and enter the joint space between the bones. A surgical procedure called arthroscopic surgery may be indicated to remove some types meniscal fragments or flaps.
Other soft tissue structures that are critical to proper knee function include the medial collateral ligament (MCL), lateral collateral ligament (LCL), anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), articular cartilage, joint capsule and synovial fluid, and bursa. The collateral ligaments resist widening of the knee joint. The cruciate ligaments, which are within the knee joint proper, resist hyperflexion and hyperextension and also slight rotational movements of the knee. Articular cartilage is bathed by synovial fluid that lubricates the knee joint.

There are two collateral ligaments of the knee, the medial collateral ligament (MCL) and lateral collateral ligament (LCL). The MCL spans from the medial femoral condyle to the top of the lateral tibia (shin bone) and had multidirectional fibers on the inside of the knee joint too. The medial collateral ligament resists medial widening of the joint that would “open-up” the knee. The LCL spans from the lateral condyle of the femur to the lateral portions of the fibula. Its main function is to resist lateral widening of the knee joint.

The anterior and posterior cruciate ligaments are located within the center of the knee joint. The PCL originates in a fan-shaped fashion from the anterolateral aspect of the medial femoral condyle near the intercondylar notch. It courses posteroinferomedially to insert on the backside of the tibial plateau. It functions to reduce internal rotational movements of the knee, and to prevent the tibia from sliding backwards on the femur. In other words, the PCL prevents hyperflexion of the knee joint. The ACL arises from the posterior part of the medial surface of the lateral condyle and courses anteroinferiorly and medially to the anterior plateau just posterior to a rather prominent synovial fold. It then inserts in a fossa in front of and lateral to the anterior intercondylar eminence of the tibia. It should be noted that the ACL lies within an intra-articular compartment of the knee joint, but is extrasynovial. The functions of the anterior cruciate ligament are to resist rotational motion of the knee and prevent the femur from translating backwards on the tibia. In other words, it limits hyperflexion of the knee joint. The most common mechanism of ACL injury is internal rotation of the femur when the knee is in full extension. A damaged ACL or PCL will result in instability of the knee when the foot is planted causing the knee to give way or to buckle.

Synovial joints are found where there is extensive movement of bone on bone such as the femur and tibia of the knee. Synovial joints are also classified as diarthroses, or freely movable joints. At the point of bone articulation there is a thin covering of hyaline cartilage covering the ends of bone called articular cartilage. This cartilage is maintained in apposition by ligaments of the knee and the surrounding joint capsule. Articular cartilage of the knee is found on the articular surfaces of the femur, tibia, and underside of the patella. Articular cartilage is void of blood vessels (avascular) and depends on diffusion of nutrients from synovial fluid that bathes it. The capsule of the knee joint is a sac that encloses the joint cavity. It is perhaps better thought of as a cavity rather a simple membrane. It completely surrounds the knee joint having compartments that surround the patella and the knee joint. The capsule is firmly attached to bone and is composed of a tough fibrous outer membrane and an inner synovial membrane. It is the inner layer of the synovial membrane that produces synovial fluid that bathes structures within the knee joint proper. Four bursa are found in the knee are found near tendons to provide smoothening of motions of their muscles. Like all bursa those of the knee are also subject to inflammation (bursitis) and to inflammatory reaction from trauma.
These two drawings demonstrate the soft tissue cartilage and tendons of the internal knee joint. The lateral collateral ligament (A) is located outside of the knee joint proper. Within the knee joint is the lateral meniscus (B), and medial meniscus (F), which act as a shock absorbers for the knee joint during weight-bearing. The anterior cruciate ligament (C) and posterior cruciate ligament (D) cross in the center of the knee joint. Their functions include stabilizing the rotational motions of the knee joint and limiting hyperflexion and hyperextension of the knee.

**Plain Film Imaging of the Femur and Knee**

Now that we have discussed the anatomy of the femur and knee we should turn our attention to radiographic imaging of these structures. The knee is probably more commonly injured than any other joint in the body. It is highly susceptible to injury considering its design and ubiquity of athletic sporting. The injury dilemma is that sometimes a normal appearing radiographic examination does not exclude ligament injury. Likewise, there may be extensive soft tissue swelling that does not include clear radiographic sign of an underlying injury. Therefore, it is imperative that good radiographs are presented for diagnosis because these dilemmas exist. Proper anatomical positioning of the part and radiographic exposure criteria must always be met.

The standard radiographic views of the knee may include the anteroposterior, lateral, medial oblique, and lateral oblique. Often when only the proximal femur is the subject of interest the affected hip is requested. Likewise, when the distal femur is the subject of interest the affected knee is requested. When either the proximal or distal femur is the subject the adjacent joint must be entirely included. For example, if the proximal femur is the subject of examination, then the hip joint must be entirely included.
Positioning of the knee for the AP projection is obtained with the patient supine or erect, so that the knee is extended and the leg internally rotated. A point for point line passing through the femoral condyles placing them equidistant from the tabletop eliminates rotation. Also, the central ray should pass through the knee just inferior to the apex of the patella to demonstrate the medial and lateral compartments of the femorotibial joint space without rotation. The tibial plateau, medial and lateral intercondylar eminences, and intercondylar notch are all clearly demonstrated. The AP projection poorly demonstrates the patella superimposed on the femur; however, including the lateral and tangential views when needed makes up for this. An “open-joint” view, sometimes called the “tunnel view,” may be requested when optimum visualization of the intercondylar eminences and intercondylar notch is needed. Additional imaging procedures may be indicated following plain film imaging that may include CT and MRI of the knee. By properly limiting the field of view when imaging the femur or knee, the patient dose can be reduced, which is in keeping with the as-low-as-reasonably-achievable (ALARA) mandate.

**Diagnostic Criteria for the AP Knee Projection**

- The supine view is good for identifying fractures/dislocations. Standing views may be requested for pre-prosthetic evaluation, or to evaluate functional loss due to arthritic joint erosion.
- For the AP view the condyles of the femur are parallel to the image receptor. The CR should pass through the knee joint just below the patellar apex at an angle of about 5 degrees cephalic. The CR should enter the part parallel with the tibial plateau to demonstrate the femorotibial joint space open and the anterior and posterior margins of the tibial condyles superimposed. The fibular head is seen about 1 cm (0.5 inch) distal to the tibial plateau. On a well-positioned AP view the femorotibial joint is centered on the radiograph; it can be found about 2 cm below the palpable medial epicondyle, or at the apex of the patella.
- The AP view demonstrates about one-fourth of the distal femur and one-fourth of the proximal tibia, and all surrounding soft tissue within in a well-collimated field. When properly positioned the AP view will demonstrate the epicondyles in profile and the intercondylar eminence of the tibia centered within the intercondylar fossa of the femur. The proximal tibia will slightly superimpose the proximal fibula, and the patella seen slightly above the patellar fossa and slightly lateral to midline. When imaging a prosthetic device, such as knee prosthesis, the entire device must be seen on a single radiograph of each view. The joint space between adjacent components of the prosthesis must be demonstrated just as with bone anatomy.
- The knee can be optimally penetrated using 60-70 kVp without a grid. However, a grid should be used if the knee measures 14 or more centimeters in the AP direction. When using a grid, 70-80 kVp is recommended. Sufficient exposure will penetrate the bones of the knee with good visualize soft tissue in and around the femorotibial joint, and the patella through the distal femur.
This radiograph demonstrates the structures seen on the AP knee radiograph when properly positioned and the correct exposure technique used. Structures labeled on are: the femur (A), patella (K), lateral epicondyle (B), femorotibial joint (C), fibular head (D), fibular neck (E), tibia (F), lateral intercondylar eminence (G), medial intercondylar eminence and medial tibia plateau (H), medial femoral condyle (I), medial femoral epicondyle (J), patellar surface of femur (arrow). Notice that the femorotibial joint is open and the intercondylar eminence of the tibia is seen between the femoral condyles.

Before performing the lateral projection the technologist should evaluate the patient to determine the correct method for accomplishing this projection. The lateral projection of the knee is routinely taken with the patient in the recumbent lateral position and the x-ray beam directed vertically. When the patient history includes trauma with swelling of the knee or pain suggestive of a fracture the patient is positioned supine and the beam directed horizontal to the long axis of the femur and tibia. It is important in either case that the knee is in a true lateral with the condyles of the femur superimposed and not rotated. Proper positioning of the knee for the lateral projection is very important in order for patholgical relationships to be differentiated. For example, significant joint effusion causes the patella to be displaced anteriorly and canted inferiorly as the joint capsule distends. Joint effusion can manifest itself as a slight displacement of the patella. In order to appreciate the extent of a joint effusion the knee should be positioned in a true lateral. Equally important is using an optimal radiographic exposure technique. Good bone penetration is necessary to identify the character of fractures. Soft tissue visualization is also important in that signs of injury are often seen in these tissues. For example, a pneumohemarthrosis may show air in the joint with the right radiographic exposure. Air-fluid level follows the contour of blood within the joint due to air being lucent. Air-fluid level can be seen with the horizontal beam lateral view when present. An avulsion type fracture of the tibial spine or femoral condyles or tibial tuberosity may indicate ligamentous injury. Although most injuries of the knee are ligamentous and radiological findings absent or subtle even when present, radiographs are essential.

Keep in mind that injuries such as fracture or dislocation of the knee joint are orthopedic emergencies and require optimal radiographic imaging. Consider that anterior dislocation of the knee causes popliteal artery injury in approximately 40% of these patients. Peroneal nerve injury is seen in about one-third of patients with anterior dislocation of the knee. This is usually manifested by foot-drop or weakness on dorsiflexion of the foot, an observation that mandates performing the horizontal beam lateral knee projection. Longitudinal traction is often applied to the lower limb to reduce the dislocation. In such case it is advisable to perform the AP and lateral views in traction unless the orthopedic physician is available to remove traction during radiological imaging. So, let’s review what should be demonstrated on the lateral view of the knee and how we know when the lateral view meets...
The lateral view should include the distal one-fourth of the femur and proximal one-fourth of the tibia/fibula. All surrounding soft tissue must be entirely demonstrated. Keep in mind that joint effusion is best diagnosed when the knee is flexed no more than 20 degrees. This is because flexing the knee more than 20-degrees causes tightening of the muscles/tendons across the knee joint and patella resulting in the patella to obscure the fat pads. The anterior and posterior suprapatellar fat pads must be visualized to evaluate joint effusion. Positioning the knee in a true lateral by aligning the tibia on the same plane parallel with the tabletop is crucial. Angling the central ray 5 to 7 degrees cephalic will project the medial condyle proximally and slightly anterior in alignment with the lateral condyle. This angle is reduced for tall thin patients having a long femur. The medial condyle is further from the image receptor for the mediolateral knee projection, which causes it to be shifted more than the lateral condyle with cephalic angulation. The radiographic exposure should demonstrate good bone penetration, yet good soft tissue detail seen. The fibula should be seen through the superimposed tibia. A grid should be used if the knee measures more than 5 cm in the mediolateral plane. Close collimation to enhance detail should be applied; however, all soft tissue of the knee should be demonstrated.

### Diagnostic Criteria for the Lateral Knee Projection

- **For the lateral view the condyles are superimposed by placing the tibia on the same plane as the femur.** The condyles of the femur are placed perpendicular to the tabletop as an imaginary line is drawn through the epicondyles. The knee is flexed 20-30 degrees unless a patella fracture is suspected. Decrease the amount of knee flexion to no more than 20 degrees when joint effusion is suspected. The patellofemoral and knee joints should be seen with a space between their articulations.

- **On an accurately positioned radiograph the femorotibial joint is centered and well collimated.** All soft tissues surrounding the bones and joints must be demonstrated. If a prosthetic device is present the entire device must be seen on the lateral view. The joint spaces must be demonstrated opened as with bone anatomy.

- **Radiographic technique should allow for visualization of soft tissue structures such as blood effusion or air within the joint or its capsule.** A grid should be used for the lateral projection if the mediolateral diameter measures 5 cm or more.
This lateral view of the right knee displays optimal positioning and exposure for visualizing bone and soft tissues. The femoral condyles are superimposed as are the tibial condyles. There is no rotation of the part so that the anterior and posterior borders are superimposed. The patella is demonstrated in a true lateral with the knee slightly flexed. The exposure technique demonstrated excellent bone penetration while preserving contrast in the soft tissues. The patellar ligament is well defined as is the fluid capsule surrounding the knee.

This radiograph demonstrates the importance of radiographic exposure technique. Notice the good bone penetration throughout the distal femur and tibia. Soft tissues of the knee are demonstrated in good contrast to bone and air is seen in the joint capsule. Labeled on the radiograph on the right is the apex of the patella (A), which is distal and the tibial tuberosity on the anterior surface of the tibia (B).

Now let’s review some images of the knee for critique.
Radiograph #64

Give your critique of this AP knee radiograph taken on a patient 32 years age that presented with a clinical history of “knee pain” and no history of trauma.

Critique of Radiograph #64

This is a good AP view of the knee. The joint space of the knee is not presented opened. Because the fibular head is more than 1 cm below the tibial plateau and proper overlapped by the tibia the closed joint space is due primarily to the angle of the CR used. The correct amount of cephalic angulation is 5-7 degrees. Another cause of a closed joint is that the femur and tibia are not on the same plane. Placing a towel or sponge under the heel will extend the knee and place the leg and femur on the same plane. This is also an alternative method of positioning so that no tube angle is required.

Radiograph #65
This radiograph was taken 1 week following surgical reduction with internal fixation of the distal femur. The reason for the exam is to “evaluate bone alignment.” Does this radiograph meet the diagnostic criteria for the AP knee or distal femur projection?

**Critique of Radiograph #65**

As required by the diagnostic criteria the entire metallic internal fixation device and the distal femur are demonstrated. The condyles are nearly parallel to the film placing the knee in a relatively true AP position. However, the fibular head is completely superimposed by the tibia indicating the leg is externally (laterally) rotated. Notice that the comminuted fragments of the distal femur extend into the intercondylar notch. Therefore, demonstrating an open femorotibial joint space is essential. Because the fibular head is less than 1 cm distal to the tibial plateau it indicates the tube angle is too caudal. The radiographic exposure technique is optimal for bone and soft tissue detail. Unfortunately, this radiograph should be repeated. The CR must be parallel with the tibial plateaus so that the knee joint is open, and the leg internally rotated to reflect a true AP view.

**Radiograph #66**
This radiograph was taken for follow up on a patient 4 months post surgical fixation of a mid-shaft femur fracture. The patient’s chief complaint was chronic knee pain when walking. Does this radiograph meet the diagnostic criteria, and did the technologist use the right exposure technique for this radiograph?

Critique of Radiograph #66

This radiograph is presented so we can discuss our professional role in patient imaging. The technologist should always take a good patient history that includes asking about postoperative trauma, past surgery of the affected knee, and what is the chief complaint. These inquiries would have revealed that the purpose for imaging the knee is to determine if there are loose screws in the fixation apparatus near the knee, or inflammatory changes indicating risk for osteomyelitis, and the like. Notwithstanding, the positioning seen here is adequate. The radiographic exposure technique is adequate to evaluate soft tissue and bone. However, an optimal radiograph will demonstrate good bone detail and an especially a well-penetrated look at the fixation apparatus. Notice that motion artifact obscures visualization of the threads of the screws essential to diagnosis. Therefore, this radiograph must be repeated without motion artifact and good detail of the fixation screws.

Radiograph #67
This AP knee projection was taken on a patient who suffered severe trauma during a sporting event. Does this radiograph meet the diagnostic criteria for the AP knee projection?

Critique of Radiograph #67

This is a good radiograph that meets the diagnostic criteria. Notice that the epicondyles are profiled, the condyles near equal in size and are parallel with the tabletop. The joint space is opened and the intercondylar eminences are easily seen. The fibular head is partially obstructed by the tibia and there is good bone penetration showing the patellar shadow. The radiographic exposure technique displays good bone detail and sharp edge differentiation of cortical bone. Soft tissues of the knee are well displayed showing good contrast with bone. The midsagittal plane of the leg is straight; however, the cassette was not aligned with the long axis of the femur and tibia. Aligning the long axis of the film with the part permits easier evaluation for unilateral widening of the joint space indicative of ligamentous injury. Overall, the anatomical positioning of the knee is very good.

Radiograph #68
This patient had an open reduction with internal fixation of the distal femur 20 weeks prior to this radiograph. He now presents for upright knee radiographs to evaluate stability of the healing femur. Does this radiograph meet the diagnostic criteria for the AP knee or distal femur projection?

Critique of Radiograph #68

This is a good film in terms of positioning of the part and collimation. The radiographic technique is adequate for bone and soft tissue. Detail about the fixation and the screws in it can be seen on this radiograph. Loosening of the screws or signs of infection in the bone can also be evaluated. It bears mentioning that the entire internal fixation apparatus should be seen on both the AP and lateral views. If the fixation goes above mid-shaft, then the femur should be ordered to demonstrate the entire surgical fixation. This is a follow-up radiograph taken in the upright position to demonstrate weight-bearing and structural stability of the healing femur. This radiograph overall shows great positioning and radiographic contrast. I recommend repeating this radiographic projection to demonstrate the entire fixation. No other factors need to be changed to make this an optimal radiograph. Compare the detail seen in the fixation screws with that seen in radiograph #66.

Radiograph #69
Patient history stated "hemiarthroplasty six months ago, follow up evaluation." Does this radiograph meet the diagnostic criteria for the AP projection of the knee?

Critique of Radiograph #69

As stated, this radiograph was taken to evaluate knee joint six months post hemiarthroplasty. The entire unilateral prosthesis is entirely seen. Soft tissue shadows are also important because they can indicate a slow smoldering infection that could represent osteomyelitis. The medial joint space is opened; however, the lateral joint space is obscured. The primary cause is that the anterior and posterior cortical margins of the tibia are not superimposed (arrows). Failure to open the femorotibial joint is the reason this radiograph should be repeated. To open the joint space the CR should enter the knee perpendicular to the tibial plateaus. This will superimpose the anterior and posterior tibial condylar margins. The radiographic exposure technique shows good contrast between the prosthesis, bone, and soft tissues.

Radiograph #70
This patient's chief complaint was "that her knees always hurt." Standing bilateral AP and lateral views of the knees were ordered. Does this radiograph meet the diagnostic criteria for the AP projection?

Critique of Radiograph #70

This is a good radiograph of bilateral standing knees. This projection is often requested to evaluate joint space degeneration due to arthritic erosion. Notice each knee is positioned correctly by internally rotating the leg. Even though both knees are being radiograph together you must position each one separately to achieve this quality in your imaging. Radiographic technique is adequate for imaging both knees. Good bone penetration is seen, and the bone trabeculae as well as soft tissues are all well demonstrated on this film.

Radiograph #71
This radiograph was taken in the recovery room following hemiarthroplasty of the knee. The orthopedic surgeon specified that the brace was to remain on during imaging. Does this radiograph meet the diagnostic criteria for the AP projection?

Critique of Radiograph #71

This is a well positioned AP knee radiograph that meets the diagnostic criteria. Comparing the lateral joint space to the right hemiarthroplasty joint space will confirm accuracy of positioning. Notice the anterior and posterior condylar margins of the lateral tibia are superimposed and the lateral joint space is open. Also notice that the medial joint prosthesis is aligned along its anterior and posterior condylar borders, and the medial joint open. The intercondylar eminence is clearly seen between the femoral condyles. Superimposed anterior and posterior condylar borders, and opened femorotibial joints is the standard for imaging knee joint prosthesis. The reason this is such a great radiograph is that the CR is parallel to the tibial plateau. The radiographic technique adequately demonstrates bone and soft tissue detail.

Radiograph #72
This radiograph was taken in the recovery room following ORIF of the proximal tibia. The orthopedic surgeon specified, “Postoperative evaluation of ORIF alignment and fixation placement.” Does this radiograph meet the diagnostic criteria for the AP projection?

**Critique of Radiograph #72**

This is a post surgical radiograph in which the surgeon specified, “proximal tibia internal fixation” evaluation. When imaging post operative cases it is important to clearly understand what surgical procedure was performed. You can get some of the information you need from the radiologic technologist who operated the C-arm during the case. Certainly, knowing the length of the fixation will lessen the likelihood of repeating the radiograph, which is in keeping with ALARA. It is important to include the entire prosthesis, which is not demonstrated on this view. Therefore, this radiograph must be repeated to include the proximal tibia, entire prosthesis, and the knee joint. Radiographic exposure technique demonstrates bone, soft tissue, and metal very nicely with good contrast.

**Radiograph #73**
This AP projection was taken several months after having prosthetic knee replacement. The patient was doing fine; however, there was a complaint of mild knee weakness when walking. The orthopedic physician requested this radiograph to evaluate the prosthesis and bone for signs of infection. Does this radiograph meet the diagnostic criteria for the AP knee projection?

Critique of Radiograph #73

This radiograph does meet the diagnostic criteria for the AP knee projection. Specifically, the positioning of the knee is optimal for demonstrating the prosthesis and joint space. Notice that the femoral condyles are not rotated. This is important when demonstrating the distal femur for prosthesis evaluation. Also notice that the fibulotibial joint space is opened, and the anterior margin of the tibial prosthesis is aligned with the posterior margin. This is excellent positioning, and I might add that this is the presentation orthopedic surgeons want for the AP knee prosthesis image. The radiographic exposure is very good too. It shows good contrast between metal, bone and soft tissues, and can show infection if it exists.

Radiograph #74
This patient was brought to a local emergency room by ambulance after suffering a tremendous fall. There was high suspicion for a fracture of the knee. Does this radiograph meet the diagnostic criteria for the AP knee projection, why or why not?

Critique of Radiograph #74

This radiograph would normally be considered adequate for demonstrating the required anatomy for the knee. The proximal third of the tibia is demonstrated; however, the dilemma is that there is a fracture that extends distal to the area covered on this radiograph. It would be a bit unfair to say that the radiographer did not meet the diagnostic criteria when the positioning of the part is optimal. Notice that the joint space is opened, the tibial plateau is well demonstrated, the condyles are symmetrical, and the fibula is within 1 inch distal to the tibial plateau. So I would consider this a good radiograph. Here’s what I would recommend. Consult with the ordering physician and ask them to order the entire tibia/fibula. This pattern of injury seen is similar to a Maisonneuve fracture so the ankle too may need to be evaluated. Consulting with the ordering physician is the best option to determine the full extent of the fractured tibia. The radiographic exposure is very good showing excellent bone and soft tissue detail.

Radiograph #75
This radiograph is taken a few days post surgery to evaluate healing of this comminuted fracture aligned by internal fixation. Does this radiograph meet the diagnostic criteria for the AP knee projection, why or why not?

**Critique of Radiograph #75**

The radiographic exposure technique selected is optimal. Notice that all fragments of this comminuted fracture is well penetrated. The quality of this radiograph allows the physician to look for signs of malunion, nonunion, osteomyelitis, and early signs of infection. It is also important that the physician can evaluate all screws in the fixation device to determine if they are loosening over time. Therefore, it is without exception that the entire fixation device be demonstrated. The identification blocker obscuring part of the fixation device has resulted in this radiograph needing to be repeated. Be careful not to use a half cassette (7 X 17) when taking post-operative radiographs. Repeating a view because of poor positioning or in this case I.D. marker artifact is not in keeping with ALARA.

**Radiograph #76**
Give your critique of this knee radiograph taken in the recovery room following prosthetic knee replacement surgery. Discuss the importance of demonstrating open joints on the lateral view, and tell why this radiograph does not, or does meet the diagnostic criteria.

Critique of Radiograph #76

The sponge under the knee indicates that this is a horizontal beam lateral projection. It is noteworthy that the medial and lateral margins of the tibial prosthesis are aligned and the knee is in a true lateral position. When imaging the knee in the lateral position it is important to demonstrate an open fibulotibial and patellofemoral joints. If you do not demonstrate these joints open and the prosthesis aligned for either the AP or lateral view, then you must repeat that projection. The technologist did a great job in demonstrating these joints. The radiographic exposure technique adequately penetrates bone structures without burnout of the soft tissues. This is an excellent radiograph of the knee for post surgical prosthesis evaluation. Take a good look at this radiograph because it meets the diagnostic criteria orthopedic surgeons want for post-surgical evaluation of the lateral knee view.

Radiograph #77
This weight-bearing radiograph of the knee was taken to evaluate the femorotibial joint space as part of an evaluation for possible knee replacement surgery. Does this radiograph meet the diagnostic criteria for the lateral knee projection?

Critique of Radiograph #77

Weight-bearing views of the knee are commonly taken to evaluate the knee joint. It is important that the joint space be demonstrated on both the AP and lateral projection. This is a mediolateral projection, which should demonstrate the medial femoral condyle posterior and distal to the lateral condyle. If the patient were in a lateral recumbent the central ray would be angled 5 degrees cephalic to achieve the proper projection. However, this is an upright patient position with a horizontal beam. The femoral condyles must be aligned parallel to the floor. Keep in mind that the femoral shaft inclines medially 10-15 degrees when positioning the knee. The lesser amount of inclination is seen in those with a narrow pelvis and long femur. The patellofemoral space can be demonstrated by rolling the knee a quarter inch towards the image receptor from the true lateral position. The radiographic exposure technique seen is adequate for bone and soft tissue detail.
Discuss why this upright lateral radiograph of the knee taken to evaluate the femorotibial joint space is positioned more accurately than what is seen on radiograph #77. Does this radiograph meet the diagnostic criteria for the lateral knee projection?

Critique of Radiograph #78

This time we see a much better positioned upright knee than the one presented on radiograph #78. The patellofemoral joint is opened; the femoral condyles are nearly superimposed displaying an opened femorotibial joint. What is different is that the knee is slightly externally rotated, that is, the patella is rotated towards the image receptor about a quarter (0.25) inch to open the patellofemoral joint space. The patient is slightly off the vertical plane so that the medial condyle is aligned with the lateral femoral condyle. This is an excellently positioned patient. The radiographic exposure technique demonstrates good soft tissue detail and excellent bone penetration and detail.

Radiograph #79
Discuss why or why this radiograph does not meet the diagnostic criteria for the lateral knee projection. Consider that this is a post surgical radiograph to evaluate the new prosthesis.

**Critique of Radiograph #79**

What is good about this radiograph is that the femorotibial joint is opened and the exposure technique demonstrates good contrast and detail between bone and soft tissue structures. However, this radiograph must be repeated because it does not demonstrate an opened femoropatellar joint. The condyles of the femur are not aligned, which diminishes the value of this radiograph. Alignment is very important here and the knee must be positioned to demonstrate true anatomical relationships. Orthopedic surgeons demand that both joints of the knee be demonstrated open and that the medial and lateral edges of the femoral and tibial prosthesis be aligned and superimposed.

**Radiograph #80**
This radiograph was taken on a patient who complained of excruciating pain related to a sports injury. The technologist put a sponge under the knee and took a horizontal beam lateral to reduce the risk of injuring the knee. Does this radiograph meet the diagnostic criteria for the lateral knee projection?

Critique of Radiograph #80

This radiograph does meet the diagnostic standards for the lateral knee. The sponge shadow under the knee indicates this is a horizontal beam lateral. There is minimal rotation of the femoral condyles; however, the patella slightly superimposes the patellar surface of the femur. This results in the suprapatellar fat pads being obscured. This positioning error must be corrected and this radiograph repeated. Decreasing the cephalic angle to about 5 degrees caudal will open the patellofemoral joint. The medial femoral condyle is anterior and slightly proximal to the lateral condyle, and the fibula is not free of the tibia. A slight rotation of the knee away from the image receptor will better superimpose the femoral condyles. The radiographic exposure technique demonstrates good bone and soft tissue detail.

Radiograph #81
This patient presents to the radiology department with a clinical history of distal femur fracture s/p 26 weeks prior, now with chronic pain on weight bearing. The orthopedic surgeon requested, "knee and distal femur AP and lateral views upright." Does this radiograph meet the diagnostic criteria for the AP knee or distal femur projection?

**Critique of Radiograph #81**

This standing lateral knee radiograph shows the entire internal fixation, distal femur, and the knee joint. The positioning is excellent in that the femoral condyles are nearly superimposed. The patellofemoral joint space is not projected opened, which commonly happens when positioning the upright patient. Getting the femoral condyles superimposed and the patellofemoral joint space opened can be challenging, especially when the extremity is imaged in the upright position. To open the patellofemoral joint and knee joint one must superimpose the femoral condyles and get them parallel with the floor. Since the x-ray beam is horizontal for the upright projection you must align the femur and tibia with each other and parallel with the image receptor. Also, flexing the knee more than 20 degrees brings the patella closer to the patellar surface of the femur projecting the patellofemoral joint space closed.

**Radiograph #82**
Critique of Radiograph #82

Patient positioning is good as the femoral condyles are superimposed, and both the patellofemoral and knee joints are opened. The space between the femur and tibial prosthetic articulations are opened, which must be demonstrated on both the AP and lateral views of the knee. The exposure technique is superbly demonstrates a delicate balance between bone penetration, and soft tissue detail. This is a very good radiograph, and I might mention that it was taken as a crosstable lateral projection.
Give your critique of this radiograph taken of a patient presenting to the emergency room with a history of hard fall, swollen painful knee, and a history of knee replacement surgery 9 months prior to this injury?

Critique of Radiograph #83

The knee is properly positioned for this radiograph. The entire prosthesis is demonstrated and there is good contrast between bone and soft tissue. The physician wanted to evaluate the bone and joint for fracture or displacement of the prosthesis. This radiograph adequately answers these concerns. The technologist elected to take the image as a horizontal beam lateral so comparisons could be made with films taken months earlier. The image shows no disruptions of the joint spaces, or dislocation. Being able to make radiographs of this quality using a horizontal beam is truly an art. The visualization of soft tissue and bone are balanced nicely on this radiograph. Notice there is no air in the joint, and the soft tissue detail shows the architecture of the artificial meniscus in the joint space. This is truly an A+ film.

Radiograph #84
This patient presented to the emergency with trauma related knee pain. Does this recumbent mediolateral projection meet the diagnostic criteria?

**Critique of Radiograph #84**

This is a fairly good radiograph that by most standards would not be repeated. It gets an “A” for radiographic exposure technique. Good bone penetration, bone detail and soft tissue are displayed. What is good about the positioning seen here is that the anterior and posterior suprapatellar fat pads are demonstrated. Also the knee is not flexed more than 20 degrees. Demonstrating the suprapatellar fat pads and the knee in slight flexion enables the radiologist to accurately diagnose joint effusion. To correct the projection of the medial femoral condyle, which is seen posterior the lateral condyle, simply rotate the patella 0.25 inch closer to the cassette.

**Summary: AP and Lateral knee Views**

- For the AP view the condyles of the femur are parallel to the image receptor:
  1. CR should pass through the knee joint just below the patellar apex. On a well positioned AP view the femorotibial joint is centered on the radiograph; it can be found about 2 cm below the palpable medial epicondyle, or at the apex of the patella.
2. At least ¼ of the distal femur and ¼ of the proximal tibia and all surrounding soft tissues should be included on the radiograph. The medial and lateral epicondyles profiled, and the intercondylar eminences of the tibia demonstrated in an opened femorotibial joint.

3. Supine view is good for identifying fractures/dislocations. Standing views may be requested for pre-prosthetic evaluation, or to evaluate functional loss due to arthritic joint erosion.

- For the mediolateral view the condyles must be superimposed. This is accomplished by placing the tibia on the same plane as the femur, and the femoral condyles perpendicular to the image receptor:
  1. Knee is flexed no more than 30 degrees unless a patella fracture is suspected. The patellofemoral and knee joint spaces should be demonstrated with their articulations opened. Decrease the amount of knee flexion to no more than 20 degrees when joint effusion is suspected.
  2. On an accurately positioned radiograph the femorotibial joint is centered and well collimated. All soft tissues surrounding the bones and joints must be demonstrated. Both the femorotibial and patellofemoral joint spaces are projected opened.
  3. Radiographic technique should demonstrate good bone penetration; good bone detail, and allow for visualization of blood effusion or air soft tissues or joint capsule.

- When imaging a prosthetic device, such as knee prosthesis, the entire device must be seen on a single radiograph of each view. The joint space between adjacent components of the prosthesis must be demonstrated just as with bone anatomy.

**Diagnostic Criteria Medial and Lateral Oblique Projections**

There are three additional views of the knee commonly requested along with the AP and lateral views. These are the medial and/or lateral oblique, tunnel (Holmbald), and the sunrise (Merchant) projections.

**Diagnostic Criteria for the Medial and Lateral Oblique Projections**

- For the medial or lateral oblique projections of the knee the condyles of the femur are rotated to a position of 45 degrees with the tabletop. When rotated too much the condyles will show slight superimposition. An over rotated lateral projection will show superimposition of the femoral condyles and the fibular head slightly free or along the posterior edge of the tibia.
- When properly positioned the oblique view demonstrates the femorotibial joint space opened, the anterior and posterior margins of the tibial condyles superimposed, and the fibular head slightly below the level of the tibial plateau.
- The medial oblique should demonstrate the fibular head without superimposition on the tibia. The lateral condyle is seen in profile with a portion of the joint space
distal to it opened.

- The lateral oblique should demonstrate the fibula and tibia superimposed, and the medial condyle profiled.

This medial oblique (MO) of the knee demonstrates the proper positioning of the knee. Notice that the femorotibial joint is opened, the intercondylar eminences clearly seen, and the superior surfaces of the tibia are seen without superimposition by the distal femur. The patella is partially free of the femur, but mostly seen through the femur. The fibula head is demonstrated free of the tibia and the lateral femoral condyle seen in profile. Structures that are labeled are: distal femur (A), lateral femoral condyle (B), lateral femorotibial joint (C), neck of fibula (D), patella (E), medial femoral condyle (F), medial tibial plateau (G), and proximal tibia (H).
This lateral oblique (LO) of the knee demonstrates the proper positioning of the knee. Notice that the femorotibial joint is opened, the intercondylar eminences clearly seen, and the superior surfaces of the tibia are seen without superimposition by the distal femur. The patella is partially free of the femur, but mostly seen through the femur. The fibula head is demonstrated free of the tibia and the medial femoral condyle seen in profile. Some labeled structures are: medial femoral condyle (A), medial tibial condyle (B), proximal tibia (C), patella seen through femur (D), and lateral tibial condyle (E). The arrow points to the closed epiphysis that is barely seen as a thin line through the proximal tibia.

**Diagnostic Criteria for the Holmbald Projection**

The purpose of the Holmbald (tunnel) projection is to demonstrate the medial, lateral, and proximal portions of the intercondylar fossa. The tunnel view specifically demonstrates the posterior femoral condyles, intercondylar eminence, and plateau of the tibia. There are several named methods of demonstrating these structures, for example, the Holmbald method, Camp Coventry method, and the AP axial projection, which is used when trauma or fracture is suspected. I would suggest you review these projections, which can be found in any standard radiographic technology textbook such as “Radiographic Positioning and Related Anatomy by Kenneth Bontrager.”

The importance of the tunnel view for evaluating osteoarthritis is well documented. Diminution of the femorotibial joint space typically affects the medial joint more than the lateral joint. Routine knee radiographs (AP and lateral views only) are limited in assessing the degree of cartilage destruction. The tunnel view, especially weight bearing, better demonstrates severe interosseous joint space loss or obliteration of the joint space. This is because the tunnel view better demonstrates the posterior portion of the condyles and congruity of the articular surfaces. Furthermore, joint alignment is maintained by muscle action during weight bearing, which furthers aids in unilateral joint compartment evaluation. Because the joint space is well defined by the tunnel view intra-articular loose bodies are clearly seen, for example bony avulsion characteristic of a cruciate ligament tear.
Diagnostic Criteria for the Holmbald Projection

- When properly positioned the Tunnel view should demonstrate the femoral and tibial condyles, the eipcondyles of the femur in profiled, and the intercondylar eminences within an opened femorotibial joint. The patella should not be projected inferiorly so that it obstructs the femorotibial joint space.
- Optimum exposure should visualize soft tissues surrounding the knee joint and within the knee joint. The patella is visualized through a well-penetrated distal femur, and trabecular markings of the femoral condyles and proximal tibia are clearly demonstrated.

This radiograph demonstrates the anatomy seen on a properly positioned PA/AP axial projection (Holmbald Method). The purpose for this view is to demonstrate the intercondylar notch and intercondylar eminences in profile. Demonstrated and labeled are: (A) lateral epicondyle (A), lateral femoral condyle (B), intercondylar eminence (C), medial femorotibial joint space (white arrow, and intercondylar notch (yellow arrow).
These two radiographs of the tunnel view demonstrate standing views (left) and recumbent view (right). Notice that the recumbent view demonstrates the intercondylar notch (arrow) better because the femur makes a 70-degree angle with the tibia. The upright view is made with the knee bent approximately 45 degrees.

**Diagnostic Criteria for the Merchant Projection**

Fractures of the patella often occur as a result of direct blow or by indirect forces transmitted by strong forced contraction of the quadriceps tendon. Most fractures of the patella are transverse; however, about 30% are comminuted and about 15% are vertical. Generally an AP and lateral view is needed at 90-degrees to each other are to evaluate a fracture or dislocation. Often the patella is poorly demonstrated on the AP view because it is seen through a superimposed femur. When visualization of the patella is of concern the axial patella projection is requested. This view demonstrates the shape of the patella in its articulation with the trochlear groove and the femoral condyles. Sometimes the axial view is taken at various degrees of knee flexion, for example, 30, 45, and 90 degrees to assess patellar travel, angle of congruity, trochlear angle, and the patellofemoral angle. Therefore, it is important that we review the diagnostic criteria for the Merchant view since this projection is commonly requested. Keep in mind that there are many names for the Merchant view, for example, sunrise, Hougston, and others. You should refer to an atlas of radiographic positions for specifics of these views.

**Diagnostic Criteria for the Merchant Projection**

- The Merchant projection is taken to demonstrate the patellofemoral joint, subluxation, and difficult to see vertical fracture of the patella. There are as many methods of taking this projection, as there are names for it. A dislocated patella
will be demonstrated laterally on the Merchant projection. The intercondylar sulci (trochlear groove) must remain positioned superiorly in order to distinguish patellar dislocation from a rotated knee projection.

- The Merchant view is used to accurately demonstrate the relationship of the patella to the patellar surface of the femur. This is a preferred projection to demonstrate dislocation of the patella and an open femoropatellar joint space. Often poor positioning can make this view ambiguous. A properly positioned Merchant projection will demonstrate the anterior femoral condyles and intercondylar sulci superiorly, and the lateral femoral condyle is often projected slightly higher than the medial condyle.

- Key point! Acute flexion of the knee should not be performed until a fractured patella has been ruled out by other projections, such as the lateral knee view.

This lateral view of the knee shows an acute patella fracture (arrow). Before positioning the knee in extreme flexion to demonstrate the open patellofemoral joint be sure a fracture of the patella is not present. When performing the axial view of the patella various degree angles of knee flexion can be used to achieve the proper view. Various degrees of knee flexion is sometimes requested when making the sunrise view to assess patellar travel, angle of congruity, trochlear angle, and the patellofemoral angle.
The labeled parts of the Merchant view are the: patella (A), patellofemoral joint (B), lateral femoral condyle (C), medial femoral condyle (D), and the intercondylar sulci (arrows) along the patellar surface of the femur.

These two radiographs demonstrate proper positioning and anatomy to be demonstrated on the axial view of the patella. The radiograph on the left demonstrates bilateral patellae. Each patellofemoral joint is open and with the patella properly aligned over the intercondylar sulcus. On the right the axial view demonstrated the patellofemoral joint following total knee replacement. Notice the positioning of the knee in this view also demonstrates an open patellofemoral joint and the patella in profile. An asterisk marks the lead apron used to protect the gonads when the tube is angled cephalic.

Radiograph #85
This radiograph was taken on a patient who suffered a hyperflexion knee injury. State what ligament of the knee resists hyperflexion, and give reasons for why this radiograph does or does not meet the diagnostic criteria for the medial knee view.

Critique of Radiograph #85

The positioning seen here is adequate, but is not optimal. The patella is projected almost free of the femur, whereas it should be superimposed on the femur. When over rotated the femoral condyles become superimposed approaching a lateral position. We can see the femorotibial joint space and intercondylar eminence. The joint space between the head of the fibula and the inferior surface of the lateral condyle of the tibia is also projected free of superimposition. A good radiograph exposure technique has been selected as it shows good bone and soft tissue detail. The knee is well-penetrated allowing for visualization of the bony architecture. Incidentally, the anterior cruciate ligament is responsible for resisting hyperflexion of the knee joint.

Radiograph #86
Does this medial oblique knee radiograph meet the diagnostic criteria? History for the exam is “chronic knee pain; evaluate for chronic osteoarthritis.”

Critique of Radiograph #86

When a history of osteoarthritis is given it is especially important to demonstrate an open femorotibial joint space. Sometimes there is no joint space due to pathological erosion of the joint. However, in this example erosion is not excessive and the joint space should have been demonstrated. Sometimes pain makes it more difficult to achieve proper rotation and flexion of the knee. Aligning the femur and tibia on the same plane can open the joint. Place a sponge or towel under the leg to get the femur and tibia on the same plane. This will also help manage pain while rotating the lower extremity. If the knee is still slightly flexed, angle the tube 5 degrees cephalic so the CR enters the knee parallel to the tibial plateau. The radiographic exposure technique is adequate for bone and soft tissue detail. Air in medial joint compartment is seen, which could indicate acute injury. Repeat this radiograph taking measures to open the medial and lateral joint space.

Radiograph #87
This patient complained of knee pain following a fall. Being an elder woman the physician was highly suspect for knee fracture. The AP, lateral, and medial oblique views were taken. Does this medial oblique view meet the diagnostic criteria?

Critique of Radiograph #87

Demonstrating an opened femorotibial joint, the tibial plateaus, and the intercondylar eminence is required. This is sometimes difficult because the knee is either excessively rotated or is slightly flexed. Clearly, the femoral condyles are projected onto the tibial condyles causing the femorotibial joint to appear closed. Sometimes placing a rolled towel under the ankle will reduce knee flexion and place the femur and tibia on the same plane. Or, you may wish to use a slight cephalic tube angle. The key point is that the central ray must be perpendicular to the tibia, and parallel to the tibial plateaus to project the joint space opened. The amount of internal rotation should be no greater than 45 degrees so that the patella is not projected free of the femur. The radiographic exposure technique is adequate for bone and soft tissue detail. Always support the knee so motion artifact does not degrade image detail.

Radiograph #88
This medial oblique knee radiograph was taken for trauma as part of a three projection series (AP, lateral, and oblique). Does this radiograph meet the diagnostic criteria for the medial oblique knee projection?

**Critique of Radiograph #88**

This radiograph demonstrates the required anatomy for evaluation of the knee in the medial oblique position. The fibular head is projected free of the tibia and the patella only slightly free of the femur. The joint space is not fully appreciated; however, it is not poorly presented. Keep in mind that the joint space must be demonstrated opened. This is the problematic criterion for the oblique knee radiograph. When the CR is parallel to the tibial plateau the joint space will be open. Paying close attention to the angle of the CR is key to getting this view right. The radiographic exposure technique shows good penetration of the femur and tibia. The surrounding soft tissues are well demonstrated. This radiograph should only be repeated if the joint space is not demonstrated on the AP and lateral view. This is a pediatric patient (epiphyseal plates are seen) so practice ALARA in deciding whether or not to repeat this view.

**Radiograph #89**
Does this radiograph meet the diagnostic criteria for the oblique knee projection? Tell what should be done to correct it if it does not.

Critique of Radiograph #89

The reason this radiograph does not meet the diagnostic criteria is that the femorotibial joint space is only partially opened, and the intercondylar eminences are not projected free of superimposition within the joint space. The fibular head is shown in profile and completely free of the tibia. Notice the femoral condyles are partially superimposed obscuring part of the lateral condyle. The patella is nearly free of the femur indicating the knee is rotated more than 45 degrees. To correct these positioning errors be sure that an imaginary line through the femoral condyles is no more than 45 degrees with the tabletop. You can feel the medial edge of the patella to make sure that it is not rotated beyond the medial edge of the femur. What is good about this radiographic is the exposure shows good bone penetration and soft tissue detail. This radiograph should be repeated correcting the positioning concerns stated.

Radiograph #90
There was a question about a subtle fracture involving the intercondylar eminence and tibial plateau. Does this radiograph meet the diagnostic criteria for the Holmblad (tunnel) view?

Critique of Radiograph #90

The purpose for the Holmblad projection is to demonstrate the intercondylar fossa in profile, the femoral and tibial condyles, intercondylar eminence, and articular facets of the femur and tibia. All of these structures are anatomically demonstrated on this radiograph. The femorotibial joint space open, and the intercondylar fossa is free of superimposition by the patella. There is symmetry in the appearance of the distal posterior femoral condyles and the fibula is properly aligned with the tibia. This radiograph does not meet the diagnostic criterion for exposure technique. A proper exposure will demonstrate the patella through a well-penetrated femur. This is a high contrast image, which is displays poor detail in the distal femur. Increase the kVp and decrease the mAs to demonstrate better bone detail in the distal femur when repeating this projection.

Radiograph #91
The AP, lateral, and medial oblique views of the knee did not adequately demonstrate the intercondylar eminences and tibial plateau. It was requested that the technologist take a “tunnel projection” to demonstrate the area of interest. This radiograph was taken with the patient supine and CR directed AP. Does this radiograph meet the diagnostic criteria for the Holmblad method?

**Critique of Radiograph #91**

The AP projection is a modification of the standard Holmblad view, which is taken with the patient prone. This projection is preferred when a fracture of the distal femur or proximal tibia is suspected. There will usually be mild distortion the anatomy unless the proper tube angle is used. The problem with demonstrating the intercondylar fossa with the AP projection is distortion due to improper tube angle or cassette placement. Increased part-cassette distance is the usual cause for increased distortion. This radiograph shows distortion of the tibia and a closed femorotibial joint. CR is not perpendicular to the tibia evidenced by the femoral and tibial condyles overlapping. To open the joint space the CR must enter the knee perpendicular to the tibia. This assures the CR is parallel to the tibial plateau when the knee is bent 40 to 45 degrees. Motion artifact has also contributed to loss of subject detail. Use sandbags or tape to immobilize the leg. As for radiographic exposure, there appears to be good bone penetration as the patella is seen through the femur. This radiograph should be repeated.

**Radiograph #92**
Critique of Radiograph #92

The tangential view used to demonstrate the intercondylar sulcus of the femur, an opened patellofemoral joint, and show clearly defined bony margins of the condyles and patella. Therefore, proper positioning is especially important because this view can demonstrate subluxation or a subtle vertical patellar fracture. The diagnostic criteria for the sunrise view have been achieved on this radiograph. The exposure technique displays good bone and soft tissue detail. The clothing artifact seen does not obstruct the image in a way that necessitates repeating the radiograph. However, you should be aware that when clothing is worn it is possible to have artifacts on the image. Rolling up the pant leg can also obscure the diagnosis of a joint effusion. So have the patient slip the leg out of clothing when the material is questionable for artifact.

Radiograph #93

Does this radiograph meet the diagnostic criteria for the tangential (skyline/sunrise) projection of the knee? In your critique state the purpose for the tangential projection.
Consider these two radiographs of the patellofemoral joint taken on the same individual. Give the name of this projection and discuss in your critique the reason for the two projections.

**Critique of Radiograph #93**

These radiographic projections are commonly called the Hughston views. Orthopedic surgeons prior to total knee prosthetic replacement surgery often request them. What is of interest is the relationship of the patella and patellar surface of the femur during flexion of the knee joint. The top radiograph is at 60 degrees flexion and the lower radiograph is taken at 20 degrees knee flexion. Sometimes the 20-degree view may not present an opened joint space due to the patient’s condition. In this case the joint space is opened on both views. The exposure technique is adequate for bone and soft tissue detail. Again, clothing artifacts are seen on both view and may simulate degenerative changes. So always remove the clothing when taking this projection.

**Radiograph #94**
This patient fell on an unknown object, now presents with "a feeling that there is something like glass under the skin. Clinical examination indicated a small puncture just below the patella. The technologist marked this area with a pointer that is seen in the radiograph. Does this radiograph meet the diagnostic criteria for the lateral patella view?

Critique of Radiograph #94

This image was intentionally collimated to the area of interest. A pen was used to mark the location of the puncture wound. Keep in mind that the patient did report a traumatic event in which a foreign body is felt below the skin. Therefore, the entire knee must be demonstrated; this radiograph does not meet the diagnostic criteria for the lateral view. Another reason this radiograph should be repeated is because the exposure technique displays high contrast. As a result, the bony architecture of the knee cannot be evaluated. Choosing an exposure that demonstrates bone and soft tissue is preferred over one that demonstrates just soft tissue. A subtle fracture must be ruled out since the clinical history revealed trauma. Repeating this radiograph to include the entire knee using a low contrast exposure technique is required. Good contrast between bone and soft tissue can be achieved by increasing the kVp to penetrate the bone. Increasing the kVp will also add more densities to the radiograph, which favors soft tissue detail.

Radiograph #95
Consider this radiograph of the patella taken as part of a three view knee series. The patient fell injuring the anterior portion of the knee. Chief complaint, “pain X 2 days and difficulty flexing the knee.” Does this radiograph meet the diagnostic criteria, state why or why not?

**Critique of Radiograph #95**

There is good positioning of the part for this projection; however, significant motion artifact is present. The patellofemoral joint space is open and the patella is properly profiled above the intercondylar sulcus. The anterior femoral condyle is symmetrically aligned. The lateral femoral condyle is demonstrated slightly higher than the medial condyle, which indicates the knee is not rotated. The main reason this radiograph should be repeated is that motion artifact has obliterated the bone trabecular pattern. This could cause a subtle fracture to be missed. Never accept a radiograph of this poor quality as some technologists may be fooled into believing the amount of motion artifact is acceptable. To reduce motion you can use the 50/15 rule to decrease the mAs and increase the kVp. Then, adjust the exposure technique by increasing the mA so that the exposure time is further reduced. This will eliminate motion that is seen here without changing the overall radiographic contrast.

**Radiograph #96**
This radiograph was taken to evaluate the patellofemoral joint space. Does this radiograph meet the diagnostic criteria, why or why not? If you say it does not, then tell what should be done to correct the errors seen on the radiograph.

Critique of Radiograph #96

The knee is properly bent evidenced by the tibia seen through the femur not obscuring the joint space. The reason this radiograph should be repeated is that the patellofemoral joint is projected closed. An alternative point of view is that the patella is dislocated superiorly causing the joint space to appear closed. In this case the joint space is not properly opened due to improper tube angle. The degree of tube angle is dependent on the amount of flexion at the knee joint. To project the patellofemoral joint open the CR must enter the knee tangential to the joint. Clearly the inferior and superior margins of the tibial condyles are not superimposed. The radiographic exposure technique is adequate for this view. The femur, tibia and patella are well penetrated. The reason this radiograph should be repeated is to demonstrate an open patellofemoral joint space. Adjustment of the tube angle is required if the position of the knee is unchanged.

Radiograph #97
This radiograph was rejected by the radiologist. Give reason(s) why this radiograph should have been repeated.

**Critique of Radiograph #97**

Unfortunately this radiograph reached the radiologist for evaluation. There is nothing about this radiograph that is diagnostic. The exposure displays poor penetration of the femoral condyles and patella. No information can be gleaned from it because bone detail is lacking. It is not even possible to comment on positioning because the image quality is so poor. It is worth mentioning that the technologist thought there was enough information about the patella to rule out a fracture and therefore passed this radiograph. The diagnostic criteria clearly states that the following structures must be seen: the patellofemoral joint, the anterior femoral condyles and intercondylar sulci superiorly, and the lateral and medial femoral condyles. This radiograph should be repeated using higher kVp to penetrate the part and demonstration of the required anatomy for the sunrise view.

**Radiograph #98**
Critique of Radiograph #98

This is a well positioned radiograph that correctly demonstrates the patellofemoral joint opened and the intercondylar sulcus and patella relationship. The anterior femoral condyles are properly aligned and the tibia well below the intercondylar sulcus. The radiographic exposure shows slight underpenetration of the part. There is also a slight bit of motion artifact present. The motion artifact appears to be caused by the patient holding the cassette. This commonly occurs with the sunrise projection because there is a gap between the part and the cassette. It is recommended that a high mA and short exposure time be used when performing the sunrise view. Also a radiolucent sponge can be used to support the cassette. Because subject detail is not degraded we can apply the principle of ALARA by not repeating this radiograph. Overall, this is an acceptable radiograph that meets the diagnostic criteria.
This patient’s chief complaint was knee pain over the patella. The clinical history included fixation of a distal femoral fracture some six months earlier. The orthopedist requested a sunrise view along with the AP and lateral projections. Does this radiograph meet the diagnostic criteria for the sunrise view?

Critique of Radiograph #99

Because the patellofemoral joint space is not open this radiograph does not meet the diagnostic criteria for the sunrise view. The knee is properly flexed and aligned with the cassette. It appears that the tube angle is not angled properly. When properly aligned, the CR should enter the knee just below the patella parallel to the patellofemoral joint. Another option is to decrease the amount of flexion of the knee so that the combined angle of the tube and knee is about 105 degrees. This too will open the patellofemoral joint space without projecting the tibia onto the femur. The radiograph shows good penetration of the femur and patella. The trabecular pattern of the distal femur is well demonstrated as well as clear cortical bone margins. This radiograph should be repeated to open the patellofemoral joint.

Radiograph #100
This radiograph is included to show the relationship of the popliteal artery to the knee. Dislocation of the knee and or crush fractures cause popliteal artery injury in approximately 40% of these patients. Usually the pulse below the site is weak, but may return to full strength following reduction. The purpose of this radiograph is to remind you that proper handling of knee fractures is a must. While the popliteal artery is demonstrated on this angiogram radiograph, it should be noted that the femoral nerve runs closely parallel with the artery and is at risk from injury.

**Summary of Critiques: Obliques, Holmbald, and Merchant Views of the Knee**

- For the medial or lateral oblique projections of the knee the condyles of the femur are rotated internally or externally 45 degrees. When rotated too much the condyles will show slight superimposition. An over rotated lateral projection will show superimposition of the femoral condyles and the fibular head slightly free or along the posterior edge of the tibia.
- Most anatomical relationships seen on the AP projection apply to the obliques. For example, when properly positioned the oblique demonstrates the femorotibial joint opened, the anterior and posterior margins of the tibial condyles superimposed, and the fibular head slightly below the level of the tibial plateau.
- The medial oblique should demonstrate the fibular head without superimposition on the tibia. The lateral condyle is seen in profile with the portion of the joint space distal to it opened.
- The lateral oblique should demonstrate the fibula and tibia superimposed, the medial condyle profiled, and the joint space distal to it opened.
- The Holmbald projection should demonstrate the relationship of the femoral and tibial condyles, the eipcondyles of the femur are profiled, and the intercondylar eminences within an opened femorotibial joint displayed. The patella should not be seen obscuring any portion of the femorotibial joint space. Optimum exposure should visualize soft tissues surrounding the knee joint and within the knee joint. The patella is visualized through a well-penetrated distal femur, and trabecular markings of the femoral condyles and proximal tibia clearly demonstrated.
- The Merchant or sunrise projection is made to accurately demonstrate the relationship of the patella and patellar surface of the femur. This view allows for accurate diagnosis of a patella dislocation, or a vertical fracture of the patella. It is mandatory that an open femoropatellar joint space be demonstrated. Often poor positioning can make this view ambiguous. A properly positioned Merchant projection will demonstrated the anterior femoral condyles and intercondylar sulci, an opened patellofemoral joint space, and the
lateral femoral condyle is often projected slightly higher than the medial condyle.

**Summary Points**

- Annually more than 352,000 hip fractures occur in the United States. Women over the age of 50 years are 2 to 3 times more likely to suffer hip fractures than men.
- The hip joint is a diarthroses, or synovial joint. It is normally capable of flexion, extension, abduction, adduction, circumduction, and internal and external rotation.
- The knee is composed of four bones, the femur, tibia, fibula, and patella. The knee joint is a hinge-type joint, which is capable of flexion and extension motions. Flexion and extension are not the only motions of the knee, in the last 50 years it has been discovered that the knee performs slight rotational movement.
- The patella is a sesamoid bone developed within the tendon of the quadriceps femoris tendon. The two primary functions of the patella are to strengthen the tendon of the quadriceps femoris muscle, and to protect the knee joint.
- The proximal tibia has two concave surfaces, the medial and lateral condyles, which articulate with the femoral condyles. Between the condyles is an upward projection called the intercondylar eminence.
- The stabilizing ligaments of the knee include the medial collateral ligament (MCL) and lateral collateral ligament (LCL), and are located outside the knee joint proper; the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) are stabilizer ligaments located within the knee joint. The patellar ligament is located outside the knee joint; it also provides support for the knee by shielding it, and strengthening the actions of the quadriceps femoris muscle.
- The knee contains two semi-lunar C-shaped menisci composed of fibrocartilage. The two menisci lie on the tibial plateaus along the lateral peripheries of the joint. The function of the meniscus is to provide shock absorption to the knee during the stress of weight bearing and movement.
- The functions of the anterior cruciate ligament are to resist rotational motion of the knee and prevent the femur from translating backwards on the tibia. In other words, it limits hyperextension of the knee joint. The most common mechanism of ACL injury is internal rotation of the femur when the knee is in full extension.
- The PCL functions to reduce internal rotational movements of the knee, and to prevent the tibia from sliding backwards on the femur. In other words, the PCL prevents hyperflexion of the knee joint.
- The CR should enter the part parallel with the tibial plateau. A well positioned AP view of the knee will demonstrate the femorotibial joint space open, the anterior and posterior margins of the tibial condyles superimposed, the proximal tibia slightly superimposes the proximal fibula, and the patella is seen above the patellar fossa and slightly lateral to midline.
- The knee lateral view should include the distal one-fourth of the femur and proximal one-forth of the tibia/fibula. All surrounding soft tissue must be entirely demonstrated. Keep in mind that joint effusion is best diagnosed when the knee is flexed no more than
20 degrees. This is because flexing the knee more than 20-degrees causes tightening of the muscles/tendons across the knee joint and patella resulting in the patella to obscure the fat pads. The anterior and posterior suprapatellar fat pads must be visualized to evaluate joint effusion.

- The tunnel (Holmbald) view should demonstrate the femoral and tibial condyles, the eipcondyles of the femur in profiled, and the intercondylar eminences within an opened femorotibial joint. The patella should not be projected inferiorly so that it obstructs the femorotibial joint space.

- The Merchant view is used to accurately demonstrate the relationship of the patella to the patellar surface of the femur. This is a preferred projection to demonstrate dislocation of the patella and an open femoropatellar joint space.

- When imaging the entire leg making use of the anode-heel-effect places the concentrated part of the divergent beam over the proximal tibia. This will provide uniform density over the thick and thin parts of the leg. To take advantage of the heel effect the cathode is positioned over the knee and the anode over the ankle.

- A request for the leg is made the entire tibia/fibula including both the knee and ankle joints should be made. If it cannot be included as a single film then two films with overlapping parts should be made.

- When imaging an extremely long bone it is acceptable to split the view into two images placed on a single radiograph. When doing so be sure that 1) the required anatomy shows overlap on the projection, 2) that scatter does not fog adjacent images, and 3) that no part of the images are superimposed. Using a lead blocker to cover each side of the cassette is recommended.

- When imaging a prosthetic implant the entire fixation must be demonstrated on a single view. Failure to demonstrate bone proximal and distal to the fixation hardware is reason to repeat a radiograph.

- A properly positioned lateral leg radiograph will demonstrate the entire tibia and fibula, knee and ankle joints, and surrounding soft tissues. The tibia will partially superimpose the fibular head with their midshaft portions free of superimposition, and the distal fibula superimposed by the distal half of the posterior portion of the tibia. The femoral condyles will be superimposed when the knee is flexed 45 degrees.

- Always mark the site of a penetrating injury such as a laceration or foreign body entry. Often a fracture that presents with a track leading from the skin to the fracture (called an open fracture) requires surgical intervention to render the site aseptic.

- The leg should not be requested if the ankle is the structure in question. This is because the AP leg will demonstrate the femorotibial and tibiotalar joint spaces closed. This is due to the divergent x-ray beam as the area of coverage is great and the central ray does not pass through either joint. For the AP tibia/fibula radiograph neither the knee joint nor the ankle joint are parallel with the cassette or perpendicular to the x-ray beam.

**References**

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Dr. Mohsen Dashti

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