

KNEE RADIOGRAPHY**TABLE OF CONTENTS**

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KNEE RADIOGRAPHY

1. Introduction

Quality control: The purpose of this manual is to standardize the examination procedures among the centers performing knee radiography in Health ABC. It is intended to support both technologists and radiologists in their respective responsibilities by spelling out technical details and radiological aspects that may otherwise be left vague or inconsistent. These procedures should be carefully reviewed by the technologists at each facility assigned to the Health ABC study.

It is expected that all technologists participating in this study already have an in-depth knowledge and extensive experience in their field. This manual can by no means be regarded as a training course. This manual simply points out details pertaining to this specific study that otherwise are likely to differ between centers. There is no claim that the proposed techniques are the only ones to yield acceptable results. Rather, this manual provides guidelines to make the results of all participating centers consistent and comparable.

Centers that cannot meet the requirements detailed in the imaging technique sections will need to contact Michael Nevitt at the Health ABC Coordinating Center to discuss whether alterations to the specified parameters are acceptable.

The Health ABC Radiology Coordinating Center will review the quality of the knee images during the study, and will notify the centers if problems with image quality are found. Possible sources of error, and possible solutions, will be suggested, but responsibility for the resolution of technical problems rests with the radiology facility and the clinical center.

During the study, questions regarding x-ray procedures should be directed to the Health ABC Coordinating Center or Radiology Technician Consultant.

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2. Background and rationale

Osteoarthritis (OA) of the knee is a major contributor to the risk of disability in old age and may also lead to decreased physical activity. Inclusion of this measure in Health ABC will allow examination of the contribution of OA of the knee (and other joints by symptom) to decline in physical activity, to incident disability, and to change in body composition as well as worsening of other chronic conditions.

The Health ABC study will include a bilateral, standing semiflexed view of the tibiofemoral (TF) compartments of the knee joint and an axial (skyline) view of the patellofemoral (PF) joint, in accord with current recommendations for standardized assessment of knee OA for epidemiological and progression studies. A view of the PF joint will be included because PF joint OA occurs in about half of all knee OA participants, often occurs independently of tibiofemoral disease, and contributes to pain and disability. Participants who report significant knee pain at the year 2 clinic visit will undergo knee radiography.

Radiological assessment of structural abnormality of joints is the current standard for classifying OA for epidemiological research and a key component of clinical diagnosis. Numerous studies have demonstrated a strong relationship between radiographic findings, symptoms, and outcome for knee OA.

3. Equipment and supplies

- screen/x-ray film combination: as specified in detailed protocols
- metal spheres, as indicated in the protocol, for assessing magnification
- plexiglass frame to control knee flexion and foot position in TF view
- tape or putty for affixing metal spheres to knee
- step stool or support frame for standing PF view

4. Inclusion/exclusion criteria and safety

4.1 Which participants get knee x-rays

This year a number of participants who have previously had knee x-rays will have follow-up knee x-rays. To see whether or not a participant should be scheduled for a follow-up knee x-ray, complete the Knee X-ray Eligibility Assessment form (page 19 in the Year 5 Clinic Visit Workbook). You will be directed to refer to the Data from Prior Visits Report to see if the participant should be getting follow-up knee x-rays.

As in previous years, participants with new significant pain in either knee will undergo bilateral radiography. Again, you will be instructed on the Knee X-ray Eligibility Assessment form to review the knee pain questions in the Year 5 Clinic Visit Workbook and to review the Data from Prior Visits Report to see if the participant had previous knee x-rays. See Chapter 2G for definitions of significant knee pain.

4.2 Exclusions

Bilateral knee replacement is an exclusion for knee x-rays.

4.3 Radiation dose

Measurement

Knee x-rays

Skin dose (mSv)

For each x-ray, skin dose is approximately 1,200 mSv.

(3 x-rays taken, one to both knees and one to each knee)

Only skin dose is available for the knee radiographs. Effective dose equivalent, not skin dose, is the appropriate quantity for the assessment of the risk of radiation injury. The effective/whole body equivalent dose from the extremity radiographs is very small with proper beam coning and shielding of gonads and visceral organs, as will be done in this study, and since only a small portion of the total body bone marrow is exposed. For example, exposure to the testes or ovaries from a bilateral AP knee radiograph is less than 0.1 microsieverts (Handbook of Radiation Doses in Nuclear Medicine and Diagnostic X-ray, CRC Press, 1980.)

5. Training and certification

5.1 Training

Participating radiology facilities were visited by a representative of the Coordinating Center prior to the beginning of the Year 2 examination and study procedures, examinations, and film quality were reviewed at that time. Refresher training will be provided as needed. The technicians have been performing x-rays on participants every year since Year 2. During the first few weeks of the Year 5 Clinic Visit all knee x-rays should be sent to the Coordinating Center weekly so that the quality of the films can be assessed.

5.2 Site and technologist certification

- a. Each x-ray facility should designate a primary contact/supervisor for this study. This person should generally be a chief technologist, technologist supervisor, or supervising radiologist at the facility, with responsibility for seeing that the Health ABC x-ray procedures are carried out correctly.
- b. The primary contact should have a detailed knowledge of the Health ABC x-ray protocols. This person is responsible for assuring that:
 - all x-ray technicians involved in the study are certified on the Health ABC x-ray protocol and are assigned a Health ABC staff ID number.
 - all Health ABC knee x-rays are taken according to the Health ABC protocol
 - copies of the x-ray protocol are available to Health ABC x-ray technologists at all times.
- c. The primary contact should complete the Health ABC X-ray Facility Certification Form (Appendix 1). The clinical center should send a copy of this form to the Health ABC Coordinating Center.
- d. The primary contact should assign specific technologists to this study. Each technologist is given a Health ABC Staff ID number by the Pittsburgh or Memphis clinical center.
 - 2 to 4 technologists are recommended
 - Technologists assigned to Health ABC should be experienced in bone and joint radiography.
- e. All assigned Health ABC technologists should read and have a thorough knowledge of the procedures outlined in the Health ABC protocol and review any questions with the primary contact. A Health ABC X-ray Technologist Identification Form, signed by each x-ray technician and the technologist supervisor should be sent in to the Coordinating Center (see Appendix 2).
- f. Individual technologists are certified by Coordinating Center review of the first 10 sets of radiographs.

6. Ongoing quality review at x-ray facility and Coordinating Center

6.1 Facility

- a. The technologist or the primary contact should review films while the participant is still at the facility so that if necessary a repeat film may be obtained without additional burden on the participant.
- b. The primary contact at each facility should review all knee films for protocol adherence and quality before they are shipped.
- c. In addition, “problem cases” where the technologist or chief technician is unsure of the quality of the image should be identified for review at the Coordinating Center. This is recorded in the “comment” section on the Knee X-ray Shipment Log (See Appendix 3).

6.2 Coordinating Center

- a. The Health ABC Coordinating Center will review the quality of all films during the study, and will assess the performance of each technologist.
- b. Clinic project directors and primary contact will be notified of persistent departures from optimal imaging and examination technique so that corrections can be made.
- c. Repeat films will be requested for films that do not provide valid information on knee OA.

7. Detailed knee imaging technique and examination procedure

I. TIBIOFEMORAL VIEW: SEMI-FLEXED PA PROJECTION - WEIGHT-BEARING

1) Imaging techniques

- | | |
|-------------------------|-----------------------------------|
| a. imaging system: | Bucky screen technique |
| b. film/screen speed: | 200-400 |
| c. film/focus distance: | 72 inches (invariable) |
| d. imaging voltage: | 70 KVP (invariable) |
| e. mAs: | 5 – 12 mAs (variable) |
| f. densitometer: | 1 to 1.2 over patella, on average |

- 2) **Film:** Size: 14" x 17" Agfa Ortho Fine or equivalent
(crosswire in Bucky)

3) Preparation

- a. The x-ray tube is positioned so that the central ray of the x-ray beam is angled at 10° toward the feet (caudad). If the alignment of the inferior and posterior tibial plateaus is not acceptable, (see figure 3) repeat the view after changing the beam angle to 0°. The x-ray film is held within an erect Bucky tray.

NOTE: For participants obtaining a follow-up x-ray, the correct beam angles to use will be specified on the form entitled: “Year 5 Repeat Knee X-ray Parameters” that is attached to the participant’s Knee X-ray Tracking Form. Always double check that the exact correct beam angle is used. If more than one angle is specified on the form, obtain views using both beam angles. The mAs used on the previous films will also be specified on the : “Year 5 Repeat Knee X-ray Parameters” form. This should serve as a guideline for settings that will provide good follow-up images, but can be altered if results are not satisfactory.

- b. The anterior wall of the plexiglass frame is in contact with the Bucky tray (figure 1). The plexiglass frame is positioned on the floor with the foot angulation support centered to the middle (left/right) of the Bucky tray. This will center the midpoint between the knees over the Bucky and the film. Lower the Bucky so that the center of the film is at the midpoint between the knees.

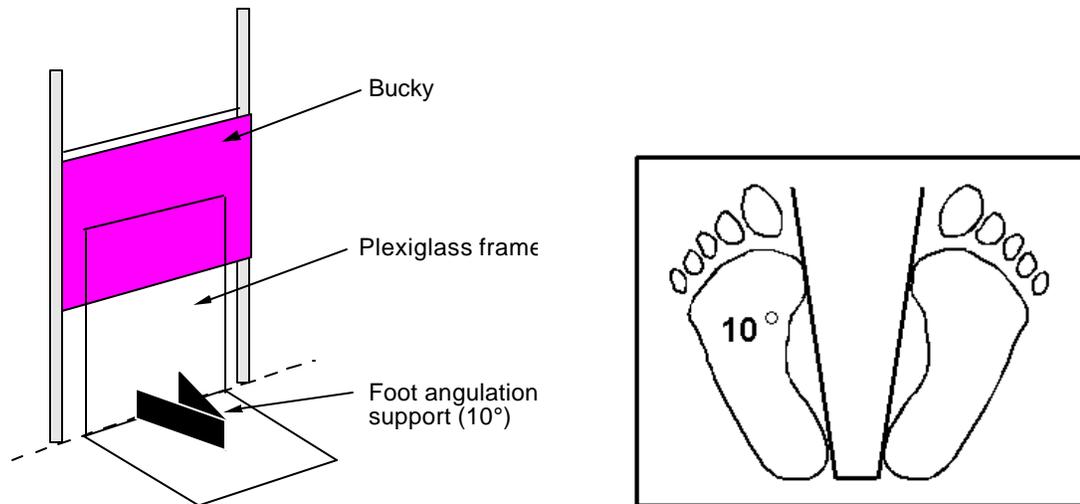


Figure 1. Plexiglas frame for reproducible knee flexion, foot fixation and external rotation. The frame is positioned with its anterior wall in contact with the Bucky such that the midpoint between the knees is centered on the film.

4) Participant position (both knees are x-rayed together)

- a. The participants should be without shoes.
- b. The participant stands with both knees facing the film cassette in an erect Bucky or film holder, with a film to focus distance (FFD) of 72 in.
- c. Both knees are radiographed together in the Postero-Anterior view.
- d. Body weight is distributed equally between the two legs and the great toes of both feet are placed in contact with the anterior wall of the plexiglass frame.
- e. The knees and thighs are pressed directly against the wall of the frame and Bucky to fix the degree of knee flexion. In this position the tibial plateau should be at, or near, a 10° angle (caudad) to the film. The participant should hold onto the Bucky tray frame for support.
- f. The external rotation of the feet is fixed at about 10° by the frame (figure 2).
- g. The participant's gonads are shielded with a half apron.

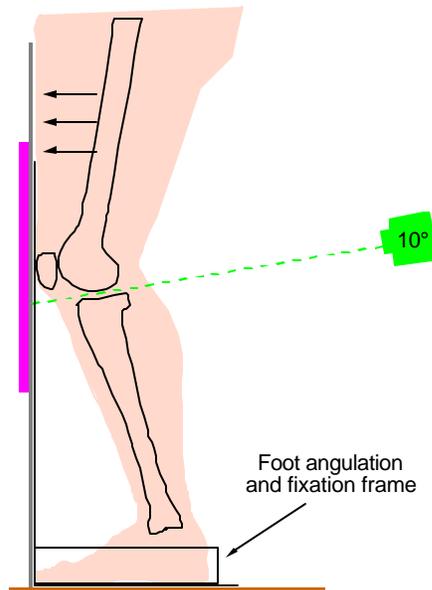


Figure 2. Proper patient positioning and beam angulation for radiography of the knee. Pressing the thigh against the Bucky fixes the degree of flexion of the femur. Reproducible positioning of the foot in 10° angulation is accomplished using a V-shaped support on a Plexiglas frame.

5) Part position

- Identify the position of the tibiofemoral joint space by locating the inferior border of the patella and the superior margin of the tibial tuberosity, trace this line around to the side of the knee and mark the skin with a felt tip pen. This mark will be used to help align the center of the x-ray beam with the joint space (see # 6 below).
- Place a **right** marker on the right edge of the cassette.
- The film marker block (ID stamp) must be in same place each time (top or bottom of film direction, always to the right).
- Measure the angle of flexion of the knees with a long-armed goniometer. Place the pivot point of the goniometer just posterior to the patella (the circular dial will rest against the plexiglass frame), one long arm aligned with the tibia (not the middle of the calf) and the other long arm aligned through the middle of the thigh as much as possible. Record the degrees of flexion (typically 20-25°) on the x-ray tracking form and the x-ray log.

6) Central ray

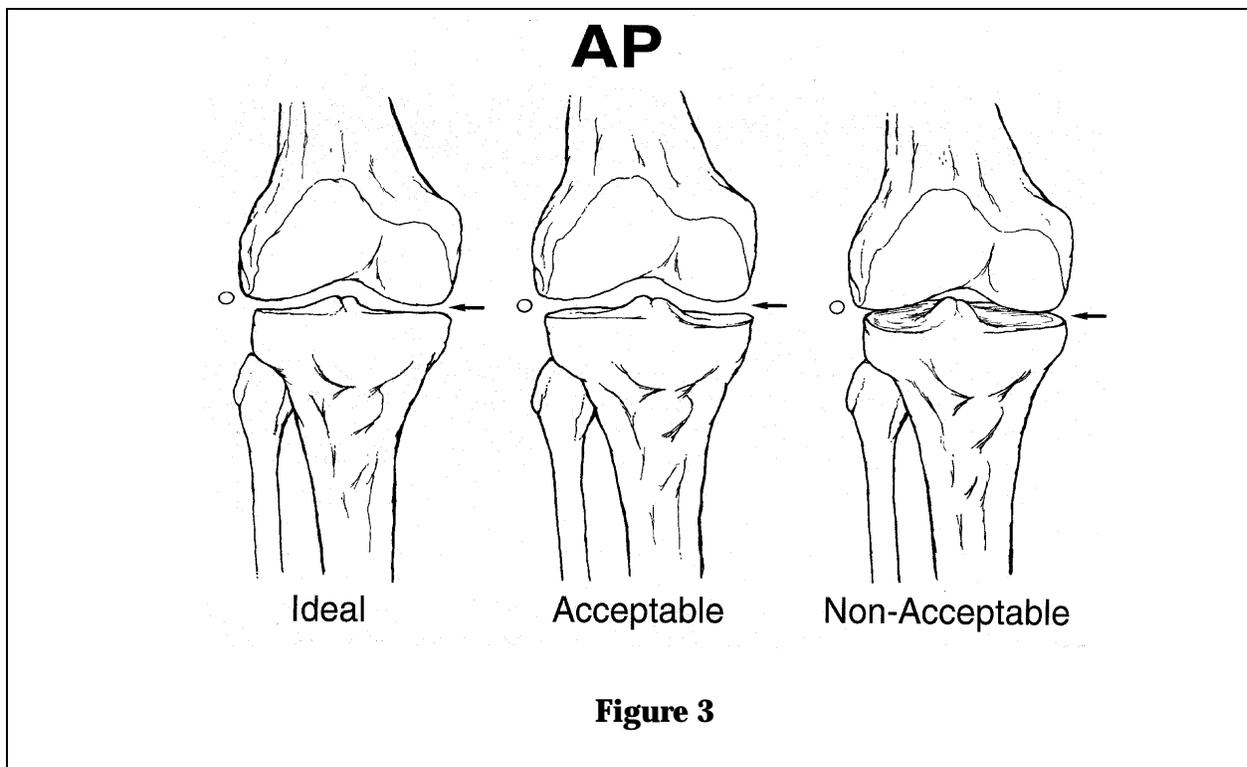
- a. The tube is positioned so that the x-ray beam is directed at the back of the knees.
- b. The tube's positioning light is used to align the center of the x-ray beam midway between the knees and in the same horizontal plane as the center of the joints, defined by the joint space (see # 5 above), and which lies above the horizontal skin crease of the popliteal fossa.
- c. The radiograph is taken immediately once this position is obtained.

7) Participant instruction

- a. Have the participant understand the importance of holding still.

8) Criteria for assessing image quality

- a. See Figure 3 for anatomic drawing of acceptable and unacceptable films. Superposition of the posterior and anterior edges of the tibial plateau is required to accurately demonstrate the joint space.

**Figure 3**

- b. If the edge of the tibial plateau nearly touches or overlaps the distal femoral condyle, repeat the x-ray to demonstrate the joint space. If the overlap is substantial or bilateral, consider attempting a repeat x-ray with the beam angled at 0°. If the tibial plateau is nearly touching, or is only touching on one side, consider a repeat x-ray at 5°. If decreasing the angle to 0° or 5° worsens the overlap, try a second repeat at 15°
 - c. Correct contrast; be able to see soft tissue; and medial and lateral sides of the knee joint.
 - d. Exposure settings should be set to provide optimal visualization of the articular surfaces. The floor of the medial tibial plateau should be clearly delineated.
 - e. The knees should be centered on the film.
- 9) PLEASE RECORD MAS, BEAM ANGLE (0° OR 10°) AND DEGREES OF FLEXION FOR BEST IMAGE ON THE X-RAY TRACKING FORM. Note: If a participant is having a follow-up knee x-ray, refer to the sheet entitled: "Year 5 Repeat Knee X-ray Parameters" that is attached to the participant's Knee X-ray Tracking Form and use the beam angle(s) and mAs settings specified on this sheet. On the Knee X-ray Tracking form, record the first beam angle listed on the Year 5 Repeat Knee X-ray Parameters sheet.**

II. PATELLOFEMORAL VIEW:

STANDING AXIAL (SKYLINE) - WEIGHT-BEARING

1) Imaging technique

- | | |
|------------------------|-----------------------------|
| a. Imaging system | - Extremity detail cassette |
| b. Film/screen speed | - 200 |
| c. Imaging voltage | - 70 kVp |
| d. Film focus distance | - 48 inches |
| e. mAs: | - mAs 6 - 16 (variable) |

- 2) Film** size: 8 x 10 cm Extremity detail
(Agfa Ortho Fine or equivalent)

3) Preparation

- a. Each knee is imaged separately.
- b. The x-ray tube is positioned so that the x-ray beam is directed vertically downwards and the film to focus distance is set to 1.5 meters.

4) Participant position (both knees are x-rayed, each separately)

- a. The participant, still wearing a lead apron, is standing and the foot of the knee under examination is placed with the front part of the foot under the step. To achieve the needed degree of flexion and weightbearing, it may help some participants to rest the knee not being x-rayed on a chair with the knee bent, or participants can also stand with their buttocks leaning gently against the x-ray table to stabilize the position.
- b. [Alternative positioning (for participants who cannot stand with knee bent for primary protocol or extremely obese participants). The participant, still wearing a lead apron, is seated on the edge of a chair or stool with as much of participant's weight as possible forward on feet. The foot of the knee under examination is placed with the front part of the foot under the step. The participant should bear weight on the knee being x-rayed. (See figure 4)]

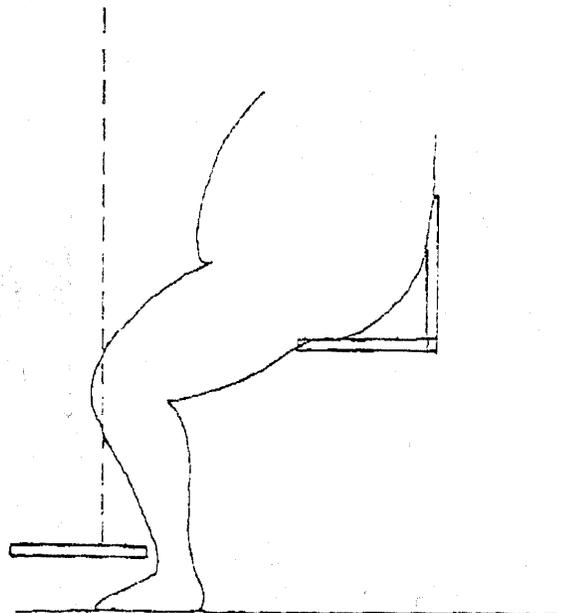
ALTERNATIVE POSITION

Figure 4. Alternative Position: Participant Seated**5) Part position**

- a. For computing radiographic magnification, a 1/4" metal sphere is taped on or as near as possible to the lateral border of each patella, and another is taped on the medial side of the cassette, along with a Left/Right marker, away from the area for the image.
- b. Knee flexion is measured using a long-arm goniometer with the pivot point located just posterior to the patella, one long arm against the tibia (not the middle of the calf) and the other long arm placed through the middle of the thigh as much as possible. **Acceptable angles are between 30 and 40°.**
- c. The leg is positioned so that it is aligned in the vertical plane. In this position the anterior surface of the patella is positioned above and a little in front of the participant's toes. The participant's stability is maintained by a support frame (single step stool with handrail) and, in this instance, by resting the front of the tibia against the cross-bar of the frame. Additional measures to improve stability are described in 4a, above.

IMPORTANT: Encourage the participant to bear weight on the forward leg.

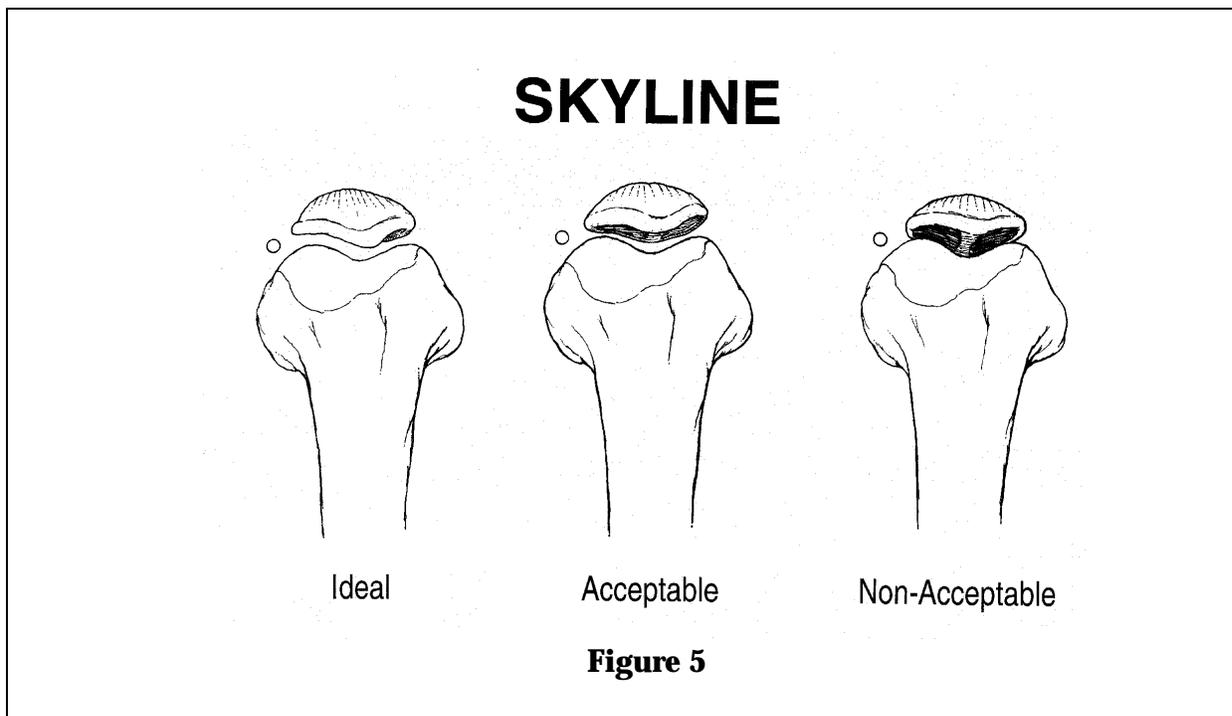
6) Central ray

- a. The radiograph plate is placed on the box or step positioned below the knee.
- b. The tube is positioned vertically above the patellofemoral joint.
- c. With the aid of the tube's positioning light, the central ray of the x-ray beam is directed so as to project through the patellofemoral joint space.
- d. The radiograph is taken immediately once this position is obtained.

IMPORTANT: Encourage the participant to bear weight on the forward leg during filming.

7) Criteria for assessing image quality

- a. The radiograph is developed. An optimal skyline view is one in which the lateral facet of the patella is seen cleanly with superimposition of the inferior and superior borders of this lateral facet. This facilitates reading the joint space of the patellofemoral joint. While it is preferred that the tibial tubercle not be included in the radiographs, occasionally perfectly aligned skyline views may include views of the tibial tubercle and that is acceptable (figure 5).



- b. Unacceptable skyline views are defined as those in which the inferior and superior margin of the lateral facet of the patella are grossly not super-imposed, and especially if the inferior margin of the patella overlaps the distal femoral condyle or intrudes into the entire joint space.
- c. If the skyline view is judged nonoptimal, it is repeated with flexion at a different angle or with adjustments of the tube.
- d. DO NOT TAKE MORE THAN 2 EXPOSURES FOR ANY SINGLE VIEW.

8) RECORD MAS ON THE X-RAY FORM.

Note: If a participant is having a follow-up knee x-ray, refer to the sheet entitled: “Year 5 Repeat Knee X-ray Parameters” that is attached to the participant’s Knee X-ray Tracking Form and use mAs settings specified on this sheet as a guideline for good follow-up images. However, this setting can be modified to improve image quality.

8. Radiograph labeling

a. The x-ray films should include the following information on the ID stamp:

- participant’s name
- clinic site (Memphis; Pittsburgh) and x-ray facility name
- Health ABC ID (and four-letter namecode [acrostic] if name not included)
- date of x-ray
- x-ray tech ID (may be on a stick-on label)

b. Be sure the ID stamp is on the right side and that each film has a left/right marker that is clearly visible.

c. To ensure legibility, all label information should be typed whenever possible.

IMPORTANT: It is the responsibility of the clinical center to verify the legibility, completeness and accuracy of all identifying information on the x-ray label before the x-ray is shipped to the Coordinating Center. Missing or illegible information should be typed on a separate stick-on label, and placed next to (NOT OVER) the ID stamp. The x-ray tech ID may also be recorded on a stick on label.

In general, additional stick-on labels with redundant information (e.g. film date) are unnecessary and are discouraged. Any stick-on labels used should be placed next to (but not over) the imaged ID plate.

9. Knee X-ray Tracking Form and X-ray Shipment Log

Each Health ABC participant who will be having a knee x-ray will have a Knee X-ray Tracking Form (see Appendix 5) which is partly filled out before the participant goes to the x-ray facility and completed when they go for their x-ray.

Section of Knee X-ray Tracking form that is filled out in clinic:

- which annual clinic visit this is

- the participant's name
- the participant's enrollment ID# and acoustic

Section of the Knee X-ray Tracking form that is filled out at the x-ray facility:

- whether each view was obtained, and if not obtained, why not
- the mAs setting used
- the beam angle and knee flexion angle for the semiflexed view
- X-ray tech study ID number

Those participants who are having repeat knee x-rays will be bringing in (along with their Knee X-ray Tracking form) a sheet generated as part of their Data from Prior Visits Report. This sheet includes instructions for the x-ray technician. See below:

YEAR 5 REPEAT KNEE X-RAY PARAMETERS

(Attach this form to the front of the Knee X-ray Tracking Form before sending the participant for the knee X-ray.)

Health ABC ID# _____

Participant Name _____

Acoustic _____

X-ray Technician Please Note: Use the first beam angle specified below. If a second angle is specified, obtain a second PA film using that angle:

First beam angle:

[] [] [] degrees

Second beam angle:

[] [] [] degrees

The following parameters were used on the first knee x-rays for this participant. These should serve as guidelines for setting up the current follow-up knee x-rays. However, if these parameters do not result in high quality x-rays, then other parameters should be tried to maximize x-ray

quality.

As each participant's knee films are completed, fill in the information requested on the Knee X-ray Shipment Log (Appendix 3). The original of this log should be kept at the X-ray facility.

Two xerox copies of the current log should be provided with the x-rays to the Health ABC clinical center at the end of each two week accumulation period.

10. Packaging and shipping films

- a. Before leaving the facility, each participant's set of knee films should be placed in a paper jacket labeled with:
 - clinic site (Memphis; Pittsburgh) and x-ray facility name
 - Health ABC ID and four-letter namecode (acrostic)
 - date of x-ray
- b. Films will be inventoried, boxed and shipped by staff at the Health ABC clinical center.
- c. A sturdy shipping container or other packaging should be used for each batch of x-rays shipped (i.e., x-rays should be double wrapped).
- d. Package a copy of the Health ABC Knee X-ray Shipment Log with the shipment. The Log will be checked against the films contained in the shipment at the Coordinating Center. Keep a copy of the X-ray Shipment Log at the Health ABC clinical center
- e. Fax a copy of the X-ray Shipment Notification Form to the Coordinating Center when the shipment is sent (Appendix 4). Fax to:
Clara Yeung Health ABC Knee X-Rays: (415) 597-9213.

- f. Send all films to:

Clara Yeung
Health ABC Knee X-Rays
Health ABC Coordinating Center/UCSF
74 New Montgomery, Suite 600
San Francisco, CA 94105

Phone: (415) 597-9271

Fax: (415) 597-9213

- g. For security and speed of delivery, use of second day courier service (e.g., UPS second day air) is recommended.
- h. Accumulated films should be shipped **every two weeks (except for the first few weeks of Year 5 when they should be shipped every week).**

APPENDIX 1 Health ABC X-ray Facility Certification Form

Yes No If no, specify

A. Imaging Technique - Facility

Our facility can meet the following protocol specifications:

Imaging system: Erect Bucky tray for 14" x 17" film

Specified film/screenspeed:

• TF view: 200-400

• PF view: 200

Extremity detail film

Plexiglass positioning frame for TF view

B. Imaging Technique - Technologists

The *film/focus distance* will be as specified for each image.

It is critical to maintain this distance carefully.

- Semiflexed TF view: 72 inches

- PF skyline: 48 inches

Exposure level:

- Semiflexed TF view: 70 kVp

- PF skyline: 70 kVp

C. Positioning

Protocols will be followed with respect to specified:

- plexiglass positioning frame used for TF view
- degrees of knee flexion assessed
- weight-bearing
- placement of steel balls for PF view
- beam centering
- review for acceptable image quality and repeat x-ray if necessary

Technologist Supervisors statement: Only identified technologists will be involved in this study. If personnel need to be added, they should be identified to the clinic and Coordinating Center.		
Clinical center	X-ray facility location	
Last name, first name	Position	Phone number
	Date	Signature
Address		

APPENDIX 2 Health ABC X-ray Technologist Identification Form

I have carefully read the Health ABC x-ray manuals. I will adhere to the protocol as stated in the manual as closely as possible.

Last name	First name	Health ABC Staff ID #	Date	Signature of X-ray Technologist

Technologist Supervisors statement:
The above-listed individuals are qualified to perform the required x-ray examinations.

Clinical center _____ **X-ray facility location** _____

Last name, first name _____ **Position** _____ **Phone number** _____

_____ **Date** _____ **Signature** _____

Address _____

APPENDIX 4 Health ABC Knee X-ray Shipment Notification

TO: Clara Yeung
FAX: (415) 597-9213

FROM: _____

SITE ID: Memphis

Pittsburgh

FAX: _____

RE: X-ray Shipment of Health ABC Participant Data

Message

The following data is being sent to you today _____
(today's date)

For delivery on _____
(date)

VIA: Mail Delivery service: _____ Airbill # _____
(airbill number)

Exam Date Range of Participants Included:

// to //
Month Day Year Month Day Year

Please call _____ at _____ if you have any questions.
(name) (telephone number)

Response from Coordinating Center

Shipment received on: //
Month Day Year

Not received as of: //
Month Day Year

Comments: _____

