

RADIOLOGY

I. INTRODUCTION. Spine films should be taken on all African American participants who attended the SOF Year 10 examination (Visit 6) and are willing to return to the clinic for the Year 12 visit, whether or not they met the inclusion criteria for the Year 12 cohort.

The purpose of this manual is to standardize the examination procedures among the centers participating in the SOF study. 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 and inconsistent.

It is expected that all radiologists and technologists contributing to this study already have an in-depth knowledge and some experience in their respective fields. This manual can by no means be regarded as a training course in taking spinal x-rays. 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*.

II. X-RAY IMAGING TECHNIQUE AND EXAMINATION PROCEDURE

Lateral spine films (thoracic and lumbar) will be used to assess the incidence of spinal fractures. Since fracture incidence represents an outcome in this study, quality assurance for this area is very important.

High quality plain film radiography requires competent and consistent quality assurance. This manual contains information that will help to obtain optimum image quality. Quality assurance guidelines for three major areas are covered:

- technical specifications of the imaging technique
- details of the examination procedure
- quality control criteria to assess the image quality

Each of these procedures is of equal importance. To obtain consistent results, the technologist performing the examination must be aware of possible sources of error that may affect the quality and reproducibility of the spine films.

The following sections provide details separately for thoracic and lumbar examinations with respect to equipment specifications and procedures. Certification and criteria for image quality will be outlined in separate sections, and examples of good and poor image quality will be given.

The SOF coordinating center will review the quality of the radiographs 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 SOF coordinating center. In addition, "problem cases" where the operator is unsure of the results of the quality of the image should be identified.

Questions regarding this manual or radiographic techniques should be directed to:

Michael Nevitt
74 New Montgomery, Suite 600
San Francisco, CA 94105
Phone: (415) 597-9198
FAX: (415) 597-9213

Please concentrate on image quality and optimum positioning of the participant. It is permissible to modify the parameters if this will improve quality, but the film/focus distance must not be changed.

II.A Thoracic Spine Measurements

Lateral Projection

Imaging Technique

- | | |
|-------------------------|---|
| • Imaging system | Bucky screen technique |
| • Focus size | ≤1.3 mm |
| • Total filtering value | ≥2.5 mm A1-equivalent value (half layer) |
| • Scattering grid | r = 12 to 1 at 40 inches |
| • Film/Screen speed | 400 |
| • Film/Focus Distance | 40 inches (not variable!) |
| • Imaging voltage | 60-70 kVp |
| • Exposure Time | breathing technique; approximately 2 second exposure (phototiming is not to be done on this view) |

Film Size

7" x 17" lengthwise is recommended. Larger size film (i.e. 14" x 17") is acceptable if this is more convenient, provided that collimation is carried out as specified below.

Positioning

- Place participant on the table in the lateral position (left lateral if possible to reduce magnification of overlying heart shadow) with legs flexed for comfort and support.
- Place support under participant's head.
- Place both arms at right angles to anterior surface of body (if arms are raised higher, scapulae may superimpose upper thoracic vertebral bodies), and flex elbows for comfort.
- Place supports between knees and ankles and under knee next to table (for support and to aid in maintaining lateral position).
- Place lead shield over lower part of the participant to protect gonads.
- Place support under mid lumbar region to position long axis of spine parallel to table. Double check the horizontal position of the thoracic spine by feeling the spine with your hand.

- Adjust body to lateral position (shoulders, hips, knees, and ankles superimposed).
- Align midaxillary (coronal) plane of body to midline of table.
- To assure lateral position, stand at head of table and look down the participant's back and hips to make certain that there is vertical superimposition of shoulders and hips.

Central Ray

- Direct the central ray to level of 7th thoracic vertebra (T7). T7 is about two finger widths (1 in, 2.5 cm) below the tip of the scapulae when arms are elevated; top of cassette should be about 2 in (5 cm) above the shoulders to include the 7th cervical vertebra.
- Center cassette (in Bucky tray) to level of 7th thoracic vertebral body.

Collimation

- Adjust collimation: 1 cm or more collimation must be seen when using 7" x 17" film, with collimation directed to the spine to exclude as much unneeded anatomy as possible.
- When using larger size film, the size of the irradiated area should be kept to a minimum (approximately the same size as on the smaller size films).

Participant Instructions

- Have the participant breathe quietly for exposure (this allows blurring of the overlying ribs and lung detail by motion). This requires complete immobilization of the participant and a long exposure time. Therefore, phototiming is not possible on this view; manual technique is required.

Special Considerations

- Include T2 (if possible) to T12 (required). In large participants T2, and T3 in extreme cases, may need to be excluded.
- Include T12 on both the thoracic and lumbar images.
- Close collimation and placing the lead sheet on the table behind the thoracic vertebra aids in reducing radiation dose and scattered radiation.
- Simultaneous over and under-exposure in different parts of a film may indicate that the voltage setting is too low on the participant.

II.B Lumbar Spine Measurements

Lateral projection

Imaging Technique

- | | |
|--------------------------|--|
| • Imaging system | Bucky screen technique |
| • Focus size | ≤1.3 mm |
| • Total filtering value | ≥2.5 mm A1-equivalent value (half layer) |
| • Scattering grid | r = 12 to 1 at 40 inches |
| • Film/Screen speed | 400 |
| • Film/Focus Distance | 40 inches (not variable!) |
| • Imaging voltage | 80 - 90 kVp |
| • Exposure Time (manual) | < 1 sec |
| (automated) | central photocell |

Film Size

11" x 14" lengthwise is recommended. Larger size film (i.e. 14" x 17") is acceptable if this is more convenient, provided that collimation is carried out as specified below.

Positioning

- Place participant on the table in lateral position (left lateral if possible) with legs flexed for comfort and support.
- Place support under participant's head.
- Place supports between knees and ankles and under knee next to table (for support and to aid in maintaining lateral position).
- Place lead shield over lower part of the participant to protect gonads
- Place radiolucent support under mid-lumbar region to position long axis of spine parallel to the table.
- If necessary, place an additional support under the lumbar region to position the vertebrae parallel to the table (prevent sagging of the spine). Double-check the horizontal position of the spine by feeling the spine with your hand.
- Adjust body to lateral position (shoulders, hips, knees, and ankles superimposed).
- Align midaxillary (coronal) plane of body to midline of table.
- To assure lateral position, stand at head of table and look down the participant's back and hips to make certain that there is vertical superimposition of shoulders and hips.

Central Ray

- Direct the central ray to level of 3rd lumbar vertebra (L3). L3 is about two finger widths above the iliac crest.

- Center cassette (in Bucky tray) to level of 3rd lumbar vertebral body.

Collimation

- Adjust collimation: 1 cm or more collimation must be seen on the roentgen film, with collimation directed to the spine to exclude as much unneeded anatomy as possible.
- When using larger size film, the size of the irradiated area should be kept to a minimum (approximately the same size as on the smaller size films).

Participant Instructions

- Have participant suspend respiration for exposure (after expiration to remove lungs from the field of view).

Special Considerations

- Include T12 to S1.
- T12 must be included on both the thoracic and the lumbar images.
- Close collimation and placing the lead shield on the table behind the lumbar spine aids in reducing radiation dose and scattered radiation.

II.C Identification, Logging, and Shipment of Films

Identification

The roentgen films should include the participant's SOF Identification Number, Acrostic and date of x-ray imaged on the film. The clinic name should also be imaged on the film. Do not use any permanent markers on the film. If using stickers or labels please be careful not to obscure the film image.

Each set of films should be contained in a paper jacket, which should be labeled with the participant's SOF Identification Number.

SOF X-Ray Form

Immediately after each x-ray is taken, fill in the participant's x-ray form:

- name of participant (this is already entered but should be confirmed by the technician)
- SOF Identification Number
- date of the x-ray
- X-Ray Technician ID number
- imaging voltage (kVp)
- exposure time(s)
- milli-ampereage [mA] for manual technique only
- machine used for x-ray
- comments

The participant's X-ray Form is returned to the SOF coordinating center along with the x-ray.

Shipping

Films will be inventoried, put into shipping envelopes, along with the SOF X-Ray Shipping Log, and sent out by the staff at each SOF clinical site. Send all films to:

Clara Yeung
SOF Coordinating Center
74 New Montgomery, Suite 600
San Francisco, CA 94105

For security and speed of delivery, use of a second-day courier service (UPS or FedEx) is recommended. Accumulated films should be shipped no less frequently than once a week.

III. CERTIFICATION AND QUALITY ASSURANCE

III.A Identification and Certification of SOF X-Ray Technologists

- Identify a radiology QC officer at each clinic site for communication regarding x-rays. This person may either be a radiologist or the head x-ray technologist and will be responsible for certifying technologists, creating and updating the List of Certified Technologists, and completing the SOF X-Ray Facility Certification Form.
- Provide this manual to the radiology QC officer for the SOF study.
- All technologists taking x-rays for the SOF study should have a SOF ID number. Technologists assigned to the SOF study should be experienced in taking spinal x-rays. At least 50 lateral spine x-rays taken over the course of the last year represents sufficient experience.
- All radiology technologists will need to be certified. After a thorough reading of this manual, technologists are required to pass a written exam, which should then be forwarded to the coordinating center for review.
- The first 5 lumbar and 5 thoracic spine films taken for the study by each technologist must be reviewed by the QC officer. This review should be based on:
 - SOF imaging and positioning techniques
 - imaging quality criteria
 - examples of problematic or acceptable films

The technologist passes this review and is certified by the QC officer if all films show that the SOF protocol was followed and the image quality meets the image criteria defined herein. If the review shows deficiencies in technique or image quality, the technologist should read the manual and review SOF procedures with the QC officer. Five more SOF lumbar and thoracic spine films should be obtained and reviewed. Participants whose x-rays are judged to be of poor quality should be brought back for a repeat x-ray as soon as possible.

The QC officer should continue monitoring the quality of all SOF films throughout the study and take appropriate action to correct any deficiencies noted.

III.B External Audit by SOF Coordinating Center

After successful internal certification of the technologists by the radiology QC person, send (1) the signed X-ray Facility Certification Form, (2) the list of certified technologists, (3) the completed Technician's Examinations, and (4) all x-rays reviewed for certification to:

Clara Yeung
SOF Coordinating Center
74 New Montgomery, Suite 600
San Francisco, CA 94105

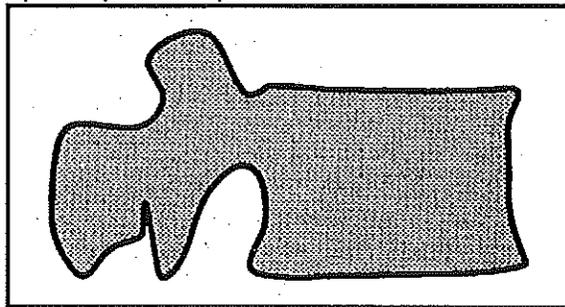
After review at the coordinating center, the CC will respond in writing to confirm the certification of the technicians. If problems remain, the CC will discuss those problems with the QC officer. The SOF coordinating center will continue to review the quality of films during the study and will assess the performance of each technologist throughout the study.

IV. ASSESSING THE QUALITY OF LATERAL SPINE FILMS

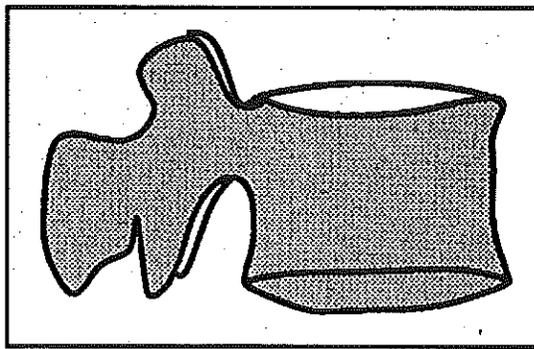
X-ray films must be of sufficient quality to allow for an accurate determination of morphometric measures such as anterior, mid, or posterior height or area of the vertebral bodies. The following criteria should be met to avoid errors caused by inappropriate projection of the vertebral contours (the spine has to be parallel to the table so that inter-vertebral spaces clearly show) or wrong technique (incorrect exposure level, short exposure times for the thoracic film):

Criteria of good image quality

- Vertebral endplate contours superimposed upon each other



optimum superposition



excessive obliquity

- Complete superposition of the posterior edges of the vertebral bodies
- Appropriate exposure (not too light or too dark) so vertebral contours and trabeculae are clearly visible
- Demonstration of the vertebral arches and inter-vertebral foramina
- Visualization of adjacent soft tissue within the collimation guidelines dictated above.
- Blurred rib contours (due to breathing technique) on lateral thoracic films.

V. ATLAS OF SPINE FILMS

Listed below are common sources of error and examples of how these errors lead to problematic spine images.

Common Mistakes

- Inappropriate positioning of the participant
 - spine not parallel to the table
 - spine rotated around the long axis
- Inappropriate centering of the x-ray beam (should be centered on T7 and L3 for thoracic and lumbar films, respectively)
- Exposure time too short on lateral thoracic film (resulting in sharp contours of the ribs obscuring the vertebrae)
- Inappropriate exposure level
 - overexposure (film too dark)
 - underexposure (film too light)

Since certain problems observed on a spine film may have several causes (e.g., both inappropriate positioning and inappropriate centering can result in imperfect superposition of the end plates) the foregoing is grouped by how the problem appears visually, with a listing of all the potential causes.

VI. Examples of Common Problems

- Imperfect superposition of vertebral endplate contours in superior spine

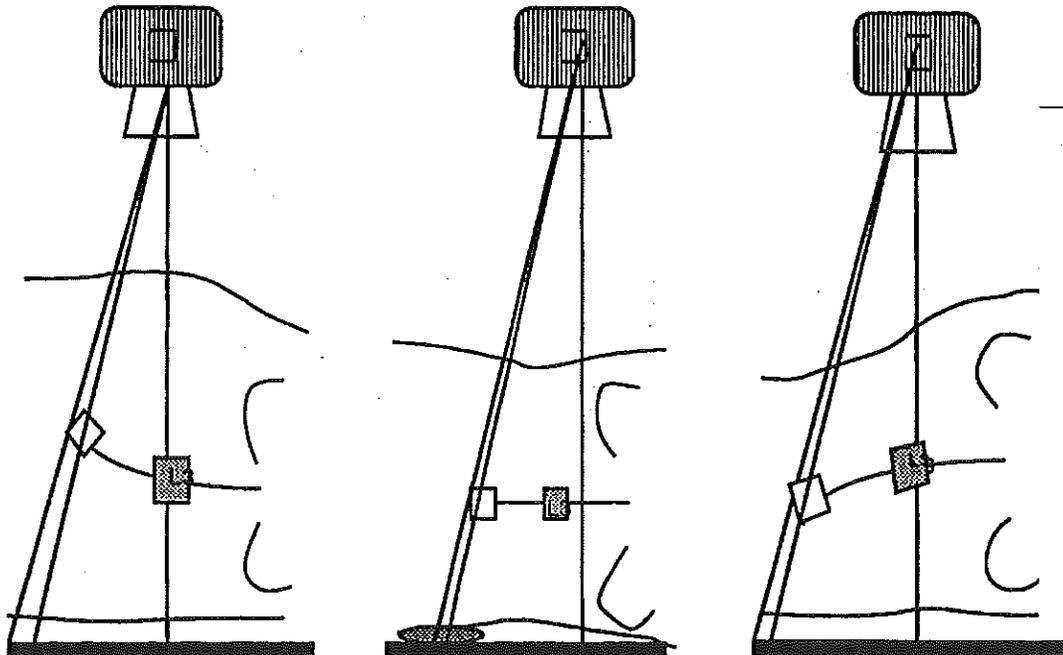


Causes

A Centering of x-ray beam is correct but superior spine is not parallel to table (curved upward)

B Participant is correctly positioned but centering of x-ray beam is inappropriate

C Centering of x-ray beam is correct but superior spine is not parallel to table (curved downward)

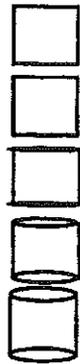


A

B

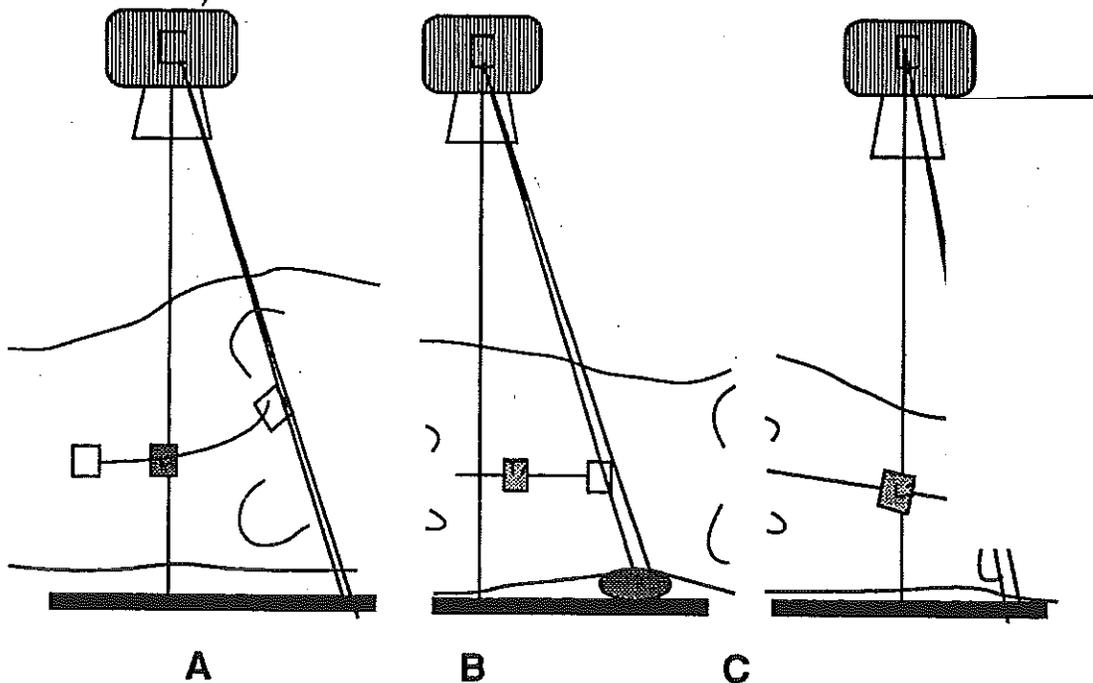
C

- Imperfect superposition of vertebral endplate contours in inferior spine



Causes

- A Centering of x-ray beam is correct but inferior spine is not parallel to table (curved upward)
- B Participant is correctly positioned but centering of x-ray beam is not appropriate
- C Centering of x-ray beam is correct but inferior spine is not parallel to table (curved downward)



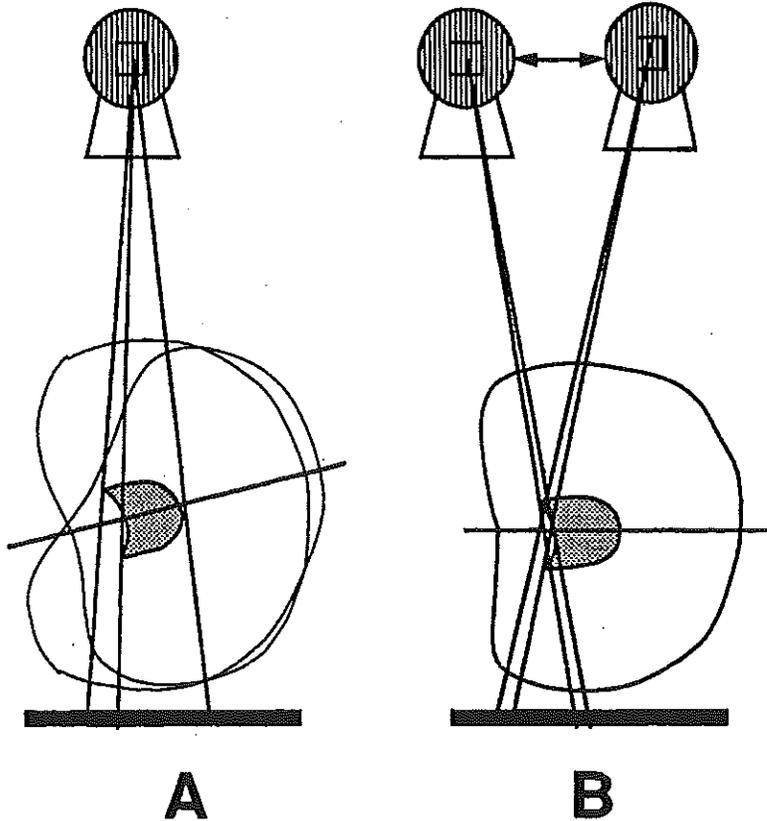
- Imperfect superposition of posterior edges of the vertebral bodies



Causes

A Centering of x-ray beam is correct but participant is not positioned squarely on the side

B Participant is correctly positioned but centering of x-ray beam is inappropriate



Acknowledgment:

This proposal for standard projections in radiological diagnostics are based in part on the recommendations issued by the Central Executive Board for Science, Research and Development of the Commission of the European Economic Community, Section for Medical Radiation Exposure, that were formulated at the International Workshop on "Optimization of Image Quality and Radiation Exposure of Patients in Radiological Diagnostics" (Oxford, Sept 27-29, 1988). Participant position and technical notes are adapted from R. Eisenberg, Radiographic Positioning (Little, Brown and Company; Boston/Toronto/London 1989).

Date	Staff ID Number	SOF ID Number	Acrostic
____/____/____ Month Day Year			

SOF YEAR 12 SUPPLEMENT X-RAY FORM

Participant's Name: _____

General Information

Date of X-ray exam:

____/____/____
Month Day Year

X-ray Technologist (SOF ID#): _____

X-ray machine: _____

Thoracic Film

kVp: _____

Exposure time: _____

Milli-Amperage (manual technique only): _____

Comments: _____

Lumbar Film

kVp: _____

Exposure time: _____

Milli-Amperage (manual technique only): _____

Comments: _____

Film Shipment

Shipped to coordinating center on:

____/____/____
Month Day Year

Shipment includes thoracic spine film?

Yes No

Shipment includes lumbar spine film?

Yes No

Staff ID#: _____

Clinic Worksheet

List of Certified Technologists

I have read the **SOF Year 12 Radiology Protocol** and have successfully undergone a review of my first 5 sets of x-ray films by a supervising technologist or radiologist at the facility where I work. I will adhere to the protocol as stated in the above-mentioned manual as closely as possible.

	Last Name	First Name	Staff ID No	Date	Signature
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Supervising Technologist Statement:

The above-listed individuals are qualified to perform the required x-ray examinations. I have reviewed 5 lateral thoracic and 5 lateral lumbar spine films of each of the above listed technologists and found them to be of good quality. No other technologists will be involved in this study. If personnel need to be added, certification procedures outlined in the manual will be followed.

Center _____ X-Ray location _____

Last Name, First Name _____ Position _____ Phone _____

Signature _____ Date _____

Date		Staff ID Number
____/____/____	____/____/____	
Month	Day	Year

SOF YEAR 12 SUPPLEMENT X-RAY FACILITY CERTIFICATION FORM

A. Imaging Technique: Facility

The focus size of our x-ray device(s) is ≤ 1.3 mm.

Yes No _____ If no, explain:

Total filtering amounts to at least 2.5 mm
A1-equivalent half value layer

Yes No _____

Our scattering grid has a ratio of 12 to 1 at 40 inches.

Yes No _____

We will use films of 400 speed.

Yes No _____

B. Imaging Technique: Technologists

The film/focus distance will be 40 inches. It is critical to maintain this distance carefully.

Yes No _____

Exposure level

- Lateral thoracic films will be taken at 60-70 kVp with long exposure (breathing technique).

Yes No _____

- Lateral lumbar films will be taken at 80-90 kVp with ≤ 1 second exposure (on expiration).

Yes No _____

The kVp, exposure time (and mA for manual technique) will be recorded for each patient and film, and the same settings will be used at all follow-up visits.

Yes No _____

C. Positioning

The spine will be parallel to the table without rotation of the body to ensure optimal superposition of vertebral contours.

Yes No _____

Careful positioning will ensure that on:

- Lateral thoracic films T2 (if possible) to T12 (required) will be included, with centering at T7

Yes No _____

- Lateral lumbar films t12-S1 will be included, with centering at L3.

Yes No _____

Certification Form

4/1/99

Name: _____ SOF ID#: _____ Date: ____/____/____

SOF X-RAY TECHNICIAN'S EXAMINATION FORM

APRIL, 1999

1. Fill in the missing parameters for the SOF imaging technique for baseline and follow-up lateral spine x-rays.

Thoracic spine

Imaging system Bucky screen

Focus size _____

Total filtering _____

Scattering grid _____

Film / screen speed _____

Film / focus distance _____

Imaging voltage _____

Exposure time _____

Lumbar spine

Imaging system Bucky screen

Focus size ≤1.3mm

Total filtering _____

Scattering grid _____

Film / screen speed _____

Film / focus distance _____

Imaging voltage _____

Exposure time -

manual _____

automated _____

[Coordinating Center review by: _____]

2. What film size is recommended for

Thoracic spine _____ ?

Lumbar spine _____ ?

3. Under what conditions is it OK to use a larger film size ?

4. Please list the missing criteria of good image quality for FLEX.

[a] _____

[b] _____

[c] _____

[d] _____

[e] _____

[f] Blurred rib contours (from breathing technique) on thoracic film.

5. Please fill in the blanks.

Optimum thoracic technique includes

" _____ lateral lying position"

" place both arms _____ "

" use supports _____ "

" check the horizontal position by _____ "

" check the lateral position by _____ "

" center the central ray and cassette to _____ "

" _____ collimation should be visible."

" include levels from T _____ to T _____ "

Section continues next page.

Continued from previous page.

" assure that T_____ is seen in both _____ and _____ images."

" reduce radiation scatter by _____."

6. Optimum lumbar technique includes:

" position long axis of spine _____."

" use radiolucent supports to _____."

" check the horizontal position of the spine by _____"

" check lateral position by _____"

" center central ray and cassettes to L _____"

" reduce radiation scatter and exposure by _____"

" include levels from _____ to _____."

7. True or False?

(Circle.)

Patient should always breath quietly for thoracic exposure.

T F

Never use phototiming for thoracic exposure.

T F

Patient should hold breath after expiration for lumbar exposure.

T F

Never use phototiming for lumbar spine.

T F

8. What are two common causes of imperfect superpositioning of vertebral endplate contours?

1. _____

2. _____

9. What are two common causes of imperfect superpositioning of posterior edges of vertebral body?

- 1. _____

- 2. _____

10. What is a common cause of

[a] a film being too dark to see vertebral contours?

[b] a film being too light to see contours?

[c] a film being simultaneously too dark and too light to see contours?

11. Should the baseline imaging parameters recorded on the Baseline X-ray Form always be repeated exactly for the follow-up x-ray? Please explain.

12. What information must be typed clearly on the x-ray plate ID?

1. _____

2. _____

3. _____

4. _____ (if space allows)

13. If stick-on labels with additional information are used, where should they be placed?

14. Who is the QC officer for the FLEX study at your x-ray facility?

15. Has this QC officer reviewed your first five sets of FLEX x-rays for quality?

(Circle.) Yes No Don't know

16. Where are the FLEX x-ray manuals kept at your x-ray facility?

17. If a patient's follow-up x-rays appear to be of poor quality, what should you do?

18. Is the FLEX x-ray protocol summary (appendix 12A) posted by your x-ray machine?

(Circle.) Yes No Don't know

Test completed. Thank you.