ACR–SPR–SSR PRACTICE PARAMETER FOR THE PERFORMANCE OF RADIOGRAPHY FOR SCOLIOSIS IN CHILDREN

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner considering all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The purpose of this document is to assist practitioners in achieving this objective.

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1 *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the "ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008)" sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.*

I. INTRODUCTION

This practice parameter was revised collaboratively by the American College of Radiology (ACR), the Society for Pediatric Radiology (SPR), and the Society of Skeletal Radiology (SSR).

Scoliosis is defined as a lateral curvature of the spine of 10° or more, usually with a rotary component [1-4]. It can be classified according to its etiology: congenital, idiopathic, traumatic, degenerative, or as part of a generalized disease or syndrome [3,5,6]. Radiography is a proven and useful procedure to confirm the presence of scoliosis, characterize and classify the spinal deformity, and assess response to treatment [2-5,7].

This practice parameter outlines the principles for performing high-quality radiography of the spine for scoliosis in children.

Radiography for scoliosis in children should be performed only for a valid medical reason and with the minimum radiation dose necessary to achieve a diagnostic-quality study. Additional views or specialized examinations may be required. Although it is not possible to detect every abnormality associated with scoliosis, adherence to this practice parameter will maximize the probability of detection.

All radiographic examinations should be performed in accordance with the ACR–AAPM–SIIM-SPR Practice Parameter for Digital Radiography [8].

II. INDICATIONS

Indications for radiography of the spine for scoliosis include, but are not limited to, the following:

1. Alterations in normal spinal alignment on physical examination
2. Alterations in normal spinal alignment detected on other imaging studies
3. Evaluation of spinal curvature progression
4. Follow-up of treatment (orthotic or surgical)
5. Evaluation of individuals with a history of scoliosis in immediate family members
6. Evaluation of individuals at risk for scoliosis (eg, cerebral palsy, Duchenne muscular dystrophy, thoracic surgery, and radiation therapy) [9,10].

In the absence of clinical progression, scoliosis radiography is not neededmore frequently than once a year [11] . However, when risk of progression is highest (eg, during puberty), more frequent imaging may be needed, but not more than every six months.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR–AAPM–SIIM-SPR Practice Parameter for Digital Radiography [13]. In addition, the interpreting physician should be familiar with the proper technique and assessment of scoliosis radiographs [1,14-16].

IV. SPECIFICATIONS OF EXAMINATION

The written or electronic request for a radiograph for a scoliosis evaluation should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state scope of practice requirements. (ACR Resolution 35, adopted in 2006 – revised in 2016, Resolution 12-b)

A. Scoliosis Survey

The number of views required for complete evaluation of scoliosis varies with the clinical indications. For scoliosis screening, a posteroanterior (PA) radiograph of the spine obtained in the upright position may be sufficient [3,15]. The field of view should extend from the cervicocranial junction to the proximal femurs. [1,3,7,15,17,18]. PA positioning of the patient decreases radiation dose to the thyroid and breast [3,4]. A supine (anteroposterior) view will suffice if the patient is unable to stand (eg, the very young child, neuromuscular or paralysis patients) [7]. For these patients who are unable to stand, a spine chair made of radiolucent plastic (eg PVC) can be used to position and secure the patient against the wall bucky for both AP and lateral views. An upright lateral radiograph facilitates assessment of sagittal deformity (abnormal kyphosis and lordosis), sagittal balance [3], and spondylolisthesis. Spondylolysis may be detected, although this is best evaluated with dedicated images when relevant. Multiple studies have shown that there is a decrease in radiation dose with digital imaging systems compared with conventional radiography. These systems should be preferentially employed for imaging of known or suspected scoliosis [19].

The patient should stand (preferably) or sit before a vertical grid. When standing, the knees are placed together in full extension with feet slightly apart. In the lateral position, arms should be placed straight in front of the patient rather than above the patient's head to prevent hyperextension of the spine. When possible, the PA image of the thoracolumbar spine should be obtained at a minimum source-to-receptor distance of 6 ft (180 cm) and an image size of either 14 in × 17 in or 14 in × 36 in. With computed radiography and digital radiography, some vendors provide software to "stitch" 2 or 3 images into one [18,20-22]. Comparison of the source images with the stitched image is helpful to determine if any artifacts were generated during stitching and to confirm overlap or "missing" levels between original source images [23,24]. For X-ray systems that are not able to "stitch" images, it is acceptable to perform 2 or 3 exposures with the patient in unchanged position to capture the full length of the spine (eg, upper and lower images of spine).

Studies have also evaluated the use of a slot scanning device and a dynamic flat-panel detector [25,26]. Although the study found higher skin doses and similar dose area product for the dynamic flat-panel detector compared with the slot scanning device, other investigators have found that the dose savings are comparable to an appropriately filtered beam [26]. Image quality for the slot scanning device was also found to be comparable to the flat-panel detector [27]. Slot scanning systems with orthogonal x-ray tubes may be used to generate 3-D models to obtain measurements, such as the Cobb angle [26].

On the initial examination, the thoracic cage and pelvis may be imaged for correlation with clinical findings (eg, shoulder elevation, trunk shift, rib cage deformities, and congenital rib abnormalities). On the follow-up examinations, the x-ray beam should be collimated to the spine to increase image quality (because of the reduction of scattered radiation) and reduce the area of the patient exposed to radiation. Methods to decrease radiation exposure may include the use of lead-acrylic filters, increased beam filtration, use of size specific protocols, and low-dose imaging systems. [3,4,7,28-30].

In accordance with the 2019 American Association of Physics in Medicine Position Statement on the Use of Patient Gonadal and Fetal Shielding (PS 8-A), gonadal shielding should be discontinued as a routine practice but may be used to comply with individual patient requests or local regulations [31,32].

B. Additional Imaging Evaluation

For patients who are being assessed or clinically treated for scoliosis, additional images may include the following:

1. Right and left lateral bending images. These are usually obtained with the patient supine [7,15]. They are used to determine the flexibility of the curve(s) and to differentiate between structural and nonstructural curves [7,33].

2. Hyperextension and hyperflexion upright views to determine the flexibility of kyphosis and lordosis, respectively [7]
3. Images in an orthosis [34]
4. PA examination of the hand and wrist may also be performed to determine bone age.
5. Supine radiographs

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [35].

V. DOCUMENTATION

A. Imaging Analysis Of Scoliosis

1. General: Reports can be tailored to accommodate ordering provider practice, but may include:
   a. Spine enumeration with attention to possible transitional anatomy.
   b. Vertebral abnormalities, such as fractures, scalloping, and congenital anomalies (eg, hemivertebrae, segmentation anomalies, dysraphism)
   c. Abnormalities of other osseous structures
   d. Evaluation of extraosseous structures included in the examination (eg, chest and abdomen)
   e. Note can be made of the presence of a brace, shoe lift, or other orthosis if this is known to the radiologist [18].
   f. Reporting should also include whether the patient is imaged standing, sitting, or supine.
   g. Imaging should include the triradiate cartilages [36].

2. Curve analysis may include the following (see appendix for definitions of terms):
   a. Presence and number of curves. If there is more than one curve, they can be referred to as "major" and "minor" (or "compensatory") based on their Cobb measurements [16,37]. The terms "primary curve" and "secondary curve" should be avoided because these refer to chronology of development, which cannot be determined from a single study [3,6]. If lateral bending images are obtained, the curves can be further classified as "structural" or "nonstructural" [7,18,37].
   b. Curve pattern (cervical, thoracic, lumbar, cervicothoracic or thoracolumbar)
   c. Location of apical vertebra(e)
   d. Curve length
   e. Curve measurement. The ends of the curve can be identified and are the basis for the Cobb angle. This corresponds to the superior (cephalad) and inferior (caudad) end plates of the vertebrae, respectively [7,15,16,18,38]. If the end plates are poorly visualized, the pedicles can be used instead [7,39,40].
   f. Vertebral rotation. After identifying the apical vertebra, the degree of axial rotation can be estimated using any of several established techniques, including those of Nash and Moe [3,7,15,16,41] and Perdriolle [3,7,38,42].
   g. Evaluation of lordosis and kyphosis. End vertebrae are identified according to the Cobb technique, using the lateral view. On occasion, the upper end vertebra is not well visualized; in this case, the superior end plate of T3 or T4 may be used [37].
   h. Several parameters can be combined to create a classification to guide surgical management for adolescent idiopathic scoliosis [3,16,18]. These include those devised by King et al [43] or Lenke et al [44], the latter being more widely used [16].
   i. Central sacral vertical line and C7 plumb line may be generated to determine sagittal and coronal balance of scoliosis [45-48].
   j. Pelvic tilt and rotation

3. Additional measurements may be obtained in special cases, such as the rib-vertebral angle in infantile idiopathic scoliosis [3,49].

4. Determination of skeletal age. This can be accomplished using the Risser classification, Greulich and Pyle atlas, Sanders scale, or other skeletal maturation assessment tool [50-53].

5. Lateral radiographs of the spine, though not routinely performed at many institutions, can assist in evaluation of other suspected anomalies, such as kyphosis, spondylolysis, or spondylolisthesis.

VI. EQUIPMENT SPECIFICATIONS

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Radiographic Equipment [54].

Radiographic images shall be exposed only with equipment having a beam-limiting device with rectangular collimators.

Imaging options include a wall-mounted device that accommodates a 14 in × 17 in or a 14 in × 36 in image receptor or a digital radiography system capable of stitching 2–3 images into a single image. A low-dose biplane x-ray imaging system is another method for imaging scoliosis, which can provide lower dose studies of the spine and has the advantage of 3-D reconstructions [55-59].

VII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, non-physician radiology providers**,** radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, "as low as reasonably achievable" (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel who work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection, application of dose constraints and limits) and the principles of proper management of radiation dose to patients (justification, optimization including the use of dose reference levels). https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1775_web.pdf

Nationally developed guidelines, such as the ACR's Appropriateness Criteria®, should be used to help choose the most appropriate imaging procedures to prevent unnecessary radiation exposure.

Facilities should have and adhere to policies and procedures that require ionizing radiation examination protocols (radiography, fluoroscopy, interventional radiology, CT) to vary according to diagnostic requirements and patient body habitus to optimize the relationship between appropriate radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used, except when inappropriate for a specific exam. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available from the following websites – Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org). These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be periodically measured by a Qualified Medical Physicist in accordance with the applicable ACR Technical Standards. Monitoring or regular review of dose indices from patient imaging should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry and relevant publications relying on its data, applicable ACR Practice Parameters, NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends; 2006, 2009, amended 2013, revised 2023 (Res. 2d).

VIII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control*, *and Patient Education* on the ACR website (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

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APPENDIX

Cobb measurement of angle: the "end vertebrae" are identified. The end vertebrae are the vertebrae tilted maximally toward the concavity of the curve. Parallel lines are drawn along with superior endplate of the upper end vertebra and the inferior endplate of the lower end vertebra or through the pedicles if the endplates are indistinct. Lines are constructed perpendicular to these endplate lines. The angle subtended by these lines is the angle of curvature.

Scoliosis Research Committee Terminology – Selected Terms [37]:

Apical vertebra (apex): in a curve, the vertebra most deviated laterally from the vertical axis that passes through the center of the sacrum

Caudad end vertebra: the first vertebra in the caudad direction from a curve apex whose inferior surface is tilted maximally toward the concavity of the curve

Cephalad end vertebra: the first vertebra in the cephalad direction from a curve apex whose superior surface is tilted maximally toward the concavity of the curve

Cervical scoliosis: a scoliosis with its apex at a point between C1 and the C6–7 disc

Cervical-thoracic scoliosis: a scoliosis having its apex at C7, T1, or the intervening disc space

Compensatory curve: a minor curve above or below a major curve that may or may not be structural

End vertebrae: the vertebrae that define the ends of a curve in a frontal or sagittal projection

Hyperkyphosis: a kyphosis greater than the normal range

Hyperlordosis: a lordosis greater than the normal range

Idiopathic scoliosis: a lateral curvature of the spine = 10° with rotation; of unknown etiology

Lumbar scoliosis: a scoliosis with its apex at a point between the L1–L2 disc space and the L4–L5 disc space

Major curve: the curve with the largest Cobb measurement on an upright radiograph of the spine

Minor curve: any curve that does not have the largest Cobb measurement on an upright radiograph

Nonstructural curve: a measured curve in the coronal plane in which the Cobb measurement corrects past zero on a supine lateral side-bending radiograph

Pelvic inclination: deviation of the pelvic outlet from the vertical, measured as an angle between the line from the top of the sacrum to the top of the pubis, and a horizontal line perpendicular to the lateral edge of the standing radiograph

Structural curve: a measured curve in the coronal plane in which the Cobb measurement fails to correct past zero on a supine radiograph with maximal voluntary lateral side-bending

Thoracic scoliosis: a scoliosis with its apex at a point between the T2 vertebral body and the T11–T12 disc

Thoracolumbar scoliosis: a scoliosis with its apex at T12, L1, or the intervening T12–L1 disc.

Vertebral axial rotation: transverse plane angulation of a vertebra. One method of measurement is with the Perdriolle technique (in degrees).

The recommended measurement of thoracic kyphosis from a lateral radiograph is the angle between the superior endplate of the highest measurable thoracic vertebra, usually T2 or T3, and the inferior endplate of T12.

The recommended measurement of lumbar lordosis from a lateral radiograph is the angle between the superior endplate of L1 and the superior endplate of S1.

Normal range for thoracic kyphosis: 20–50 degrees

Normal range for lumbar lordosis: 20–60 degrees

*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised, or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

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