ACR–SPR PRACTICE PARAMETER FOR THE PERFORMANCE AND INTERPRETATION OF SKELETAL SURVEYS 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) and the Society for Pediatric Radiology (SPR).

A skeletal survey is a systematically performed series of radiographic images that encompasses the entire skeleton or those anatomic regions appropriate for the clinical indications. Radiographic skeletal surveys are used for a variety of clinical problems in children. Common clinical indications include suspected nonaccidental trauma/child abuse, skeletal dysplasia, metabolic disorder, or bony metastases [1-10]. The goal of the skeletal survey is to accurately identify focal and diffuse abnormalities of the skeleton, including acute or healing fractures, bone lesions, evidence of metabolic bone disease, or characteristics of skeletal dysplasia, and to differentiate them from developmental changes and other anatomic variants that may occur in infants and children.

II. INDICATIONS

Indications for skeletal surveys include, but are not limited to:

1. Known or suspected physical abuse in infants and young children
2. Known or suspected skeletal dysplasias, syndromes, and metabolic disorders
3. Known or suspected neoplasia and related disorders

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR–AAPM–SIIM–SPR Practice Parameter for Digital Radiography [11].

A. Physician
The radiologist should understand the utility of alternate imaging techniques such as ultrasonography, CT, nuclear medicine, and MRI in order to fulfill a consultative role and to interpret pediatric skeletal surveys in the context of other available imaging results.

B. Medical Physicist
The medical physicist should have the training to aid in the development and routine review of imaging protocols in the various imaging modalities in pediatrics and provide consultative advice in the adoption of new technologies and routine testing of these systems. The physicist should also be able to give dose estimates and general advice on the use of such information to the radiologist when requested.

C. Technologist
The technologist should have training and experience in performing radiographic examinations in infants and children. In particular, the technologist should be familiar with positioning and patient restraint, as well as customary measures to minimize radiation exposure. The technologist should be aware of the unique circumstances created when children with suspected abuse are brought to the radiology department by caretakers, guardians, and child protective service representatives.

IV. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for radiographic skeletal surveys 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's scope of practice requirements. (ACR Resolution 35 adopted in 2006 – revised in 2016, Resolution 12-b)

The skeletal survey examination should be performed in accordance with traditional principles of high-quality diagnostic radiography. These include proper technique factors, positioning, collimation, image identification, and immobilization methods.

The imaging protocol for the skeletal survey will depend on the particular clinical indication. Additionally, the radiologist should consider modifying a complete protocol based on imaging that was already performed on the infant or child so as to minimize unnecessary radiation exposure.

IV. SPECIFICATIONS OF THE EXAMINATION

A. Known or Suspected Nonaccidental Trauma/Child Abuse

Each anatomic region (see Table 1) should be imaged with a separate radiographic exposure to ensure uniform image density and maximize image sharpness. A single radiograph (babygram) of the entire infant should not be performed. Each extremity should be radiographed in at least the frontal projection. Radiographs of the axial skeleton should be obtained in two projections: anteroposterior (AP)/frontal and lateral. Right and left posterior oblique views of the entire rib cage aid analysis for rib fractures [12-17]. Additional views as needed should be obtained to fully document suspected abnormalities and may include lateral (orthogonal) views of the long bones [18], a Towne view of the skull, AP and lateral views of selected joints, or additional obliquities of the ribs or other areas of concern [19]. The skeletal survey should be reviewed by a qualified radiologist as defined in Section III. A second interpretation by a pediatric radiologist may add value [20].

A follow-up skeletal survey may be indicated in the setting of nonaccidental injury. Many times, a complete repeat examination is appropriate, though a limited follow-up examination could also be considered [21-26]. Postmortem skeletal surveys may also be helpful [27,28] in addition to postmortem histopathology.

Some clinical and radiological findings (such as burns, bruising, single unexplained fractures, and retinal and intracranial hemorrhages), particularly in children younger than 2 years old, suggest a need to consider child abuse and to perform a skeletal series [29-32].

In the skeletal series, evaluation for any traumatic injury should be performed. In particular, classic metaphyseal lesions, such as metaphyseal corner and buckle handle fractures that are considered highly specific for nonaccidental trauma/child abuse (as are posterior rib, scapular, spinous process and sternal fractures), are best seen by the skeletal series [10,33,34]. Knowledge of variants and simulators of traumatic findings are necessary [35,36].

Skeletal series findings may suggest complementary imaging for diagnosis, including CT/MR for brain analysis [37], nuclear scintigraphy [38,39], and extremity CT for a focal area of concern [40]. CT of the brain may use 3-D skull reconstructions at no additional radiation cost for complementary analysis of calvarium [41,42].

IV. SPECIFICATIONS OF THE EXAMINATION

B. Skeletal Dysplasias, Syndromes, and Metabolic Disorders

1. Skeletal dysplasias and syndromes
   Imaging of skeletal dysplasias, including those in children with disproportionate stature and a wide variety of syndromes, should conform to the standard skeletal survey protocol (see the Complete Skeletal Survey Table below), with the following exceptions:
   a. Entire arms and legs can be exposed on a single film when the size of the child permits.
   b. In newborns and young infants, whole-body AP and lateral radiographs may be appropriate, but separate views of the skull (frontal and lateral), hands (posteroanterior (PA)), and feet (AP) are advisable. Lateral views of the feet and ankles may be useful in selected cases.
   c. As previously noted, review by a qualified physician is essential, with additional views obtained as required (eg, flexion and extension lateral views of the cervical spine for certain skeletal dysplasias).
   d. In some patients, selected images of specific regions or additional views may be appropriate, depending on the differential diagnoses being considered [43-46].
2. Metabolic disorders (rickets and rickets-like disorders)
   In general, it is not necessary to survey the entire bony skeleton for metabolic disorders. A targeted examination focusing on the appropriate anatomic regions of interest to include PA views of the wrists and AP views of the knees is recommended. Occasionally, a complete skeletal survey may be warranted [47].

IV. SPECIFICATIONS OF THE EXAMINATION

C. Neoplasia and Related Conditions

Langerhans cell histiocytosis can present with a solitary bone lesion or widely disseminated disease. A complete skeletal survey should be performed as part of the initial imaging evaluation. Additional orthogonal projections of areas suspected to be abnormal on clinical or other imaging grounds should be obtained. A complete skeletal survey may also be obtained as part of the evaluation for metastatic disease to the bone [48-50].

COMPLETE SKELETAL SURVEY TABLE

APPENDICULAR SKELETON
Right and left humerus (AP)
Right and left ulna & radius (AP)
Right and left hand (PA)
Right and left femur (AP)
Right and left tibia & fibula (AP)
Right and left foot (AP)

AXIAL SKELETON
Thorax (AP, lateral, right and left obliques), to include sternum, ribs [51,52], and thoracic and upper lumbar spine
Abdomen/pelvis, to include the thoracolumbar spine and sacrum (AP)
Lumbosacral spine (lateral)
Skull (frontal and lateral), to include cervical spine (if not completely visualized on lateral skull)* *If a contemporaneous head CT was performed prior to the skeletal survey and its resolution sufficient to provide high quality multiplanar 2-D reconstructions and surface rendered 3-D skull reconstruction, the radiologist may exclude the AP and lateral views of the skull from the skeletal series.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [53].

An official interpretation (final report) of the examination should be included in the patient's medical record. The report should provide a concise description of all sites of definite and suspected abnormality. A standardized summary with descriptive text may be helpful [54]. When a constellation of radiographic findings is sufficient to raise strong suspicion of abuse, this should be so stated in the radiology report and communicated to the referring physician, and this communication should be documented in the final report. A physician diagnosing suspected child abuse is often legally required to notify local child protection authorities. Thus, if the attending physician does not report the case, the radiologist may still be required to do so.

VI. EQUIPMENT SPECIFICATIONS

The quality of a skeletal system survey is a function of the resolution and dose efficiency of the imaging system. Attention to contrast and resolution should be addressed when selecting imaging equipment along with the protocols and processing algorithms used.

Radiology departments should carefully select their digital radiographic systems with particular attention to high diagnostic efficiency. Appropriate technical factor and processing parameter optimization should be made for the demanding application of skeletal survey for suspected child abuse [3,9,55,56]. The lowest possible radiation dose consistent with acceptable diagnostic image quality should be used, particularly in pediatric examinations.

In infants, the entire examination should be performed with suitable high-detail imaging. A grid should not be used in an infant. In the toddler and older child, the increase in patient thickness compared with that of the infant may require greater radiation dosage for optimal penetration. Scatter due to increased thickness may reduce image contrast unless a moving grid is used to image larger body regions. Kilovoltage peak (kVp) should be set at a sufficiently low level to provide adequate subject contrast.

When selecting a digital radiographic system, it should have high spatial resolution and exhibit optimal dose efficiency characteristics. If the system has multiple-resolution mode capability, the high-resolution mode should be used. The higher-resolution mode may require an increase in milliampere-seconds to maintain the signal-to-noise ratio and to optimize visualization of skeletal structures. Digital processing menus and image display parameters should be selected to enhance bone detail [9,55,57-64]. It should be noted that the use of such bone detail–processing algorithms will result in an increase in noise, which may require compensation by increasing milliampere-seconds. Optimal use of high-resolution imaging systems will result in an increase in radiation dose compared with typical low-dose systems widely used for general pediatric imaging. When judiciously applied for appropriate indications, this increased dose is justified so as to obtain superior skeletal detail. When modern high-detail imaging systems are coupled with meticulous radiographic technique, the patient dose remains well within accepted levels, and the associated risks are extremely small. Appropriate collimation should be used to limit radiation exposure to the anatomic area of interest and reduce unnecessary scatter. Past versions of the skeletal series document have underlined the need to make sure shielding is not included within the imaging field so as to avoid the negative impacts of shielding on exposure controls and image quality as well as the obscuration of anatomy, compromising diagnosis. Current ACR, SPR, and AAPM documents have concluded that shielding should no longer be used [65].

The kVp range employed in skeletal survey imaging is 55 to 70, which is generally used for all images of the appendicular skeleton, skull, and spine of infants with the exception of images of the hands and feet, which may be performed at a lower kVp. In the toddler, the kVp is increased as necessary when imaging the skull and spine. The milliampere-seconds is adjusted according to the kVp, image recording system, and x-ray equipment design (eg, filtration, generator, etc). Techniques should be governed more by patient size rather than absolute age. Filtration can be used to remove unwanted low energy x-rays that add to the overall examination dose but are unlikely to penetrate a larger body region. The source to image distance is 101.6 cm (40 in). Skeletal survey images in infants are usually performed on the tabletop. In toddlers and older children, dose considerations may require sacrificing some resolution and/or contrast. The use of the under-table cassette slot in conjunction with a moving antiscatter grid is likely to produce optimal results in larger patients. Meticulous positioning and collimation over each anatomic region are essential. Both joints are included in all long-bone images. Chest imaging uses bone detail technique.

Equipment performance monitoring should be in accordance with the ACR-AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Radiographic Equipment [66].

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 *ACR Position Statement on Quality Control & 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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