Revised 2008 (Resolution 29)*

ACR–SSR PRACTICE GUIDELINE FOR THE PERFORMANCE OF DUAL-ENERGY X-RAY ABSORPTIOMETRY (DXA)

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines 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 physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, 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 the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also 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 these guidelines 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 sole purpose of these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

This guideline was revised collaboratively by the American College of Radiology (ACR) and the Society of Skeletal Radiology (SSR).

Dual-energy X-ray absorptiometry (DXA) is a clinically proven method of measuring bone mineral density (BMD) in the lumbar spine, proximal femur, forearm, and whole body. It is used primarily in the diagnosis and management of osteoporosis and other disease states characterized by abnormal BMD, as well as to monitor response to therapy for these conditions. This guideline outlines the principles of performing high-quality DXA.

(For pediatric language see sections III and V.)

II. GOAL

The goal of DXA is to measure BMD accurately and reproducibly and compare that measurement to a reference population. This comparison establishes the diagnosis of osteoporosis in asymptomatic individuals according to the World Health Organization (WHO) criteria. It also establishes an estimate of future fracture risk and provides guidance for appropriate therapy and

fracture prevention programs**.** It is also useful in evaluating the effectiveness of prior or current therapy.

III. INDICATIONS AND CONTRAINDICATIONS

BMD measurement is indicated whenever a clinical decision is likely to be directly influenced by the result of the test. Indications for DXA include, but are not limited to:

A. Individuals with established or suspected low BMD, or at risk for low BMD, including:

1. All women age 65 years and older and men age 70 years and older (asymptomatic screening).

2. Women younger than age 65 years who have additional risk for osteoporosis, based on medical history and other findings. Additional risk factors for osteoporosis that might be considered include:
   a. Estrogen deficiency.
   b. A history of maternal hip fracture that occurred after the age of 50 years.
   c. Low body mass (less than 127 lbs).
   d. History of amenorrhea (more than 1 year before age 42 years).

3. Women younger than age 65 years or men younger than age 70 years who have additional risk factors including:
   a. Current use of cigarettes
   b. Loss of height, thoracic kyphosis.

4. Individuals of any age with radiologic evidence of low bone mass (osteopenia), including the presence of vertebral compression fractures.

5. Individuals age 50 years and older who develop a wrist, hip, spine, or proximal humerus fracture with minimal or no trauma.

6. Individuals of any age who develop 1 or more insufficiency fractures.

7. Individuals receiving (or expected to receive) glucocorticoid therapy for more than 3 months.

8. Individuals beginning or receiving long-term therapy with medications known to adversely affect BMD (e.g., anticonvulsant drugs, androgen deprivation therapy, aromatase inhibitor therapy, or chronic heparin).

9. Individuals with an endocrine disorder known to adversely affect BMD (e.g**.,** hyperparathyroidism, hyperthyroidism, or Cushing's syndrome).

10. Hypogonadal men older than 18 years.
11. Individuals with metabolic and/or other medical conditions that could alter BMD, such as:
    a. Chronic renal failure.
    b. Rheumatoid arthritis and other inflammatory arthritides.
    c. Eating disorders, including anorexia nervosa and bulimia.
    d. Organ transplantation.
    e. Prolonged immobilization.
    f. Conditions associated with secondary osteoporosis, such as gastrointestinal malabsorption or malnutrition, osteomalacia, vitamin D deficiency, endometriosis, acromegaly, chronic alcoholism or established cirrhosis, and multiple myeloma.
    g. Individuals who have had gastric bypass for obesity. The accuracy of DXA in these patients might be affected by obesity.

12. Individuals being considered for pharmacologic therapy for osteoporosis.

13. Individuals being monitored to assess response to or effectiveness of osteoporosis drug therapy.

14. Children or adolescents with defects in bone development and/or growth disturbances caused by conditions associated with abnormal BMD, such as osteogenesis imperfecta, growth hormone deficiency, or inflammatory bowel disease (IBD).

B. DXA may be indicated in the diagnosis, staging, and follow-up of individuals with conditions that result in pathologically increased BMD, such as osteopetrosis or prolonged exposure to fluoride.

C. DXA may be indicated as a tool to measure total body fat and lean tissue composition as part of a comprehensive disability evaluation in the elderly or for other individuals, including those with malabsorption or eating disorders and high performance athletes.

D. Central and peripheral BMD may be discordant. Individuals at high risk for osteoporosis who have a normal peripheral examination should be further evaluated by central DXA or quantitative computed tomography (QCT).

There are no absolute contraindications to performing DXA. However, a DXA examination may be of limited value or require modification of the technique or rescheduling of the examination in some situations, including:

1. Recently administered gastrointestinal contrast or radionuclides.
2. Pregnancy.
3. Severe degenerative changes or fracture deformity in the measurement area.
4. Radiopaque implants in the measurement area, most commonly at the hip.
5. Inability to attain correct position and/or remain motionless for the measurement.
6. Extreme obesity or extremely low body mass index (BMI) that may adversely affect the technique and the ability to obtain accurate and precise measurements. QCT may be a desirable alternative in these individuals.

For the pregnant or potentially pregnant patient, see the ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation.

IV. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

A. Physician

1. The examination must be performed under the supervision of and be interpreted by a licensed physician with the following qualifications:
   a. Knowledge and understanding of bone structure, metabolism, and osteoporosis.
   b. Documented training in and understanding of the physics of X-ray absorption and radiation protection, including the potential hazards of radiation exposure to both patients and personnel and the monitoring requirements.
   c. Knowledge and understanding of the process of DXA data and image acquisition, including proper patient positioning and placement of regions of interest, and artifacts and anatomic abnormalities that may falsely increase or decrease BMD values.
   d. Knowledge and understanding of the analysis and reporting of DXA, including, but not limited to, bone density measurements, percent of mean, T-score, Z-score, fracture risk, and the WHO classification system.
   e. Knowledge and understanding of the criteria for accurate and precise comparison of serial measurements, including limitations of comparing measurements made by different techniques and different devices**,** the rationale behind precision testing, and the statistical significance of serial changes in BMD.
   f. Knowledge and understanding of the utility of the entire spectrum of bone density techniques, including DXA, QCT, radiographic absorptiometry (RA), peripheral DXA, single X-ray absorptiometry, and quantitative ultrasound (QUS), to fulfill a consultative role in recommending further bone density studies, future serial measurements, or diagnostic procedures to confirm suspected abnormalities seen on DXA images.

2. The supervising physician shall be responsible for overseeing the DXA facility and its equipment quality control program. The physician accepts final responsibility for the quality of all DXA examinations.

Continuing Medical Education

The physician's continuing medical education should be in accordance with the ACR Practice Guideline for Continuing Medical Education (CME).

B. Qualified Medical Physicist

A Qualified Medical Physicist is an individual who is competent to practice independently one or more of the subfields in medical physics. The ACR considers certification and continuing education and experience in the appropriate subfield(s) to demonstrate that an individual is competent to practice one or more of the subfields in medical physics, and to be a Qualified Medical Physicist. The ACR recommends that the individual be certified in the appropriate subfield(s) by the American Board of Radiology (ABR), the Canadian College of Physics in Medicine, or for MRI, by the American Board of Medical Physics (ABMP) in magnetic resonance imaging physics.

The appropriate subfields of medical physics for this guideline are Therapeutic Radiological Physics, Diagnostic Radiological Physics, Medical Nuclear Physics, and Radiological Physics.

A Qualified Medical Physicist should meet the ACR Practice Guideline for Continuing Medical Education (CME). (ACR Resolution 17, 1996 – revised in 2008, Resolution 7)

C. Radiologic and Nuclear Medicine Technologist

The technologist should have:

1. Responsibility for patient comfort and safety, preparing and properly positioning the patient, placement of regions of interest for assessing

BMD measurements, monitoring the patient during the measurements, and obtaining the measurements prescribed by the supervising physician.
2. Responsibility for determining precision error and calculating least significant change (LSC) (see section VIII. D).
3. Documented formal training in the use of the DXA equipment, including performance of all manufacturer-specified quality assurance (QA) procedures.
4. Access to the manufacturer's operator manual for the specific scanner model being used, and must read and become familiar with the manual prior to performing scans.
5. State licensure and/or certification, if required. Organizations providing certification in bone densitometry include: the American Registry of Radiologic Technologists (ARRT), the Nuclear Medicine Technology Certification Board (NMTCB), and the International Society for Clinical Densitometry (ISCD).

Continuing Medical Education

The technologist's continuing medical education should be in accordance with the national registry or state licensure requirements, where applicable.

V. SPECIFICATIONS OF THE EXAMINATION

A. The written or electronic request for a DXA examination 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)

B. A history should be obtained from the patient regarding risk factors as listed in section III, including family history, prior fragility fractures, and prior bone trauma/fractures or surgery that could potentially affect the accuracy of measurements. Questionnaires can be found on www.iscd.org or www.nof.org.

C. Standard DXA examination in adults should consist of a posteroanterior (PA) scan of the lumbar spine and scan of either or both proximal femurs**.** For purposes of WHO classification, the determination is based on measurement of the PA spine, proximal femur, or total femur. In instances where these measurements are not feasible, alternate sites can be used for evaluating the patient, including the lateral lumbar spine, forearm, and total body. In some cases (extensive abdominal aortic calcification, degenerative disease of the lumbar spine or hip, scoliosis, fractures, orthopedic implants), other sites should be scanned, such as the opposite hip, nondominant forearm, or whole body.

D. If the DXA scanning device has the appropriate capability, a low dose lateral image of the dorsal and lumbar spine may be added to determine whether vertebral fractures are present (vertebral fracture assessment [VFA]). This may be warranted because the presence of spine fractures, which may be asymptomatic, greatly increases the likelihood of future fractures if not treated. This should be considered in patients at risk such as the elderly or patients with height loss or back pain who have not been assessed by conventional X-ray, computed tomography (CT), or magnetic resonance imaging (MRI). Appropriate additional training and experience are required to properly perform and interpret VFA. It is intended solely to identify whether spine compression is present and does not replace conventional diagnostic imaging for other purposes.

E. DXA of the nondominant forearm may be useful when DXA of the spine or hip cannot be performed or accurately interpreted, in very obese individuals who exceed the weight limit of the DXA table, and in individuals with hyperparathyroidism.

F. In children, DXA examination usually consists of an examination of the lumbar spine and/or whole body; evaluation of other anatomic regions in children may be performed, but is not routine or standardized. The reference population to which the child is compared must be noted, as well as adjustment for height, radiographic bone age, sexual maturity stage, weight or other factors if used. The relationship of BMD to fracture risk in children is not clearly established.

G. Images indicating the areas of BMD measurement should be obtained with the DXA device; generally radiographs are not necessary. If prior radiographs of these anatomic areas are available, they should be reviewed to determine if specific sites should not be analyzed.

H. Positioning and soft-tissue-equivalent devices issued by the manufacturer must be used consistently and properly. Comfort devices, such as pillows under the head or knees, must not interfere with proper positioning and must never appear in the scan field.

I. Anatomic areas of known fracture or surgery should be excluded from measurement. For the lumbar spine, vertebrae should be excluded if other abnormalities result in a T-score difference of more than 1.0 compared to the adjacent vertebrae.

J. If significant discordance is present between 2 areas measured with no evident explanation from the history, DXA images or radiographic correlation, additional DXA acquisitions (e.g., opposite proximal femur or nondominant forearm), or other bone density measurement techniques (e.g., QCT) should be considered.

K. For postmenopausal women and men age 50 years and older, measured values must be compared with young adult reference population values, yielding a T-score that corresponds to a WHO diagnostic category. Comparison with population-specific age-matched values (Z-scores) should be performed routinely, including all children, premenopausal women, and men younger than age 50 years. Relative and/or absolute future fracture risk can be estimated from the calculated BMD values and additional epidemiologic factors; software for calculating T-scores, Z-scores, and fracture risk is typically programmed into the DXA scanner.

L. Comparison should be made to any prior comparable DXA examinations of the same skeletal site, region of interest, and area size. The precision error and calculated least significant change of the specific scanner(s) should be checked to determine if measured changes are statistically significant. If the prior DXA examination was performed on the same unit, quantitative comparison of the examinations can be performed. If the examination was on a different unit, then comparison is qualitative. Comparability of scans, in order of decreasing validity, is as follows:

1. Previous examinations on the same well-maintained device.
2. Previous examinations on another device from the same manufacturer.
3. Previous examinations on a device from another manufacturer.

VI. DOCUMENTATION

Reporting should be done in accordance with the ACR Practice Guideline for Communication of Diagnostic Imaging Findings.

A. A permanent record shall be maintained, including:

1. Patient identification, facility identification, examination date, image orientation, and device manufacturer and model.
2. Clinical notes or questionnaire containing any pertinent history.
3. Positioning, anatomy, and/or technique settings that would be important for performing serial measurements.
4. Printouts of the images and regions of interest, if provided by the device and the BMD measurements obtained.

B. For postmenopausal women and men age 50 years and older, at a minimum the reports should include the BMD (in g/cm^2), T-score, and classification according to WHO criteria. WHO score is assigned based on the lowest T-score of the lumbar spine, total hip, femoral neck or distal third of the forearm/radius, and is not assigned separately for each site. Osteoporosis by WHO category is not further defined as “mild, moderate, or severe,” but the report should indicate that fracture risk increases along an increasing gradient as T-scores decline. A statement about fracture risk is also recommended, if appropriate. Preferably, an absolute fracture risk (instead of a relative fracture risk) calculated from the measured BMD, and clinical risk factors can be reported. The WHO 10-year absolute fracture risk assessment tool (FRAX) has been FDA approved and may be applied in post menopausal women. Relative fracture risk may also be reported.

C. For premenopausal women, men younger than age 50 years, and children, the BMD and Z-score should be reported for each skeletal site examined. In these populations there is no documented correlation between bone density and fracture risk. The WHO classification does not apply to these individuals. Z-scores above +/-2.0 are considered within the expected range for their age. Individuals with Z-scores of -2.0 and lower are considered to have low bone density for their age. T-scores should not be reported for children.

D. For all examinations the report should indicate whether artifacts or other technical issues may have influenced the reported measurement(s) of BMD. A statement comparing the current study to prior available comparable studies should include an assessment of whether any changes in measured BMD are statistically significant. When appropriate, suggestions for radiographs or other ancillary imaging tests should be provided. Recommendations for, and the timing of, a follow-up DXA scan can also be included. Reports may also specify the reference database(s) used for calculating the T-score and Z-score and estimating fracture risk.

E. Recommendations for treatment or evaluation of secondary osteoporosis may be included in the DXA report.

VII. EQUIPMENT SPECIFICATIONS

Multiple equipment designs are available that can accurately and precisely measure bone density using DXA**.** The equipment should provide the following:

1. Normal young adult and age-matched reference population values matched for sex and applicable to the equipment being used. Some devices also provide reference values matched for ethnicity and body weight.
2. Labeled images of the anatomic site measured and measurement results. These should be recorded permanently for patient records.
3. Precision errors of measurement of the phantom or standard that do not exceed the specifications or recommendations of the manufacturer and are less than 1%. In-vitro (phantom) precision should not be equated with in-vivo (patient) precision, as the role of the technologist in patient positioning and scan analysis is critical.

A phantom or other standard must be measured according to the manufacturer's recommendations in order to monitor instrument calibration.

VIII. EQUIPMENT QUALITY CONTROL

DXA equipment quality control is extremely important for long-term monitoring of the effectiveness of therapy or progression of disease.

A. Each imaging facility should have documented policies and procedures for monitoring and evaluating the effective management, safety, and operation of imaging equipment. The quality control program should be designed in consultation with a qualified medical physicist to minimize risks for patients, personnel, and the public and to maximize the quality of the diagnostic information.

B. At installation, an environmental radiation safety survey should be conducted by a qualified medical physicist. Survey should include any additional evaluation as required by the state regulations.

C. Quality control procedures should be performed and permanently recorded by a trained technologist. These procedures are generally required at least 3 days a week and always before the first patient measurement of the day. They should be interpreted immediately upon completion according to the guidelines provided by the manufacturer to ensure proper system performance.

If a problem is detected according to manufacturer guidelines, the service representative should be notified and patients should not be examined until the equipment has been cleared for use.

D. Each facility should determine its precision error and calculate least significant change (LSC). If a facility has more than one technologist, these values should represent an average of pooled data from all technologists [5,10].

E. Upon replacement of the DXA unit, precision error and LSC should be cross-calibrated and recalculated.

F. If a new technologist joins the facility, he/she should do a precision study and those results, if acceptable, should be pooled with the precision data for the facility.

IX. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, radiologic technologists, and all supervising physicians have a responsibility to minimize radiation dose to individual patients, to staff, and to society as a whole, while maintaining the necessary diagnostic image quality. This concept is known as "as low as reasonably achievable (ALARA)."

Facilities, in consultation with the medical physicist, should have in place and should adhere to policies and procedures, in accordance with ALARA, to vary examination protocols to take into account patient body habitus, such as height and/or weight, body mass index or lateral width. The dose reduction devices that are available on imaging equipment should be active; if not, manual techniques should be used to moderate the exposure while maintaining the necessary diagnostic image quality. Periodically, radiation exposures should be measured and patient radiation doses estimated by a medical physicist in accordance with the appropriate ACR Technical Standard. (ACR Resolution 17, adopted in 2006 – revised in 2009, Resolution 11)

X. 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 web page (http://www.acr.org/guidelines).

Equipment performance monitoring should be in accordance with the ACR Technical Standard for Diagnostic Medical Physics Performance Monitoring of Radiographic and Fluoroscopic Equipment.

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Suggested Reading (Additional articles that are not cited in the document but that the committee recommends for further reading on this topic)

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