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Executive Summary of the 2019 ISCD Position Development Conference on Monitoring


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Abstract

To answer important questions in the fields of monitoring with densitometry, DXA machine cross-calibration, monitoring, spinal cord injury, peri-prosthetic and orthopedic bone health, transgender medicine and pediatric bone health, the ISCD held a Position Development Conference (PDC) from March 20-23, 2019. Potential topics requiring guidance were solicited from ISCD members in 2017. Following that, a Steering Committee selected, prioritized and grouped topics into Task Forces. Chairs for each Task Force were appointed and the members were co-opted from suggestions by the Steering Committee and Task Force Chairs. The Task Forces developed key questions, performed literature searches and came up with proposed initial positions with substantiating draft publications, with support from the steering committee. An invited Panel of Experts first performed a review of draft positions using a modified RAND Appropriateness Method with voting for appropriateness. Draft positions deemed appropriate were further edited and presented at the PDC meeting in an open forum. A second round of voting occurred after discussions to approve or reject the positions. Finally, a face-to-face closed session with experts and Task Force Chairs and subsequent electronic follow-up resulted in thirty-four Official Positions of the ISCD approved by the ISCD Board on May 28, 2019. The Official Positions and the supporting evidence were submitted for publication on July 1, 2019. This paper provides a summary of the all the ISCD Adult and Pediatric Official Positions, with the new 2019 Positions highlighted in bold.

Key words: monitoring; vertebral fracture assessment; trabecular bone score; peri-prosthetic fracture; spinal cord injury; cross-calibration; atypical femur fracture; transgender; Dual-energy X-ray Absorptiometry, pediatric, lateral distal femur
Introduction

The International Society for Clinical Densitometry (ISCD) convenes its Adult and Pediatric Position Development Conferences (PDC) at intervals to advance the field of skeletal measurement, in demonstration of its stated mission of “advancing high-quality musculoskeletal health assessments in the service of superior patient care.” Specifically, the purpose of the conferences is to update the Society’s Official Positions, “which pertain to the use of bone mass measurement and other skeletal health assessment technologies inclusive of the performance, interpretation, reporting, and clinical relevance of those technologies” [1]. The Official Positions are intended to serve as guidance to the field of osteoporosis assessment and as a foundation for elements of the ISCD’s education, certification and facility accreditation activities. The positions are disseminated in official ISCD publications and widely cited peer-reviewed literature.

The first adult PDC was held in 2001 and the most recent past PDC in Chicago, IL in 2015, with a total of eight adult PDC’s held since inception. Pediatric PDC’s have been held in 2007 and 2013. All of ISCD’s Official Adult and Pediatric Positions have been published in the Journal of Clinical Densitometry and online. [2-10] The 2019 PDC was convened within ISCD’s 25th Annual Meeting from March 20th to March 23rd, 2019, in Kuala Lumpur, Malaysia, and for the first time included both adult and pediatric topics.
The PDC process is designed to create guidance for researchers and clinicians in emerging clinical domains, as well as to update more typical bone strength assessment recommendations. Many times, clinicians lack high-quality evidence to guide care, and the PDC process is designed to marry best available evidence with expert evaluation and discussion, through the modified UCLA/RAND Appropriateness Methodology (RAM) [11].

**PDC Process: Personnel Groups and Activities**

Three key personnel groups drive the PDC process. The PDC Steering Committee is the source of PDC scientific organization and content management, convened by the ISCD Executive Committee approximately 12-18 months before a PDC is held. ISCD’s (author info removed) is typically designated as Organizing Chair, with Co-Chairs recommended by the Organizing Chair. It is prudent to include a seasoned former PDC participant in a substantial advisory role (author information removed). Additional Co-Chairs are added as needed; (author information removed). The Steering Committee schedules weekly teleconferences to set direction for the PDC and its Task Forces, and to monitor progress. Initially, work focuses on topic area solicitation, topic area ranking and refinement with Scientific Advisory Council (SAC), and development of the key questions, the answers forming the basis for draft Official Positions. Final key questions are approved by the Steering Committee after discussion and refinement with the Task Force Chairs; these are the questions that are answered in the form of a draft Official Position statement. Each Steering committee member is then assigned as a liaison to
one or more task forces. Attendance at the PDC proceedings is required for all Task Force Chairs or their co-chair designees.

Starting about nine months before the PDC, members of the Steering Committee invite Task Force Chairs to organize and manage the individual task forces and coordinate the task force work products: presentations of proposed Official Positions for the public and Expert Panel at the PDC, and the drafting of review articles submitted for publication on the accepted Official Positions. Task Force Chairs are chosen not only for their broad knowledge of the topic area, but also for their ability to lead the teams and deliver quality papers and presentations in a timely manner. The Chairs constitute their task forces with subject matter experts from around the globe, working via teleconference and email for approximately six months before the PDC. For the 2019 PDC Task Force Chairs and members totaled 69 personnel.

The third personnel group is the Expert Panel. Bone experts worldwide (including six adult and two pediatric experts for this PDC) are invited to serve. Since the 2019 PDC was held in the Asia-Pacific region, there was a special interest in involving experts from that region. Two pediatric experts were included in this year’s panel, since pediatric topics were part of the process and all experts voted on all positions. All expert panelists are expected to be available starting about two months before the PDC to review draft task force papers and proposed Official Positions, to confidentially rank submitted proposed Official Positions and provide comments and feedback to task force chairs. Experts who agree to participate are extensively briefed on PDC process, expectations for their service, and the modified RAM used by ISCD PDC’s to assess evidence and
adapt recommendations to clinical practice. Later, attendance at all PDC live sessions and at the final closed session is required; a total of eight experts attended the PDC in Kuala Lumpur. After the PDC meeting is concluded, experts may be required to further review accepted positions for crafting final language, and for this PDC that occurred remotely utilizing secure online document management with ability to comment.

All PDC personnel were required to disclose conflicts per ISCD standard procedures.

**Adult PDC Topic Selection and Key Question Development**

Adult PDC topic areas are determined by a multi-step process that begins soon after the conclusion of the prior PDC. Between PDC’s, ISCD members continually submit questions and concerns which are then logged by ISCD staff, Executive Committee and Board of Directors members. ISCD requests members’ direct input on possible topics and any key questions with e-mail solicitation starting approximately 18 months before the next PDC. Potential topics are reviewed and consolidated by the PDC Steering Committee and ranked by ISCD’s SAC. The summary rankings and advice yielded five adult topic areas for the 2019 PDC: Monitoring Patients on Treatment, Cross-Calibration and Least Significant Change (LSC), Spinal Cord Injury and DXA, Transgender/Gender Non-Conforming and DXA, and Peri-prosthetic Orthopedics and Bone Strength Measurement. Monitoring included four sub-areas: monitoring with bone mineral density (BMD) testing, monitoring with vertebral fracture assessment (VFA), monitoring with trabecular bone score (TBS), and DXA monitoring for atypical femoral fracture (AFF). BMD
monitoring is a very common clinical scenario already addressed in prior PDC, but ISCD had not previously addressed monitoring with the more advanced TBS and VFA technologies. The rapidly developing information of AFF risks while on anti-resorptive treatment made considering recommendations in that area critical. As DXA devices decline in individual clinician offices and care is consolidated into facilities ([12], densitometry occurs increasingly in care systems with wide geographic distribution, which made reconsideration of ISCD’s previous positions on Cross-Calibration and LSC pertinent. Finally, topic areas of bone health in spinal cord injury (SCI), transgender and gender non-conforming (TGNC) individuals, and orthopedic patients with/without peri-prosthetic implants (PPO) were selected due to maturation in the substantiating scientific literature, and their salient clinical relevance for ISCD’s constituents and constituents’ organizations with similar missions and goals.

The Steering Committee submitted key questions to each task force chair. The Monitoring Task Force received the following key questions:

1. Can serial BMD testing be used to determine whether treatment should be initiated in untreated patients?
2. When is it appropriate to do a follow-up BMD test in a patient on osteoporosis treatment?
3. Can serial BMD testing identify individuals unresponsive to therapy?
4. Is serial BMD testing useful in patients following cessation of osteoporosis therapy?
5. Is TBS useful to monitor patients treated with oral bisphosphonates?
6. Is TBS useful to monitor patients treated with zoledronic acid?

7. Is TBS useful to monitor patients treated with denosumab?

8. Is TBS useful to monitor patients treated with teriparatide and abaloparatide?

9. When should VFA be repeated?

10. Can DXA systems detect incomplete AFFs or abnormalities in the spectrum of AFFs?

11. What densitometer-based test should be used for the detection of abnormalities in the spectrum of AFFs, and how should it be analyzed, interpreted and reported?

12. In which patient population should densitometer-based FFI be used to screen for abnormalities in the spectrum of AFFs?

Key questions for the Cross-Calibration and LSC Task Force:

1. How should a provider with multiple DXA systems of the same make and model calculate LSC?

2. How should a provider with multiple DXA systems with the same manufacturer but different models calculate LSC?

3. How should a provider with multiple DXA systems from different manufacturers and models calculate LSC?

4. Are there specific phantom procedures that one can use to provide trustworthy in-vitro cross calibration for same models, different models, different makes?

Key questions for the SCI Task Force:
1. What are the indications for initial DXA in individuals with spinal cord injury?

2. Do indications for initial DXA vary based on other factors such as age, sex, race, neurological impairment, etiology of injury, time since injury, medications, or prevalent fracture?

3. Should alternative skeletal sites be measured to diagnose osteoporosis, assess fracture risk, or monitor response to therapy in individuals with spinal cord injury?

4. Can bone densitometry by DXA be used to predict lower extremity fracture risk in persons with spinal cord injury?

5. How should DXA be used to monitor osteoporosis therapy (drug, nutraceuticals, rehabilitation interventions) in individuals with SCI?

6. Are there DXA based criteria that are absolute or relative contra-indication to exercise-based therapy?

Key questions for the TGNC Task Force:

1. What are the indications for performing a baseline DXA in TGNC individuals?

2. In which TGNC individuals should DXA measurements be repeated, and at what interval?

3. Which databases can be used for diagnosis?

4. What parameters need to be included in the DXA report for TGNC individuals?
Key questions and sub-questions for the PPO Task Force:

1. Which preoperative elective orthopedic surgical patients should have bone mineral density measured?
   a. Are there specific orthopedic conditions that are risk factors for bone failure or impaired healing that change indication for bone health assessment?

2. What are appropriate Regions of Interest (ROI) and important technical factors in the surgical field to determine skeletal status using DXA in arthroplasty patients?

3. What non-BMD measures or indices are useful for preoperative decision making in arthroplasty (for example, do specific geometries such as proximal femur cortical index or cortical thickness indicate poor bone health or a negative change in bone health)?

4. Can these be accurately measured with DXA, plain radiographs, or computed tomography (CT)?

5. What are the CT Hounsfield Units methods and thresholds to identify low bone mass or those at high risk for fractures or predict post-surgical complications in the upper and lower extremities?

Pediatric PDC Topic Selection and Key Question Development

Traditionally, ISCD Pediatric Position Development Conferences (PediPDC) are held when required to update the pediatric bone field, separate from adult PDCs. On this occasion, a Pediatric Task Force was created inside the adult PDC framework to address questions
concerning the pediatric bone field since the last PediPDC in 2013. Pediatric topics were developed after pediatric bone leaders involved in ISCD conducted informal polls at major bone meetings since the last PediPDC. A list of approximately one dozen topic areas was reviewed and prioritized by the Steering Committee working with advice from ISCD members who are leading experts in the field. The PDC Steering Committee then reviewed topics submitted and worked with advisors to prioritize topics and develop key questions.

The PediPDC Task Force addressed the following topic areas: proximal femur and 33% radius measures in pediatric patients, lateral distal femur measures in special populations, and use of vertebral fracture assessment (VFA) in pediatric patients. These topics were chosen to highlight advances in pediatric bone assessment literature since the last PediPDC, to fill in clinical areas of critical need, and to bring forward potential new assessment techniques in special pediatric populations.

Key questions and sub-questions for the PediPDC Task Force:

1. For the assessment of BMC/aBMD at the proximal femur, lateral distal femur, and distal forearm:
   a. Are there adequate reference data?
   b. What is the precision?
   c. Does it predict fracture or other proxy outcomes?
   d. Should it be used in all children or restricted to special groups?
2. For VFA:
   a. Should VFA be used as a substitute for spine radiography in the identification of symptomatic/asymptomatic osteoporotic VF in children?
   b. When does an abnormal VFA in a child require follow-up spine imaging?
   c. What is the VFA method that should be used to detect an osteoporotic VF in children?
   d. Are there technical and biological factors that limit the accuracy of DXA-based VFA in children (for example DXA model and software, age, sex, pubertal stage, obesity)?

The UCLA/RAND Appropriateness Methodology (RAM)

For most of routine daily practice, there are few randomized controlled trials or other high-quality evidence available to clinicians to help with specific patient diagnostic or treatment options. Nevertheless, bone health providers must make decisions every day, often with incomplete guidance. The UCLA/Rand Appropriateness Methodology (RAM) combines best available science with expert assessment and recommendation to bridge the scientific gap in practice. It is based on work at the RAND Corporation beginning in the 1950’s, and refined at UCLA for health care in the 1980 (reference the monograph).

Originally, the appropriateness of medical and surgical procedures was the focus of the RAM [11]. ISCD uses a modification of the RAM; instead of indications voted on for appropriateness
to perform a procedure, a set of statements (draft Official Positions) are assessed for appropriateness as clinical guidance to the bone health community. Despite this modification, much of the rest of RAM procedures remain true to the original methodology.

A thorough literature search on key questions forms the basis for the decision-making in the RAM and for the PDC, with careful attention to documentation of search strategies and results. From these searches, task forces formulate draft Official Positions, which are action statements about clinical practice and which answer key questions. Expert panelists received the draft positions, along with supporting draft manuscripts detailing task force literature searches, rationales for proposed positions, discussion about the quality of the evidence and proposed future directions in early January 2019. The first round of confidential rating occurred (dates); ratings and comments were collected via secure online format.

Experts rate draft positions according to the four domains in the RAM: 1) Appropriateness, on a scale of 1-9, with appropriateness referring more specifically to the clinical usefulness of a given position, 2) Quality of Evidence, characterized as Poor, Fair or Good, 3) Strength of Recommendation graded as A, B, or C, and 4) Applicability worldwide or locally.

Additionally, a measure of consensus among expert panelists is important for the RAM process. To this end, the dispersion of votes from the median value is recorded for each Appropriateness score. For draft positions with medians in the “inappropriate” range (i.e., 1-3) and three or more experts voting in the “appropriate” range (i.e., 7-9), the position would be classified as
“uncertain”, because of disagreement. Conversely, those positions with medians in the range of 7-9 would be classified as “uncertain” if three or more experts voted “inappropriate”.

Details regarding the RAM grading conventions for 2019 PDC are shown in Table 1.

Table 1: Details for RAM Voting Categories

<table>
<thead>
<tr>
<th>Rating Domain</th>
<th>Rating Scale</th>
<th>Rating Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriateness</td>
<td>From 1 to 9; 1 = “highly inappropriate”, 9 = “highly appropriate”</td>
<td>“Appropriate”: panel median 7-9, no disagreement; “Uncertain”: panel median 4-6 OR any median value with disagreement; “Inappropriate”: panel median 1-3, no disagreement</td>
</tr>
<tr>
<td>Quality of evidence</td>
<td>Good, Fair, Poor</td>
<td>Good: at least two well-designed (Prospective randomized trials or high quality observational studies); Fair: studies sufficient on outcomes but otherwise limited in number, quality or consistency; Poor: insufficient to determine effects or consequences on implementation, due to major flaws in the evidence.</td>
</tr>
<tr>
<td>Strength of Recommendation</td>
<td>A, B, C</td>
<td>A: strong recommendation supported by the available evidence; B: recommendation supported by the evidence; C: recommendation supported primarily by expert opinion</td>
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</tr>
<tr>
<td>Applicability</td>
<td>Local (L) or Worldwide (W)</td>
<td>Local: factors limiting the applicability of the recommendation; Worldwide: no factors limiting the applicability of the statement</td>
</tr>
</tbody>
</table>

**PDC Process: Conduct of Conference**

One Open Session of 60-120 minutes duration was held for each task force to present its draft positions and supporting rationales. During this time, there are comments and questions from the public and from the Expert Panel. The panel voted again confidentially in Open Session and aggregate results were displayed real-time in categories of Appropriateness, Strength, Quality and Applicability. At this stage some draft positions are removed with a designation of “Inappropriate Without Disagreement”; the others remaining in “Uncertain” categories required further discussion at Closed Session, and those designated as “Appropriate Without Disagreement” are provisionally adopted pending word crafting at the Closed Session.
The PDC Closed Session was held March 23, 2019 immediately following the Annual Meeting. Task force chairs, expert panelists and the Steering Committee members were present. “Uncertain” draft positions held over from the Open Sessions were discussed and modified in some cases, then re-voted according to the previously outlined paradigm. Those already accepted were reviewed for word-crafting and consolidation. At the close of the Closed Session, approximately twelve statements still required word-crafting.

**PDC Process: Work After the Conference**

Expert panelists submitted word-crafting comments online for the twelve remaining statements up until April 10, 2019, when the comment period was closed. There were eighty-two initial draft positions forwarded to the Expert Panel for first-round voting, of which thirty-five ultimately were approved. The Steering Committee then finalized draft Positions and submitted them to the ISCD Board, with unanimous approval obtained on May 28, 2019. New Official Positions are inserted into the existing list of ISCD Official Positions and will be published online at the ISCD website, and in print.

The Steering Committee served as editors and worked closely with the Task Force Chairs to refine the draft review papers for review manuscript submission. In total, nine manuscripts were submitted for publication in July, 2019.
Acknowledgements

The authors extend sincere thanks to the staff at ISCD in the USA and to Medical Conference Partners in Kuala Lumpur, Malaysia for making the 2019 PDC possible successful, to Task Force Chairs and members and Expert Panelists for their tenacity and passion, and to William Leslie, MD and Aliya Khan, MD for their sage advice during the PDC process.

Personnel Listing for 2019 PDC

Steering Committee Members

(author information removed)

Task Force Chairs

(author information removed)

Expert Panelists

Sanford Baim, MD
Robert Blank, MD, PhD
Neil Binkley, MD
Joon Kiong Lee, MD
2019 ISCD Official Positions - Adult

These are the Adult Official Positions of the ISCD as updated in 2019. The Official Positions that are new or revised since 2015 are in **bold type**.

**Indications for Bone Mineral Density (BMD) Testing**

- Women aged 65 and older
- For post-menopausal women younger than age 65 a bone density test is indicated if they have a risk factor for low bone mass such as:
  - Low body weight
  - Prior fracture
  - High risk medication use
o Disease or condition associated with bone loss.

- Women during the menopausal transition with clinical risk factors for fracture, such as low body weight, prior fracture, or high-risk medication use.
- Men aged 70 and older.
- For men < 70 years of age a bone density test is indicated if they have a risk factor for low bone mass such as;
  o Low body weight
  o Prior fracture
  o High risk medication use
  o Disease or condition associated with bone loss.
- Adults with a fragility fracture.
- Adults with a disease or condition associated with low bone mass or bone loss.
- Adults taking medications associated with low bone mass or bone loss.
- Anyone being considered for pharmacologic therapy.
- Anyone being treated, to monitor treatment effect.
- Anyone not receiving therapy in whom evidence of bone loss would lead to treatment.

Women discontinuing estrogen should be considered for bone density testing according to the indications listed above.

**Reference Database for T-Scores**

- Use a uniform Caucasian (non-race adjusted) female normative database for women of all ethnic groups*. 
● Use a uniform Caucasian (non-race adjusted) female reference for men of all ethnic groups *

● Manufacturers should continue to use NHANES III data as the reference standard for femoral neck and total hip T-scores.

● Manufacturers should continue to use their own databases for the lumbar spine as the reference standard for T-scores.

● If local reference data are available they should be used to calculate only Z-scores but not T-scores.

*Note: Application of recommendation may vary according to local requirements.

Central DXA for Diagnosis

● The WHO international reference standard for osteoporosis diagnosis is a T-score of -2.5 or less at the femoral neck.
  o The reference standard from which the T-score is calculated is the female, white, age 20-29 years, NHANES III database.

● Osteoporosis may be diagnosed in postmenopausal women and in men age 50 and older if the T-score of the lumbar spine, total hip, or femoral neck is -2.5 or less:*
  o In certain circumstances the 33% radius (also called 1/3 radius) may be utilized

*Note: Other hip regions of interest, including Ward’s area and the greater trochanter, should not be used for diagnosis. Application of recommendation may vary according to local requirements.
● Skeletal sites to measure
  o Measure BMD at both the PA spine and hip in all patients
  o Forearm BMD should be measured under the following circumstances:
    ▪ Hip and/or spine cannot be measured or interpreted.
    ▪ Hyperparathyroidism
    ▪ Very obese patients (over the weight limit for DXA table)
● Spine Region of Interest (ROI)
  o Use PA L1-L4 for spine BMD measurement
  o Use all evaluable vertebrae and only exclude vertebrae that are affected by local structural change or artifact. Use three vertebrae if four cannot be used and two if three cannot be used
  o BMD based diagnostic classification should not be made using a single vertebra.
  o If only one evaluable vertebra remains after excluding other vertebrae, diagnosis should be based on a different valid skeletal site
  o Anatomically abnormal vertebrae may be excluded from analysis if:
    ▪ They are clearly abnormal and non-assessable within the resolution of the system; or
    ▪ There is more than a 1.0 T-score difference between the vertebra in question and adjacent vertebrae
  o When vertebrae are excluded, the BMD of the remaining vertebrae is used to derive the T-score
The lateral spine should not be used for diagnosis, but may have a role in monitoring.

- **Hip ROI**
  - Use femoral neck, or total proximal femur whichever is lowest.
  - BMD may be measured at either hip.
  - There are insufficient data to determine whether mean T-scores for bilateral hip BMD can be used for diagnosis.
  - The mean hip BMD can be used for monitoring, with total hip being preferred.

- **Forearm ROI**
  - Use 33% radius (sometimes called one-third radius) of the non-dominant forearm for diagnosis. Other forearm ROI are not recommended.

**Fracture Risk Assessment**

- A distinction is made between diagnostic classification and the use of BMD for fracture risk assessment.
- For fracture risk assessment, any well-validated technique can be used, including measurements of more than one site where this has been shown to improve the assessment of risk.

**Use of the Term “Osteopenia”**

- The term “osteopenia” is retained, but “low bone mass” or “low bone density” is preferred.
People with low bone mass or density are not necessarily at high fracture risk.

BMD Reporting in Postmenopausal Women and in Men Age 50 and Older

- T-scores are preferred.
- The WHO densitometric classification is applicable.

BMD Reporting in Females Prior to Menopause and in Males Younger Than Age 50

- Z-scores, not T-scores, are preferred. This is particularly important in children.
- A Z-score of -2.0 or lower is defined as “below the expected range for age”, and a Z-score above -2.0 is “within the expected range for age.”
- Osteoporosis cannot be diagnosed in men under age 50 on the basis of BMD alone.
- The WHO diagnostic criteria may be applied to women in the menopausal transition.

Z-Score Reference Database

- Z-scores should be population specific where adequate reference data exist. For the purpose of Z-score calculation, the patient’s self-reported ethnicity should be used.

Serial BMD Measurements

- Serial BMD testing, in combination with clinical assessment of fracture risk, bone turnover markers, and other factors including height loss and trabecular bone score, can be used to determine whether treatment should be initiated in untreated patients, according to locally applicable guidelines.
- Serial BMD testing can monitor response to therapy by finding an increase or stability of bone density.

- **Serial BMD testing should be used to monitor individuals following cessation of osteoporosis pharmacologic therapy.**

- Serial BMD testing can detect loss of bone density, indicating the need for assessment of treatment adherence, evaluation of secondary causes of osteoporosis, and re-evaluation of treatment options.

- **Follow-up BMD testing should be done when the results are likely to influence patient management.**

- Intervals between BMD testing should be determined according to each patient’s clinical status: typically one year after initiation or change of therapy is appropriate, with longer intervals once therapeutic effect is established.

- In conditions associated with rapid bone loss, such as glucocorticoid therapy, testing more frequently is appropriate.

**Phantom Scanning and Calibration**

The Quality Control (QC) program at a DXA facility should include adherence to manufacturer guidelines for system maintenance. In addition, if not recommended in the manufacturer protocol, the following QC procedures are advised:

- Perform periodic (at least once per week) phantom scans for any DXA system as an independent assessment of system calibration.

- Plot and review data from calibration and phantom scans.
● Verify the phantom mean BMD after any service performed on the densitometer.
● Establish and enforce corrective action thresholds that trigger a call for service.
● Maintain service logs.
● Comply with government inspections, radiation surveys and regulatory requirements.

**Precision Assessment**

● Each DXA facility should determine its precision error and calculate the LSC.
● The precision error supplied by the manufacturer should not be used.
● If a DXA facility has more than one technologist, an average precision error combining data from all technologists should be used to establish precision error and LSC for the facility, provided the precision error for each technologist is within a pre-established range of acceptable performance.
● Every technologist should perform an in vivo precision assessment using patients representative of the clinic’s patient population.
● Each technologist should do one complete precision assessment after basic scanning skills have been learned (e.g., manufacturer training) and after having performed approximately 100 patient-scans.
● A repeat precision assessment should be done if a new DXA system is installed.
● A repeat precision assessment should be done if a technologist’s skill level has changed.
● To perform a precision analysis:
  ○ Measure 15 patients 3 times, or 30 patients 2 times, repositioning the patient after each scan
o Calculate the root mean square standard deviation (RMS-SD) for the group
o Calculate LSC for the group at 95% confidence interval

- The minimum acceptable precision for an individual technologist is:
  o Lumbar Spine: 1.9% (LSC=5.3%)
  o Total Hip: 1.8% (LSC=5.0%)
  o Femoral Neck: 2.5% (LSC=6.9%)
  o Retraining is required if a technologist’s precision is worse than these values

- Precision assessment should be standard clinical practice. Precision assessment is not research and may potentially benefit patients. It should not require approval of an institutional review board. Adherence to local radiologic safety regulations is necessary. Performance of a precision assessment requires the consent of participating patients.

Cross-Calibration of DXA: Changing Hardware or Systems

- When changing hardware, but not the entire system, or when replacing a system with the same technology (manufacturer and model), cross-calibration should be performed by having one technologist do 10 phantom scans, with repositioning, before and after hardware change.
  o If a greater than 1% difference in mean BMD is observed, contact the manufacturer for service/correction
• When changing an entire system to one made by the same manufacturer using a different technology, or when changing to a system made by a different manufacturer, one approach to cross-calibration is:
  o Scan 30 patients representative of the facility’s patient population once on the initial system and then twice on the new system within 60 days
  o Measure those anatomic sites commonly measured in clinical practice, typically spine and proximal femur
  o Facilities must comply with locally applicable regulations regarding DXA
  o Calculate the average BMD relationship and LSC between the initial and new machine using the ISCD DXA Machine Cross-Calibration Tool (www.ISCD.org)
  o Use this LSC for comparison between the previous and new system. Inter-system quantitative comparisons can only be made if cross-calibration is performed on each skeletal site commonly measured
  o Once a new precision assessment has been performed on the new system, all future scans should be compared to scans performed on the new system using the newly established intra-system LSC

Cross-Calibration of DXA: Adding Hardware or Systems

• When adding a DXA scanner with the same technology (manufacturer and model) of the original (index) scanner, for the purpose of allowing patients to be scanned across
devices, cross-calibration should be performed by scanning one spine phantom on both the index scanner, and on the additional scanner(s) on 20 different days to establish the respective mean BMD values. If a greater than 0.5% difference in mean BMD is observed between devices, contact the manufacturer for service/correction to return the additional machines to match the index scanner calibration and verify the new calibration with the same process.

- Certain additional conditions that may apply are:
  - When the DXA scanners are installed in the same building or campus and using the same technologists, then the original LSC of the index scanner can be used for inter-scanner comparisons. or
  - When the systems are installed in geographically distinct locations, or using different technologists, or seeing a different patient population, then precision studies must be done at each site and an average LSC of all the individual technologist precision assessments can be calculated.
  Use the ISCD positions on calculating an LSC when multiple technologists are using a single scanner.

- When adding a DXA system or systems made by either the same or different manufacturer using different technologies, while maintaining the original scanner in service, the preferred approach to cross-calibration is:
One scanner should be designated the index (gold standard) device. Each additional different technology device should be cross-calibrated to the index device.

- Scan a minimum of 30 patients, representative of the facility’s patient population twice on the index system and twice on the new system within 60 days. Individual patients may be measured on both scanners the same day, or ideally on different days, but no more than 30 days apart for any one patient.

- Measure those anatomic sites commonly measured in clinical practice, typically spine and proximal femur(s).

- Calculate the average LSC between the index and new machine using the ISCD DXA Machine Cross-Calibration Tool.

- Use the average LSC for comparison between the two systems. Inter-system quantitative comparisons can only be made if cross-calibration is performed for each skeletal site commonly measured for monitoring.

- Once the in-vivo cross-calibration equivalence is established, the long term-stability of all the systems must be carefully monitored with frequent scanning of a suitable external phantom on all cross-calibrated devices. Stability of a running average of phantom BMD on each system should be within 0.5% of the value established at the time of the cross-calibration.

- Inter-machine LSC should not be applied to patients who have both scans done on a single device. A separate intra-machine LSC, established using the
duplicate scans on the second device during the generalized LSC (gLSC) process should be used for any patient having both scans on a single device.

- Facilities must comply with locally applicable regulations regarding DXA.

- If a cross-calibration assessment is not performed, no quantitative comparison to the prior machine can be made. Consequently, a new baseline BMD and intra-system LSC should be established.

**BMD Comparison Between Facilities**

- It is not possible to quantitatively compare BMD or to calculate a LSC between facilities without cross-calibration.

- Patients should return to the same DXA device that was used to perform their most recent prior study, provided that the facility in-vivo precision and LSC values are known and do not exceed established maximum values.

**Vertebral Fracture Assessment Nomenclature**

- Vertebral Fracture Assessment (VFA) is the correct term to denote densitometric spine imaging performed for the purpose of detecting vertebral fractures.

**Indications for VFA**

- Lateral Spine imaging with Standard Radiography or Densitometric VFA is indicated when T-score is < -1.0 and of one or more of the following is present:
  - Women age ≥ 70 years or men ≥ age 80 years
Historical height loss > 4 cm (>1.5 inches)
Self-reported but undocumented prior vertebral fracture
Glucocorticoid therapy equivalent to ≥ 5 mg of prednisone or equivalent per day for ≥ 3 months

Methods for Defining and Reporting Fractures on VFA

- The methodology utilized for vertebral fracture identification should be similar to standard radiological approaches and be provided in the report.
- Fracture diagnosis should be based on visual evaluation and include assessment of grade/severity. Morphometry alone is not recommended because it is unreliable for diagnosis.
- The Genant visual semi-quantitative method is the current clinical technique of choice for diagnosing vertebral fracture with VFA.
- Severity of deformity may be confirmed by morphometric measurement if desired.

Indications for Following VFA With Another Imaging Modality

- The decision to perform additional imaging must be based on each patient’s overall clinical picture, including the VFA result.
- Indications for follow-up imaging studies include:
  - Two or more mild (grade 1) deformities without any moderate or severe (grade 2 or 3) deformities
  - Lesions in vertebrae that cannot be attributed to benign causes
- Vertebral deformities in a patient with a known history of a relevant malignancy
- Equivocal fractures
- Unidentifiable vertebrae between T7-L4
- Sclerotic or lytic changes, or findings suggestive of conditions other than osteoporosis

Note: VFA is designed to detect vertebral fractures and not other abnormalities.

Serial Lateral Imaging

- Repeat VFA or radiographic lateral spine imaging in patients with continued high risk (e.g., historical height loss > 4 cm (>1.5 inches), self-reported but undocumented vertebral fracture, or glucocorticoid therapy equivalent to ≥ 5 mg of prednisone or equivalent per day for greater than or equal to three months).

DXA to Detect Abnormalities In The Spectrum of AFF

- Femur DXA images should be reviewed for localized cortical abnormalities in the spectrum of AFF.

- When using DXA systems to detect abnormalities in the spectrum of AFF, scanning methods that generate bilateral full-length femur images (FFI) should be used. The FFI report should state the absence or presence of abnormalities in the spectrum of AFF.
If a focal cortical thickening is present on the lateral cortex, the report should state whether a lucent line is seen. Consider additional imaging when clinically appropriate.

- Consider bilateral FFI for detecting abnormalities in the spectrum of AFF in patients who are receiving bisphosphonate or denosumab therapy or discontinued it within the last year, with a cumulative exposure of 3 or more years, especially those on glucocorticoid therapy.

Baseline DXA Report: Minimum Requirements

- Demographics (name, medical record identifying number, date of birth, sex).
- Requesting provider.
- Indications for the test.
- Manufacturer and model of instrument used
- Technical quality and limitations of the study, stating why a specific site or ROI is invalid or not included.
- BMD in g/cm² for each site.
- The skeletal sites, ROI, and, if appropriate, the side, that were scanned.
- The T-score and/or Z-score where appropriate.
- WHO criteria for diagnosis in postmenopausal females and in men age 50 and over.
- Risk factors including information regarding previous non-traumatic fractures.
- A statement about fracture risk. Any use of relative fracture risk must specify the population of comparison (e.g., young-adult or age-matched). The ISCD favors the use of absolute fracture risk prediction when such methodologies are established.

- A general statement that a medical evaluation for secondary causes of low BMD may be appropriate.

- Recommendations for the necessity and timing of the next BMD study.

**Follow-Up DXA Report**

- Statement regarding which previous or baseline study and ROI is being used for comparison.

- Statement about the LSC at your facility and the statistical significance of the comparison.

- Report significant change, if any, between the current and previous study or studies in g/cm² and percentage.

- Comments on any outside study including manufacturer and model on which previous studies were performed and the appropriateness of the comparison.

- Recommendations for the necessity and timing of the next BMD study.

**DXA Report: Optional Items**

- Recommendation for further non-BMD testing, such as X-ray, magnetic resonance imaging, computed tomography, etc.

- Recommendations for pharmacological and non-pharmacological interventions.
• Addition of the percentage compared to a reference population.

• Specific recommendations for evaluation of secondary osteoporosis.

DXA Report: Items That Should Not Be Included

• A statement that there is bone loss without knowledge of previous bone density.
• Mention of “mild,” “moderate,” or “marked” osteopenia or osteoporosis.
• Separate diagnoses for different ROI (e.g., osteopenia at the hip and osteoporosis at the spine).
• Expressions such as “She has the bones of an 80-year-old,” if the patient is not 80 years old.
• Results from skeletal sites that are not technically valid.
• The change in BMD if it is not a significant change based on the precision error and LSC.

Components of a VFA Report

• Patient identification, referring physician, indication(s) for study, technical quality, and interpretation.
• A follow-up VFA report should also include comparability of studies and clinical significance of changes, if any.
• VFA reports should comment on the following
  o Unevaluable vertebrae
  o Deformed vertebrae, and whether or not the deformities are consistent with vertebral fracture
Unexplained vertebral and extra-vertebral pathology

- Optional components include fracture risk and recommendations for additional studies.

**Trabecular Bone Score (TBS)**

- TBS is associated with vertebral, hip and major osteoporotic fracture risk in postmenopausal women.
- TBS is associated with hip fracture risk in men over the age of 50 years.
- TBS is associated with major osteoporotic fracture risk in men over the age of 50 years.
- TBS should not be used alone to determine treatment recommendations in clinical practice.
- TBS can be used in association with FRAX and BMD to adjust FRAX-probability of fracture in postmenopausal women and older men.

- **In patients receiving anti-fracture therapy:**
  - The role of TBS in monitoring anti-resorptive therapy is unclear.
  - TBS is potentially useful for monitoring anabolic therapy.

- TBS is associated with major osteoporotic fracture risk in postmenopausal women with type II diabetes.

**Hip Geometry**

- Hip axis length (HAL) derived from DXA is associated with hip fracture risk in postmenopausal women.
• The following hip geometry parameters derived from DXA (CSA, OD, SM, BR, CSMI, NSA) should not be used to assess hip fracture risk.

• Hip geometry parameters derived from DXA (CSA, OD, SM, BR, CSMI, HAL, NSA) should not be used to initiate treatment.

• Hip geometry parameters derived from DXA (CSA, OD, SM, BR, CSMI, HAL, NSA) should not be used for monitoring.

General Recommendations for Non Central DXA Devices: QCT, pQCT, QUS, and pDXA

The following general recommendations for QCT, pQCT, QUS, and pDXA are analogous to those defined for central DXA technologies. Examples of technical differences amongst devices, fracture prediction ability for current manufacturers and equivalence study requirements are provided in the full text documents printed in the *Journal of Clinical Densitometry*.

• Bone density measurements from different devices cannot be directly compared.

• Different devices should be independently validated for fracture risk prediction by prospective trials, or by demonstration of equivalence to a clinically validated device.

• T-scores from measurements other than DXA at the femur neck, total femur, lumbar spine, or one-third (33%) radius cannot be used according to the WHO diagnostic classification because those T-scores are not equivalent to T-scores derived by DXA.

• Device-specific education and training should be provided to the operators and interpreters prior to clinical use.

• Quality control procedures should be performed regularly.
Baseline Non Central DXA Devices (QCT, pQCT, QUS, pDXA) Report: Minimum Requirements

- Date of test
- Demographics (name, date of birth or age, sex)
- Requesting provider
- Names of those receiving copy of report
- Indications for test
- Manufacturer, and model of instrument and software version
- Measurement value(s)
- Reference database
- Skeletal site/ROI
- Quality of test
- Limitations of the test including a statement that the WHO diagnostic classification cannot be applied to T-scores obtained from QCT, pQCT, QUS, and pDXA (other than one-third (33%) radius) measurements
- Clinical risk factors
- Fracture risk estimation
- A general statement that a medical evaluation for secondary causes of low BMD may be appropriate
- Recommendations for follow-up imaging

Note: A list of appropriate technical items is provided in the QCT and pQCT sections of the full text documents printed in the Journal of Clinical Densitometry.
Non Central DXA Devices (QCT, pQCT, QUS, pDXA) Report: Optional Items

- Report may include the following optional item:
  - Recommendations for pharmacological and non-pharmacological interventions.

QCT and pQCT

- Acquisition
  - With single-slice QCT, L1-L3 should be scanned; with 3D QCT, L1-L2 should be scanned.
  - QCT acquisition of the proximal femur should extend from the femoral head to the proximal shaft.
  - For density-based QCT measurements the in-scan calibration phantom can be replaced by asynchronous calibration if scanner stability is maintained.
  - Opportunistic CT to screen for patients with low BMD or low bone strength of the spine or proximal femur is possible only if validated machine-specific cutoff values and scanner stability have been established.

- Diagnosis
  - Femoral neck and total hip T-scores calculated from 2D projections of QCT data are equivalent to the corresponding DXA T-scores for diagnosis of osteoporosis in accordance with the WHO criteria.

- Fracture Prediction
  - Spinal trabecular BMD as measured by QCT has at least the same ability to predict vertebral fractures as AP spinal BMD measured by central DXA in...
postmenopausal women. There is lack of sufficient evidence to support this position for men.

- There is lack of sufficient evidence to recommend spine QCT for hip fracture prediction in either women or men.
- Total femur trabecular BMD measured by QCT predicts hip fractures as well as hip BMD measured by DXA in postmenopausal women and older men.
- pQCT of the forearm at the ultra-distal radius predicts hip, but not spine, fragility fractures in postmenopausal women. There is lack of sufficient evidence to support this position for men.

- **Therapeutic Decisions**
  - Central DXA measurements at the spine and femur are the preferred method for making therapeutic decisions and should be used if possible. Where QCT and DXA are both available and provide comparable information, DXA is preferred to limit radiation exposure.
  - However, if central DXA cannot be done, pharmacologic treatment can be initiated if the fracture probability, as assessed by QCT of the spine or pQCT of the radius using device specific thresholds, and in conjunction with clinical risk factors, is sufficiently high.

- **Monitoring**
  - Trabecular BMD of the lumbar spine measured by QCT can be used to monitor age-, disease-, and treatment-related BMD changes.
Integral and trabecular BMD of the proximal femur measured by QCT can be used to monitor age- and treatment-related BMD changes.

Trabecular and total BMD of the ultra-distal radius measured by pQCT can be used to monitor age-related BMD changes.

- **Finite Element Analysis (FEA)**
  - Vertebral strength as estimated by QCT-based FEA predicts vertebral fracture in postmenopausal women.
  - Vertebral strength as estimated by QCT-based FEA is comparable to spine DXA for prediction of vertebral fractures in older men.
  - Femoral strength as estimated by QCT-based FEA is comparable to hip DXA for prediction of hip fractures in postmenopausal women and older men.
  - FEA cannot be used to diagnose osteoporosis using the current WHO T-score definition.
  - Vertebral or femoral strength as estimated by QCT-based FEA can be used to initiate pharmacologic treatment using validated thresholds and in conjunction with clinical risk factors.
  - Vertebral or femoral strength as estimated by QCT-based FEA can be used to monitor age- and treatment-related changes.

- **Reporting**
  - For QCT using whole body CT scanners the following additional technical items should be reported:
    - Tomographic acquisition and reconstruction parameters
- kV, mAs
- Collimation during acquisition
- Table increment per rotation
- Table height
- Reconstructed slice thickness, reconstruction increment
- Reconstruction kernel

For pQCT using dedicated pQCT scanners, the following additional technical items should be reported:

- Tomographic acquisition and reconstruction parameters
- Reconstructed slice thickness
- Single / multi-slice acquisition mode
- Length of scan range in multi-slice acquisition mode

**QUS**

- Acquisition
  - The only validated skeletal site for the clinical use of QUS in osteoporosis management is the heel.
- Fracture Prediction
  - Validated heel QUS devices predict fragility fracture in postmenopausal women (hip, vertebral, and global fracture risk) and men over the age of 65 (hip and all non-vertebral fractures), independently of central DXA BMD.
Discordant results between heel QUS and central DXA are not infrequent and are not necessarily an indication of methodological error.

Heel QUS in conjunction with clinical risk factors can be used to identify a population at very low fracture probability in which no further diagnostic evaluation may be necessary. (Examples of device-specific thresholds and case findings strategy are provided in the full text documents printed in the *Journal of Clinical Densitometry*.)

- **Therapeutic Decisions**

  Central DXA measurements at the spine and femur are preferred for making therapeutic decisions and should be used if possible. However, if central DXA cannot be done, pharmacologic treatment can be initiated if the fracture probability, as assessed by heel QUS, using device specific thresholds and in conjunction with clinical risk factors, is sufficiently high. (Examples of device-specific thresholds are provided in the full text documents printed in the *Journal of Clinical Densitometry*.)

- **Monitoring**

  QUS cannot be used to monitor the skeletal effects of treatments for osteoporosis.

- **Fracture Prediction**
Measurement by validated pDXA devices can be used to assess vertebral and global fragility fracture risk in postmenopausal women, however its vertebral fracture predictive ability is weaker than central DXA and heel QUS. There is lack of sufficient evidence to support this position for men.

Radius pDXA in conjunction with clinical risk factors can be used to identify a population at very low fracture probability in which no further diagnostic evaluation may be necessary. (Examples of device-specific thresholds and case findings strategy are provided in the full text documents printed in the Journal of Clinical Densitometry.)

- **Diagnosis**
  - The WHO diagnostic classification can only be applied to DXA at the femur neck, total femur, lumbar spine and the one-third (33%) radius ROI measured by DXA or pDXA devices utilizing a validated young-adult reference database.

- **Therapeutic Decisions**
  - Central DXA measurements at the spine and femur are the preferred method for making therapeutic decisions and should be used if possible. However, if central DXA cannot be done, pharmacologic treatment can be initiated if the fracture probability, as assessed by radius pDXA (or DXA) using device specific thresholds and in conjunction with clinical risk factors, is sufficiently high. (Examples of device-specific thresholds are provided in the full text documents printed in the Journal of Clinical Densitometry.)

- **Monitoring**
pDXA devices are not clinically useful in monitoring the skeletal effects of presently available medical treatments for osteoporosis.

**Body Composition**

- **Indications**
  - DXA total body composition with regional analysis can be used in the following conditions:
    - In patients living with HIV to assess fat distribution in those using antiretroviral agents associated with a risk of lipoatrophy (currently stavudine [d4T] and zidovudine [ZDV, AZT]).
    - In obese patients undergoing bariatric surgery (or medical, diet, or weight loss regimens with anticipated large weight loss) to assess fat and lean mass changes when weight loss exceeds approximately 10%. The impact on clinical outcomes is uncertain.
    - In patients with muscle weakness or poor physical functioning to assess fat and lean mass. The impact on clinical outcomes is uncertain.
  - Pregnancy is a contraindication to DXA body composition. Limitations in the use of clinical DXA for total body composition or bone mineral density are weight over the table limit, recent administration of contrast material and/or artifact. Radiopharmaceutical agents may interfere with accuracy of results using systems from some DXA manufacturers.

- **Acquisition**
- No phantom has been identified to remove systematic differences in body composition when comparing in-vivo results across manufacturers.

- An in-vivo cross-calibration study is necessary when comparing in-vivo results across manufacturers.

- Cross-calibrating systems of the same make and model can be performed with an appropriate whole body phantom.

- Changes in body composition measures can be evaluated between two different systems of the same make and model if the systems have been cross-calibrated with an appropriate total body phantom.

- When changing hardware, but not the entire system, or when replacing a system with the same technology (make and model), cross-calibration should be performed by having one technologist do 10 whole body phantom scans, with repositioning, before and after hardware change. If a greater than 2% difference in mean percent fat mass, fat mass or lean mass is observed, contact the manufacturer for service/correction.

- No total body phantoms are available at this time that can be used as absolute reference standards for soft-tissue composition or bone mineral mass.

- The Quality Control (QC) program at a DXA body composition facility should include adherence to manufacturer guidelines for system maintenance. In addition, if not recommended in the manufacturer protocol, the following QC procedures are advised:
• Perform periodic (at least once per week) body composition phantom scans for any DXA system as an independent assessment of system calibration.

• Plot and review data from calibration and body composition phantom scans.

• Verify the body composition phantom mean percent fat mass and tissue mass after any service performed on the densitometer.

• Establish and enforce corrective action thresholds that trigger a call for service.

• Maintain service logs.

• Comply with radiation surveys and regulatory government inspections, radiation surveys and regulatory requirements.
  
  o Consistent positioning and preparation (e.g. fasting state, clothing, time of day, physical activity, empty bladder) of the patient is important for precise measures.

  o Positioning of the arms, hands, legs and feet whenever possible should be according to the NHANES method (palms down isolated from the body, feet neutral, ankles strapped, arms straight or slightly angled, face up with neutral chin).

  o “Offset-scanning” should be used in patients who are too wide to fit within the scan boundaries, using a validated procedure for a specific scanner model.
Every technologist should perform an in-vivo precision assessment for all body composition measures of interest using patients who are representative of the clinic’s patient population.

The minimum acceptable precision for an individual technologist is 3%, 2% and 2% for total fat mass, total lean mass, and percent fat mass, respectively.

Consistently use manufacturer’s recommendations for ROI placement.

Consistently use manufacturer’s recommendations for artifact removal.

Analysis and Reporting

For adults total body (with head) values of BMI, BMD, BMC, total mass, total lean mass, total fat mass, and percent fat mass should appear on all reports.

Total Body BMC as represented in the NHANES 1999-2004 reference data should be used when using DXA in 4-compartment models.

DXA measures of adiposity and lean mass include visceral adipose tissue (VAT), appendicular lean mass index (ALMI: appendicular lean mass/ht^2), android/gynoid percent fat mass ratio, trunk to leg fat mass ratio, lean mass index (LMI: total lean mass/ht^2), fat mass index (FMI: fat mass/ht^2) are optional. The clinical utility of these measures is currently uncertain.

When comparing to the US population, the NHANES 1999-2004 body composition data are most appropriate for different races, both sexes, and for ages from 8 to 85 years. [Note: Reference to a population does not imply health status.]
Both Z-scores and percentiles are appropriate to report if derived using methods to adjust for non-normality.

The use of DXA adiposity measures (percent fat mass or fat mass index) may be useful in risk-stratifying patients for cardio-metabolic outcomes. Specific thresholds to define obesity have not been established.

“Low lean mass” could be defined using appendicular lean mass divided by height squared (ALM/height²) with Z-scores derived from a young adult, race, and sex-matched population. Thresholds for low lean mass from consensus guidelines for sarcopenia await confirmation.

**DXA In Patients With Spinal Cord Injury**

- All adults with spinal cord injury resulting in permanent motor or sensory dysfunction should have a DXA scan of the total hip, proximal tibia and distal femur, as soon as medically stable.

- In adults with SCI, total hip, proximal tibia and distal femur bone density should be used to diagnose osteoporosis, predict lower extremity fracture risk and monitor response to therapy when normative data are available.

- Serial DXA assessment of treatment effectiveness among individuals with SCI should include evaluation at the total hip, distal femur, and proximal tibia, following a minimum of 12 months of therapy at 1- to 2-year intervals. Segmental analysis of total
hip, distal femur and proximal tibia sub-regions from a whole-body scan should not be used for monitoring treatment.

- There is no established threshold BMD value below which weight-bearing activities are absolutely contraindicated. BMD and clinical risk factors should be used to assess fracture risk prior to engaging in weight-bearing activities.

DXA In Transgender and Gender Non-conforming Individuals

- Baseline BMD testing is indicated for Transgender and Gender Non-Conforming (TGNC) individuals if they have any of the following conditions:
  - History of gonadectomy or therapy that lowers endogenous gonadal steroid levels prior to initiation of hormone therapy.
  - Hypogonadism with no plan to take gender-affirming hormone therapy.
  - Existing ISCD indications for BMD testing, such as glucocorticoid use and hyperparathyroidism, apply.

- Follow-up BMD testing in TGNC individuals should be done when the results are likely to influence patient management. Examples include:
  - Low bone density as defined by current ISCD guidelines.
  - Individuals taking treatment to suppress puberty, such as GnRH analogs.
  - Non-adherence with or inadequate doses of gender-affirming hormone therapy.
  - Plan to discontinue gender-affirming hormone therapy.
o Presence of other risks for bone loss or fragility fracture.

o Bone mineral density testing intervals should be individualized based on each patient’s clinical status: typically, every one to two years until BMD is stable or improved is appropriate, with longer intervals thereafter.

● T- and Z-Score Calculation in TGNC Individuals

o T-scores should be calculated using a uniform Caucasian (non-race adjusted) female normative database for all transgender individuals of all ethnic groups; we recommend using a T-score of < -2.5 or less for diagnosis of osteoporosis in all TGNC individuals age 50 years or older, regardless of hormonal status.

o Calculate Z-scores using the normative database that matches the gender identity of the individual.

o If requested by the ordering provider, Z-scores may also be calculated using the normative database that matches the sex recorded at birth.

o In gender-nonbinary individuals, the normative database that matches the sex recorded at birth should be used.

o Gender data should be obtained on the intake questionnaire.

● The parameters to be included in the DXA report for transgender individuals are the same as are included in reports for the general population, but when specially requested, the report should include Z-scores calculated according to both male and female databases.

Peri-prosthetic and Orthopedic Uses of DXA
Bone health assessment should be considered in patients prior to elective orthopedic and spine surgery. BMD should be measured in those meeting ISCD or regional indications for DXA testing.

- Routine DXA scans should include PA lumbar spine and hip.
- Forearm DXA should be considered in patients having upper limb surgery.
- VFA should be considered in patients having spine surgery.

Elective orthopedic and spine surgery patients with the following conditions are at greater risk for impaired bone health and should have DXA testing:

- Diabetes mellitus (long term duration of diabetes (>10yrs) and poor control)
  - Trabecular bone score measurement should be obtained in patients with diabetes, if available
- Inflammatory arthritis
- Exposed to chronic corticosteroids (≥ 5mg/day for three or more months of treatment)
- A low-trauma fracture after 50 years of age
- Chronic kidney disease stage 3, 4 and 5
- Limited mobility
- Smoking

When poor bone quality is identified during surgery, bone health assessment including DXA testing is indicated.
● When assessing hip and knee arthroplasty, ROI should include periprosthetic metaphyseal and diaphyseal bone around and away from the implant:
  o After total hip arthroplasty, Gruen zones are recommended at the femur and the DeLee / Charnley or Wilkinson method are recommended at the pelvis.
  o Modifications of ROI based on patient conditions and implant geometry are acceptable.

● Indications for pre-operative DXA testing for patients having hip surgery include:
  o A Dorr classification of B or C.
  o A Cortical Index of less than 0.4 measured at 10 cm below the mid lesser trochanter.

● The Cortical Index and/or cortical thickness adjacent to the femoral hip implant can be used to monitor bone ingrowth or resorption, identify peri-prosthetic loosening, predict subsidence, and assess the effectiveness of medical and surgical methods to modulate BMD around the hip prostheses.

● Opportunistic CT-based attenuation using Hounsfield Units (HU) can be used to estimate the likelihood of osteoporosis (L1 HU < 100) and normal (L1 HU > 150) bone density to support decisions regarding bone health assessment.
Glossary

**AFF** – atypical femur fracture

**ALMI** – appendicular lean mass index

**BMC** – bone mineral content

**BMD** – bone mineral density (equivalent to areal BMD, aBMD)

**BMI** – body mass index

**BR** – buckling ratio

**CSA** – Cross Sectional Area

**CSMI** – cross-sectional moment of inertia

**DXA** – dual-energy X-ray absorptiometry

**FEA** – Finite element analysis

**FMI** – fat mass index

**HAL** – hip axis length

**ISCD** – International Society for Clinical Densitometry

**LMI** – lean mass index
LSC – least significant change

NHANES III – National Health and Nutrition Examination Survey III

NSA – neck shaft angle

OD – outer diameter

PA – posterior anterior

pDXA – peripheral dual-energy x-ray absorptiometry

pQCT – peripheral quantitative computed tomography

QC – quality control

QCT – quantitative Computed Tomography

QUS – quantitative Ultrasound

ROI – region(s) of interest

SCI – spinal cord injury

SM – section modulus

SSI - strain strength index

TBLH – total body less head
TBS – trabecular bone score

TGNG – transgender and gender non-conforming

VAT – visceral adipose tissue

VFA – Vertebral Fracture Assessment

vBMD – volumetric BMD

WHO – World Health Organization

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2019 ISCD Official Positions – Pediatric: Skeletal Health Assessment In Children from Infancy to Adolescence

These are the Official Pediatric Positions of the ISCD as updated in 2019. The Official Pediatric Positions that are new or revised since 2013 are in bold type.
Fracture Prediction and Definition of Osteoporosis

- Evaluation of bone health should identify children and adolescents who may benefit from interventions to decrease their elevated risk of a clinically significant fracture.
- The finding of one or more vertebral compression (crush) fractures is indicative of osteoporosis, in the absence of local disease or high-energy trauma. In such children and adolescents, measuring BMD adds to the overall assessment of bone health.
- The diagnosis of osteoporosis in children and adolescents should not be made on the basis of densitometric criteria alone.
- In the absence of vertebral compression (crush) fractures, the diagnosis of osteoporosis is indicated by the presence of both a clinically significant fracture history and BMD Z-score ≤ -2.0. A clinically significant fracture history is one or more of the following: 1) two or more long bone fractures by age 10 years; 2) three or more long bone fractures at any age up to age 19 years. A BMC/BMD Z-score > -2.0 does not preclude the possibility of skeletal fragility and increased fracture risk.

DXA Assessment in Children and Adolescents With Disease That May Affect the Skeleton

- DXA measurement is part of a comprehensive skeletal health assessment in patients with increased risk of fracture.
- In patients with primary bone disease, or at risk for a secondary bone disease, a DXA should be performed when the patient may benefit from interventions to decrease their elevated risk of a clinically significant fracture, and the DXA results will influence that management.
• DXA should not be performed if safe and appropriate positioning of the child cannot be assured.

**DXA Interpretation and Reporting in Children and Adolescents**

• DXA is the preferred method for assessing BMC and areal BMD.

• The posterior-anterior (PA) spine and total body less head (TBLH), are the preferred skeletal sites for performing BMC and areal BMD measurements in most pediatric subjects. Other sites may be useful depending on the clinical need.

• Soft tissue measures in conjunction with whole body scans may be helpful in evaluating patients with chronic conditions associated with malnutrition or with muscle and skeletal deficits.

• **Proximal femur DXA measurements can be used, if reference data are available, for assessing children with reduced weight bearing and mechanical loading of the lower extremities or in children at-risk for bone fragility who would benefit from continuity of DXA measurements through the transition into adulthood.**

• DXA measurements at the 33% radius (also called 1/3 radius) may be used clinically in ambulatory children who cannot be scanned at other skeletal sites, provided adequate reference data are available.

• **Lateral distal femur (LDF) DXA measurements, if reference data are available, correlate well with increased lower extremity fragility fracture risk in non-ambulatory children.**
LDF DXA can:

- Assess BMD in children when the presence of non-removable artifacts (orthopedic hardware, tubes), positioning difficulties, abnormal skeletal morphometry, or severe scoliosis with torsion interfere with DXA acquisition at other anatomical sites.

- Monitor the effects of changes of weight-bearing in non-ambulatory children.

- Precision assessment at each skeletal measurement site should be calculated in a sample representative of the patient population being evaluated.

- If a follow-up DXA scan is indicated, the minimum interval between scans is 6-12 months.

- In children with short stature or growth delay, spine and TBLH BMC and areal BMD results should be adjusted. For the spine, adjust using either BMAD or the height Z-score. For TBLH, adjust using the height Z-score.

- An appropriate reference data set must include a sample of healthy representatives of the general population sufficiently large to capture variability in bone measures that takes into consideration gender, age, and race/ethnicity.

- When upgrading densitometer instrumentation or software, it is essential to use reference data valid for the hardware and software technological updates.

- Baseline DXA reports should contain the following information:
  
  - DXA manufacturer, model, and software version
  - Referring physician
  - Patient age, gender, race-ethnicity, weight, and height
o Relevant medical history including previous fractures

o Indication for study

o Tanner Stage or Bone age results, if available

o Technical quality

o BMC and areal BMD

o BMC and/or areal BMD Z-score

o Source of reference data for Z-score calculation

o Adjustments made for growth and interpretation

o Recommendations for the necessity and timing of the next DXA study are optional

• Serial DXA reports should include the same information as for baseline testing. Additionally, indications for follow-up scan; technical comparability of studies; changes in height and weight; and change in BMC and areal BMD Z-scores should be reported.

• Terminology

  o T-scores should not appear in pediatric DXA reports.

  o The term “osteopenia” should not appear in pediatric DXA reports.

  o The term “osteoporosis” should not appear in pediatric DXA reports without a clinically significant fracture history.

  o “Low bone mineral mass or bone mineral density” is the preferred term for pediatric DXA reports when BMC or areal BMD Z-scores are less than or equal to -2.0 SD.

VFA in Pediatric Patients
● DXA VFA may be used as a substitute for spine radiography in the identification of symptomatic and asymptomatic VF.

● The Genant semi-quantitative method should be used for VFA in children.

● Following VFA, additional spine imaging should be considered in the following circumstances:
  o Vertebrae that are technically un-evaluable by VFA (i.e. not sufficiently visible), provided the detection of a VF would change clinical management
  o Assessment of a single, Genant Grade 1 VF, if confirmation of a Grade 1 VF alone would change clinical management
  o Radiographic findings that are not typical for an osteoporotic VF (e.g. suspected destructive inflammatory or malignant processes, congenital malformations, acquired misalignments or dislocations)

pQCT in Children and Adolescents

● There is no preferred method for QCT for clinical application in children and adolescents.

● QCT, pQCT and HR-pQCT are primarily research techniques used to characterize bone deficits in children. They can be used clinically in children where appropriate reference data and expertise are available.
• It is imperative that QCT protocols in children using general CT scanners use appropriate exposure factors, calibration phantoms and software to optimize results and minimize radiation exposure.

Densitometry in Infants and Young Children

• DXA is an appropriate method for clinical densitometry of infants and young children.
• DXA lumbar spine measurements are feasible and can provide reproducible measures of BMC and aBMD for infants and young children 0-5 years of age.
• DXA whole body measurements are feasible and can provide reproducible measures of BMC and aBMD for children ≥ 3 years of age.
• DXA whole body BMC measurements for children < 3 years of age are of limited clinical utility due to feasibility and lack of normative data. Areal BMD should not be utilized routinely due to difficulty in appropriate positioning.
• Forearm and femur measurements are technically feasible in infants and young children, but there is insufficient information regarding methodology, reproducibility and reference data for these measurements sites to be clinically useful at this time.
• In infants and children below 5 years of age, the impact of growth delay on the interpretation of the DXA results should be considered, but it is not quantifiable presently.

DXA Nomenclature

• DXA – not DEXA.
• T-score – not T score, t-score, or t score
• Z-score – not Z score, z-score, or z score

DXA Decimal Digits

Preferred number of decimal digits for DXA reporting:

• BMD:
  (example, 0.927 g/cm²)  3 digits

• T-score:
  (example, -2.3)  1 digit

• Z-score:
  (example, 1.7)  1 digit

• BMC:
  (example, 31.76 g)  2 digits

• Area:
  (example, 43.25 cm²)  2 digits

• % reference database:
  (example, 82%)  Integer
Glossary

BMC – bone mineral content

BMD – bone mineral density

DXA – dual-energy X-ray absorptiometry

HR - High resolution

ISCD – International Society for Clinical Densitometry

LDF – lateral distal femur

LSC – least significant change

NHANES III – National Health and Nutrition Examination Survey III

PA – posterior anterior

pDXA – peripheral dual-energy x-ray absorptiometry

pQCT – peripheral quantitative computed tomography

QC – quality control

QCT – quantitative Computed Tomography
QUS – quantitative Ultrasound

ROI – region(s) of interest

SSI – strain strength index

TBLH – total body less head

VF - vertebral fracture

VFA – Vertebral Fracture Assessment

vBMD – volumetric BMD

WHO – World Health Organization

References


