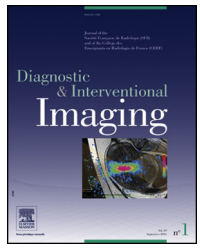
Diagnostic and Interventional Imaging (2016) **97**, 499—502



TECHNICAL NOTE /*Musculoskeletal imaging*

Quantitative computed tomography in pediatric patients

L. Gervais-André[a], L. Vija[b], S. Franchi-Abella[a], E. Gonzales[c,d], A. Linglart[c,e], C. Adamsbaum[a,c,*]

[a] *AP—HP, CHU Bicêtre, service d'imagerie pédiatrique, 78, rue du Général-Leclerc, 94275 Le Kremlin-Bicêtre cedex, France*
[b] *AP—HP, CHU Bicêtre, service de médecine nucléaire, 78, rue du Général-Leclerc, 94275 Le Kremlin-Bicêtre cedex, France*
[c] *Université Paris Sud, faculté de médecine, 94276 Le Kremlin Bicêtre cedex, France*
[d] *AP—HP, CHU Bicêtre, service d'hépatologie pédiatrique, 78, rue du Général-Leclerc, 94275 Le Kremlin-Bicêtre cedex, France*
[e] *AP—HP, CHU Bicêtre, service d'endocrinologie pédiatrique, 78, rue du Général-Leclerc, 94275 Le Kremlin-Bicêtre cedex, France*

KEYWORDS
Quantitative computed tomography (QCT);
Bone;
Pediatrics;
Bone mineral density

The assessment of bone fragility as early as possible is crucial in children, particularly for those who present with repeated fractures or vertebral compression fractures, chronic liver and renal disease affecting skeletal mineralization, long-term corticosteroid therapy, and inherited or acquired disorders of calcium and phosphorus metabolism [1]. Bone mineral acquisition occurs throughout childhood, and ends with peak accretion during puberty. Bone has two major structural components, which are both important for the mechanical strength of the skeleton. One is the spongy (or trabecular) bone, which reflects bone metabolism and contains fatty and hematopoietic cells. The other is the compact (or cortical) bone, which is peripheral [2—4]. Differentiating between these two components is important, because demineralization affects trabecular bone first, and with its lower calcium stores (mineral density) than cortical bone, minimal changes in bone mineral density (BMD) are detectable only when the two densities can be differentiated.

* Corresponding author. AP—HP, CHU Bicêtre, service d'imagerie pédiatrique, 78, rue du Général-Leclerc, 94275 Le Kremlin-Bicêtre cedex, France.
E-mail address: catherine.adamsbaum@bct.aphp.fr (C. Adamsbaum).

http://dx.doi.org/10.1016/j.diii.2015.08.008

The purpose of this technical note was to describe the technical aspects of quantitative computed tomography (QCT) in pediatric patients, also known as CT densitometry and highlight the advantages of this technique by comparison with dual energy X-ray absorptiometry (DXA).

Advantages of QCT

The existing literature on bone fragility in children focuses primarily on the role of DXA [2,5]. However, DXA provides a real (rather than volumetric) BMD and does not distinguish trabecular from cortical bone density. X-ray attenuation depends both on the nature and thickness of tissue and on the X-ray emission energy. The human body can be modeled using two different types of tissue (i.e., soft tissues and bones). The mass attenuation coefficients for both types of tissue are known. Conceptually, DXA is based on the measurement of the difference in attenuation of two beams with different emission energies. The amount of tissue per unit area for each tissue type (soft tissue and bone) is then determined by solving a system of two linear equations in two variables. It is not, however, possible to separate trabecular and cortical bone mineral densities [1,2]. The individual z-score is calculated by comparing this global measurement with a gender- and age-matched control group (the difference between the individual BMD and mean BMD, divided by the standard deviation for the control group). In addition, because DXA requires that the subject stays totally motionless for about 3 minutes, it is difficult to perform DXA in children under age 5 years.

Currently, QCT is the single technique that is capable of distinguishing between trabecular and cortical BMD and of measuring volumetric density. However, there is little data in the literature regarding QCT in children; the reference article is that of Gilsanz et al. [4].

Technical aspects of DXA

Yet QCT is a quick and easy method performed with a standard CT unit without sedation, regardless child age. Dedicated software is required along with a specific BMD phantom for calibration. The phantom is placed on the CT table, just below the lumbar spine (Fig. 1A). The child lies on his back on an ergonomic pillow in order to minimize air interface between the phantom and the child skin. A lateral scout view of the lumbar spine is used to define three planes through the vertebral bodies (L2, L3 and L4) and pedicles (Fig. 1C). These three 10-mm thick sections are performed sequentially rather than helicoidally, in order to obtain sections parallel to the vertebral plates. Sequential data acquisition of each individual vertebra allows changing the angle of the CT gantry that can be tailored depending of the degree of lumbar lordosis. Regions of interest (ROI) are then drawn on the cortical bone, trabecular bone and the phantom (Fig. 1B). These ROIs are drawn automatically by the software, but must always be checked visually and, if necessary, adjusted manually. The average pixel values of the ROIs are compared to those of the phantom to estimate the average BMD for the cortical and trabecular bone in each vertebra. Those values are expressed in g or mg of Ca-HA per cm^3 or mL for each vertebra. The mean and standard

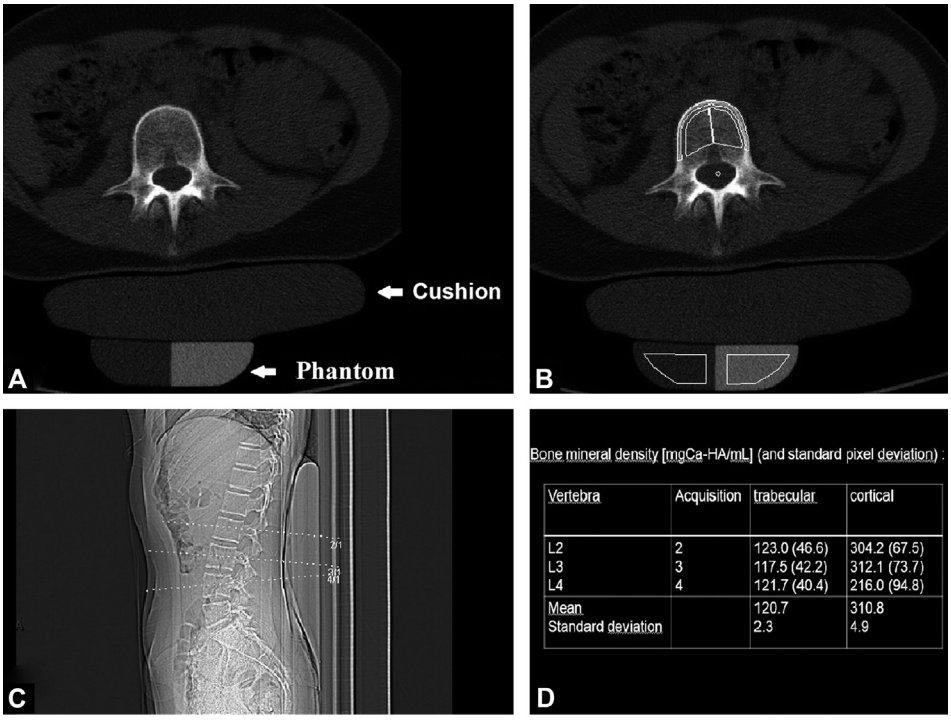


Figure 1. Quantitative computed tomography set-up and results. A. Correct positioning of the phantom. B. Regions of interests are correctly placed on the vertebra and on the phantom, allowing correct segmentation of vertebra and phantom. C. Section planes, passing through vertebral bodies (L2-L4) and pedicles. D. Results are directly visible on the display console.