In vivo assessment of the mechanical properties of the child cortical bone using quantitative computed tomography

Y. Zhu[1], F. Bermond[1], J. Payen de la Garanderie[3], J-B Pialat[4], B. Sandoz[2], J-P Pracros[3], W. Skalli[2], D. Mitton[1]

[1]Université de Lyon, F-69622, Lyon; IFSTTAR, LBMC, UMR_T9406; Université Lyon 1, France

[2]Arts et Metiers ParisTech, LBM, 151 bd de l'hopital, 75013 Paris, France

[3]Service de radiologie, Hôpital Femme Mère Enfant, Lyon, France

[4]Service de radiologie, Hôpital Edouard Herriot, Lyon, France

The mechanical properties of the rib cortical bone are extremely rare on children due to difficulties to obtain specimens to perform conventional tests. Some recent studies used cadaveric bones or bone tissues collected during surgery but are limited by the number of samples that could be collected. A non-invasive technique could be extremely valuable to overcome this limitation. It has been shown that a relationship exists between the mechanical properties (apparent Young's modulus and ultimate strength) and the bone mineral density (assessed using Quantitative Computed Tomography, QCT), for the femur and recently by our group for the adult ribs *ex vivo*. Thus the aim of this study was to assess the mechanical properties of the child rib cortical bone using both QCT images *in vivo* and the previous relationship between bone mineral density and mechanical properties of the rib cortical bone.

Twenty-eight children were included in this study. Seven age-groups have been considered (1, 1.5, 3, 6, 10, 15, 18 years old). The QCT images were prescribed for various thoracic pathologies at the pediatric hospital in Lyon. A calibration phantom was added to the clinical protocol without any modifications for the patient. The protocol was approved by the ethical committee. A 3D reconstruction of each thorax was performed using the QCT images. A custom software was then used to obtain cross-sections to the rib midline. The mean bone mineral density was then computed by averaging the Hounsfield Units in a specific cross-section and by converting the mean value (Hounsfield Units) in bone mineral density using the calibration phantom. This bone mineral density was assessed for the 6^{th} rib of each subject. Our relationship between the bone mineral density and the mechanical properties of the rib cortical bone was used to derive the mechanical properties of the child ribs *in vivo*.

The results give values for the apparent Young's modulus and the ultimate strength. The mechanical properties increase along growth. As an example the apparent Young's modulus in the lateral region ranges from 7 GPa +/-3 at 1 year old up to 13 GPa +/- 2 at 18 years old. These data are in agreement with the few previous values obtained from child tissues.

This methodology opens the way to *in vivo* measurement of the mechanical properties of the child cortical bone based on calibrated QCT images.