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MEETING REPORTS

Advances in Bone Imaging/Diagnostics: Meeting Report from the 3rd Joint Meeting of the European Calcified Tissue Society and the International Bone and Mineral Society

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Imaging methods played a significant role in a very substantial fraction of the research presented at the 3rd Joint Meeting of the European Calcified Tissue Society and the International Bone and Mineral Society. Several technological innovations were on display in the poster session, with some studies on preclinical imaging, some using *ex vivo* imaging methods on human specimens and a few presenting new *in vivo* data acquired in humans.

Most of the clinical projects involving imaging continue to be based on dual X-ray absorptiometry (DXA). Several groups presented DXA-based data evaluated beyond areal bone mineral density (BMD) assessment. L. Yang (Sheffield, United Kingdom) presented a finite element modeling approach based on 2D DXA data. Disappointingly, compared to areal hip BMD, no improvement in hip fracture discrimination was achieved. A different approach is related to structural analysis of DXA data: recently trabecular pattern score (TBS), a new approach based on texture analysis of DXA images (1), has been shown to provide information on fracture risk independent of areal BMD. Since questions remain regarding what type of structural information is reflected by DXA-based TBS measurements, data were presented comparing TBS results with μ-CT-based histomorphometric measures obtained on excised vertebrae. In multivariate models, higher TBS was found to be associated with higher BV/TV and lower Tb.Th (r^2=0.68, T. Piveteau *et al*., Pessac, France).

High-resolution peripheral quantitative computed tomography (HR-pQCT) was investigated in several projects. Dall'Ara *et al*. (Vienna, Austria) investigated the question of whether finite element (FE) models as currently used might benefit from improved spatial resolution of the underlying QCT data. They compared vertebral BMD and FE data obtained *ex vivo* on a clinical QCT scanner (voxel size 390 x 390 x 450 μm^3) with FE data of the same specimens measured *ex vivo* by HR-pQCT (isotropic voxel size of 82 μm^3). BMD and FE variables were compared with mechanical tests on these specimens. FE data showed significantly stronger associations with bone strength compared to BMD. HR-pQCT-based FE data showed a correlation with measured strength of r^2=0.88, compared to r^2=0.79 for FE based on QCT (borderline significant difference p=0.052). This documents potential for improvement if image data of higher resolution could be obtained. However, higher radiation exposure and very long computation times for nonlinear models need to be considered.

HR-pQCT was also used by Hansen *et al*. (Odense and other centers in Denmark) to study whether structural variables add to areal BMD in the prediction of femoral bone strength. 31 femurs were tested in a side impact configuration that resulted in 12 cervical and 19 pertrochanteric fractures. The correlation of maximum compressive strength increased from r^2=0.78 for areal BMD, to 0.88 by adding BV/TV, and to 0.90 by further adding Ct.Th, assessed by HR-pQCT.

There is continued strong interest in HR-pQCT, primarily because of the excellent image quality and despite the measurement being restricted to peripheral measurement sites. For the large cross-sectional OFELY study, microstructural variables of the radius and linear μFE models were presented (N. Vilayphiou *et al*., Lyon, France) and showed the expected menopause- and age-related declines. These data could potentially be used as HR-pQCT reference data.

Data from the large prospective CaMOS study could demonstrate, for the first time, power for predicting incident fractures for cortical axial transmission type quantitative ultrasound (QUS) using the OmniSense (2) device (W.P. Olszynski *et al*., Saskatchewan and other centers in Canada). All fracture prediction or non-vertebral fracture prediction was feasible for measurements at the tibia or at the radius but not at the finger phalanges and the risk increased by about 25-30% per 1 SD change in speed of sound.

Renewed interest was observed in positron emission tomography (PET), providing local information about bone turnover. Using ^{18}F-fluoride PET, T. Puri, G.M Blake *et al*. (Dublin, Ireland and London, England) documented that standardized uptake values (SUVs) associated with fluoride uptake measured at the lumbar spine were about 3-times higher compared to the proximal femur and about 4-times higher compared to the femoral shaft. This reflects higher bone turnover in trabecular bone. Radiation exposure levels of such approaches are around 4 mSv (3).

The microscopic assessment of elastic modulus attracts interest because it may permit an understanding of how microscopic material properties affect macroscopic measures of bone strength. S. Blouin *et al*. (Vienna, Austria) showed how site-matched scanning acoustic microscopy (SAM, (4)) and quantitative backscanner electron imaging (qBEI, (5)) can be combined to map the distribution of the elastic modulus in the vicinity of osteons. Osteoid and interstitial bone differed in elastic modulus by about a factor of four.

Finally, on a very different imaging topic, L. Ferrar (Sheffield, United Kingdom) showed data on vertebral fracture assessment gathered in the context of the OPUS study. Using the ABQ algorithm (6) on vertebral fracture analysis (VFA) data acquired on DXA devices, she showed strong predictive power of prevalent vertebral fractures assessed by ABQ/VFA for incident vertebral fractures. After adjusting for age and areal BMD, a prevalent vertebral fracture increased the odds of sustaining a vertebral fracture in the next 6 years by a factor of 5.3 ($p<0.014$). For a mild prevalent fracture the odds ratio was 3.7 ($p<0.063$) while a prevalent deformity with only short vertebral height and no fracture according to ABQ did not increase future vertebral fracture risk (odds ratio of 1.4, n.s.), supporting the notion that short vertebral height deformities should not be considered as osteoporotic fractures.

In summary, imaging techniques keep evolving and current interest focuses on microstructural assessment of changes in cancellous or cortical bone. FE modeling complements these data by providing accurate estimates of whole-bone strength under relevant loading conditions.

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