HR-PQCT-BASED ASSESSMENT OF CORTICAL POROSITY IN PRIMARY AND SECONDARY BONE MALIGNANCIES BY USING LOCAL STRUCTURE TENSOR TEXTURE FEATURES

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EIN UNTERNEHMEN DER VINZENZ GRUPPE WIEN

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Introduction:

High-resolution peripheral quantitative computed tomography (HR-pQCT) has been introduced recently as a non invasive method for in vivo 3D characterization of bone microarchitecture in humans. Furthermore, it is a new promising method for the diagnosis of osteoporosis and other bone diseases and additionally it permits quantification of the geometric, structural, and mechanical features of human cortical and trabecular bone in the peripheral skeleton. The high isotropic resolution of 82 microns in vivo offers novel options for the assessment of bone microstructure and bone density.

Allowing for non-invasive bone microstructure assessment, HR-pQCT has lead to the in-vivo description of novel disease features as cortical porosity. The impact of cortical porosity on the mechanical properties of cortical bone has been investigated by several groups and fracture risk changed significantly with cortical porosity and was independent from mineral content. Previous studies have demonstrated that age is highly correlated with increased cortical porosity, therefore an additional future aspect may be to assess other influences on cortical porosity as bone malignancies.

Osteosarcoma is a well-defined clinical entity with a characteristic radiographic appearance. As a malignant bone tumor, it presents with an agressive cortical destruction pattern, either moth-eaten or permeative. To date, there are no studies which have assessed the cortical micropores of the border zone of malignant bone tumors. In this study we focused on the characterization of cortical micropores found in ex-vivo HR-pQCT scans of bone malignancies. (Fig.1)

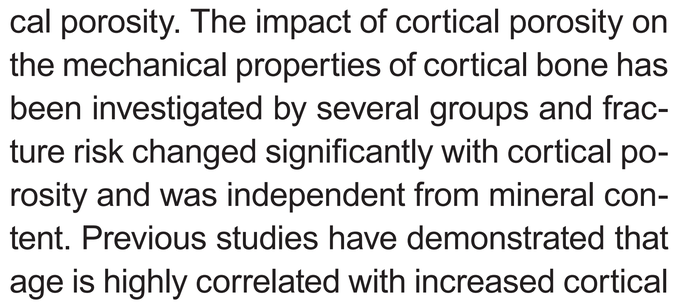

Fig.1. Ex-vivo HR-pQCT scans of malignancies

Methods and Materials:

Eight post-surgical obtained long bone specimens (Fig.2.) containing either primary or secondary malignancies were scanned at a resolution of 41 µm on an HR-pQCT device (XtremeCT, Scanco Medical, Bruetisellen, Switzerland).

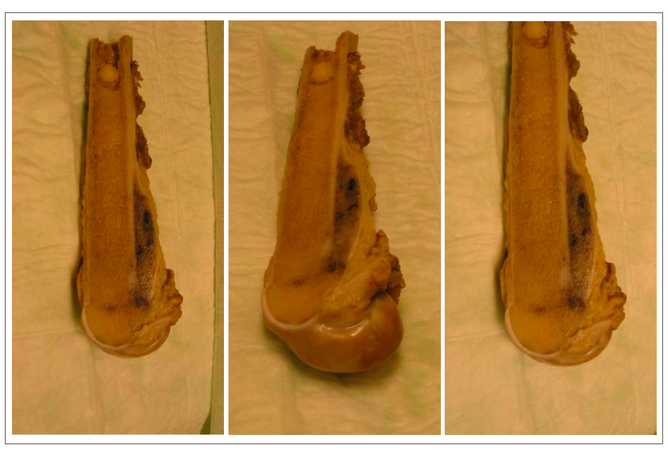

Fig.2. Example of post surgical bone specimen (Osteosarcoma)

Eight sex-matched healthy-control samples were obtained from the Department of Anatomy of the Medical University Vienna.
Primary osteosarcoma (n=6), renal cell cancer metastasis (n=1) and angiosarcoma (n=1) had been diagnosed histologically.

Based on the choice of a musculoskeletal radiologist, representative HR-pQCT single slices were selected and submitted to a manual annotation procedure to separate cortical bone from spongiosa and soft tissue. (Fig.3)

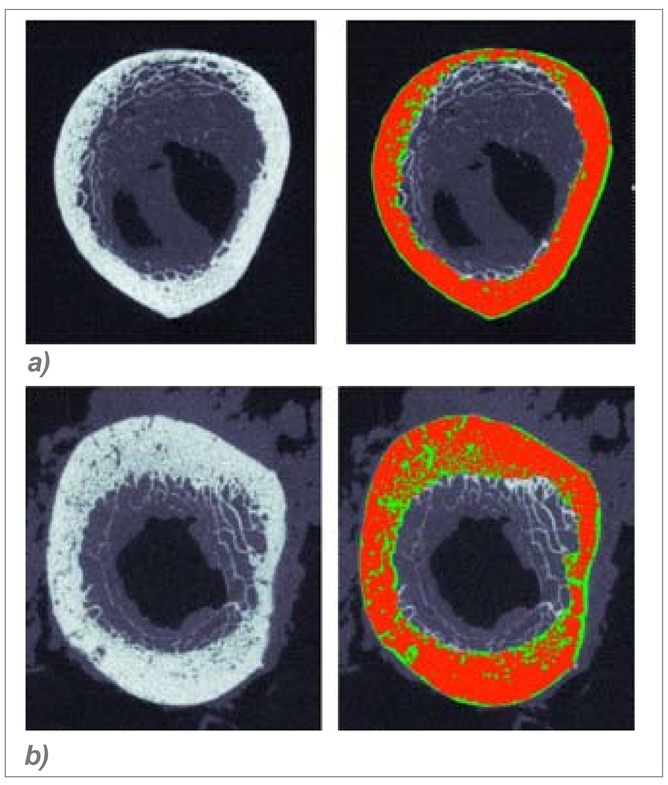

Fig.3. Novel cortical porosity assessment. (a: Healthy control; b: tumor group) Structure tensor approach (2D)

For texture feature extraction the local structure tensors and the hessian matrix, which are both matrix representations of 1st and 2nd order partial derivatives of an image were assessed. Each pixel within cortical was unsupervised clustered into bone and pore areas.

The method is divided into three steps:

1. The segmentation of the cortical and trabecular bone,
2. Feature extraction with a three-dimensional gray level co-occurrence matrix and partial derivative based method and
3. k-medians clustering and classification of the extracted features of the cortical bone.

Results:

Cortical porosity was significantly increased in tumor samples compared to healthy controls. (p= 0,01; 25,5% vs. 17,5%) (Tab.1)

Tumor	Control
0,3389	0,1927
0,2334	0,155
0,1814	0,1704
0,2068	0,2192
0,2013	0,2355
0,3765	0,1537
0,2591	0,1472
0,242	0,1227
0,254925 **(25,5%)**	0,17455 **(17,5%)**

Tab.1. Cortical porosity of the malignancies and healthy control.

Conclusion:

Our study demonstrates the presence of increased porosity in non-tumor-destructed cortices of patients suffering from bone malignancies. Structure tensor-based texture analyses are feasible in ex-vivo HR-pQCT scans and give insight to this novel disease aspect. Considering the increased microporosity detected in our study, according to the biomechanical importance of cortical bone, might be important for the assessment of local malignancy-related fracture risk estimation.