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## Cross-Anatomical Deep Learning: Predicting Proximal Humerus Bone Mineral Density from Shoulder CT using a Hip-Trained 3D ResNet Model

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### Introduction and Background

Preoperative assessment of bone mineral density (BMD) in the proximal humerus is critical for surgical decision-making in rotator cuff repair and shoulder arthroplasty, particularly regarding anchor stability and implant fixation. However, central DEXA scans are not routinely performed for shoulder conditions, and reliable shoulder-specific BMD tools are limited. We aimed to evaluate whether a deep learning model trained on hip/pelvis CTs—where DEXA ground truth is abundant—could accurately predict humerus BMD using shoulder CT scans.

### Material and Method

First, we retrospectively collected 238 patients with hip/pelvis CTs and matched femoral neck DEXA T-scores. Using this dataset, we trained a 3D ResNet model (and comparative architectures) to predict BMD from CT images. Anonymized DICOM data were used, preserving age and sex for T-score calculation. Following external validation on the hip dataset, the pre-trained model was adapted and tested on a separate cohort of 92 patients with shoulder CTs. In this shoulder cohort, model-predicted BMD values were compared against a previously established manual calculation method based on regional CT Hounsfield Units.

### Results

In the validation phase on the hip dataset, the 3D ResNet model achieved an accuracy of approximately 86%. The average difference between the model-predicted and actual BMD T-scores was minimal, at approximately 0.3 standard deviations (SD). When applied to the shoulder cohort, the model demonstrated a strong correlation with manual CT-based BMD measurements. The 3D ResNet architecture consistently outperformed other comparative models in both training stability and predictive accuracy.

### Conclusions

A 3D deep learning model trained on hip CTs can be successfully adapted to predict proximal humerus BMD from shoulder CT scans. This cross-anatomical approach provides an automated, opportunistic screening tool for assessing local bone quality without additional radiation or dedicated DEXA scans, potentially optimizing preoperative planning for shoulder surgery.

