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UTE MRI Can Detect Bone Quality Degradation in Diabetes

Introduction

Diabetes-associated skeletal fragility remains poorly characterized. Type 2 diabetes (T2D) is often associated with higher bone mineral density (BMD), a phenomenon known as the “diabetic paradox of bone fragility”. This dissociation between BMD and fracture risk underscores the critical role of bone quality, rather than bone quantity alone, in skeletal fragility. Chronic hyperglycemia disrupts bone metabolism through nonenzymatic glycation of the collagen matrix, oxidative stress, and microvascular dysfunction, all of which compromise the bone matrix and increase cortical porosity. T2D also shifts mesenchymal stem cell differentiation toward adipogenesis, further impairing osteoblast function. No validated imaging approach (e.g., DXA, CT, ultrasound, clinical MRI) can simultaneously assess cortical porosity, collagen matrix, and fat deposition in bone. Here, we proposed ultrashort echo time (UTE) MRI for comprehensive assessment of cortical bone quality.

Methodology

UTE-MRI was applied to 18 human bone samples (diabetes: n=10, control: n=8) using a 3T clinical scanner (GE Healthcare). Pore water and fat were mapped with spectrally selective and interleaved water imaging and fat imaging UTE (siWIFI-UTE), while water bound to collagen (bound water) was mapped with short TR adiabatic inversion recovery UTE (STAIR-UTE). Maps of pore water, bound water, and fat deposition were calculated to assess cortical porosity, organic matrix density, and fat deposition in cortical pores.

Results

The siWIFI-UTE sequence shows excellent pore water and fat maps, while STAIR-UTE shows high contrast bound water maps. The pore fat maps highlight fat deposition in diabetic bones. Increased pore water, reduced bound water, and increased fat deposition were observed in diabetic bones over control bones.

Conclusion

UTE-MRI detects increased pore water, reduced bound water, and increased fat deposition in diabetic bones.



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Keywords: Diabetes, bone, fragility, porosity, collagen, fat

Biography

Dr. Du is a Professor of Radiology and Bioengineering at UCSD. He has developed many UTE MRI techniques for quantitative imaging of clinical MRI “invisible” species such as bone and myelin. Dr. Du has published over 200 research articles, 30 book chapters, and one book. He has secured >\$30M in research funding. Dr. Du has chaired many conferences and workshops and served on the peer-review committees of numerous organizations. Dr. Du has received numerous awards, including the RSNA Research Scholarship, the AHA Young Investigator Award, the ARBIR Distinguished Investigator Award, and Fellow of AIMBE, ISMRM, and IAMBE.