Cortical Porosity in Type-2 Diabetic Postmenopausal women with and without fragility fractures

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INTRODUCTION

The goal of our study was to investigate cortical and trabecular bone structure and strength in T2DM subjects with and without fragility fractures and compare them to age-matched controls with and without osteoporotic fragility fractures. In particular, this study focuses on the cortical porosity-related measurements of the radius and tibia. Using high-resolution peripheral quantitative computed tomography (HR-pQCT), the structural differences in the trabecular and cortical regions of these sites were evaluated; in addition micro-finite element analysis (µFEA) was performed in these datasets to compute estimates of bone strength and the distribution of load between cortical and trabecular bone. Findings were compared to Dual-energy X-ray absorptiometry (DXA) measurements of the hip, spine and radius, which served as a standard of reference.

METHODS

Age-, BMI-, height-, and ethnicity-matched postmenopausal female patients were recruited into one of four groups with ten subjects each: type-2 diabetics (T2DM), type-2 diabetics with fractures (T2DMx), healthy controls (CTRL), and osteoporotic controls with fragility fractures (CTRLx). Distal/cortical radius/tibia were scanned on a clinical HR-pQCT scanner using a standard in vivo protocol (Fig.1). All subjects were additionally examined with DXA of the lumbar spine, proximal femur and distal radius. Results were reported as percentage differences between the groups (Δ%) and significances were calculated using student t-tests with a significance level of p<0.05.

RESULTS

Using HR-pQCT, two distal scans and two cortical scans were performed on the radius and tibia in all participants. Four radii and two tibia absorptions were excluded due to motion artifacts. Thus in a cohort of 40 patients, 154 datapoints were acquired. Trabecular bone structure was not significantly different between all four groups. In the distal radius, the T2DMx cohort had significantly higher cortical porosity than the CTRL cohort (36.7% difference, p = 0.04) as well as the diabetics without fractures (T2DM) cohort (223.6% difference, p = 0.04). The distal tibia of the T2DMx cohort had higher cortical porosity compared to the T2DM cohort (+60.45%, p = 0.03).

In addition to elevated cortical porosity, T2DMx had larger cortical pore volume (Ct.PoV) when compared with both the CTRL cohort (+36.75%, p = 0.03) and T2DM (+55.04%, p = 0.03). Biomechanical tests using µFEA of the distal tibia demonstrated a significant difference in the cortical load fracture (ΔCt.LF) in the T2DMx versus the T2DM cohort (+85.97%, p = 0.05) than the T2DMx.

In total, DXA was performed on 40 patients. In one patient the DXA of the spine was excluded from the analysis due to severe scoliosis and another patient presented with osteophytes, therefore the L1 vertebra was excluded and L2 to L4 were averaged. When paired-t tests were performed between the T2DMx and CTRL groups, the trend of elevated aBMD in the fracture cohort persisted for the lumbar spine, femoral neck, and the radius, however, the differences were not significant (p>0.05). The T2DMx group had significantly lower aBMD in the femoral neck compared to T2DM group without fracture (-11.96%, p = 0.02). This trend between the diabetic fracture (T2DMx) and non-fracture group (T2DM) persisted in the lumbar spine and the radius, however, no significant differences were found (p>0.05).

Figure 1. Representative scout radiograph for the radius (A) and tibia (B) with localization for the tomographic acquisitions (filled green) of distal (1) and cortical (2) region.

DISCUSSION

In this study we have found significant differences in intracortical porosity between type-2 postmenopausal women with and without fractures. Generally, the cortical porosity was found to be elevated in the diabetic patients with fragility fractures compared to diabetic subjects and normal controls. By using in vivo HR-pQCT measurements, we have investigated the biomechanical significance of these features using differential µFE analyses. The differences in biomechanical deficits attributable to cortical porosity increased significantly with the presence of fractures in the diabetic subjects. It was determined that cortical porosity and the associated differential µFE indices provided more robust measurements comparing the different cohorts than standard cortical density or trabecular geometric measures.

DXA measurements did not show a significant difference between diabetic subjects with and without fragility fractures. In summary these data suggest microarchitectural deficits in cortical bone of diabetics with fractures compared to diabetics without fractures and normal controls. Interestingly no significant differences were found for trabecular bone structure parameters and DXA was also limited in differentiating the different cohorts.

SIGNIFICANCE

This study addresses the unique pathology of elevated fracture risk in type-2 diabetic women despite normal to elevated aBMD using high-resolution peripheral quantitative computed tomography to measure cortical porosity.

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