Older Women with Longstanding Type 1 Diabetes Have Lower Femoral Strength and Region-Specific Deficits in Trabecular Bone Mineral Density of the Femoral Neck

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Type 1 diabetes (T1D) is associated with an increased risk of hip fracture, but the factors underlying skeletal fragility in older adults with T1D are not well understood. This study assessed regional differences in bone mineral density (BMD) and strength of cadaveric femora from postmenopausal women with longstanding T1D and non-diabetic controls.

Whole femora were acquired post-mortem from female Joslin Medalists with T1D ≥50yrs (n=11); age and sex-matched non-diabetic control femora were obtained from a tissue bank (n=10). Femora were scanned via axial computed tomography (CT, Siemens). CT scans were analyzed using Medical Image Analysis Framework (MIAF)-Femur, with cortical thickness (Ct.Th) and volumetric BMD (total=Tt; trabecular=Tb) assessed at the total hip (TH) and femoral neck (FN). FN volumes were further divided into quadrants: superior anterior (SA) and posterior (SP) as well as inferior anterior (IA) and posterior (IP). Femoral strength and DXA-equivalent TH and FN areal BMD (aBMD) and T-score were calculated using Biomechanical CT analysis (BCT, O.N. Diagnostics). Individuals were considered high fracture risk if they had either low aBMD (T-score≤-2.5) or fragile bone strength (≤3000N). The ratio of fall force to femoral strength was computed using a soft-tissue attenuated fall force and femoral strength from BCT. Wilcoxon rank sum tests assessed group differences; percent differences are between group medians.

The T1D group had an average (mean±SD) BMI=25.1±3.4kg/m^2, HbA1c=8.3±0.9%, T1D duration=65±5yrs, age at onset=13±8yrs, and age at death=78±10yrs; age and BMI were not different between groups. 73% of T1D and 40% of controls were considered high risk (p=0.2). TH Tt.BMD and aBMD did not differ between groups. FN aBMD (p=0.07) and Tb.BMD (p=0.06) were lower in T1D (Table). Within the FN, women with T1D had Tb.BMD deficits that were largest in the SP (-35%, p=0.04) and SA (-35%, p=0.10) quadrants. Ct.Th did not differ between groups at any site. Women with T1D also had lower femoral strength (-26%, p=0.03), but similar fall force (p=0.25), resulting in a greater load-to-strength ratio (+28%, p=0.04).

These findings reveal deficits in femoral BMD and strength and greater load-to-strength ratio in older women with T1D, indicating increased susceptibility to hip fracture. As hip fractures may initiate in the superior FN, trabecular bone deficits in this region may contribute to the high risk of hip fracture in older adults with T1D.

Funding (not included in character count): NIH (DK122593, DK124710, T32 AG023480), Mary K. Iacocca Fellowship, Beatson Foundation.

	Control N = 10[1]	T1D N = 11[1]	p-value[2]
Total Hip			
aBMD (g/cm^2)	0.64 (0.57, 0.79)	0.56 (0.50, 0.67)	0.282
Tt.BMD (mg/cm^3)	210 (189, 255)	184 (171, 214)	0.314
Femoral Neck			
aBMD (g/cm^2)	0.58 (0.54, 0.67)	0.50 (0.44, 0.59)	0.072
Tt.BMD (mg/cm^3)	251 (246, 271)	226 (198, 267)	0.314
Tb.BMD (mg/cm^3)	104 (81, 129)	66 (41, 81)	0.061
Tb.BMD by Quadrant (mg/cm^3)			
Superior-Posterior (SP)	78 (66, 91)	51 (21, 63)	**0.036**
Superior-Anterior (SA)	72 (61, 75)	47 (27, 63)	0.099
Inferior-Anterior (IA)	105 (92, 140)	79 (64, 100)	0.173
Inferior-Posterior (IP)	154 (87, 193)	105 (55, 118)	0.114
BCT Analysis			
Femoral Strength (N)	3,375 (2,662, 4,212)	2,500 (2,125, 3,025)	**0.029**
Attenuated Fall Force (N)	3,960 (3,848, 4,147)	4,109 (3,980, 4,307)	0.245
Load-to-Strength Ratio	1.24 (0.92, 1.49)	1.59 (1.31, 2.04)	**0.036**
High Risk	4 (40%)	8 (73%)	0.198

[1] Median (IQR); n (%); [2] Wilcoxon rank sum test; Fisher's exact test

BMD = Bone Mineral Density; Tt = Total / Integral; Tb = Trabecular; High Risk = high fracture risk by either low aBMD (T-score≤-2.5) or fragile bone strength (≤3000N)