High Resolution MRI of the Wrist at 7 Tesla Detects Subregional Variation in Trabecular Bone Micro-architecture in Healthy Subjects

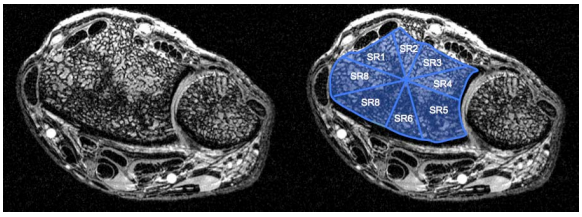
G. Chang[1], L. Wang[1], G. Liang[2], G. C. Wiggins[1], P. K. Saha[2], and R. R. Regatte[1]
[1]NYU Langone Medical Center, New York, NY, United States, [2]University of Iowa, Iowa City, Iowa, United States

Introduction. The trabecular bone micro-architectural network composing cancellous bone strongly contributes to bone strength (1). High resolution magnetic resonance imaging (MRI) of trabecular bone can provide great insight into the perturbations in trabecular micro-architecture that occur in osteoporosis and states of increased fracture risk (2, 3). There have been an increasing number of publications highlighting the benefit of ultra high field (7 Tesla and above) MR for musculoskeletal imaging applications (4, 5, 6). The goal of this study was to determine the feasibility of utilizing 7 Tesla MRI to quantitatively assess trabecular bone micro-architecture of the wrist in healthy subjects.

Materials and Methods. The wrists of 4 healthy subjects (1 female, 21 years; 3 males, 33+/-9.3 years) were scanned on a whole body 7T MR scanner using an 8 channel array coil and a 3D fast-low-angle-shot (FLASH) sequence (TR/TE=20 msec/4.5 msec, 0.165 mm x 0.165 mm x 1 mm, 30 axial images, TA=246 seconds). A region of interest (ROI) encompassing total trabecular bone of the distal radius was manually segmented on MR images using a two-dimensional graphical user interface. Each of these ROIs were further subdivided into eight angular subregions using a computerized algorithm (Figure 1). Fuzzy distance transform and digital topological analysis were used to compute total bone volume (TBV), bone volume fraction (BVF), surface-curve ratio (SC, marker of trabecular plate-to-rod ratio), and erosion index (EI, inverse marker of trabecular connectivity). Means, standard deviations, and biological variation (BVar) (standard deviation divided by the mean) were calculated. Subjects were scanned twice and measurement reproducibility was assessed via within-subject root mean square coefficient of variation (WS-RMSCV) and the intraclass correlation coefficient (ICC).

Results. Axial 7 Tesla MR images of trabecular bone micro-architecture of the wrist (0.165 mm x 0.165 mm, 1 mm slice thickness) (Figure 1, left panel) with angular segmentation of the distal radius into 8 subregions (SR) (Figure 1, right panel) are shown below.

Figure 1. Axial 7T MR images of wrist trabecular bone.



Within the group, BVar in trabecular micro-architecture was detected between individuals (Table 1).

Table 1. Group mean values and BVar for trabecular bone micro-architectural parameters with analysis done at whole wrist and subregional levels.

Group Mean	TBV	BVar	BVF	BVar	SC	BVar	EI	BVar
Whole Wrist ROI	86136	46%	0.27	18%	9.53	63%	1.33	80%
Subregional ROI	8489	43%	0.27	17%	9.61	87%	1.43	68%

Within each individual, BVar in trabecular micro-architecture was detected between the 8 subregions for TBV, SC, and EI, but not BVF (<5%) (Table 2).

Table 2. Mean subregional value and BVar for trabecular bone micro-architectural parameters within each individual.

Subregional Mean	TBV	BVar	BVF	BVar	SC	BVar	EI	BVar
Subject 1	5021	39%	0.19	4%	1.66	24%	3.31	28%
Subject 2	5921	39%	0.28	4.9%	9.96	23%	0.86	11%
Subject 3	12908	54%	0.28	1%	9.21	12%	0.93	5.2%
Subject 4	10106	41%	0.30	3.2%	17.62	13%	0.64	6.4%

WS-RMSCVs for TBV, BVF, SC, EI were: 0.020, 0.022, 0.08, 0.079. ICCs for TBV, BVF, SC, EI were:0.99, 0.95, 0.94, 0.98.

Discussion. High resolution 7 Tesla MRI can detect subregional variations in trabecular bone micro-architecture of the wrist in healthy subjects, even when BVF varies less than 5%. This may account for differences in individuals' bone strength and fracture risk. This work provides further support for the use of trabecular bone micro-architectural information derived from high resolution MRI as a method to assess bone quality and fracture risk (2, 3).

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