7T MRI OF TRABECULAR MICROARCHITECTURE AT THE DISTAL RADIUS: HOW BONE QUALITY VARIES AT THE EPIPHYSIS, METAPHYSIS, AND DIAPHYSIS

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Purpose. Osteoporosis is a disease of "low bone mass and microarchitectural deterioration of bone tissue" leading to weak bone and a higher risk of fracture.[1] Micro-magnetic resonance imaging (MRI) assessment of bone microarchitecture is commonly performed at the distal radius [2,3], but it is unknown how microarchitectural parameters vary depending on scan location. Our goal was to determine how microarchitectural parameters change depending on the scan location (i.e., distance from the end-of-bone) at the distal radius. As a secondary goal, we also assessed the relationship between microarchitectural parameters at each site.

Methods. This prospective study had institutional review board approval and written informed consent was obtained from all subjects. We scanned the non-dominant distal radius of 24 females (mean age = 56 years, range = 24 – 78 years; mean body mass index = 22) on a 7 T whole body MRI scanner (Siemens, Erlangen, Germany) using an 8 channel receive coil constructed in-house and a 3-D fast low-angle shot sequence (3-D FLASH, TR/TE = 20 msec/4.1 msec, flip angle = 10°, field-of-view = 86 mm, matrix = 512 x 512, resolution = 0.169 mm x 0.169 mm, slice thickness = 1 mm, parallel imaging (GRAPPA) acceleration factor = 2, imaging time = 2 minutes 9 seconds).[4] We applied digital topological analysis to 10 mm thick volumes of interest (VOIs) centered at the distal epiphysis (5 mm from end of bone), metaphysis (15 mm from end of bone), and diaphysis (25 mm from end of bone) to compute: a marker of bone mass, (bone volume, BV), trabecular thickness (Tb.Th.), and markers of trabecular number (skeleton density, Sk.D.), connectivity (Junc), and network resorption (erosion index, EI). Differences were assessed using Paired t-test or Wilcoxon signed-rank tests and correlations were assessed using Pearson or Spearman correlations.

Results. *Change in Microarchitectural Parameters with Scan Location:* bone volume, trabecular number (Sk.D.), and trabecular connectivity (Junc) was greater at the metaphysis than at the diaphysis and greater at the epiphysis than at the metaphysis ($p < 0.05$ for all, see figures 1 and 2). Trabecular network resorption (EI), was lower at the metaphysis compared to other sites ($p < 0.05$). *Interrelationship between Microarchitectural Parameters:* At all sites, trabecular number (Sk.D.) correlated with bone volume ($R > 0.6$, $p < 0.005$ for all) and trabecular connectivity (Junc) ($R > 0.75$, $p < 0.001$ for all). At the metaphysis and epiphysis only, trabecular network resorption (EI) was negatively associated with bone volume ($R \geq 0.8$, $p < 0.0001$) and trabecular thickness ($R > 0.85$, $p < 0.0001$).

Conclusion: High-resolution 7T MRI reveals how trabecular bone microarchitectural parameters and their interrelationships vary depending on scan location. Because trabecular bone quality appears to be higher at the epiphysis and lower at the diaphysis, it will be important to standardize scan location for clinical studies of fracture risk or treatment response. In addition, though microarchitectural parameters do correlate with each other, the imperfect correlation between parameters suggests that each parameter provides different information about bone quality not provided by the other parameters. Future work is needed to determine which parameter will be most useful as a biomarker of fracture risk or treatment response.

References

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Figure 1. In vivo 7T MR images shows how microarchitecture varies at the epiphysis, metaphysis, and diaphysis (0.169 mm x 0.169 mm x 1 mm).

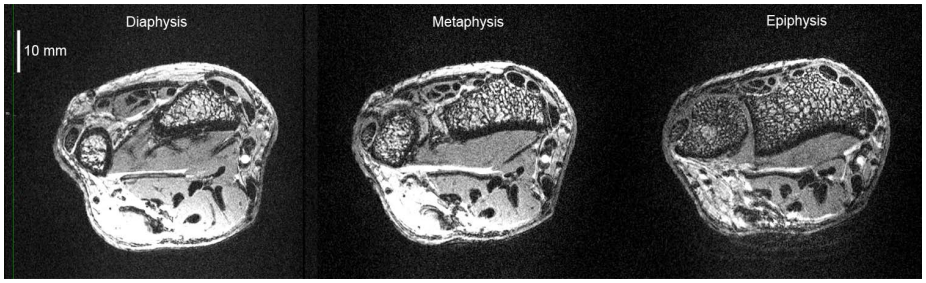

Figure 2. How microarchitecture varies across the radius (all differences significant, $p < 0.03$).