

Multi-Center MRI Reproducibility of Cancellous Bone Microstructure at the Distal Radius

B. R. Gomberg¹, P. Seaman¹, and M. Kleerekoper¹

¹MicroMRI Inc., Philadelphia, PA, United States

Background

The assessment of cancellous bone micro-architecture by microscopic magnetic resonance imaging (μ MRI) has been documented on single scanners [1, 2], but unfortunately most studies of metabolic bone disease require many more patients than can be recruited at a single site. Thus multiple medical centers (MC) are required for these clinical investigations. In this work we report validation data across multiple MCs, as implemented commercially by us, but based on technology developed academically [3].

Methods

As part of an NIH-sponsored study of μ MRI in clinical use, we installed the μ MRI technology on 9 1.5T MRI scanners located in 7 MCs in the US, 1 in Argentina, and 1 in Israel. During the typical installation and training process at each site, 4 subjects are scanned 3 times at the right distal radius. Training scans of low quality or high subject motion were excluded processed using a previously reported technique [2]. Across MC accuracy comparisons were done by scanning 4 subjects at all 9 MCs altogether for a total of 33 scans. Micro-architecture parameters are derived from μ MRI for a 12-mm slab of the complete radius cross section, 4-mm proximal from the distal cortical endplate. Slab overlap was adjusted for position along the anatomical axis to ensure positioning. Root mean square of the coefficient of variation (RMS-CV) was used to determine reproducibility and accuracy was determined by root mean square differences (RMS-diffs).

Results

Reproducibility by μ MRI showed all parameters having equal or slightly lower RMS-CV than the previously published "VBB" values. Of a total of 117 scans 107 from 25 subjects were of sufficient quality for analysis (90.7% yield). Results for the 6 primary endpoints of the 15 μ MRI parameters are provided in table 1. The amount of cancellous bone is represented by BV/TV (volume of cancellous bone), trabecular thickness (Tb.thk) and topological skeleton density (Skel Dens). Topological parameters are represented by surface to curve ratio (Surf/Curv) and erosion index. Figure 1 below shows a typical scan and rescans. For comparison of accuracy we looked at the parameters from the same subject at several MCs (table 2). There were no significant differences across MCs for any parameter and for any subject ($p > 0.05$). Figure 1 shows typical scan rescan examples.

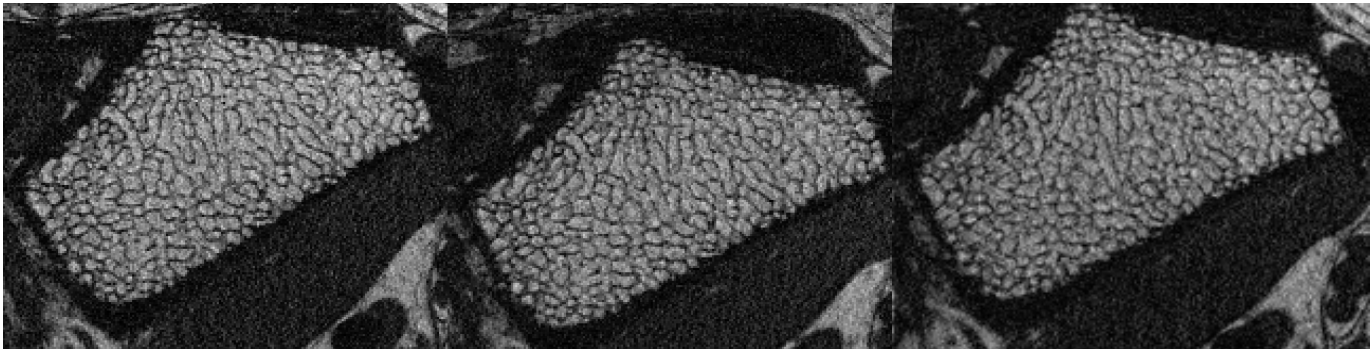
Table 1: example parameters from microscopic magnetic resonance imaging (n=107).

Parameter	mean	min	max	RMS-CV
BV/TV	0.124	0.0840	0.163	4.2%
Tb.thk	94.0	70.3	119.7	3.7%
Skel Dens	0.0718	0.0454	0.0927	4.5%
Surf/Curv	6.33	2.88	12.45	9.9%
Erosion Index	1.368	0.768	2.399	8.5%

Table 2: parameter accuracy across centers (n=33).

parameter	RMS-diff
BV/TV	4.2%
Tb.thk	3.9%
Skel Dens	3.8%
Surf/Curv	10.8%
Erosion Index	9.8%

Figure 1: scan rescan examples



Conclusions

This study demonstrates that the reproducibility across multiple MCs is comparable to values published for a single MC. Yield is very good, the accuracy is within the range of the measurement error and there was no significant difference across MCs for the same subject's endpoints. We conclude that the commercial μ MRI method tested is suitable for multi-center clinical studies.

Acknowledgement

This work was performed with partial support from the NIH (1R44CA125885-01), and with the assistance of Felix W. Wehrli.

References

1. Newitt, D.C., *et al.* Osteoporos Int, 2002. **13**(4): p. 278-87.
2. Gomberg, B.R., *et al.* Bone, 2004. **35**(1): p. 266-76.
3. Ladinsky, G.A. *et al.* Curr Osteoporos Rep, 2006. **4**(4): p. 140-7.