The Precision Of Partial Image Analysis Of Trabecular Bone Microarchitecture By High-resolution Magnetic Resonance Imaging (hrMRI)

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Background & Objective

High-resolution magnetic resonance imaging (hrMRI) can assess trabecular bone microarchitecture but the number of image slices required for reliable assessment is unclear. Our aim is to determine the number of images that needs to be processed to yield representative estimates of trabecular bone microarchitecture.

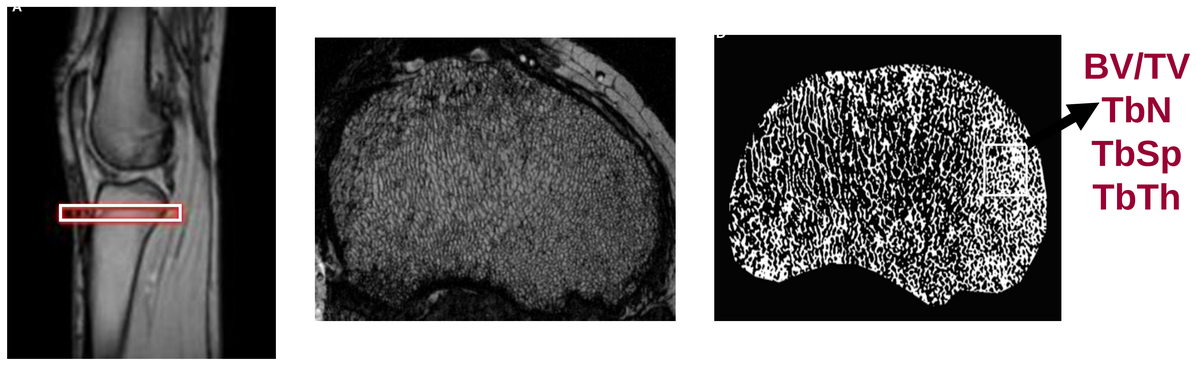

Figure 1. The procedure used to assess trabecular bone microarchitecture in the proximal tibia using hrMRI and image processing using Matlab software.

Methods

MRI was performed just below the growth plate of the proximal tibia from 20 healthy controls (all female; median age 21 years (range 18,35) and 10 cases (3M:7F; median age 19.5 years (range 16,48) with known childhood-onset bone abnormalities including osteogenesis imperfecta and other endocrinopathies using a 3T-MRI with an isotropic resolution of 0.3mm. Images were analysed using Matlab to generate the trabecular bone microarchitecture parameters, including apparent trabecular volume to total volume (appBV/TV), trabecular thickness (appTbTh), trabecular number (appTbN) and trabecular separation (appTbSp) (Figure 1).

The mean values obtained from twenty of the most central images (20IM) were compared to that for 10 images (10IM), 5 images (5IM) and one image (1IM) from the centre of the total image set using linear regression analysis. Analysis of variance was used to compare the means between groups and Levene's tests used to assess the significance of the co-efficient of variations (CoV) within subjects.

Results

Table 1: Measures of trabecular bone microarchitecture parameters in 20 healthy adults

	20IM*	10IM*	5IM*	1IM*
appBV/TV	0.442 ± 0.024	0.441 ± 0.024	0.442 ± 0.025	0.447 ± 0.027
appTbTh (mm)	0.771 ± 0.049	0.769 ± 0.049	0.764 ± 0.048	0.787 ± 0.051
appTbN (mm)	0.576 ± 0.043	0.578 ± 0.043	0.584 ± 0.044	0.569 ± 0.045
appTbSp (mm)	0.979 ± 0.104	0.976 ± 0.105	0.966 ± 0.104	0.981 ± 0.114

appBV/TV = apparent trabecular bone volume fraction; appTbTh = apparent trabecular thickness; appTbN = apparent trabecular number; appTbSp = apparent trabecular separation; IM = number of images analysed; Values in mean±SD. *Between group comparisons all *p<0.05*

Table 2: Measures of within subject coefficient of variation (CoV) for apparent bone volume fraction (appBV/TV)

Image sets	Intra-subject CoV for appBV/TV				
	Controls n=20	Cases (All) n=10	*p*	Cases (OI only) n=4	*p*
20IM	2.6 ± 1.1	3.7 ± 2.1	*>0.05*	4.6 ± 2.7	*0.037*
10IM	3.0 ± 1.5	4.7 ± 3.0	*>0.05*	7.1 ± 3.1	*0.028*
5IM	3.1 ± 1.5	4.3 ± 3.1	*>0.05*	5.9 ± 3.6	*0.017*

The mean trabecular bone microarchitecture estimates from 10IM, 5IM and 1IM were strongly and positively related to the estimates from 20IM for appBV/TV (*r*=1.00, *r*=0.99, *r*=0.97, all *p*<0.001) (Figure 2), appTbTh (*r*=1.00, *r*=0.99, *r*=0.97, all *p*<0.001), appTbN (*r*=1.00, *r*=1.00, *r*=0.98, all *p*<0.001) and appTbSp (*r*=1.00, *r*=0.99, *r*=0.98, all *p*<0.001).

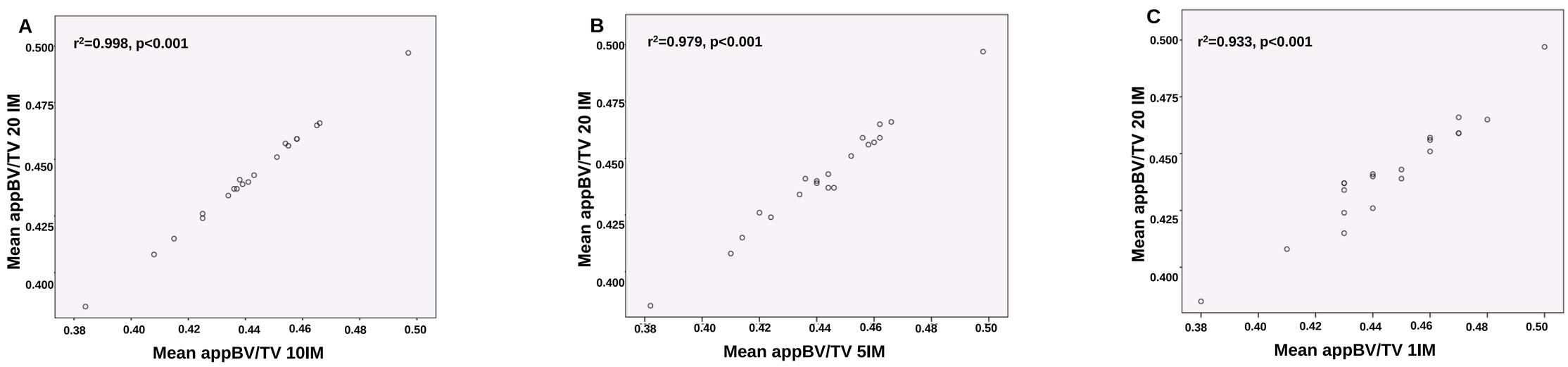

Figure 2. Scatter plots of the relationships between estimates of apparent trabecular bone volume fraction (appBV/TV) from a total image set in the proximal tibia (i.e. 20 images) and estimates from (A) 10 images, (B) 5 images, and (C) 1 image, *in healthy controls*

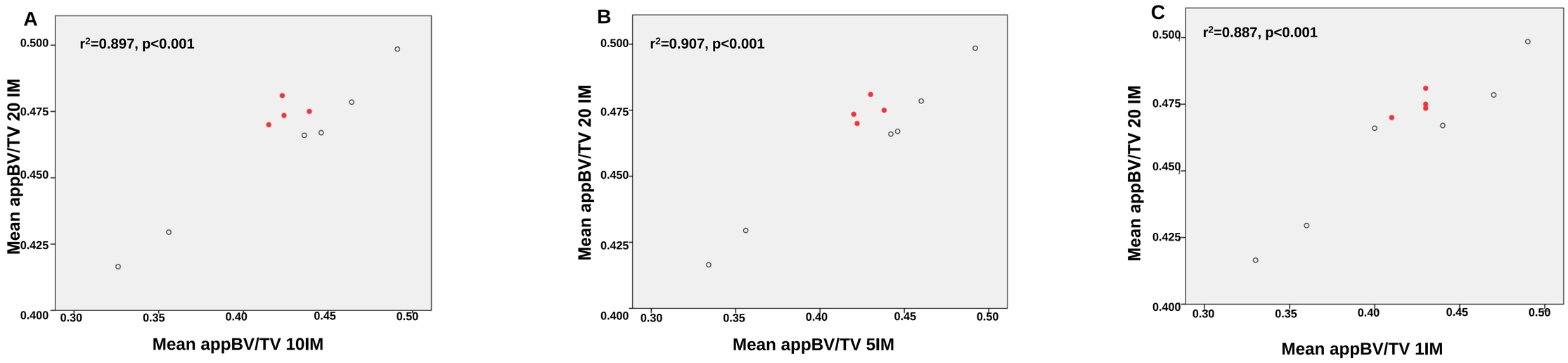

Figure 3. Scatter plots of the relationships between estimates of apparent bone volume fraction (appBV/TV) from a total image set in the proximal tibia (i.e. 20 images) and estimates from (A) 10 images, (B) 5 images, and (C) 1 image, *in cases with childhood-onset bone abnormalities.* Sub-analysis of the 4 cases (marked ●) of osteogenesis imperfecta (more severe osteopathy) demonstrated even higher mean CoV (Table 2).

Conclusion

These findings indicate that partial MRI sets can reliably represent a larger complete set of images when assessing trabecular bone microarchitecture parameters. However, in cases with severe abnormalities of bone health, a larger set of images may need to be analysed to improve precision.