INTRODUCTION
The determination of bone microarchitecture is clinically relevant, especially with respect to clinical fracture assessment and skeletal strength predictions\(^1\). The most common and clinically relevant fragility fractures occur in the hip or spine, both of which are central sites\(^2\).

Two current in vivo 3D methods to determine bone microarchitecture are:

1. High-resolution quantitative computed tomography (HR-QCT)
2. High-resolution magnetic resonance imaging (HR-MRI)

Both methods are generally restricted to peripheral sites\(^3\), due to ionizing radiation dose (HR-QCT) or long scan times for adequate signal to noise (HR-MRI).

To overcome these limitations, Acutias Medical has developed the fine structural analysis (FSA) algorithm (utilized in the MR based product *fine5\(^a\)*).

FSA can:

1. Be applied to 1D MRI data acquired in central sites with short scan times and adequate SNR.
2. Generate spectrum / spectra of spatial frequencies representative of the semi-periodic structure in tissue scanned.

PURPOSE
Evaluate metrics extracted from fine structural analysis spectra, for examining trabecular microarchitecture at central sites by using cadaveric vertebrae and comparing against the micro-CT morphometric measure Tb.N.

MATERIALS AND METHODS

Ten vertebral bodies (VB) (T7-L5) from two cadaveric human spines were individually imaged via micro-CT and MRI followed by FSA MRI data acquisition.

(A) FSA MRI 1D data acquisition using two internally-excited volumes (prisms) in each VB, (Siemens Trio Tim MRI 3.0T); prism dimensions 5×5×70 mm\(^3\); 300 μm resolution matching current in vivo FSA parameters.

(B) ROIs (green lines) selected from 1D MRI signal intensity profile across each prism.

(C) All FSA spectra generated using FSA algorithm with sliding filter window of length 14mm (red lines in B) across ROI.

(D) Root mean square (RMS) MR FSA frequency spectrum and (E) interpolated wavelength spectrum calculated for each ROI.

(H) Whole VB micro-CT scanning, 37 μm isotropic voxel size (Scanco μCT 30, Scanco USA Inc. Wayne, PA).

(G) Trabecular number (Tb.N) calculated from same MR data ROI locations in micro-CT data.

(F) Matched and extracted using rigid-body registration.

→ Within each VB – two ROIs limited to anterior and central trabecular bone areas for comparative analysis.

RESULTS

(FSA ANTHROPOMETRIC STANDARDIZED Vertebral microstructure:

- Tb.N values for ROIs ranged from 0.979 mm\(^1\) to 1.561 mm\(^1\)
- Frequency cut-offs 0.36mm\(^1\) to 2.49mm\(^1\) equivalent to wavelengths of 0.4mm to 2.75mm.
- 10 equally spaced frequency bins
- 19 datasets

Pearson Correlation Analyses:

- Anterior Prism
  - Coefficient of 0.90, \(R^2 \approx 0.81\), \(p<0.05\)
- Central Prism
  - Coefficient of 0.87, \(R^2 \approx 0.76\), \(p<0.05\)
  - Pearson correlation coefficient of 0.889, \(R^2 \approx 0.79\), \(p<0.05\) anterior & central locations.

Strong and statistically significant correlations were found between the FSA metric and the micro-CT Tb.N data.

CONCLUSIONS

The study demonstrated close similarity between the information provided by micro-CT and the fine structure analyses of MR data acquired on a set of cadaver vertebrae.

These results indicate the utility of MRI-based fine structure analysis for extracting a measure strongly correlated to Tb.N for in vivo applications such as the determination of osteoporosis and fracture risk prediction.


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