



Porosity and Location-Dependent Variation of Trabecular Length and Trabecular Number per Connection in Human Calcanei

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Introduction

Trabecular bone remodels its microarchitecture due to lack of mechanical stimulation leading to bone loss and osteoporosis. Trabecular thickness (Tb.Th), trabecular number (Tb.N), and trabecular separation (Tb.Sp) are highly correlated to porosity (ϕ) [1]. However, changes on trabecular length (Tb.L), inter-trabecular angle (ITA) and trabecular number per connection point (Tb.N/Conn) in the calcaneus have not been fully investigated, which is the aim of this study.

Methods

Human calcanei from 44 female Caucassian donors were micro-CT scanned at 13.5- μ m resolution. Two non-overlapping volumes of interest (VOIs) were obtained from the anterior and posterior portion of each calcaneus. Global morphological indexes: Tb.Th, Tb.N, Tb. Sp and ϕ were measured in CTAn (CT Analyzer, Skyscan). Images were binarized and skeletonized using ImageJ and Matlab software for the measurements of Tb.L. The Tb.N/Conn and ITA were computed for all possible combinations of branches. The code was validated on trabecular-bone phantoms. Triple, quadruple and quintuple connections were then measured. Data was normalized by the total volume of each sample and analyzed versus location (anterior vs posterior regions) and porosity (low porosity: $\phi \leq 75$; medium porosity: $75 \leq \phi \leq 85$; high porosity: $\phi \geq 85$).

Results

Analyses of variance (Wilcoxon matched pairs signed rank test) revealed statistically significant difference ($p < 0.05$) between anterior and posterior VOIs for all microarchitectural parameters. The higher porosity of the posterior VOIs is consistent with the smaller Tb.Th, Tb.L and Tb.Sp. Conversely, the values of Tb.N is larger in the posterior than in the anterior VOI. The Tb.Sp comparison between the mean values of the low and high-porosity was found statistically significant. The posterior regions resulted populated by larger trabeculae ($p < 0.05$), but it was found no statistically significant when analyzed as a function of porosity. The number of triple connections was always thrice the amount of quadruple points for all locations. The triple/quadruple ratio was also preserved when the data was analyzed against porosity. Histograms of ITA were also plotted for triple, quadruple and quintuple connections. Mode values of respectively 109°, 95° and 79° and 107°, 93° and 89° was found for the ITA of respectively triple, quadruple and quintuple connections in the anterior and the posterior VOIs.

Discussion

Analysis of Tb.L, Tb.N/Conn and ITA as a function of location and porosity from 44 human calcanei indicate that they change slightly with porosity and more strongly with location in this skeletal site. These results suggest that changes on Tb.L, Tb.N/Conn and ITA microarchitecture are associated with bone loss during elderly and osteoporosis in the calcaneum.

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References

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