Quantitative approach to the stochastics of bone remodeling

Abstract

During life bones constantly adapt their structure to their mechanical environment via a mechanically controlled process called bone remodeling. For trabecular bone, this process modifies the thickness of each trabecula leading occasionally to full resorption. We describe the irreversible dynamics of the trabecular thickness distribution (TTD) by means of a Markov chain discrete in space and time. By using thickness data from adult patients, we derive the transition probabilities in the chain. This allows a quantification, in terms of geometrical quantities, of the control of bone remodeling and thus to determine the evolution of the TTD with age.

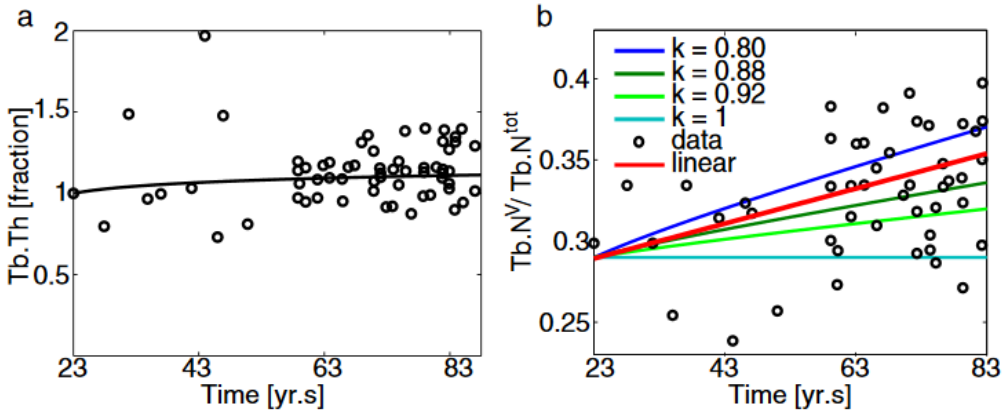

Fig. 4: (Color online) (a) Time evolution of the fraction of trabecular thickness, comparison between computational results (solid) and experiments (circles) [5]. The quantities are normalized to 1 at the first available datapoint from a patient of 23 years of age (the first datapoint of [5]). (b) Time evolution of the proportion of vertical trabeculae, $\mathrm{Tb.N^V/Tb.N^{tot}}$, for different reductions of the horizontal load. The parameter k denotes how much of the vertical load is applied in horizontal direction. Simulation results are compared with experimental data from [5] and with a linear fit of the data (red line, $y = 0.0011\,x + 0.29$).