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Topology optimization of trabecular bone in the human spine AHMED ELBANNA, University of Illinois Urbana Champaign — It is widely believed in the realm of biology that the trabecular structure of long bones self-optimizes in response to mechanical loads, in accordance with Wolff's law. Here, we examine this idea by applying techniques from topology optimization the human spine. We consider different domain geometries as well as different load cases to account for the various loading conditions and changes in shape that take place within the spine during day-to-day activities and over the years. We show that the classical approach of minimizing compliance subject to a volume constraint does not yield a sponge-like architecture but results in only vertical trabeculae. Additional constraints/objective functions have to be considered simultaneously. We show that more realistic trabecular geometries may be produced by taking into consideration the function of trabecular bone as a reservoir for minerals and bone marrow production. By maximizing the surface area of the generated voids while minimizing the total volume of the trabeculae subject to a constraint on their buckling strength, we recover the sponge-like structure. Our results shed light on the optimizing conditions for bone structure beyond Wolff's law and provide guidelines for biomimetic material design.

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