

Expression of human cancellous bone Eshelby tensor

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INTRODUCTION: The mechanical properties of orthopaedic biomaterials are important for mechanical biocompatibility. Theoretically, homogenization is a technique used to characterize the mechanical properties of porous biomaterials. The dilute distribution assumption, which has no interaction between cavities inside porous materials, or the self-consistent technique (or the Mori-Tanaka technique), which has interaction between cavities inside porous materials. Cancellous bone is a highly porous material, but the Eshelby tensor for human cancellous bone is unknown. Mainly, the fabric tensor is widely used to characterize the mechanical properties of human cancellous bone. The fabric tensor expression is a polynomial series expansion with many unknown coefficients, which must be determined by comparing with the mechanical properties of human cancellous bone. The advantage of using the human cancellous Eshelby tensor is to find the interaction between the porous spaces inside cancellous bone because the porous spaces are connected. In this study, we will find the human cancellous bone Eshelby tensor using the well-known fabric tensor and show which component is important to characterize the mechanical properties of human cancellous bone.

METHODS: The expression between the drained elastic constants and the Eshelby tensor is obtained by assuming the pore space is empty. The drained elastic constants are calculated when the pore space is empty, and nothing exists inside the pores. These drained elastic constants are also expressed by the fabric tensor by polynomial series expansion. However, the relationship between the drained elastic constants and the fabric tensor requires many unknown coefficients to fit. Thus, we establish a new relationship between the Eshelby tensor and the fabric tensor by comparing these two tensors.

RESULTS SECTION: Figure 1 shows the Eshelby tensor component p_{12} , which varies with two variables – an apparent density ρ_s and the porosity ϕ . However, Figure 2 shows the Eshelby tensor component p_{44} , which varies with only one variable – the porosity.

DISCUSSION: We find an exciting result: The human cancellous bone Eshelby tensor p_{44} is not influenced by an apparent density, but by the porosity only. It means that an apparent density does not change the shear modulus of human cancellous bone, but only the porosity. Thus, we can separate the porosity effect from the apparent density effect in characterizing the mechanical properties by using the obtained Eshelby tensor.

SIGNIFICANCE/CLINICAL RELEVANCE: (1-2 sentences): The human cancellous bone Eshelby tensor can separate an apparent density effect from the porosity effect in characterizing the mechanical properties of human cancellous bone.

IMAGES AND TABLES:

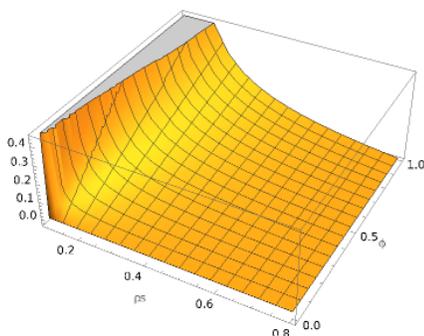


Figure 1. The Eshelby tensor component p_{12} against the apparent density ρ_s and the porosity ϕ .

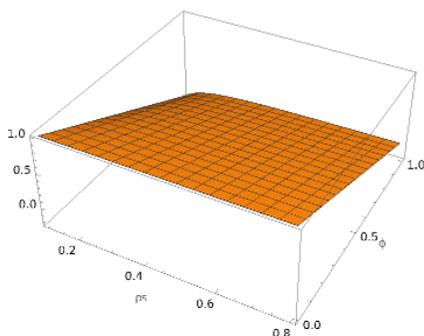


Figure 2. The Eshelby tensor component p_{44} against the apparent density ρ_s and the porosity ϕ .