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Finite element modeling of porous media in mechanobiology: from bone to cell mechanics

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ABSTRACT

Despite biological tissues are porous media [1], the impact of their mechanics on biology is limited in comparison with other fields like geosciences. However, in this work, we aim to show the importance of porous media mechanics on biology, in particular, the relevant role of fluid flow as a regulatory mechanical stimulus at cell level. With this purpose in mind, we are going to show different applications in mechanobiology, where the role of fluid flow on deformable porous media is fundamental.

First, we present a FE-based dual porosity approach to simulate deformation-induced fluid flow in cortical bone [2]. This biophysical phenomenon has been recognized as the main stimulus to regulate the adaptative bone response to loads, which is known as bone remodeling.

Secondly, we present a poroelastic approach to simulate how interstitial fluid flow influence on bone healing [3]. Actually, different regulatory theories based on fluid flow are proposed to guide the process of bone regeneration [4]. We have demonstrated that the application of high-frequency and low-magnitude cyclical displacements can also accelerate the recovery process of bone healing, which mainly modifies the fluid flow at the fracture site.

All these regulatory processes occur at cell level, where the cell as structural and functional unit of life, senses this flow and responds actively. In this sense, it has been shown that cells present a poroelastic behaviour [5]. Therefore, we are currently working to model the mechanical behaviour of the cell body, when the cell is embedded in a porous matrix, in order to determine how the interaction of the cell with the surrounding interstitial fluid flow affects in the cell migration process.

References

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