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Influence of helical inclusions in an embedding matrix: an application of helical symmetry to tendon fascicles

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Tendon is a highly hierarchical connective tissue: its components (i.e. collagen, cells, extracellular matrix) are distributed among six distinct hierarchies with different structural and material properties. Recent studies [1] have shown that some hierarchies of such connective tissue distribute themselves in an helical manner within the next level. Tendons withstand large deformation, and the helical distribution might be one of the mechanisms (along with fibril sliding and others) that allow to keep local strains small enough and to maintain integrity of the tissue [2]. A better understanding of the mechanics of such a construction would enable further progress in tissue engineering and healing practices. When it is assumed that the deformed body keeps the helical geometry, the uniformity of state variables along the helical axis [3] allows the definition of a two-dimensional FE model. Such a model can be used to simulate at low computational cost the response of the structure to macro-deformations (e.g. axial extension and axial torsion).

The current research analyses the effect of helical inclusions embedded into a surrounding and more compliant matrix. Such a structure is taken as representative of a – certainly more complex – distribution of fascicles within the tendon. Generally, stress and strain concentrations are introduced and they depend quite predictably both on material and geometrical parameters. An inhomogeneous effective Poisson's ratio distribution is also present, due to the unwinding mechanism of helices. Further developments in the current research are finally outlined, such as the implementation of different material models, that better mimics the true biological assembly.

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