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THE BONE TISSUE REMODELLING ANALYSIS DUE TO THE INSERTION OF A FEMORAL STEM USING A MESHLESS METHOD

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This work uses a recently developed numerical approach [1] to study the remodelling and osteointegration process due to the insertion of a femoral orthopaedic implant. The biomechanical numerical approach used in this work is able to predict accurately the trabecular architecture in the implant/bone interface. The phenomenological bone tissue mathematical law used in this work is based on experimental data found in the literature, allowing to relate the bone apparent density with its own mechanical properties. The remodelling algorithm is based on the minimization of the strain energy density. The used biomechanical model is able to gradually correlate the bone density with the obtained level of stress using an anisotropic material law for the mechanical behaviour of the bone tissue.

The most important feature of the proposed numerical approach is the inclusion of an organic meshless method, the Natural Neighbour Radial Point Interpolation Method, which is used to obtain the strain energy density field. The inclusion of the NNRPIM in the process is an asset since meshless methods, when compared with other numerical approaches, produce smoother and more accurate strain energy density fields [2].

The NNPRIM uses the Natural Neighbour concept in order to enforce the nodal connectivity. Based on the Voronoï diagram small cells are created from the unstructured set of nodes discretizing the problem domain, the “influence-cells”. These cells are in fact influence-domains entirely nodal dependent. The Delaunay triangles, which are the dual of the Voronoï cells, are used to create a node-depending background mesh used in the numerical integration of the NNRPIM interpolation functions. Unlike the FEM, where geometrical restrictions on elements are imposed for the convergence of the method, in the NNRPIM there are no such restrictions, which permits a random node distribution for the discretized problem. The NNRPIM interpolation functions, used in the Galerkin weak form, are constructed in a similar process to the Radial Point Interpolation Method (RPIM) [3], with some differences that modify the method performance. In the construction of the NNRPIM interpolation functions no polynomial base is required and the used Radial Basis Function (RBF) is the Multiquadric

RBF. The NNRPIM interpolation functions possess the delta Kronecker property, which simplify the imposition of the natural and essential boundary conditions.

This work presents the numerical bone tissue remodelling process of the femoral diaphysis, due to the inclusion of an implant system. The obtained remodelling and osteointegration results are in accordance with the clinical observation and with other numerical approaches results available in the literature.

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