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Investigating possible pathways of tissue development to predict endochondral ossification during bone fracture healing using mechano-regulation algorithms

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Bone secondary healing process consistof two different ossification mechanisms i.e., intra-membranous ossification and endochondral ossification (EO). EO is distinguished by differentiation of mesenchymal stem cells (MCs) into chondrocytes and sequential tissue differentiation of fibrous tissue (FT); cartilage (CT); immature bone (IB) and mature bone (MB). Several mechano-regulation (MR) algorithms have been proposed in the literature to date in order to predict the healing process exclusively followed EO. Some clear differences were observed among possible pathways of tissue development proposed in different algorithms. The aim of this study was to address the question of which pathways can predict EO the best by investigating the impact of different pathways on the EO. For This purpose, a 2D model of a broken tibia with a 3mm fracture gap was constructed and differentiation of stem cells and development of tissues in the determined pathways was implemented as a biofeedback loop through using Python scripting in Abaqus software. Results of this study showed that the algorithm which restricts tissue differentiation from granulation tissue (GT) to CT failed to predict bony bridge and some small islands of bone were left in some area of internal and peripheral callus. On the other hand, healing patterns predicted by algorithms which allow pathway of jumping from GT and FT to IB without passing through the CT showed no differences in comparison with the original theory in which no constraints were applied in tissue differentiation processes. However, by considering the constraint that in order to develop BT, CT should already exists, it significantly improves our prediction which is in agreement with experimental evidence showing that EO can take place though calcification of CT. Based on this investigation, two pathways should be considered crucial for correct prediction of EO: first, GT to CT and second, GT and FT should not be allowed to directly differentiate into bone phase. Results of this work suggest new regulatory algorithm by defining development pathways according to biological events and is able to correctly predict EO.

Biography

Jalil Nourisa has graduated his BSc and MSc both from Amirkabir University of Technology (Tehran Polytechnic) and currently he is a Research Assistant at Orthopaedic & Dental Biomechanics Lab (ODBL). He is actively focused his research on the biomechanical investigation of fixation devices for distal tibial fracture, mechano-regulation algorithms and bone scaffolds..

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