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PREDICTION OF THE RISK OF VERTEBRAL FRACTURES IN METASTATICALLY INVOLVED SPINES

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Summary: Introduction. The presence of bone metastases in the spine usually involves an increase of the risk of vertebral fractures even in low energy trauma, with possible catastrophic consequences on the patient condition which is already severely compromised by cancer. In this work, a methodology to predict the risk of vertebral fractures in specific patients with bone metastases based on CT images and on numerical biomechanical models was developed.
Materials and Methods. We created finite element models of thoracolumbar vertebrae based on CT scans which take into account the patient-specific anatomy and the local bone densities. A set of such models (20 thoracolumbar vertebrae from 3 spines) was used to run a sensitivity analysis in which bone metastases have been artificially added to the models. For each vertebra, 30 different models including randomized metastases with variable size, location, shape and material properties were generated. All the resulting 600 models were loaded in simple compression as well as with spinal loads during daily activities such as standing, walking and weight lifting predicted by means of validated musculoskeletal models of the whole body.
Results. Statistical analysis of the numerical results highlighted the fundamental role of the size of the metastasis in determining the degree of vertebral collapse under the action of physiological loads. The craniocaudal position of the tumor was a stronger predictor of the loss of vertebral height, with respect to the tumor location in the anteroposterior and lateral directions. Poor bone quality also induced a significantly higher vertebral collapse, whereas the vertebral level had a negligible influence.
Discussion. The limitations of the models included the lack of the surrounding structures, such as intervertebral discs and ligaments, the simplified loading scenario as well as the linear material properties assumed for the bone tissue, which impeded a proper simulation of vertebral failure. Despite these limitations, the simulations allowed determining the most relevant biomechanical risk factors for metastatic fractures, which can be useful in the selecting the most appropriate medical management options (such as the use of bracing) for patients with vertebral metastases.