Title	**Prediction of the failure strength of metastatic femurs with metastases: comparison between idealized and physiological loading conditions**
Location	**LBMC Univ Eiffel-UCBL UMR_T 9406, Lyon, https://lbmc.univ-gustave-eiffel.fr** **LYOS INSERM-UCBL, UMR1033, Lyon, www.lyos.fr**
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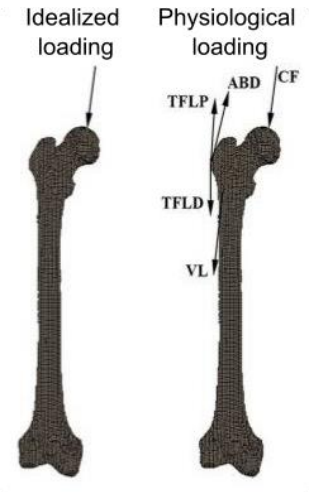
Project description:

Cancers, such as lung or breast cancers, can lead to bone tumour formation, called metastasis. Osteolytic bone metastases are responsible for long bone fracture leading to restricted mobility or surgery, which severely alter quality of life and have a huge socio-economic impact[1,2]. It is estimated that 50% of patients with bone metastases will suffer from bone complications[3]. Currently, most patients with bone metastases associated with a risk of fracture benefit from a computed tomography (CT) scan centred on the lesion to characterise its size and location, but this examination remains qualitative. Clinicians need more accurate tools to predict the fracture risk of femurs with metastases and choose the most suitable treatment for the patient.

LBMC UMR_T9406 and LYOS INSERM U1033 are developing patient-specific finite element (FE) models based on QCT scans to assess the strength of tumoral bone segments and provide clinicians with quantitative data. QCT scans of patients have been collected using a clinical protocol including several centres in France. In these FE models, idealized loading conditions that only simulate a single hip force are applied on the femur. Incorporating physiologic musculo-tendon forces into the FE models could 1/ influence local strains and femoral strength, especially for metastases close to the insertion site[4], and 2/ allow the application of personalised loading conditions. Due to muscular redundancy, the distribution of musculo-tendon forces can also vary from an optimal muscle control, to altered controls in case of muscle weakness, neurological degeneration, joint pain…and this can maximise the risk of fracture[5].



Idealized and physiological loading conditions applied to the femur to mimic single leg stance position. Adapted from Johnson et al (2023)[4].

Scientific objectives: In this context, the objectives of this internship are to 1/ apply patient-specific bodyweight-scaled musculo-tendon forces obtained from a musculoskeletal model in standing posture to the femur in the FE model, 2/ assess the influence of physiological loading on strain distribution and femoral strength, in comparison with idealized loading conditions, and /3 test the effect of non-optimal muscle control by introducing a distribution of musculo-tendon forces which may minimise/maximise joint loading.

Methodology: To achieve these goals, the methodology will be as follows:

- Conduct a literature review on the combination between musculoskeletal models and FE models of femur

- From QCT scans (Dicom images), 3D-reconstruct left and right femurs of each patient, and create the associated mesh, register the muscle origins and insertions
- Apply patient-specific bodyweight-scaled musculo-tendon forces to the femur based on musculoskeletal model available in the laboratory (model in standing posture or during simulated squat[6], scaled to the height and weight of the subject)
- Use the musculoskeletal model to define musculo-tendon forces corresponding to minimal joint loads, minimal or maximal co-activations.
- Compare strain and stress distribution and the failure loads obtained using idealized and different physiological loading conditions

Expected results: This project will contribute to the application of numerical methods for the prediction of metastatic bone strength, on patient data.

Duration of the internship: **6** months, **Location:** Lyon

Profile of the candidates: Candidates with solid mechanics and numerical simulation background. A good knowledge of Python and/or matlab is desirable.

References

[1]Weilbaecher et al, Nat Rev Cancer, 2011
[2]Hofbauer et al, Lancet Diabetes Endocrinol, 2011
[3]Jensen et al, BMC Cancer, 2011
[4]Johnson et al, Biomed Eng Comput Biol, 2023
[5]Viceconti et al, J Biomech, 2012
[6]Latypova et al, Clin Biomech, 2016