Developing a Pipeline for Virtual Bone Mechanical Testing and its Application in Cancer Research

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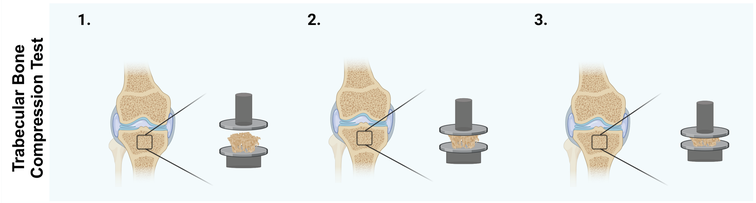
Introduction

Compression and bending tests are the golden standard to study trabecular and cortical bone mechanical behavior, helping researchers understand extrinsic properties like **stiffness, strength,** and **deformation**. In preclinical bone metastasis research, this test is especially useful for investigating bone fragility induced by bone metastasis progression. However, the *solo* experimental approach has some limitations such as the necessity for micro-dimension machine, animal sacrifice, and the inability to perform longitudinal study on the same subject. This project focuses on overcoming these limitations by developing an **integrated *in vivo/in silico* model** to compare the **mechanical properties of different cancer cell lines**. Our model is based on micro-CT-derived bone geometries, segmented and 3D reconstructed for *in silico* mechanical tests. Additionally, a comprehensive morphometrical analysis is incorporated to evaluate the changes in geometric features.



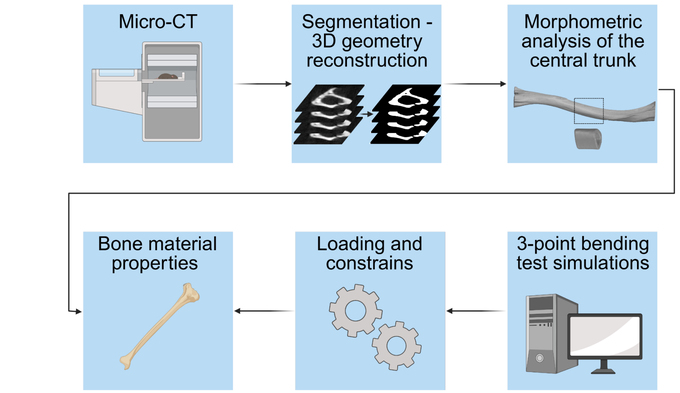
Advantages

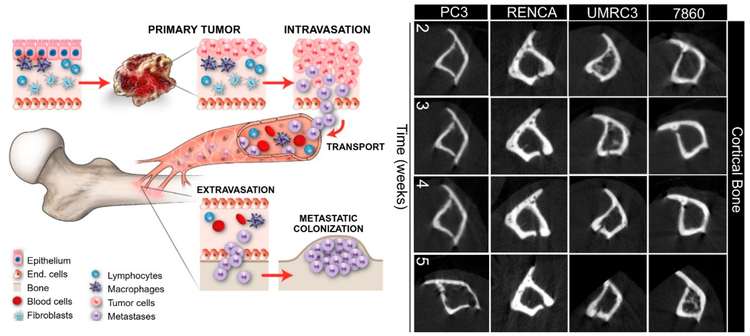
- Golden standard
- Intrinsic & extrinsic properties evaluation
- Fracture assessment

Drawbacks

- Micro-compression machine
- Invasive tests - Animal sacrifice
- Lack of longitudinal study on the same subject

Methodology





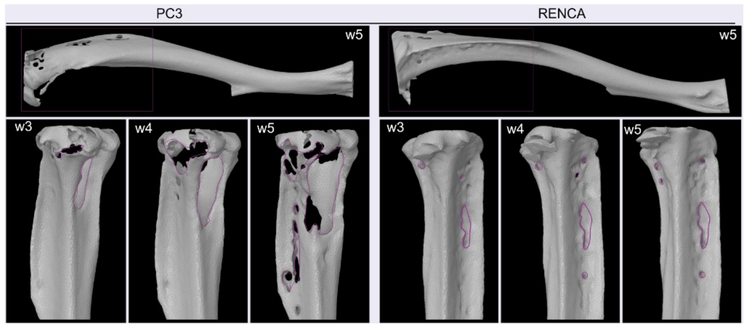


Fig. 2 Bone metastasis cartoon and micro-CT derived geometries. Bone metastasis formation and osteolytic phenomenon investigated through the micro-CT analysis, bone segmentation and 3D geometry reconstruction.

Results

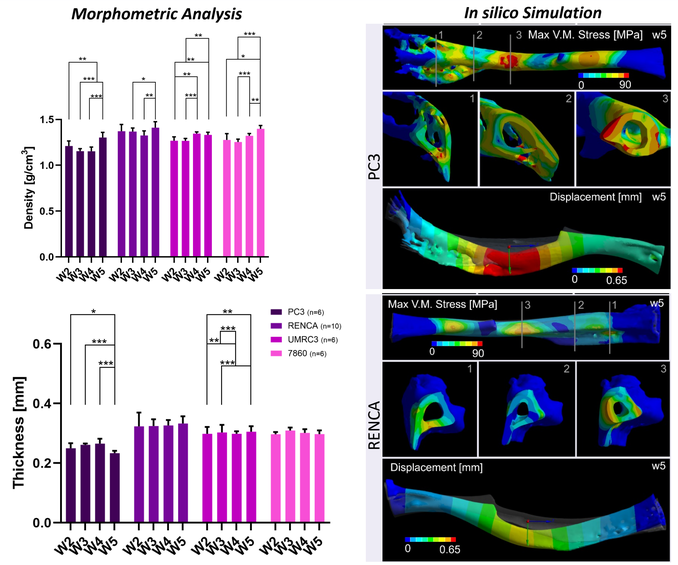


Fig. 3 Morphometric analysis and *in silico* 3-point bending results. Density and thickness evaluation of the cortical bone trunk for PC3, RENCA, UMRC3, 7860 cell lines (p-value: * < 0.05, ** 0.01, ***<0.001). Stress and displacement results for PC3 and RENCA cortical bone samples.

Discussion and Conclusions

- ✓ Accurate bone segmentation contributed to successful computational replica of 3-point bending tests, for virtual prediction of cortical bone mechanical behavior
- ➢ Incorporation of compression test for cortical bone necessary to capture things such as the metastatic lesions on the proximal epiphysis
- ➢ Future aspirations include making the segmentation process more efficient through implementation of AI neural networks.

Acknowledgments

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