THE MECHANICAL INTERPLAY BETWEEN BONE AND SCAFFOLD MICROSTRUCTURES

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INTRODUCTION

CLINICAL CONTEXT

Segmental bone defects are clinically challenging. While autografts are limited by donor-site morbidity, synthetic 3D printed scaffolds offer a promising alternative.

GAP IN KNOWLEDGE

Beyond scaffold geometry and material properties, understanding the mechanical interplay between the scaffold and the host bone is crucial for successful regeneration.

RESEARCH QUESTION

How does the insertion of a bone scaffold impact the mechanical loading on the surrounding bone?

COMPUTATIONAL METHODS

- **Study Cases**

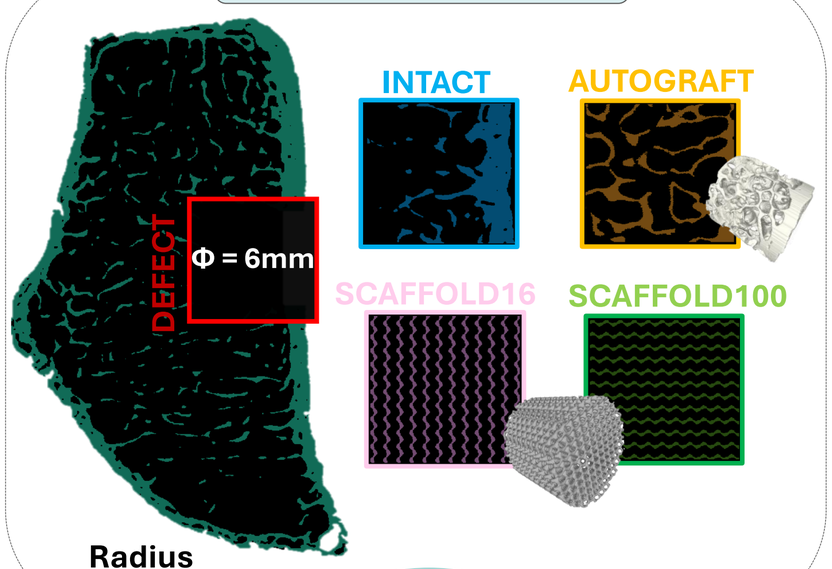
Radius µ-CT to model **intact bone** and virtual **defect** implanted with iliac crest **autograft** (same patient) and gyroid **scaffold** (**16** vs **100** GPa).

- **µ-Finite Element Analysis (µ-FEA)**

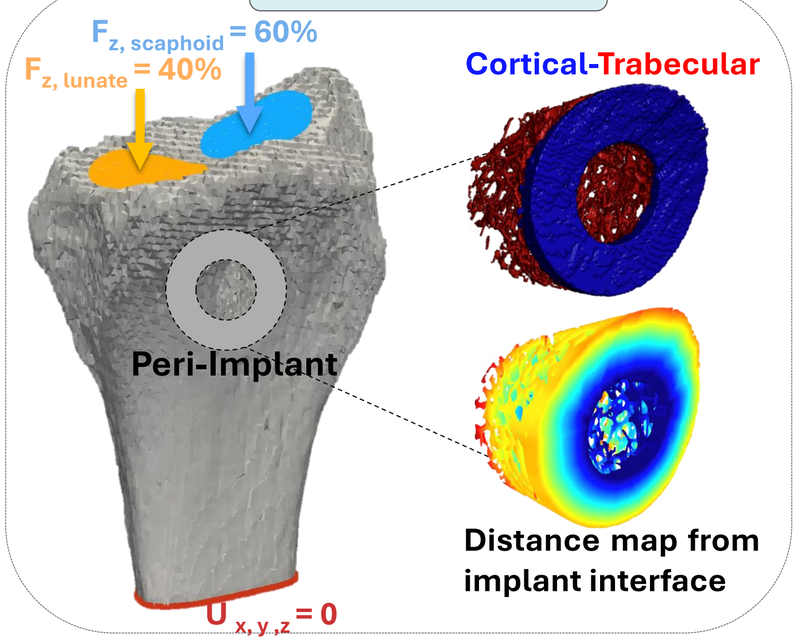
Peri-implant effective strain (EFF) values were normalized to the intact bone reference and analyzed for their frequency distribution, spatial probability variation, and cortical–trabecular contributions.

dragonfly materialise

Study Cases

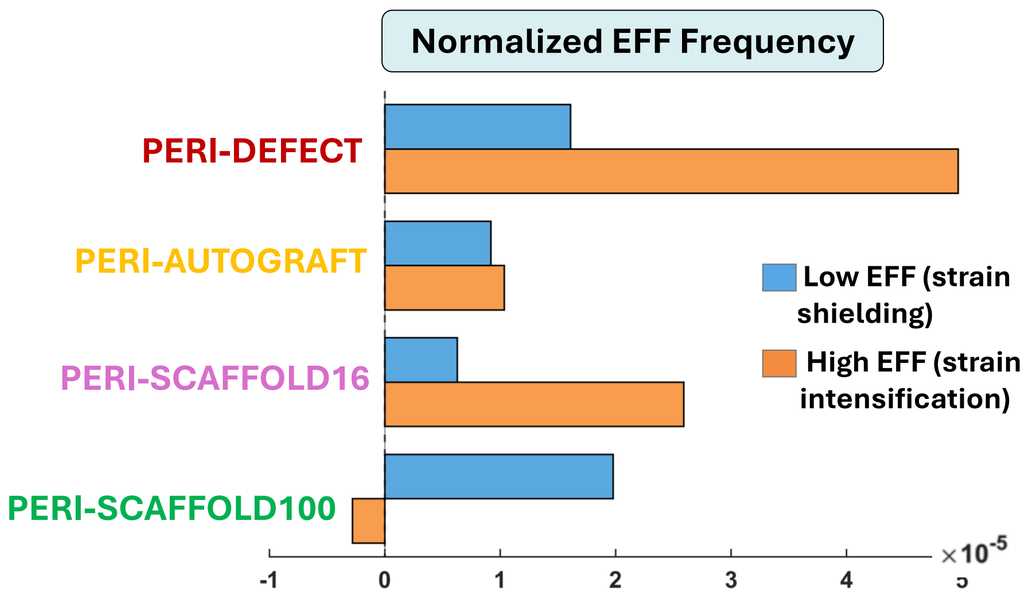


µ-FEA: ParOSol

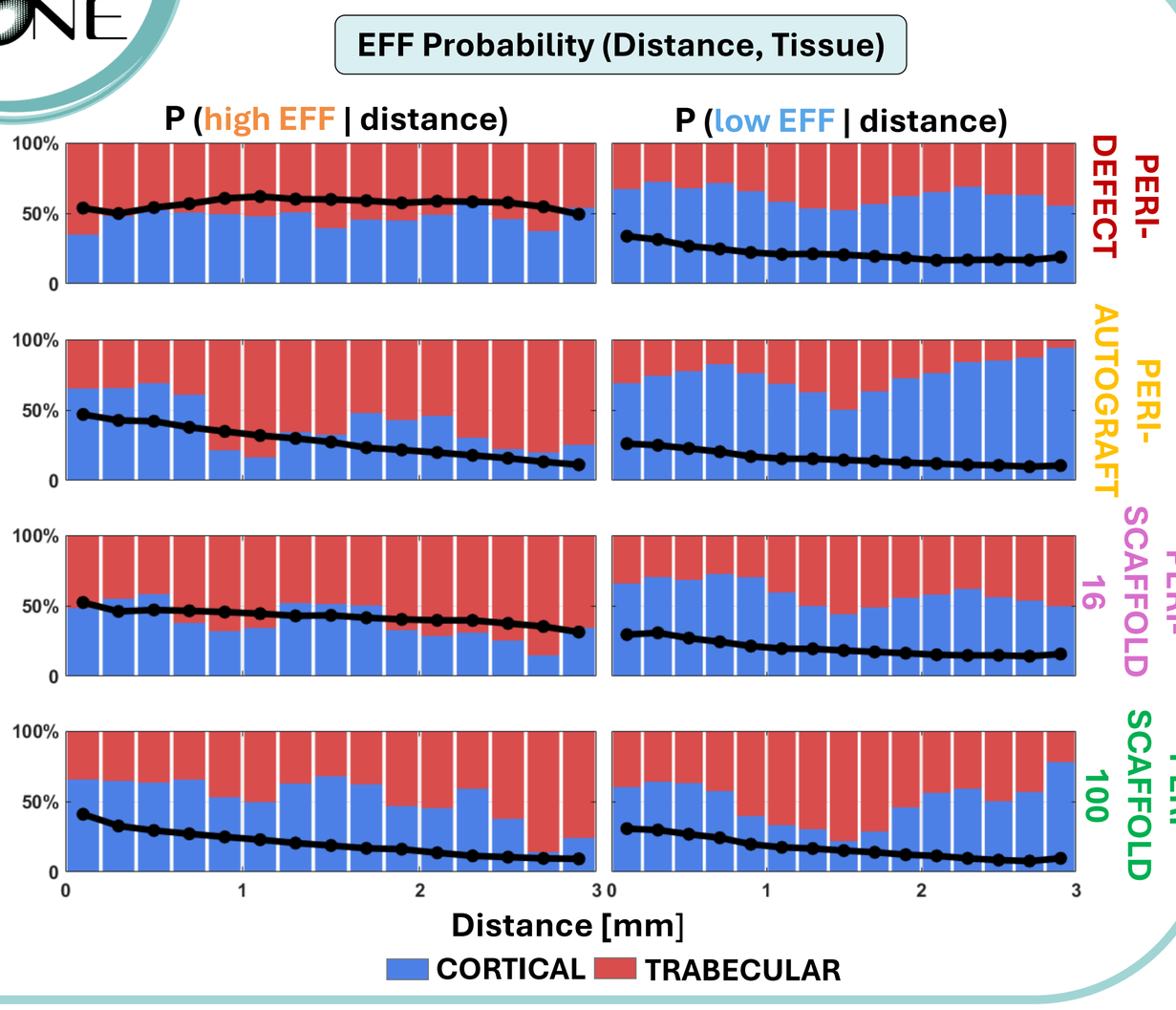


RESULTS

Normalized EFF Frequency



EFF Probability (Distance, Tissue)



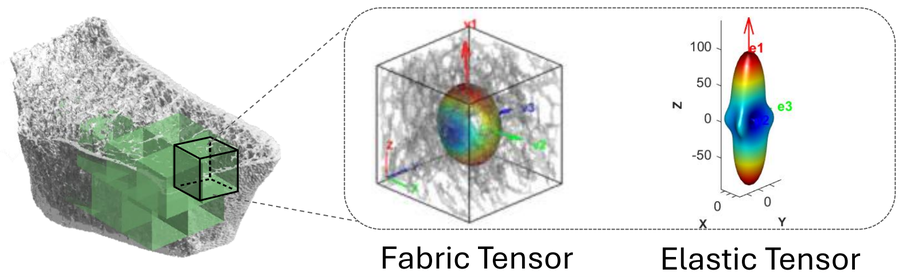
- High-EFF occurrence in peri-defect and peri-scaffold16, and low-EFF occurrence in peri-scaffold100.
- Probability of high-EFF does not decrease with distance in peri-defect and peri-scaffold16.
- Cortical bone experiences strain-shielding, while trabecular bone overloading. This reverses in peri-scaffold100.

TAKE HOME MESSAGES

- Peri-implant bone loading is modulated by scaffold stiffness and architecture, with strain varying across tissues and distance from the interface.
- Stiffer scaffold causes trabecular unloading, while autograft-like microstructure reduces probability of trabecular overloading away from the interface.

FUTURE PERSPECTIVES

Correlate bone microarchitecture and mechanics, to guide scaffold design.



ACKNOWLEDGMENT: Funded by the *European Union's Horizon Europe research and innovation program* through the **ReBone Project (Grant Agreement No. 10111988)**

Funded by the European Union

ECTS European Calcified Tissue Society

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