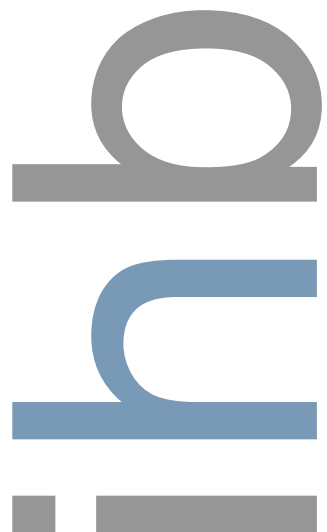


institute of health and biomedical innovation

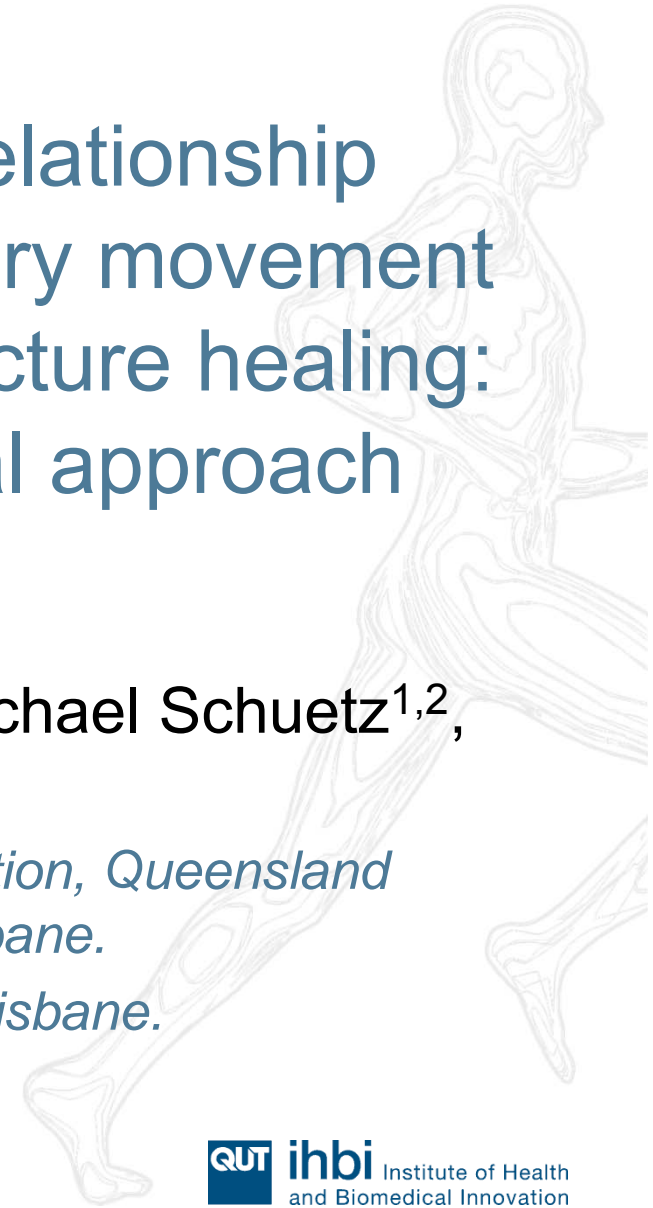


Understanding the relationship between interfragmentary movement and callus growth in fracture healing: a novel computational approach

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Mechano-regulation of fracture healing

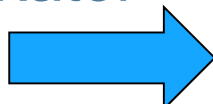
- Movement at fracture affects healing process.

More
movement:

more callus



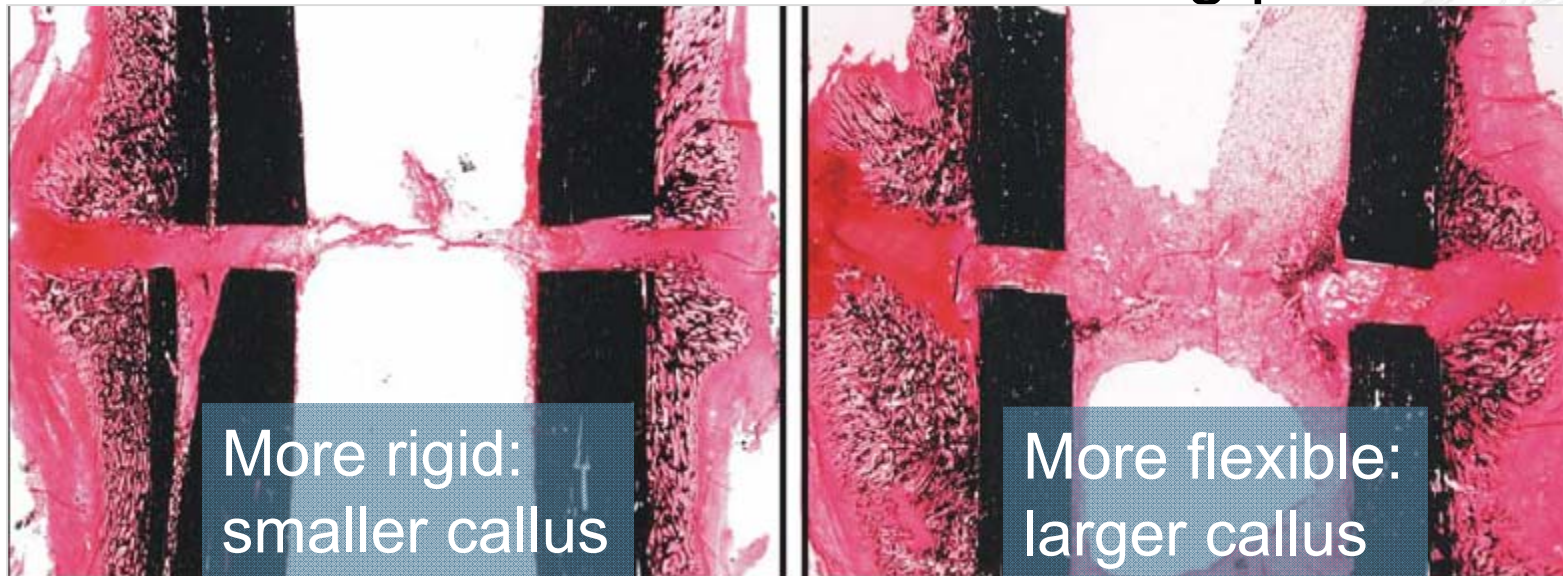
Sheep osteotomy @ 2 weeks

External
fixator

Less
movement

Epari et al.,
Bone, 2006

Mechano-regulation of fracture healing

- Movement at fracture affects healing process.

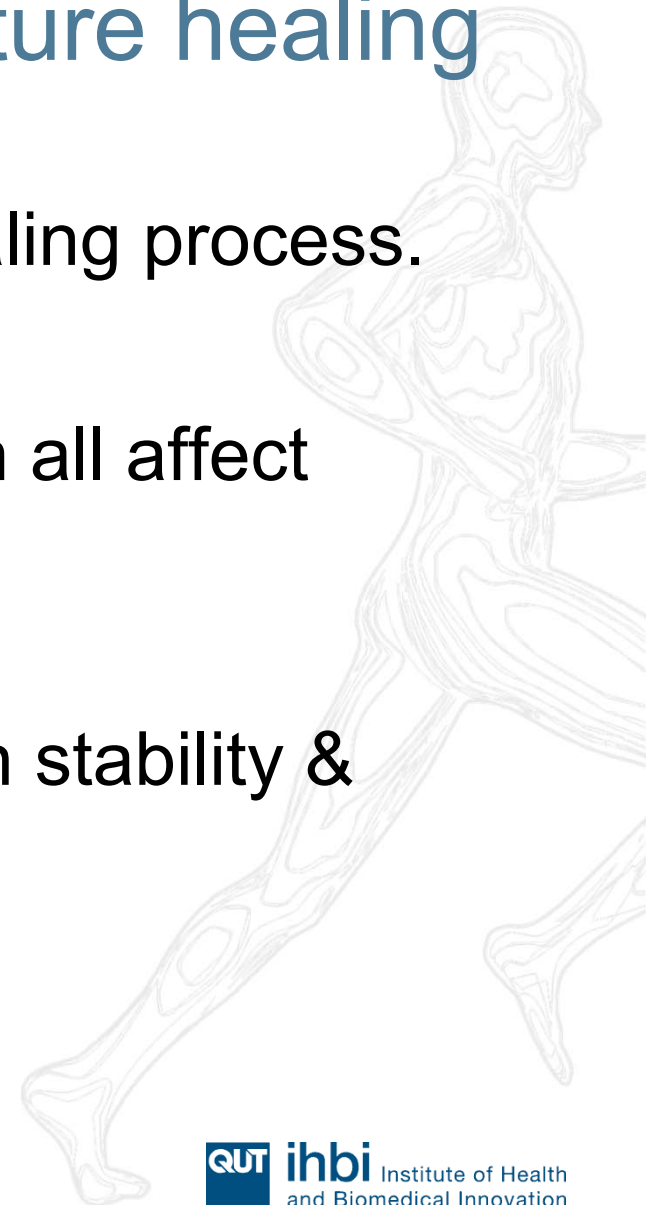


Sheep osteotomy @ 3 weeks

Epari et al.,
Bone, 2006

Mechano-regulation of fracture healing

- Movement at fracture affects healing process.
- Callus size, shape & composition all affect mechanical function.
- For optimal outcomes, how much stability & when?

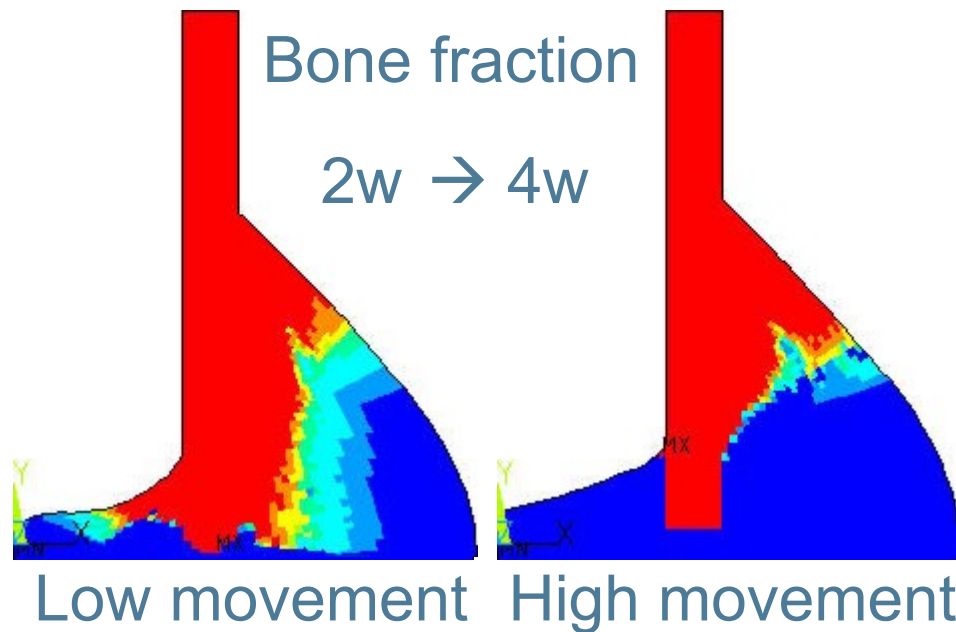


Simulation of fracture healing

- Pauwels (1940, 1960):
 - local mechanical conditions determine changes in healing tissue.
- Can't measure directly → simulation.
- Carter (1988), Prendergast (1997), Claes (1999):
 - finite element analyses vs histology → hypothetical quantitative relationships.

Simulation of fracture healing

- Iterative schemes: test hypothetical relationships.



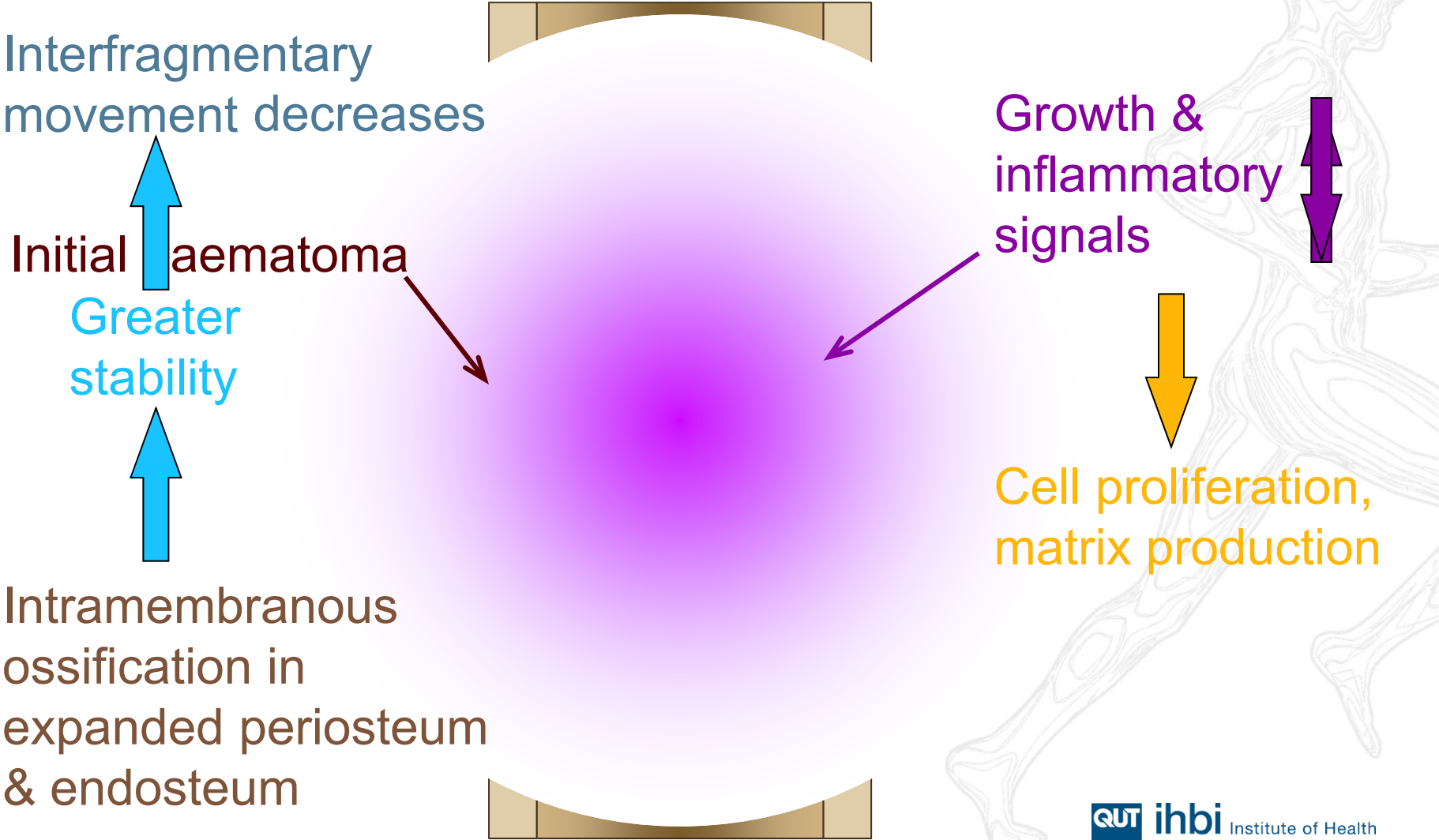
Simon et al., *Comput Methods Biomech Biomed Engin*, 2011



Adapted from Stürmer,
Unfallchirurgie, 1984

- Callus size? Morphology?

Methods: incorporating growth

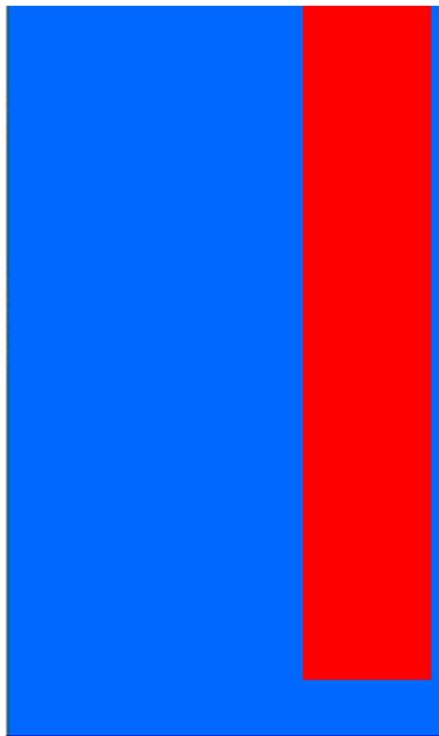


Results: sheep tibial osteotomy models

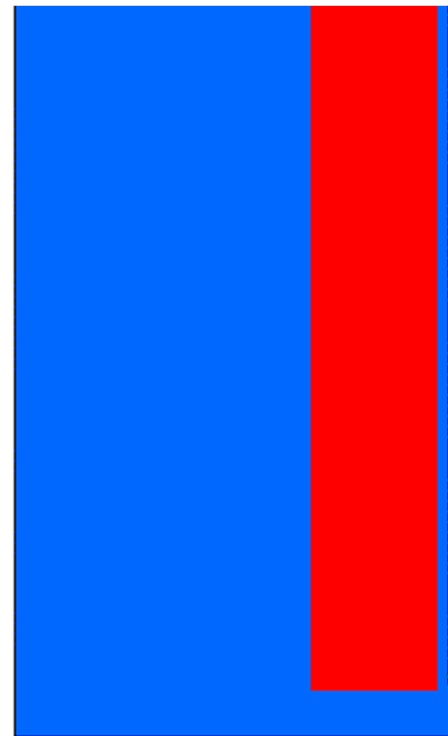
Elastic modulus
over 4 weeks

Stiff Fixation

Flexible Fixation



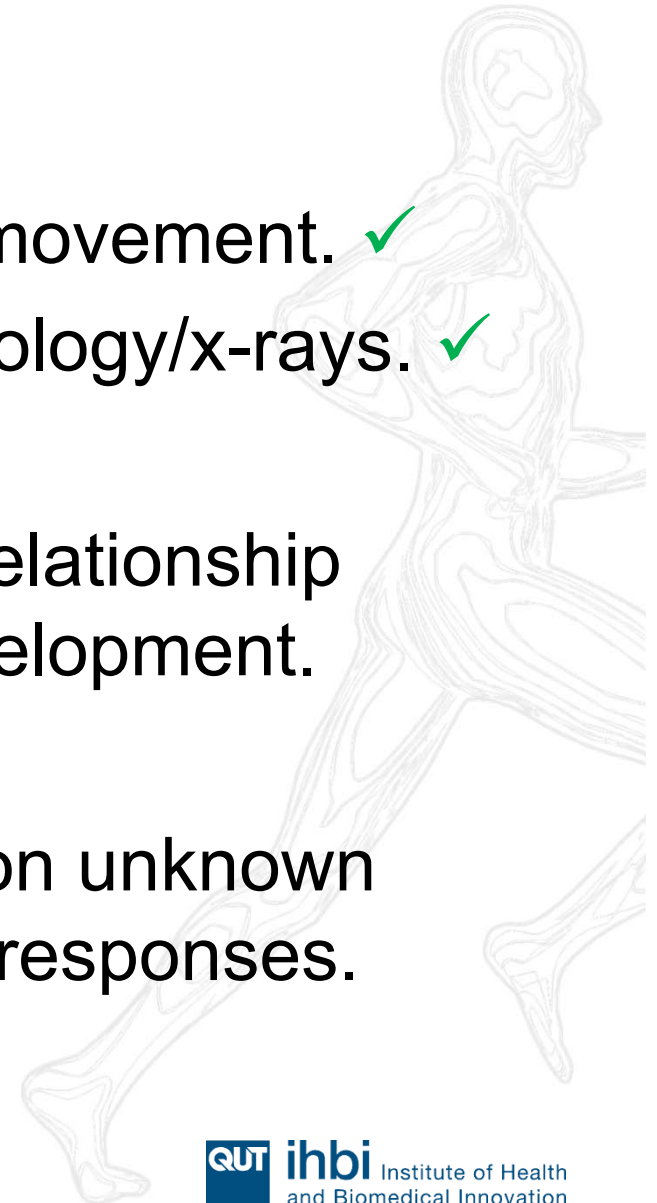
ODB: TibiaSq_p1e1_8000_70d_GFGrow_01_35_056.
Step: Loading1, Initial gait load application
Increment 6: Step Time = 1.000



ODB: TibiaSq_p1e1_2600_70d_GFGrow_01_35_056.o
Step: Loading1, Initial gait load application
Increment 6: Step Time = 1.000

Discussion & Conclusions

- Faster callus growth with larger movement. ✓
- Callus morphology similar to histology/x-rays. ✓
- Tool to test simple hypothetical relationship between movement & callus development.
- Approach reduces dependence on unknown mechanical properties & cellular responses.

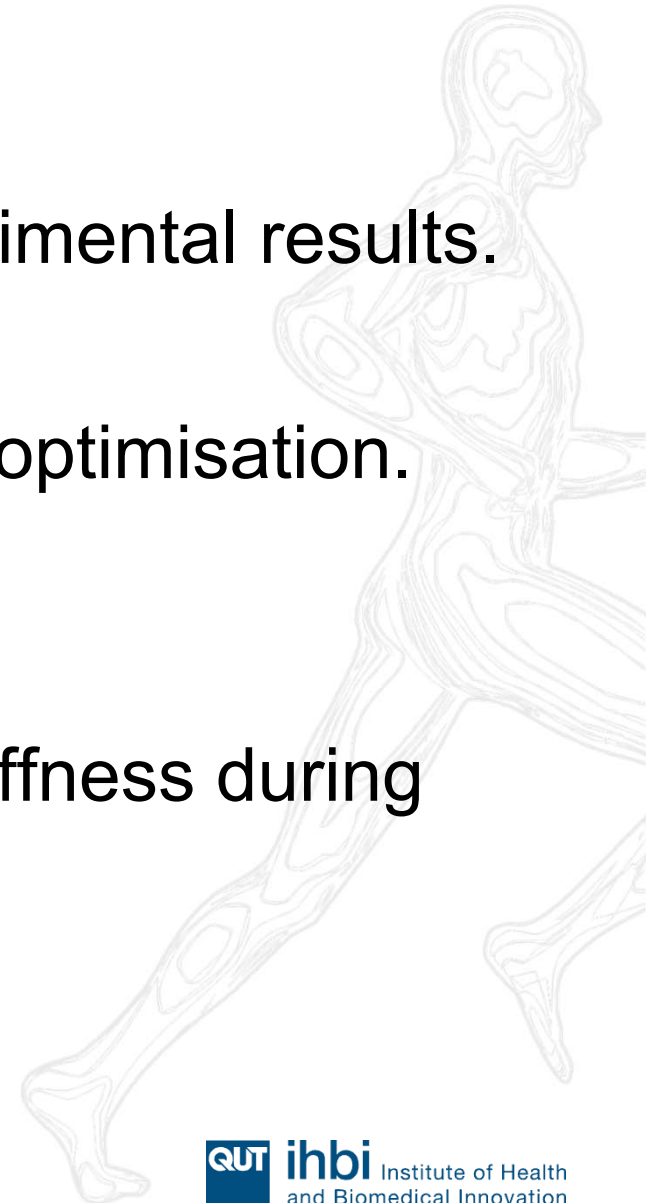


Ongoing work

- Predict & compare against experimental results.
- Sensitivity analysis & parameter optimisation.

Clinical aim:

- Test effects of varying fixation stiffness during healing.

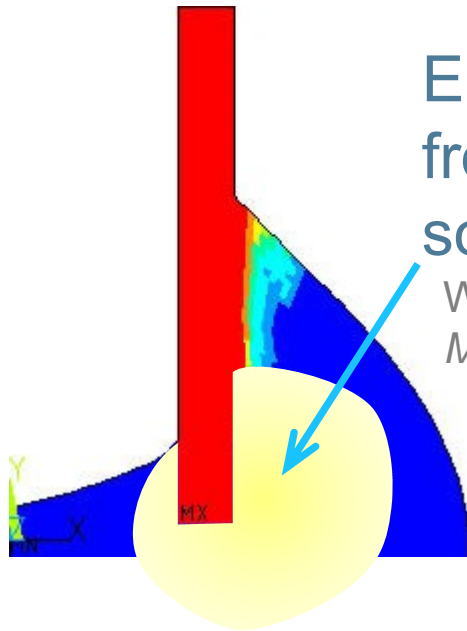


Thank-you



Simulation of fracture healing

- Discrepancy due to presumed callus domain:



Elevated strain
from presumed
soft tissue

Wilson et al., *Biomech Model Mechanobiol*, 2015

Simon et al., *Comput Methods Biomech Biomed Engin*, 2011



Adapted from Stürmer,
Unfallchirurgie, 1984