Vessel Growth and Remodeling in FEBio

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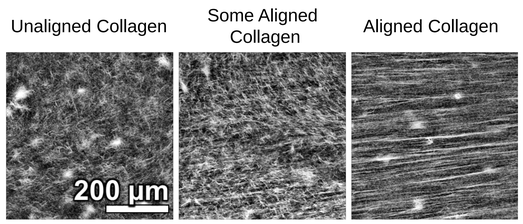
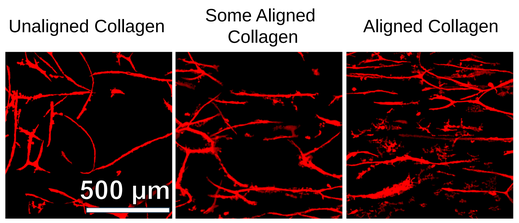
Vessel Growth in Wound Healing & Cancer

- New vessels grow from existing vessels in a process called angiogenesis.
- Angiogenesis creates new paths to deliver blood, nutrients, and waste throughout the body.
- Collagen (fibrillar protein) is the main structural component of bodily tissues.
- The organization (orientation and density) of the collagen can guide vessels and affect growth.

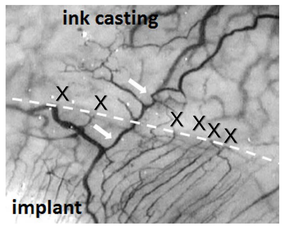


Images of unaligned and oriented collagen gels.

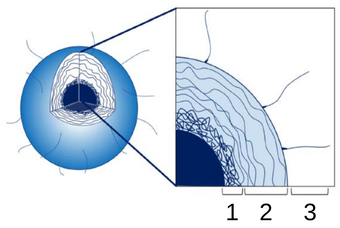


Collagen alignment increased vessel growth and guidance in culture experiments.

- Altered collagen near wounds and implants can prevent vessel growth and tissue healing.
- Some cancers alter nearby collagen to attract new vessels that bring nutrients for tumor growth.

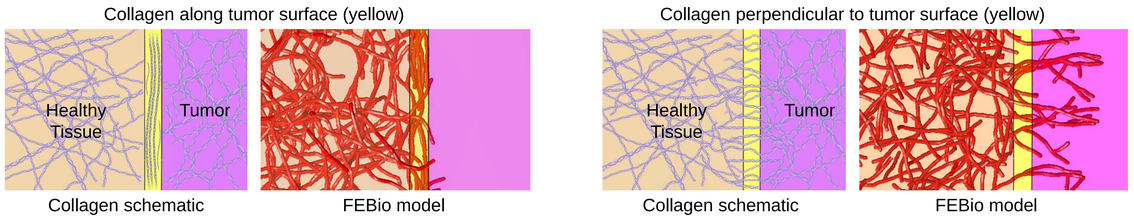


Collagen aligned along a boundary between an implant and host tissue prevents most vessels from crossing.



Ways tumors (dark, center) may alter nearby collagen:
1) Make the collagen denser.
2) Align the collagen along the tumor surface.
3) Align the collagen outward from the tumor.

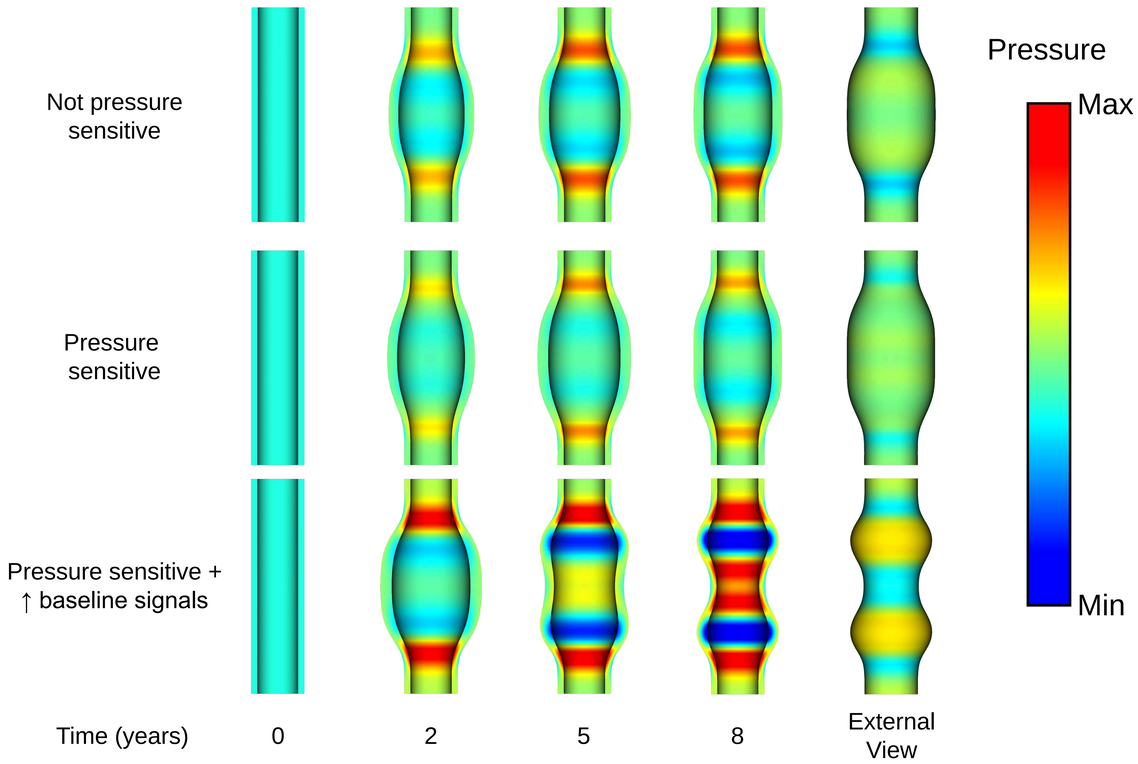
- FEBio was used to model how vessels grow and respond to nearby collagen.
- Simulations helped us understand how collagen organization affects vessel growth during wound healing and cancer.



FEBio models predicted that tumor vascularization differs when nearby collagen is aligned along the tumor (left) vs. perpendicular to the tumor (right). The latter case increased tumor vascularization and is more dangerous.

Aneurysm Growth & Vessel Remodeling

- Aneurysms occur when high blood pressure weakens vessels, causing them to bulge.
- Chemical signaling pathways affect how vessel weakness spreads.
- Signaling pathways can be driven by pressure.
- FEBio was used to investigate the role of pressure-sensitivity and baseline signal levels during aneurysm growth.



- Three types of aneurysm were modeled in FEBio across 8 years of growth.
  1) Aneurysm with chemical signaling that was insensitive to pressure.
  2) Pressure-sensitive aneurysms that softened in high pressure regions (color map).
  3) Pressure-sensitive aneurysms with elevated baseline signal levels. These aneurysms became unstable and buckled, forming double aneurysms.

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