Optical Coherence Tomography for Guiding Tissue Engineering

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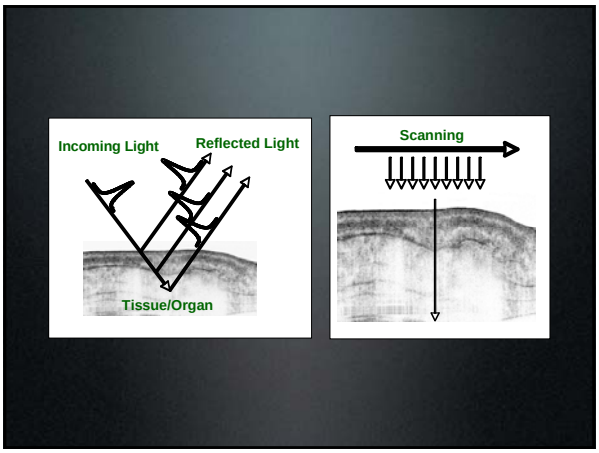
OUTLINE

- Basic OCT Physics
- Previous Work in Humans
- Example Images of Tissue Scaffolding
- TD-OCT vs SS-OCT
- Adjuvant OCT Techniques

PS-OCT, elastography, wavelet analysis, automated edge detection.

OCT is analogous to ultrasound, measuring the backreflection of infrared light rather than sound.



- Due to the high speed associated with the propagation of light, the echo delay time can not be measured electronically.

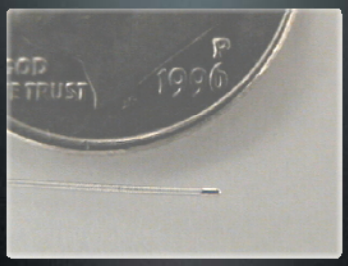
- Therefore the technique of low coherence interferometry if used, which requires a reference arm. The physics of this will not be discussed here.

Advantages of OCT

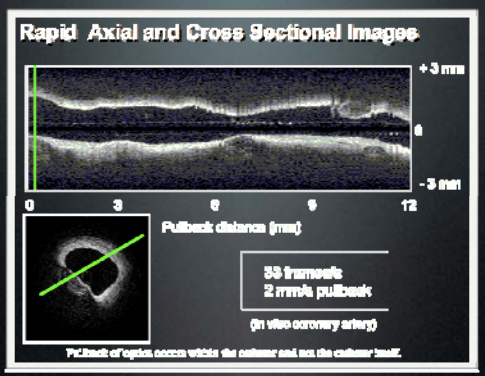
- High Resolution (2-20 µm)
- Video Rate
- Small Catheters, Endoscopes, and other probes
- Ability to Be Combined with a Range of Spectroscopic Techniques Including PS-OCT for Collagen

Lightlab OCT Imaging Engine

OCT Imaging Wire



Rapid Axial and Cross Sectional Images



Microscope SS-OCT System

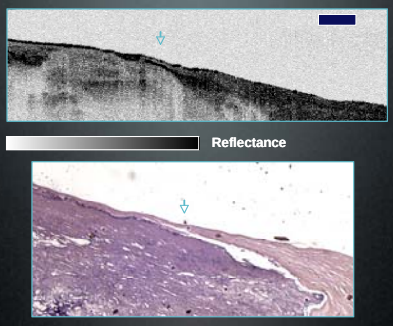
Also Available in Handheld Probe

Previous OCT Work

Clinical Applications

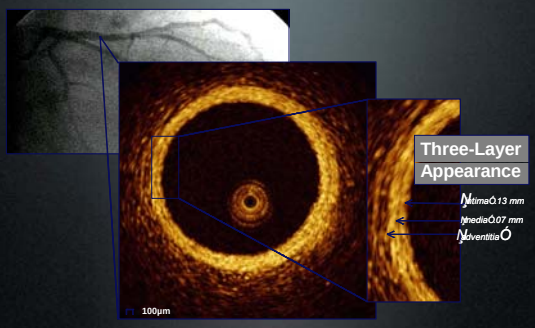
- Cardiovascular
- Musculoskeletal Disease
- Early Cancer Detection
- Guiding Microsurgical Procedures
- Dentistry

Atherosclerotic Plaque



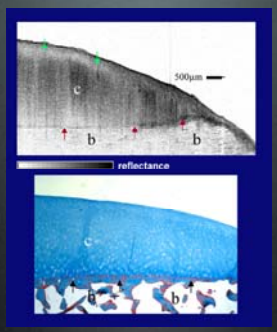
Brezinski, M.E., Circ. 93;1206:1996.

Comparison with Angiography



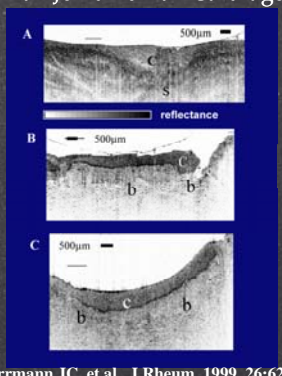
Courtesy Lightlab Imaging, Dr. Grube and J. Schmitt PhD, et. al.

Normal Human Cartilage



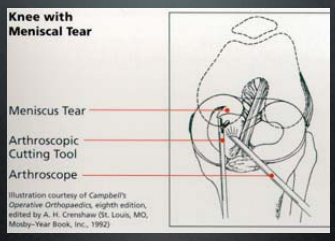
Herrmann, J., et.al.,1999 J. Rheum. 26:627-635.

Small Joint Human Cartilage

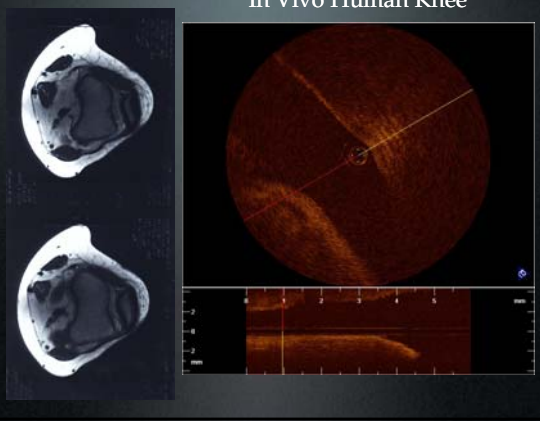


Herrmann JC, et.al., J Rheum. 1999, 26:627-635

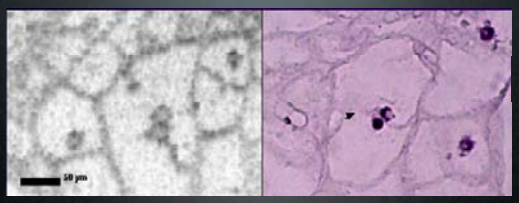
Example Arthroscopic Procedure



In Vivo Human Knee



Cellular Level Imaging



OCT in Tissue Engineering

OCT for Tissue Engineering

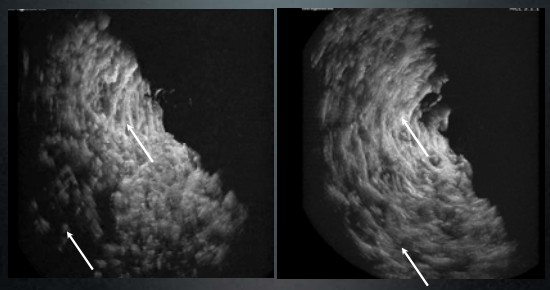
- High Resolution (2-20 µm) allows high resolution imaging both of scaffoldings and constructs
- Can be imaged within or outside of the bioreactor.
- Imaging is at video rate
- Combined with PS-OCT for collagen/muscle, elastography for tensile stength, speckle/texture for cells, and Doppler for flow.

Structural Imaging

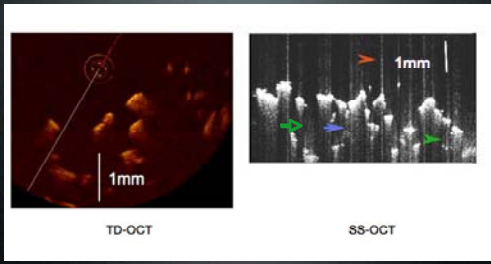
PGLA Scaffoling

Video

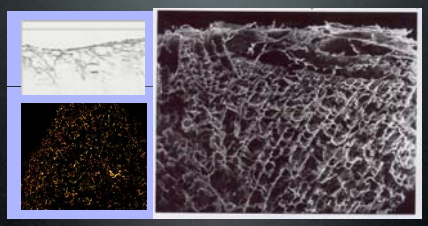
PGLA Scaffolding With and Without Seeding



Comparison of TD-OCT and SS-OCT



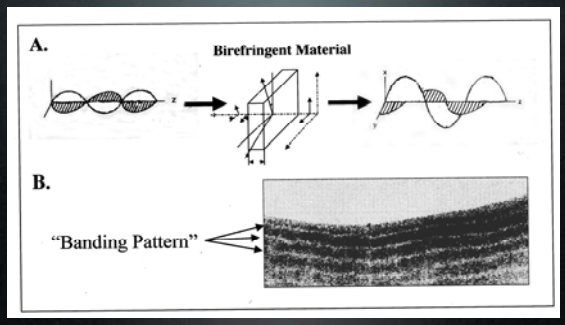
Helistat© (collagen I) by Picrosirus and SEM



Imaging Chondrocyte Transplant

Images Unavailable at Time of Publication

Polarization Sensitive OCT (PS-OCT)

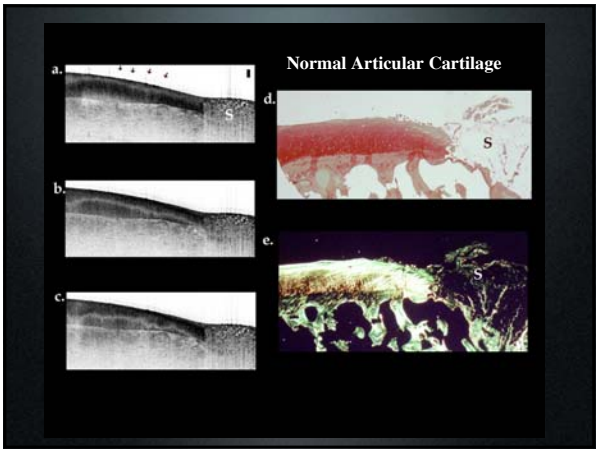


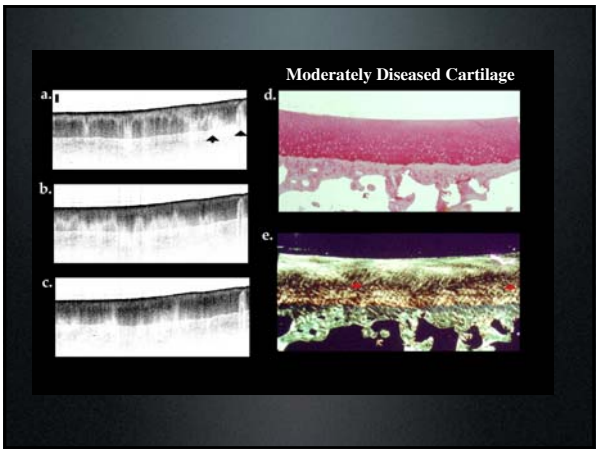
Important Polarization Sensitive Structures

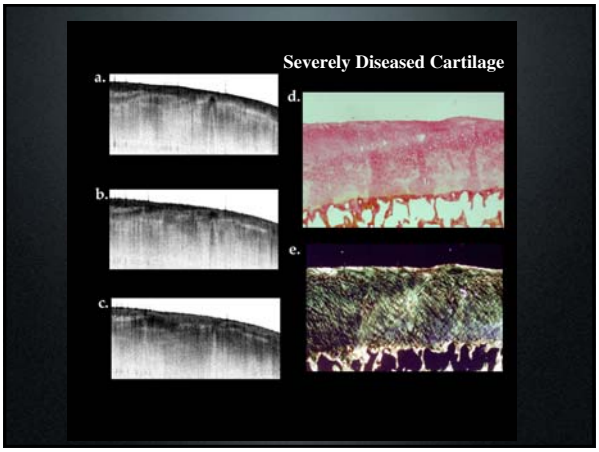
- Collagen
- Nerve Fibers
- Cholesterol Crystals
- Actin-Myosin
- Enamel

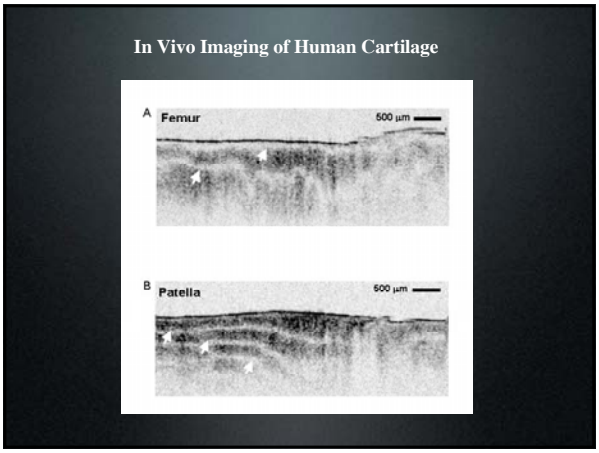
Polarization Sensitive Imaging of Cartilage

- Most tissue does not change imaging properties with changes in the polarization state of the incident light.
- In tissue with highly organized structure, the imaging can be sensitive to the polarization state of incident light.
- For example, healthy cartilage has highly organized structure, particularly collagen.
- We have demonstrated that collagen organization is characteristic of hyaline cartilage but not present in, for example, hyaline cartilage.




Moderately Diseased Cartilage
a.
b.
c.
d.
e.


Severely Diseased Cartilage
a.
b.
c.
d.
e.


In Vivo Imaging of Human Cartilage
A
Femur
500 µm
B
Patella
500 µm

Elastography,Image Processing, and Automated Edge Detection Data Not Available for Handout

Work Supported By

NIH
R01 AR44812 (Brezinski)
R01 HL55686 (Brezinski)
R01 EB02638/HL63953 (Brezinski)
R01 AR46996 (Brezinski)
R01 EB000419 (Brezinski)