Retinal Hemodynamics: Parafoveal Capillary Leukocyte Velocity

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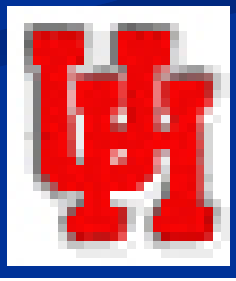


Houston


110
SOUTH
Bermuda Triangle
10
Good
Luck!


EXIT 48A
10 EAST
Beaumont
EXIT ONLY
10 WEST
GUITMAN ST
LEFT EXIT
EXIT 48B
10 WEST
San Antonio
EXIT ONLY

Why is studying retinal hemodynamics important?

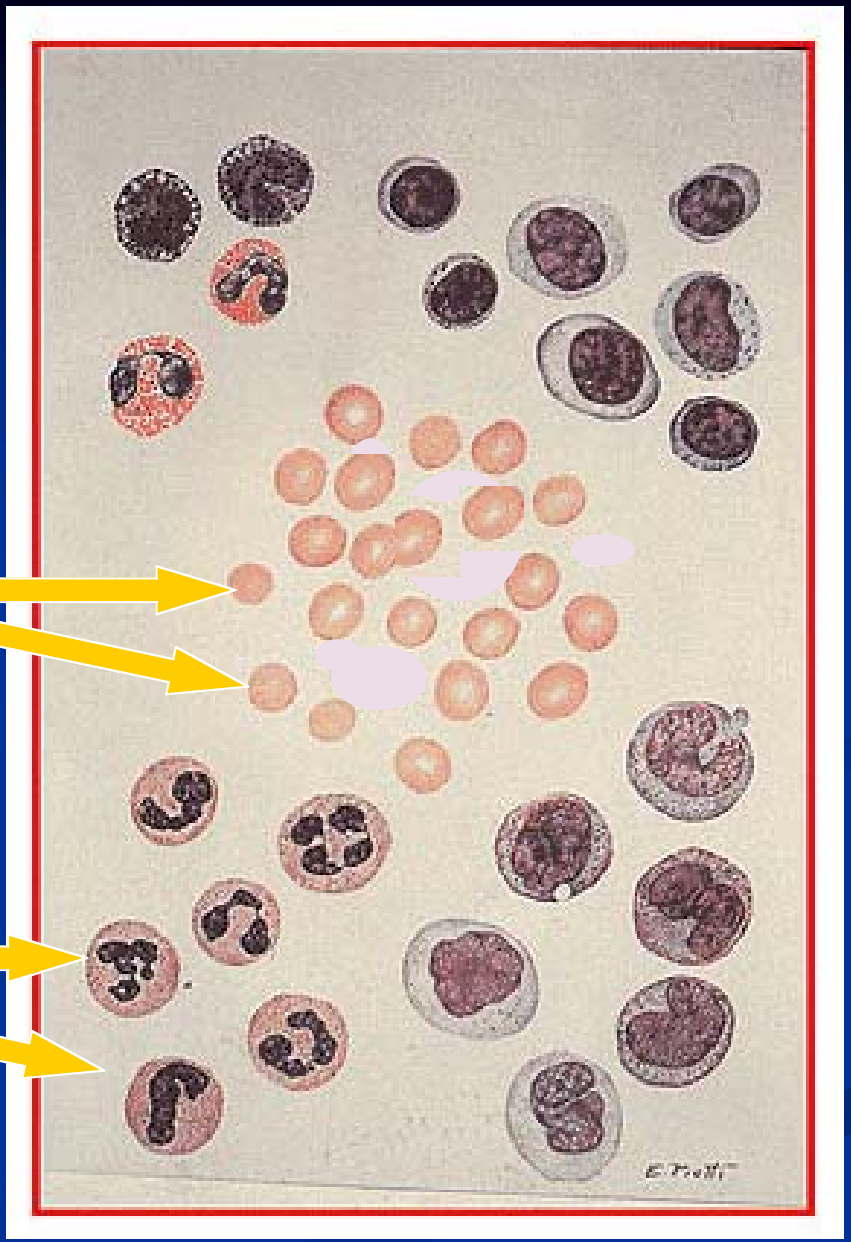
- Blood flow has been implicated in several retinal diseases including: ARMD, Diabetic Retinopathy, and Glaucoma
- Mechanisms of the Disease
  - Developing better understanding of normal and abnormal hemodynamics and the role of vascular changes in disease processes
- Early Diagnosis
  - Retinal circulatory alterations are thought to be an early indicator of pathology
- Treatment of the Disease
  - Research and Development of pharmaceuticals to aid in management or treatment of retinal disease

RBC=4.2-6.2 million/mm_: WBC=5-10 thousand/mm_

Erythrocytes (RBC)

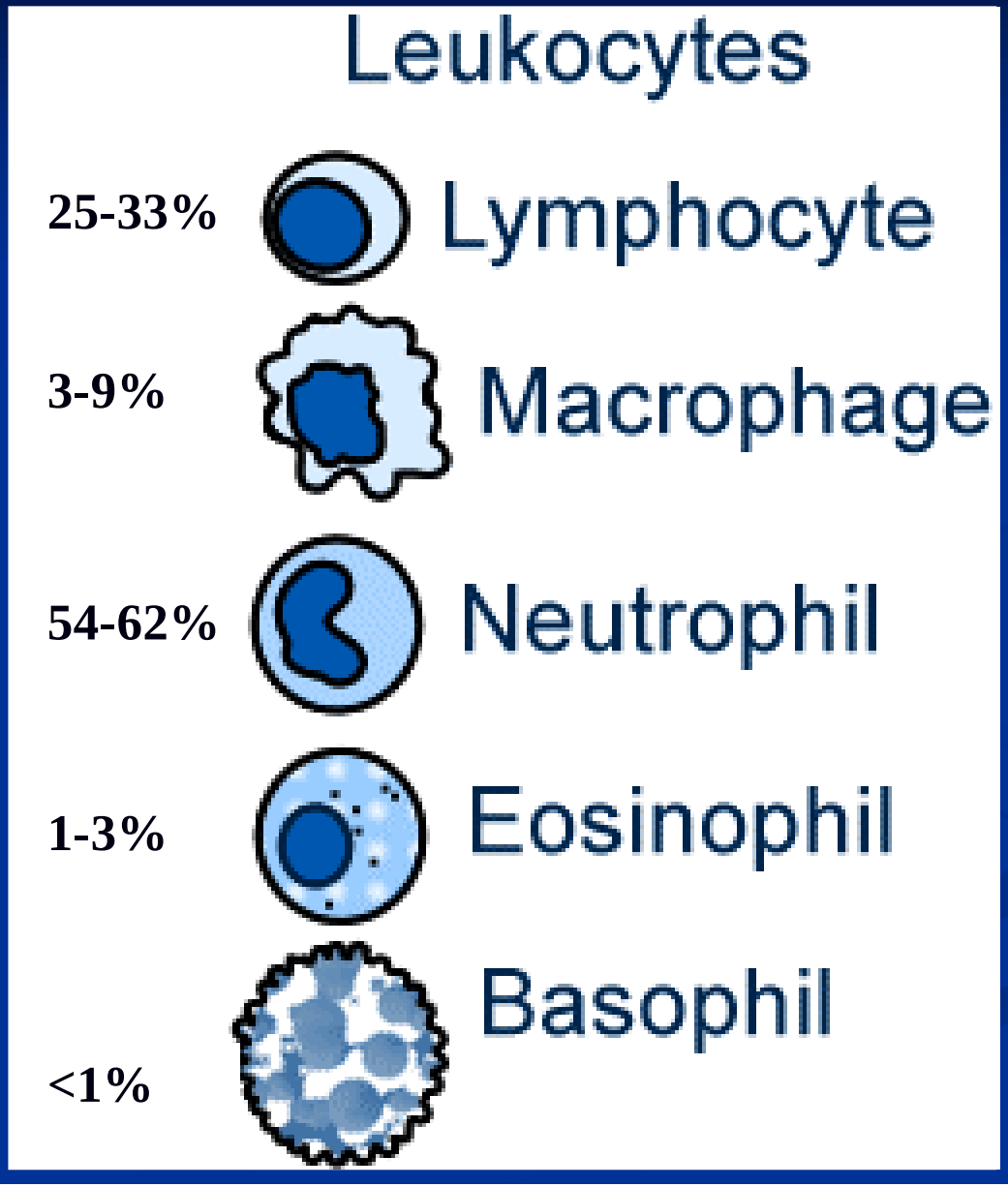
Leukocytes (WBC)

2-3x Larger than Erythrocytes



Hole's Human Anatomy and Physiology,Shier et al., 1996

Proportion of Leukocytes



Hole's Human Anatomy and Physiology
Shier et al., 1996

Dimensions

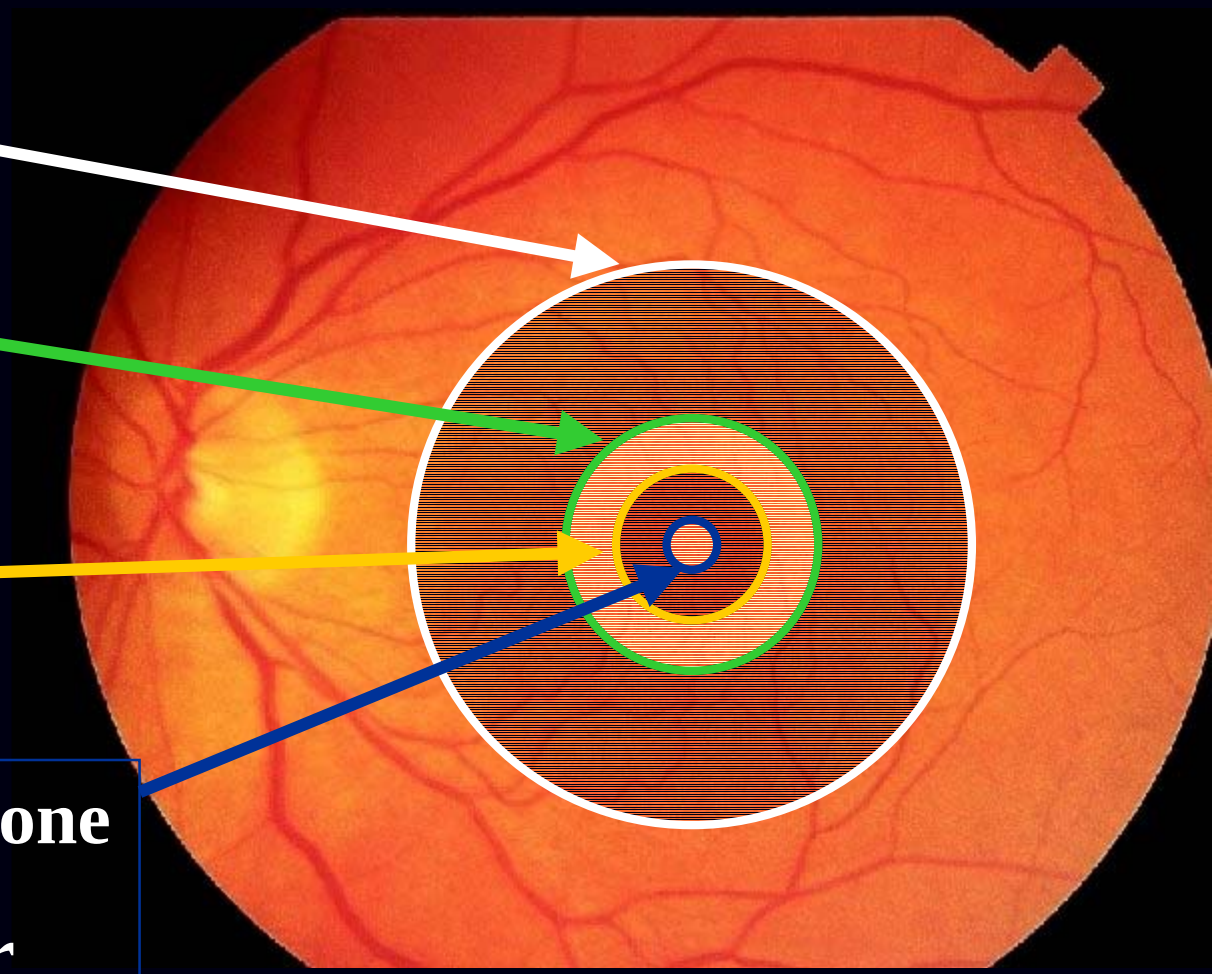
- Retinal Capillary
  - Diameter ~ 5 microns
  - Smaller diameters located closest to the fovea
- Erythrocyte
  - Diameter ~7.5 microns
- Leukocyte
  - Diameter ~ 9-12 microns

Snodderly et.al., J. of Neuroscience, 1992

Color Textbook of Histology, 2001

The Retinal Circulation, 1971

Macula Organization



Macula

Parafovea

~8.4º diameter

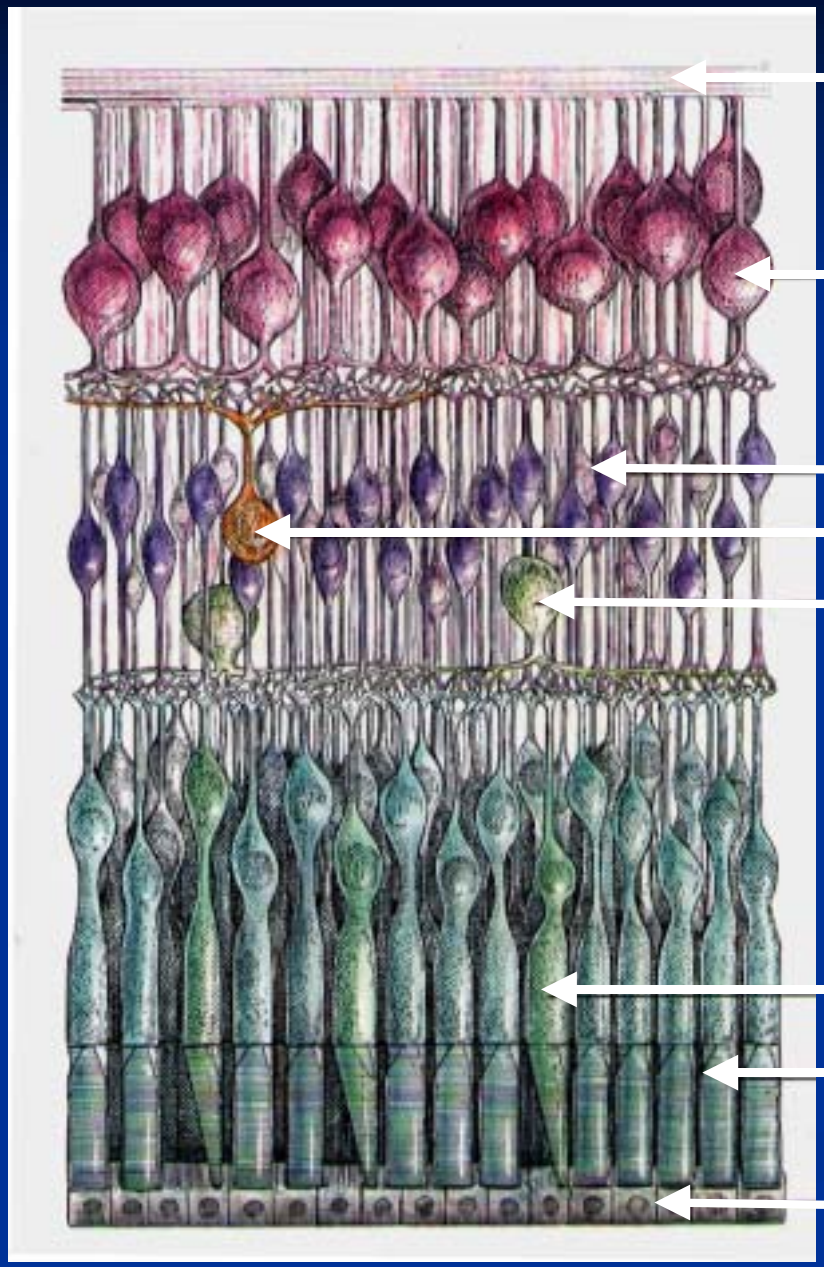
Fovea

~5º

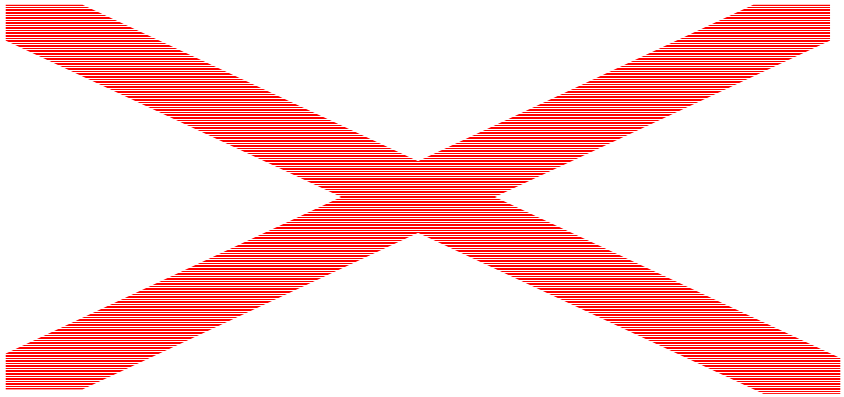
Foveal Avascular Zone

~1.3 - 1.6º diameter

The Retina is a Thick, Multi-layered Structure



Diabetic Retinopathy Lesions



Clinical Ophthalmology, 1999

Current techniques for studying retinal hemodynamics:

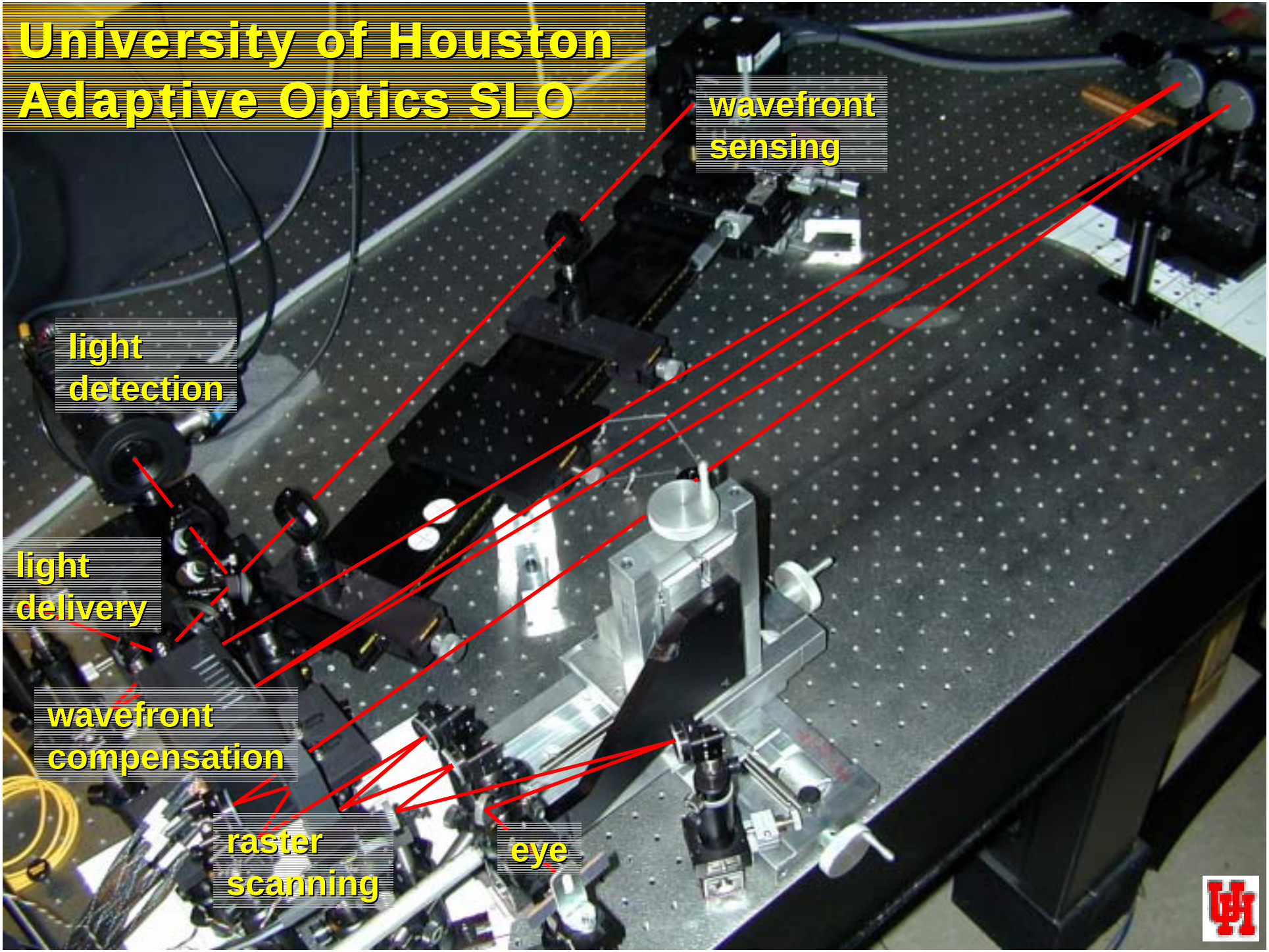
- Leukocyte Velocity
  - Blue Field Entoptic Phenomenon (Riva and Petrig, 1980)
  - SLO with Fluorescein Angiography (O. Arend)
- Erythrocyte Velocity
  - Retinal Function Imager (Optical Imaging Ltd.)
  - Laser Doppler Velocimetry (C. Riva, 1972)
- Blood Flow
  - Heidelberg Retina Flowmeter
  - Laser Speckle tissue blood flow analysis

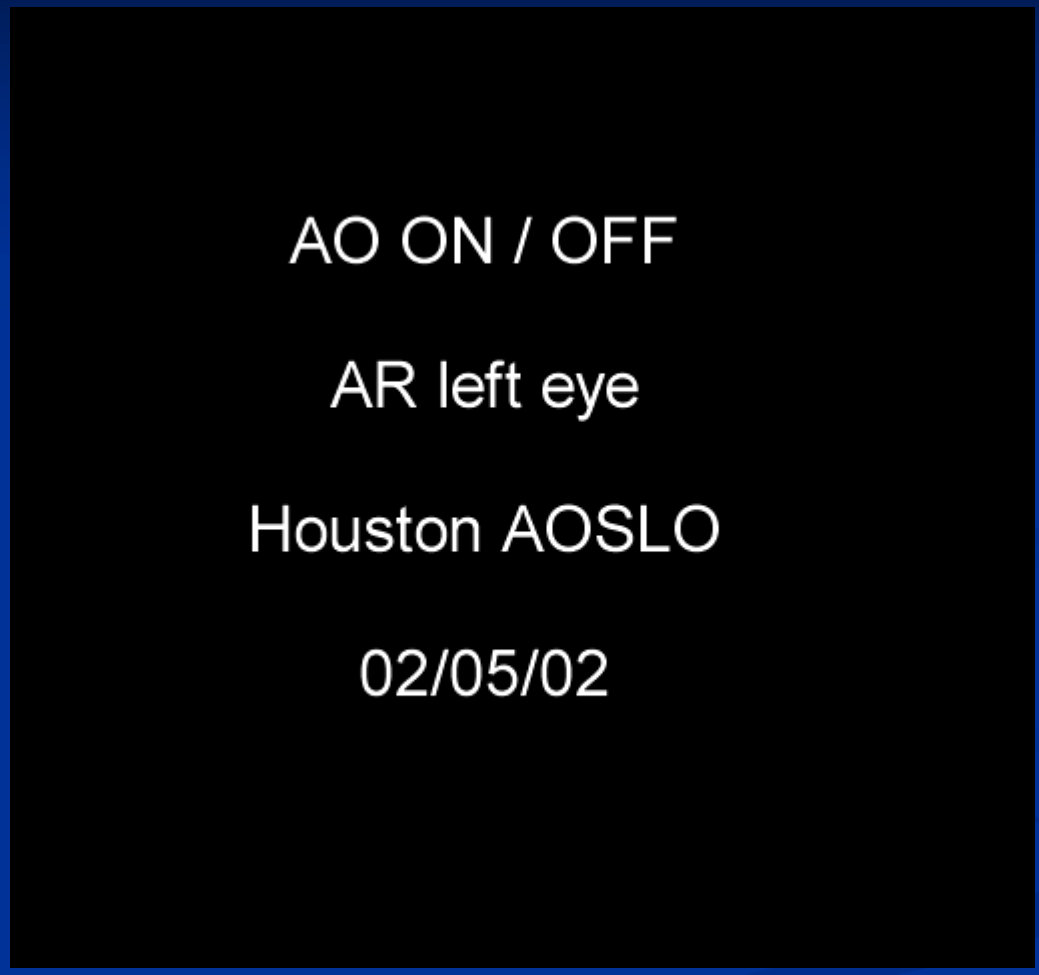
Current Technique's Limitations

- Comparison between techniques is difficult due to variability in location of measurement
- No single technique offers long term, direct, objective, and non-invasive blood flow measurement

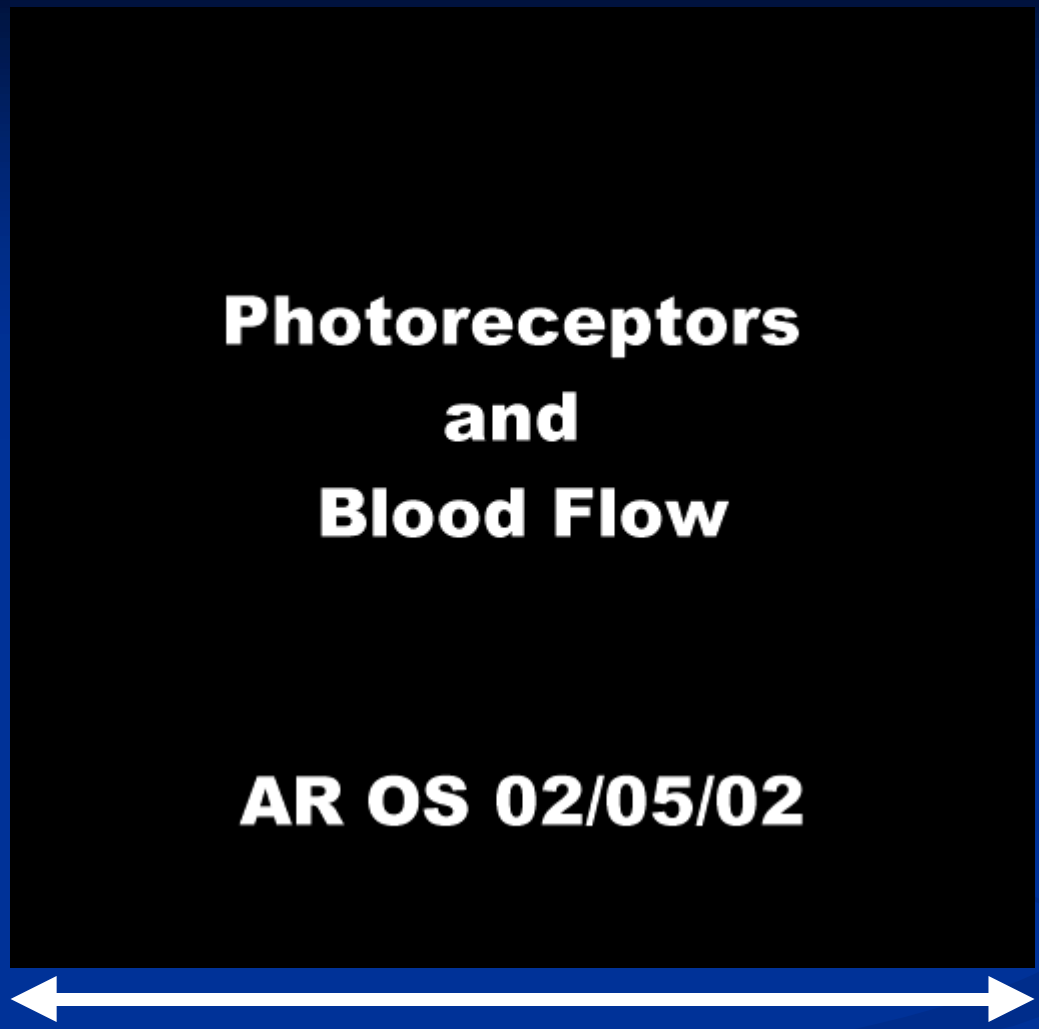
Research Purpose

- Develop a technique that allows for long term, direct, and non-invasive retinal parafoveal capillary blood flow measurement


University of Houston
Adaptive Optics SLO
wavefront sensing
light detection
light delivery
wavefront compensation
raster scanning
eye



1.5 deg = 0.45 mm



1.5 deg = 0.45 mm

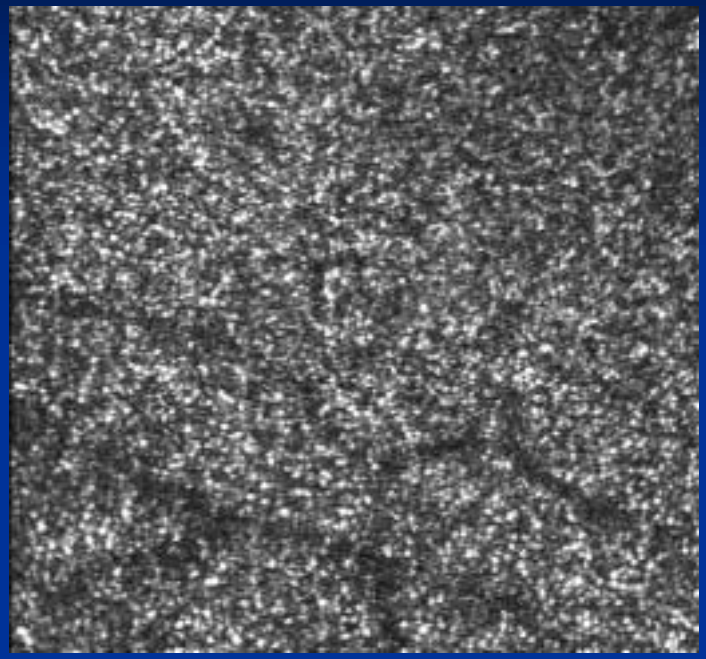
Materials and Methods

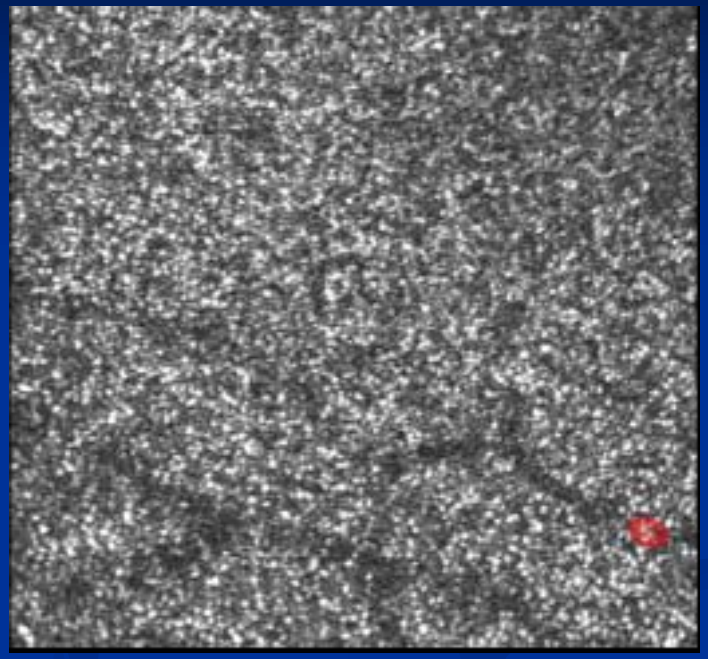
- 7 normal healthy subjects were imaged using an Adaptive Optics Scanning Laser Ophthalmoscope (AOSLO)
- 17-35 years of age
- Velocity was determined near the foveal avascular zone in the parafoveal region

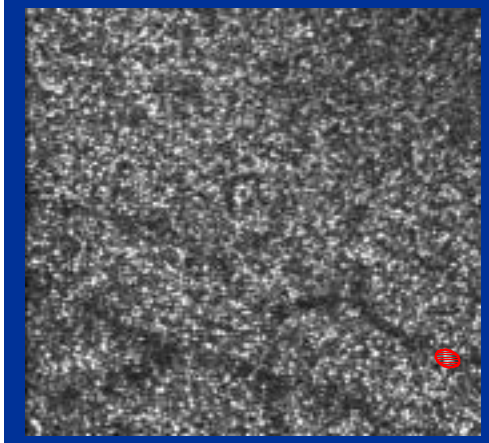
Materials and Methods

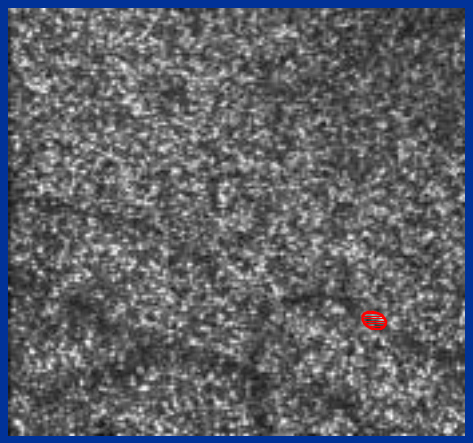
- Imaging wavelength: 660nm
- Frame rate: 30 Hz
- Velocity was measured directly from movie segments with clearly visible leukocytes
- Five repeated manual measurements were performed to determine individual leukocyte velocity

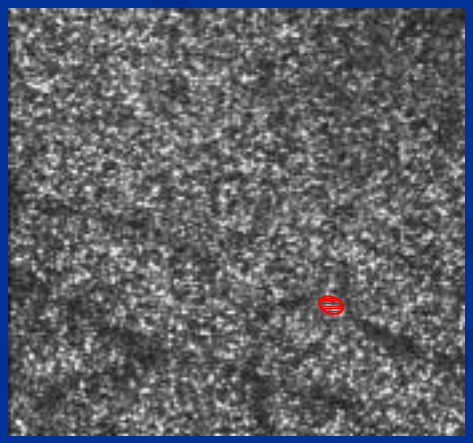
Leukocyte Velocity Measurement

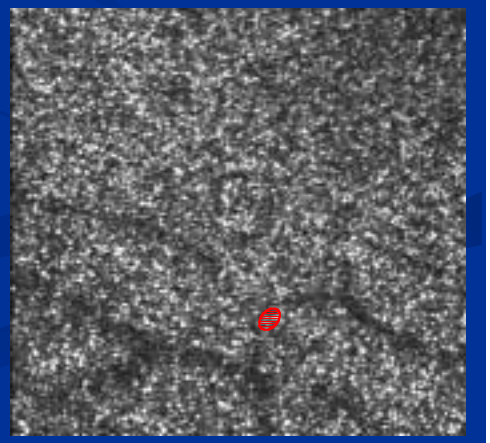










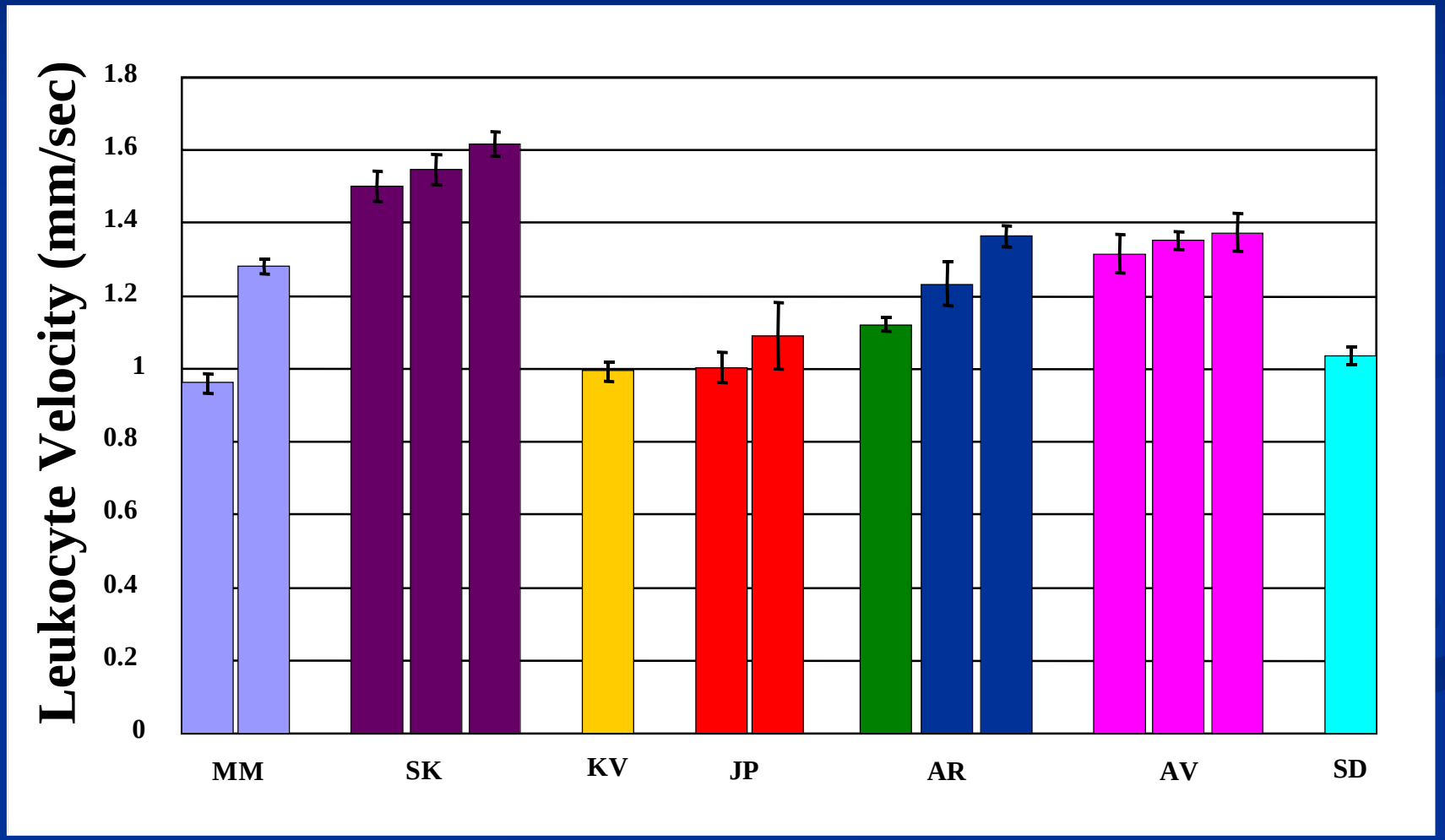


MM Superior Temporal

Results

- Leukocyte velocity was determined in all seven subjects
- Leukocytes were not visible in all parafoveal capillaries
- Mean Velocity = 1.19 mm/sec
- Range: 0.96 – 1.62 mm/sec

Parafoveal Capillary Leukocyte Velocity

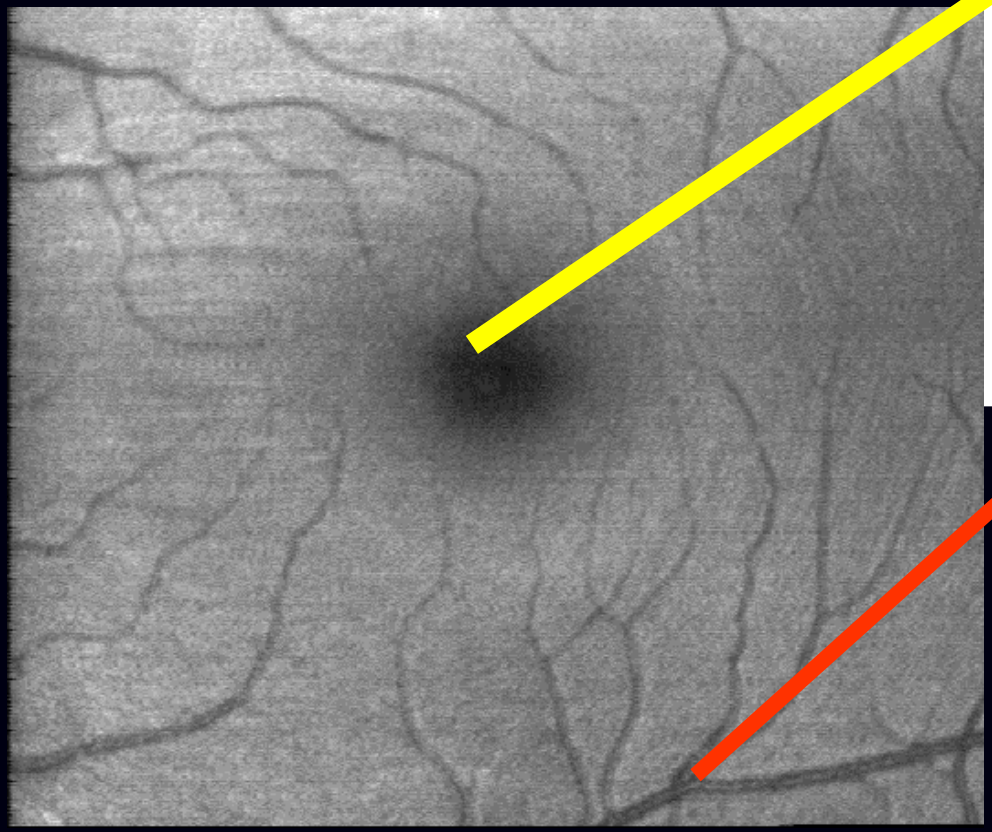


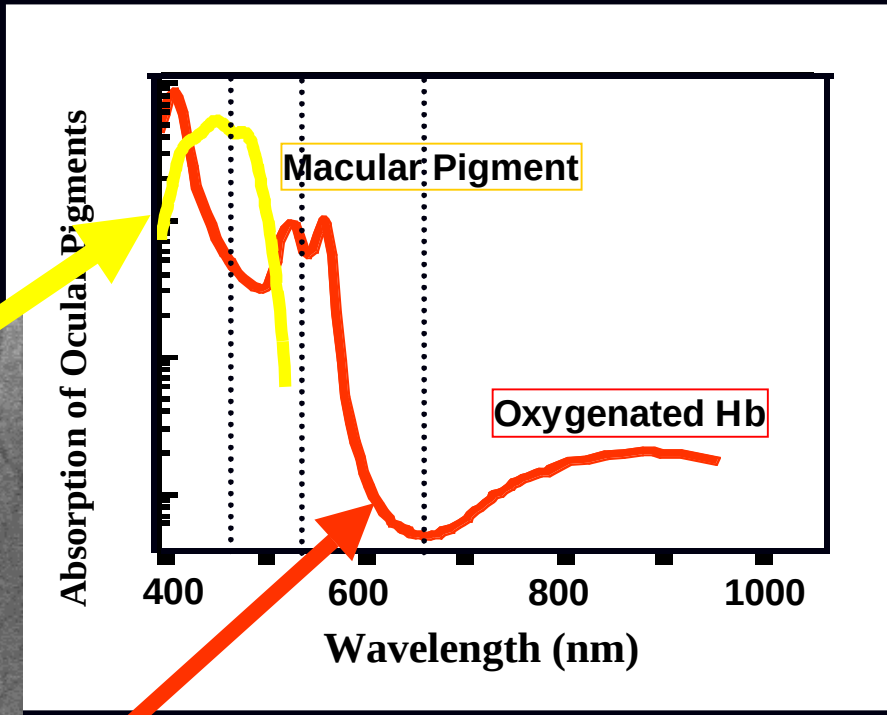
Discussion

Improving Leukocyte Contrast

- Currently AOSLO system is imaging with red wavelength
- Use of shorter green wavelength:
  - Maximize contrast of capillary and leukocytes

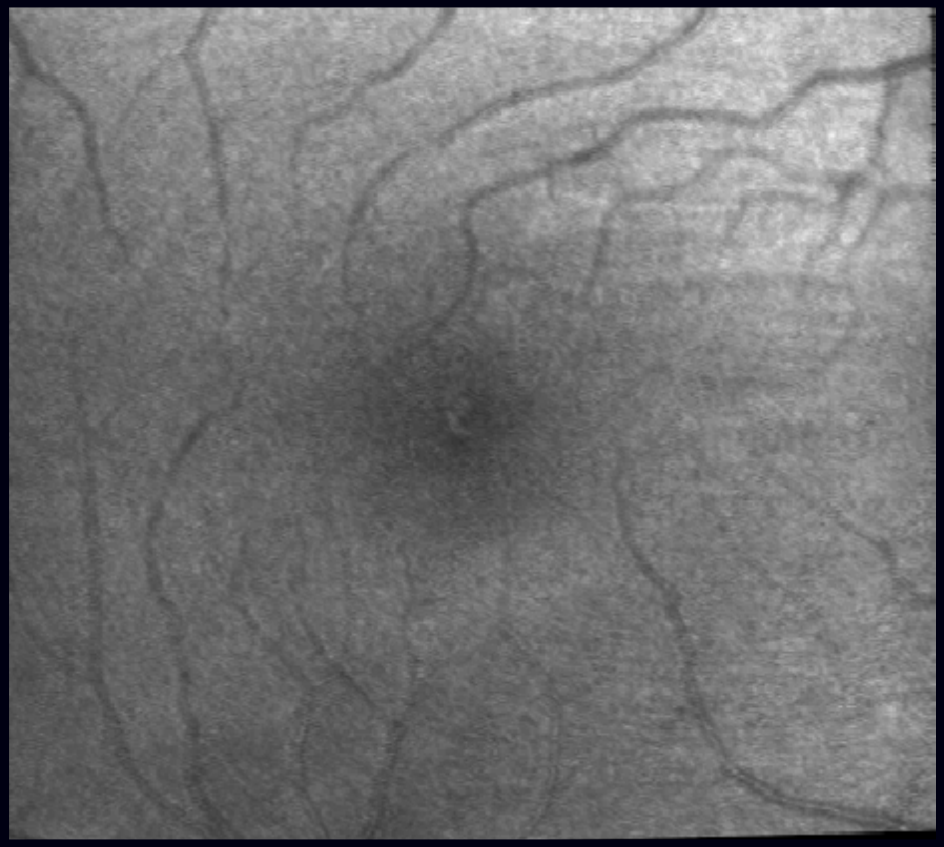
488 nm





Courtesy of Steve Burns and Ann Elsner,
Schepens Eye Research Institute, Boston, MA

633 nm



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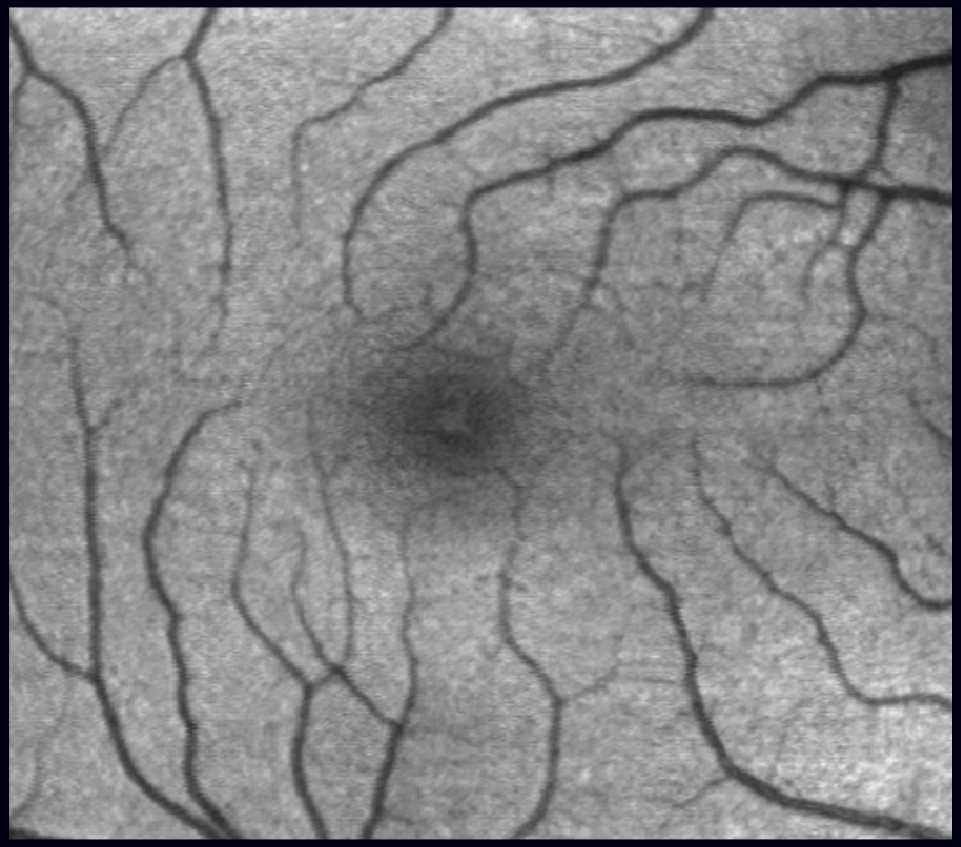
Schepens Eye Research Institute, Boston, MA

543 nm



Courtesy of Steve Burns and Ann Elsner,
Schepens Eye Research Institute, Boston, MA

Limitations

- Need for clear optical media which can be decreased in some subjects:
  - Cataracts and dry eye
- Bite bar used to aid in patient stabilization

Advantages

- Non-invasive
- Direct velocity measurement
- Visualization of capillaries during measurement to determine status as perfused or ghost vessels
- Confocal AOSLO allows for vessel depth localization
- Longitudinal retinal hemodynamics studies are made possible

Conclusions

- Parafoveal capillary leukocyte velocity can be directly and non-invasively measured using an AOSLO

Long Term Scientific Plans

- Measure leukocyte velocity and blood flow in normal healthy subjects
- Measure leukocyte velocity and blood flow in diseased populations: Type I diabetes, glaucoma, and ARMD

Technical Plans

- Confocal imaging of capillaries allowing calculation of vessel diameter and blood flow
- Computer automation of blood velocity and flow measurements
- Use of shorter imaging wavelength
- Replace bite bar with pupil tracking

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