



# Prospective Observational Study of Ocular Health of International Space Station Astronauts

**Brandon R. Macias, PhD<sup>5</sup>**

**C. Otto<sup>1</sup>, R. Ploutz-Snyder<sup>2</sup>, B. Samuels<sup>8</sup>, C. Gibson<sup>3</sup>, A. Sargsyan<sup>5</sup>,  
N. Patel<sup>7</sup>, R. Riascos<sup>6</sup>, L. Kramer<sup>6</sup>, D. Alexander<sup>4</sup>, & S. Lee<sup>5</sup>**

<sup>1</sup>Memorial Sloan Kettering Cancer Center, New York, NY

<sup>2</sup>University of Michigan, Ann Arbor, MI

<sup>3</sup>Coastal Eye Associates, Webster, TX

<sup>4</sup>NASA Johnson Space Center, Houston, TX

<sup>5</sup>KBRwyle, Houston, TX

<sup>6</sup>The University of Texas Medical School at Houston, Houston, TX

<sup>7</sup>The University of Houston, College of Optometry, Houston, TX

<sup>8</sup>University of Alabama at Birmingham, AL

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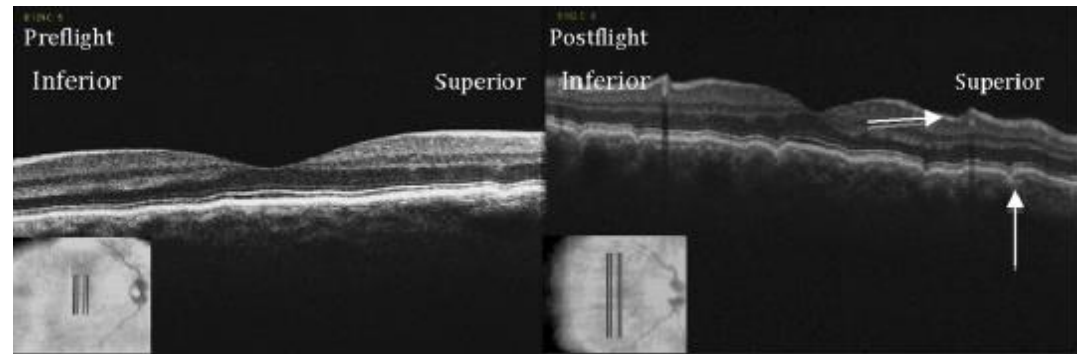


# Ocular Clinical Findings

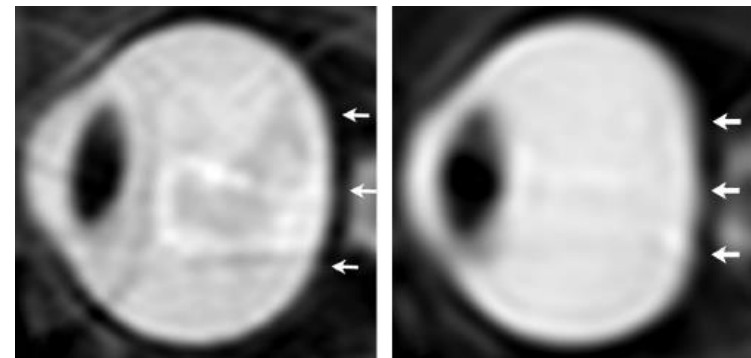


~35-50% U.S. operating segment astronauts have developed some or all of the following findings during or after long-duration spaceflight:

- Optic disc edema
- Hyperopic shift
- Choroidal folds
- Optic nerve sheath distention
- Optic nerve kinking
- Globe flattening



Mader et al 2011



Kramer et al 2012



# Ocular Health Study



**Purpose:** Characterize the time course of ocular, cerebral, and cardiovascular changes that occur during ISS missions and their recovery post-flight.

## Methods:

- Medical ocular data (MedB) collected pre-, in-, and post-flight
  - ✓ Flight Medicine Clinic
  - ✓ UTMB Victory Lakes
  - ✓ Coastal Eye Associates
  - ✓ ISS
- MedB and complementary data collected at additional time points
- 11/13 crewmembers have completed pre-, in- and post-flight testing
  - ✓ Optic disc edema: 2/13 crewmembers (15.4%)
- Preliminary data for 6 subjects (1 case) will be presented



# Timeline



## Pre-flight Exams

L-21/18 mo

### Flt Med. Clinic

- Vision Testing\*
- Fundoscopy
- Refraction
- Pupil Reflexes
- Extra-Ocular Muscle Bal.
- IOP (Tonometry)

### Coastal Eye Associates

- OCT
- Biomicroscopy/ Hi Res Photogr.

### UTMB Victory Lakes

MRI

L-12-3 mo

### Flt Med. Clinic

- Vision Testing\*
- Fundoscopy
- Refraction
- Pupil Reflexes
- Extra-Ocular Muscle Bal.
- IOP (Tonometry)
- Ocular Ultrasound

### Coastal Eye Associates

- OCT
- Biomicroscopy/ Hi Res Photogr.

### Cardiovascular & Vision Laboratory

- Cardiac Ultrasound
- Blood Pressure
- Transcranial Doppler Ultrasound

## In-flight Exams

L+10

L+30

L+60

L+90

L+120

R-30

### ISS

- Vision Testing\*
- Fundoscopy
- IOP (Tonometry)
- Ocular Ultrasound
- OCT
- Cardiac Ultrasound
- Blood Pressure
- Transcranial Doppler

MedB Sessions

Added Research Sessions

## Post-flight Exams

R+1-3

R+30

R+90

R+180

R+365

### Flt Med. Clinic

- Vision Testing\*
- Fundoscopy
- Refraction
- Pupil Reflexes
- Extra-Ocular Muscle Bal.
- IOP (Tonometry)
- Ocular Ultrasound
- Blood Pressure

### Coastal Eye Associates

- OCT
- Biomicroscopy/ Hi Res Photogr.

### UTMB Victory Lakes

MRI

### Cardiovascular & Vision Laboratory

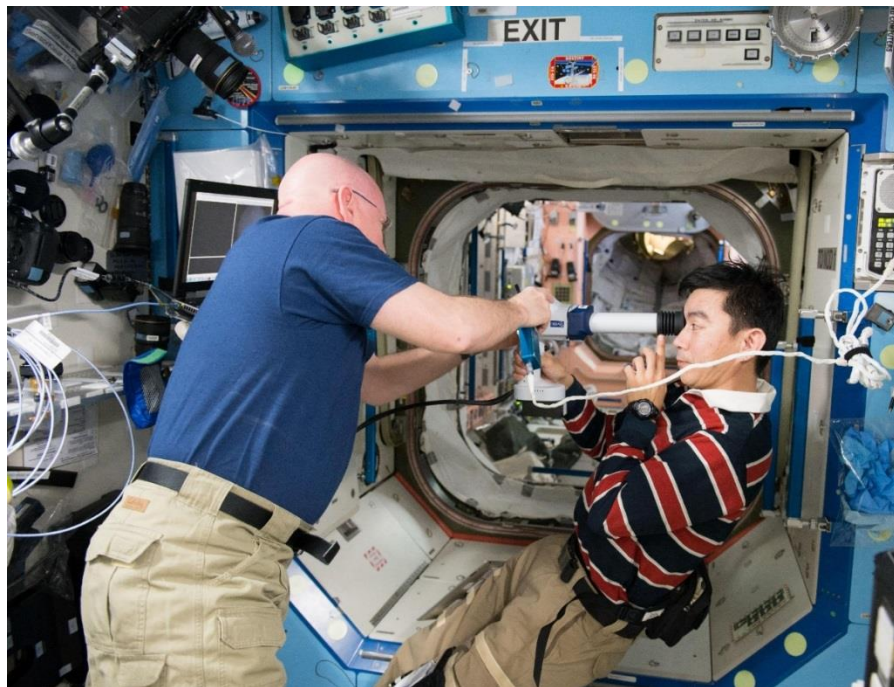
- Cardiac Ultrasound
- Blood Pressure
- Transcranial Doppler Ultrasound



# Inflight Vision Testing



## Fundoscopy



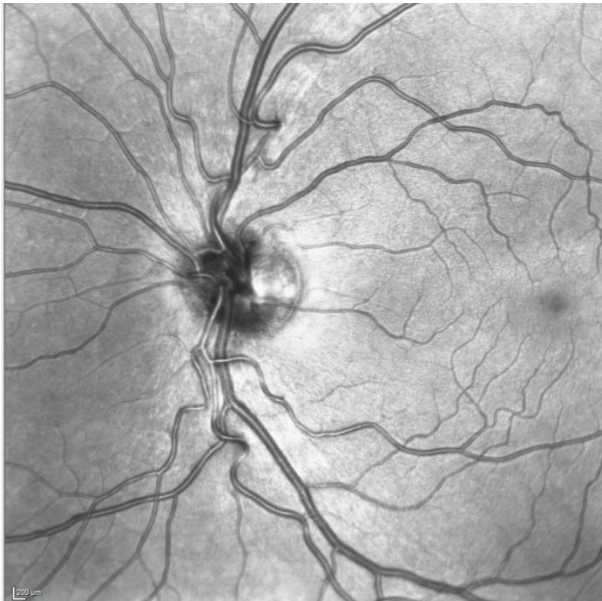
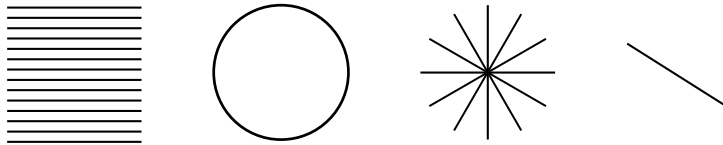
## Optical Coherence Tomography (OCT)



# OCT Scan Patterns

Scans taken in both eyes:

Centered over optic nerve head



Centered over macula





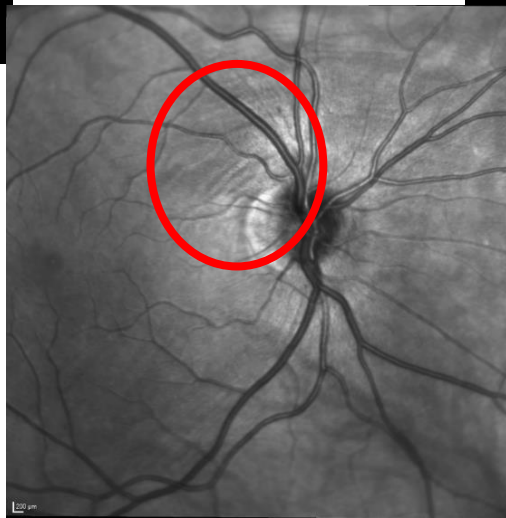
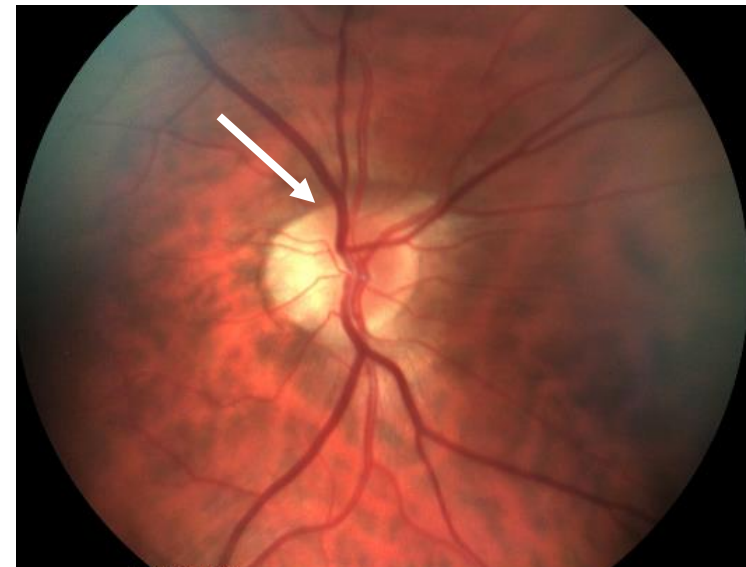
# Case: Right Eye



Pre-flight

FD90

R-30



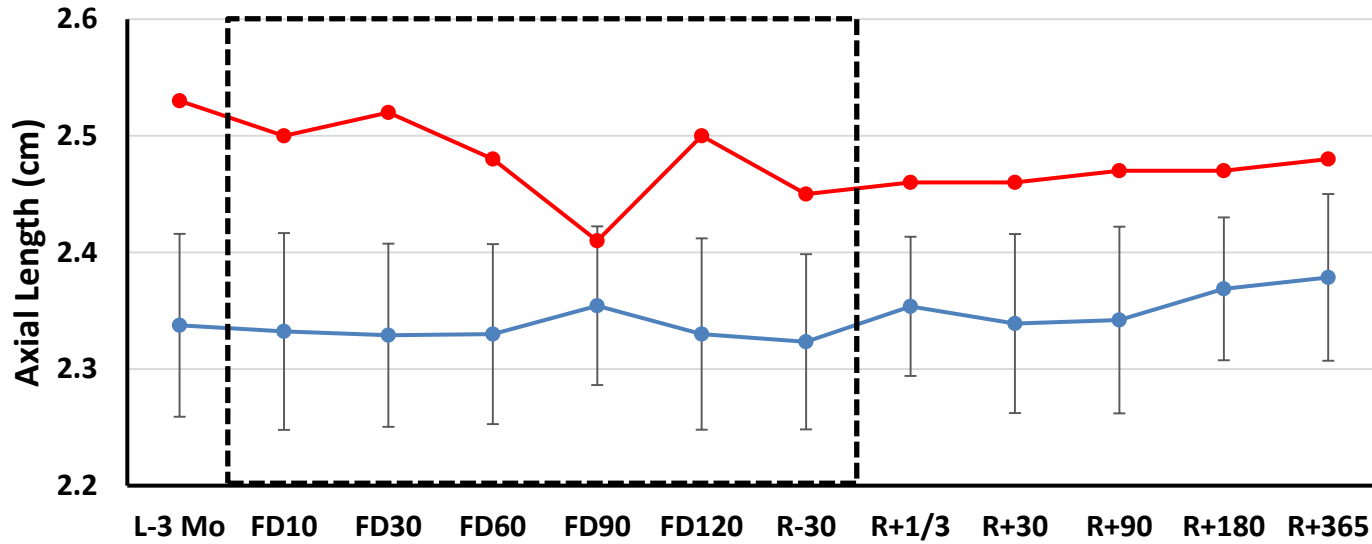


# Axial Length

Preliminary Data



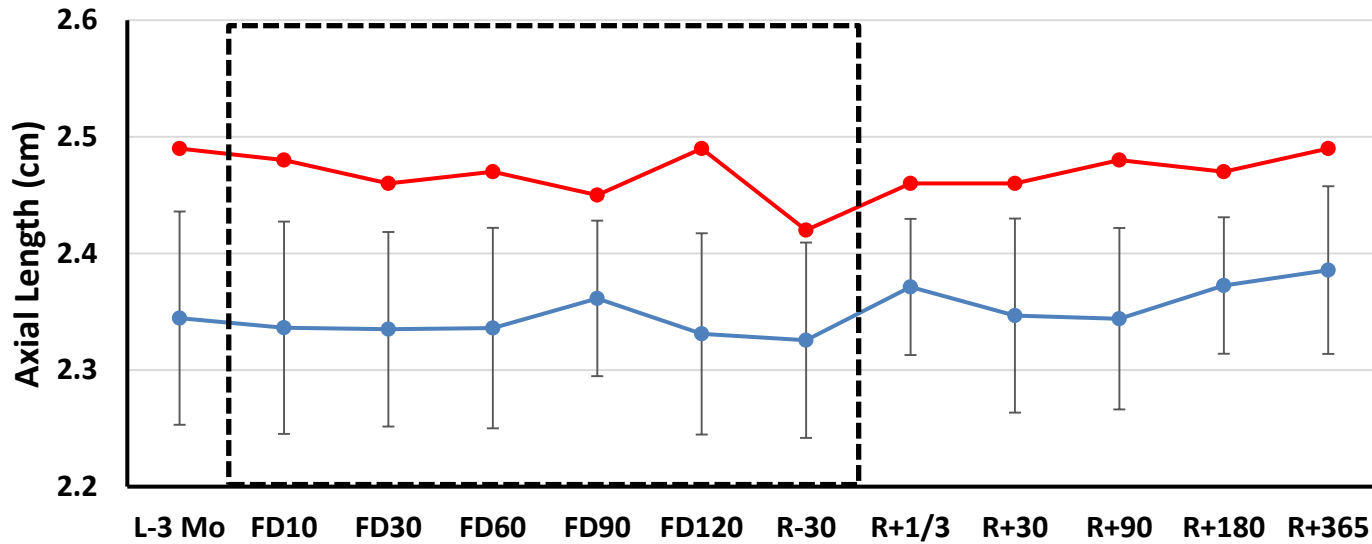
Right Eye



Non-Cases

Case

Left Eye





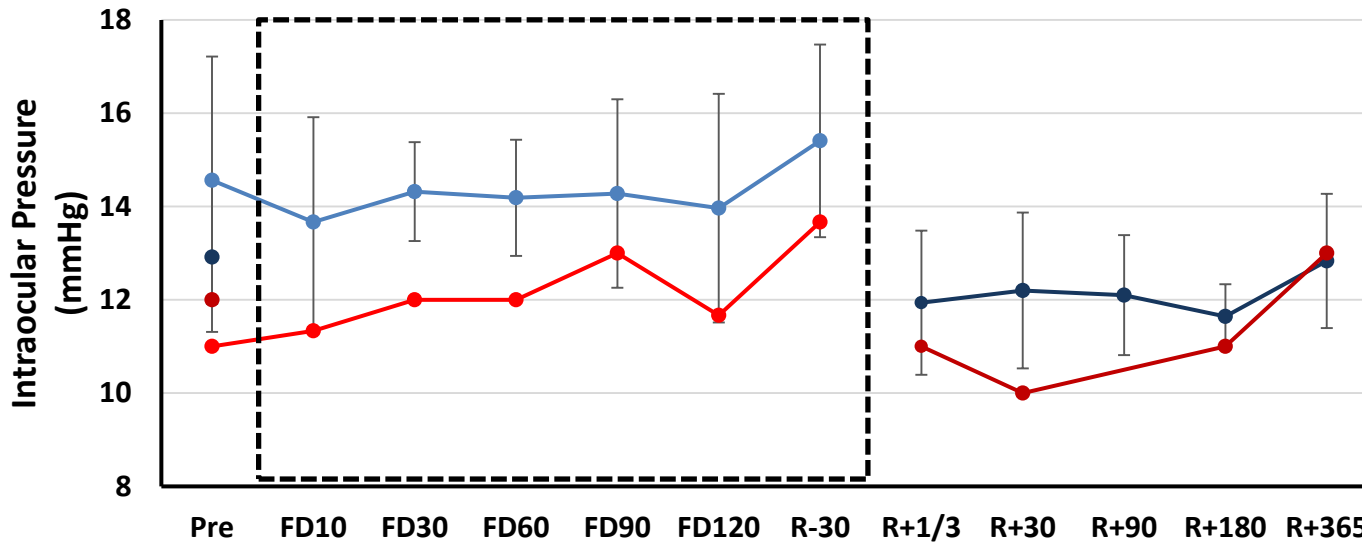


# Intraocular Pressure

Preliminary Data

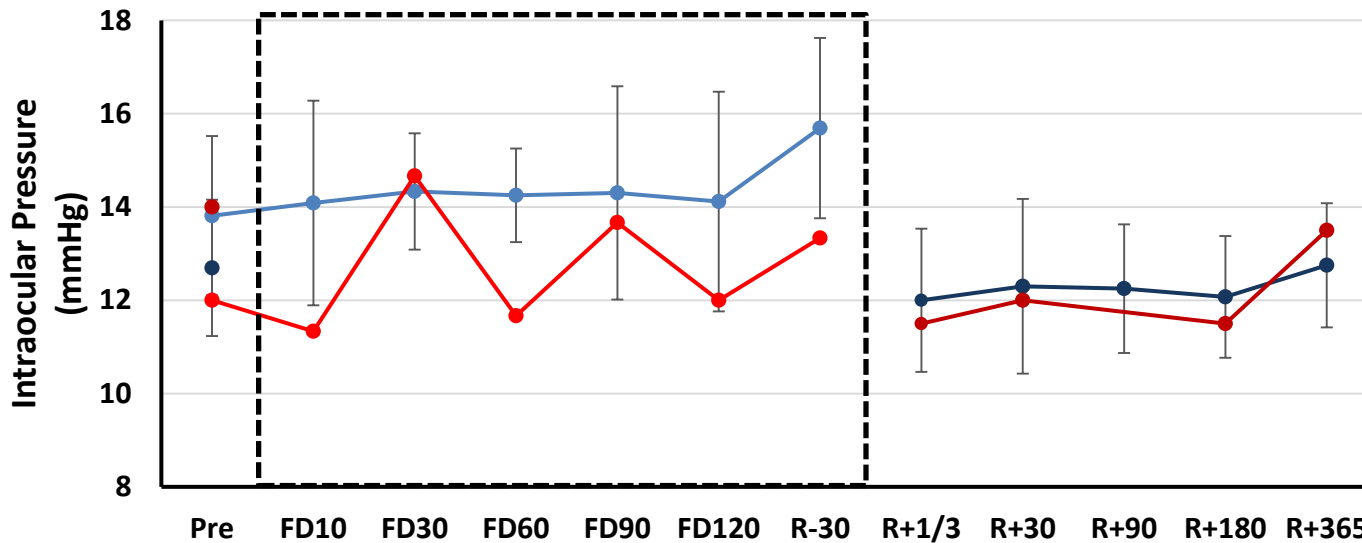


Right Eye



- Non-Cases Tonopen
- Case Tonopen
- Non-Cases Applanation
- Case Applanation

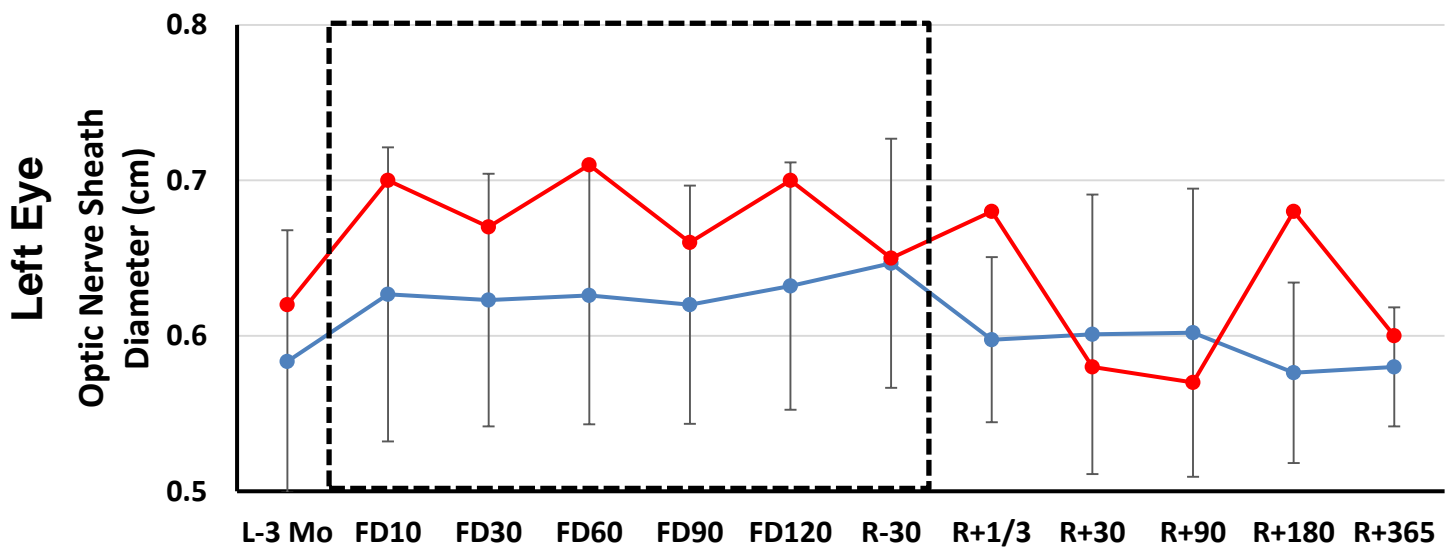
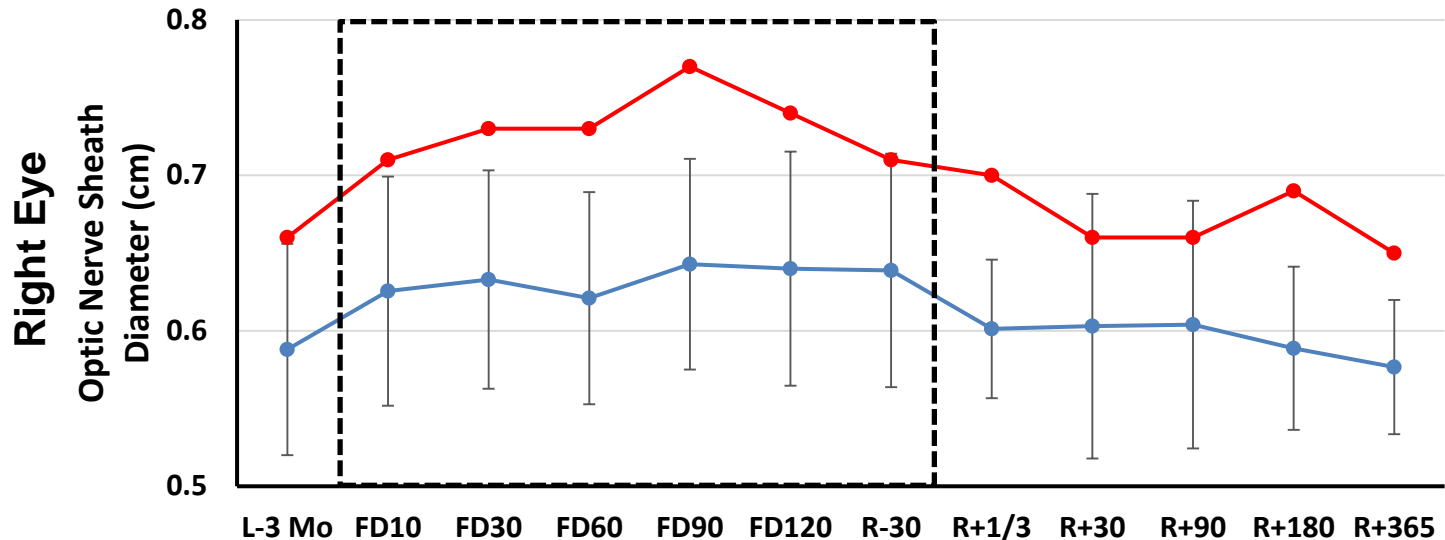
Left Eye





# Optic Nerve Sheath Diameter

Preliminary Data



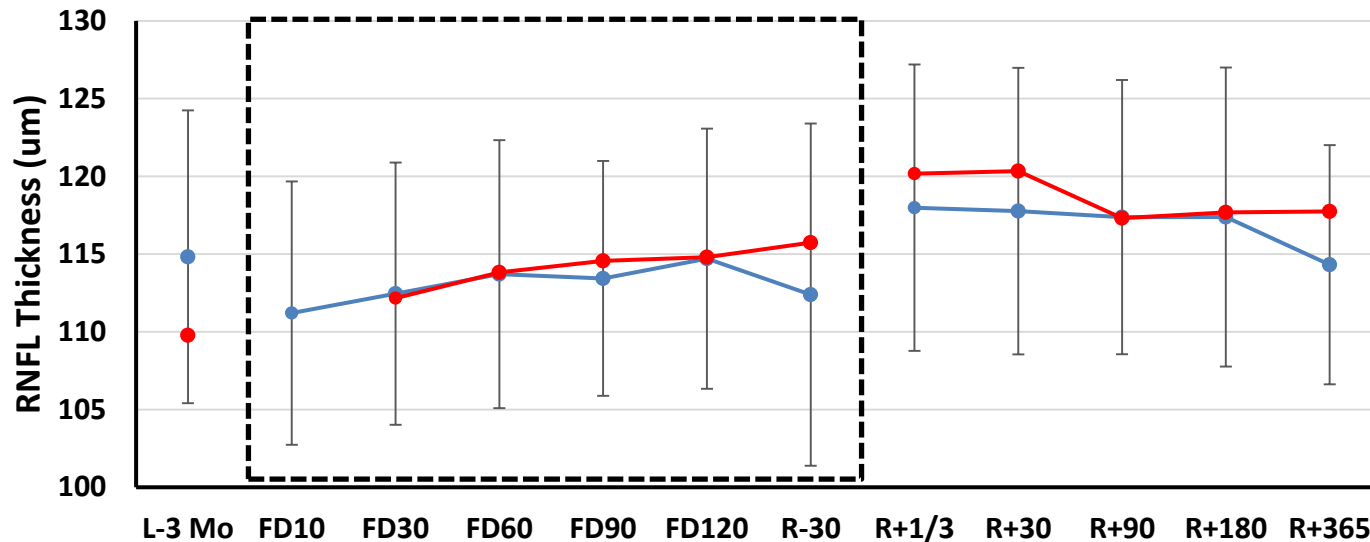


# Retinal Nerve Fiber Layer Thickness

Preliminary Data



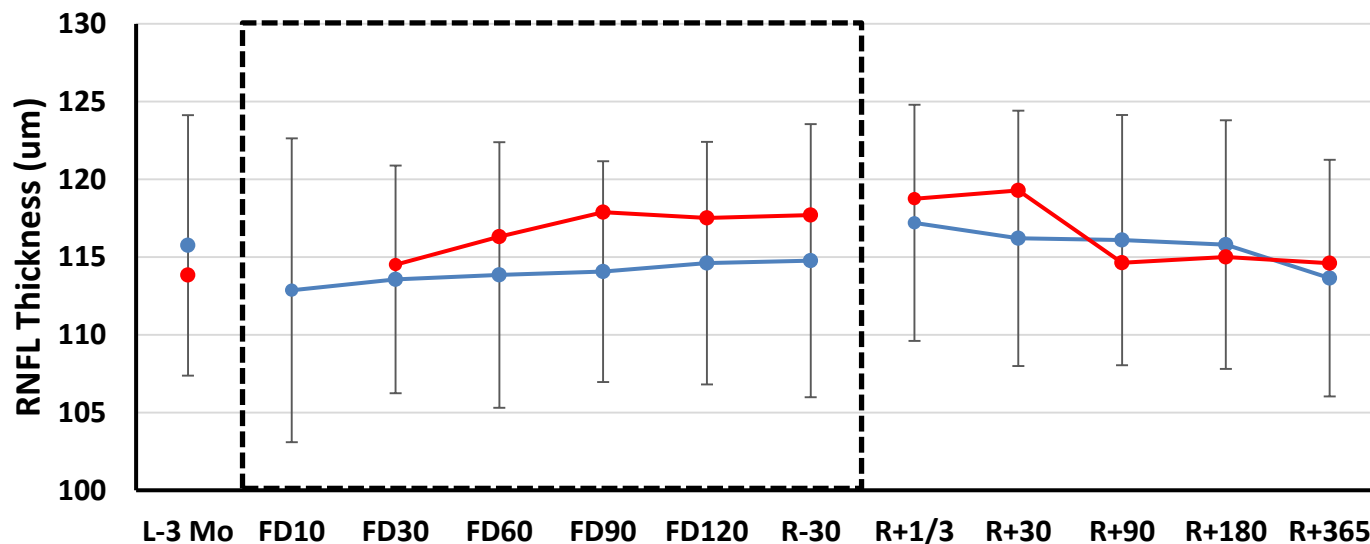
Right Eye



Non-Cases

Case

Left Eye



L-3 Mo

FD10

FD30

FD60

FD90

FD120

R-30

R+1/3

R+30

R+90

R+180

R+365

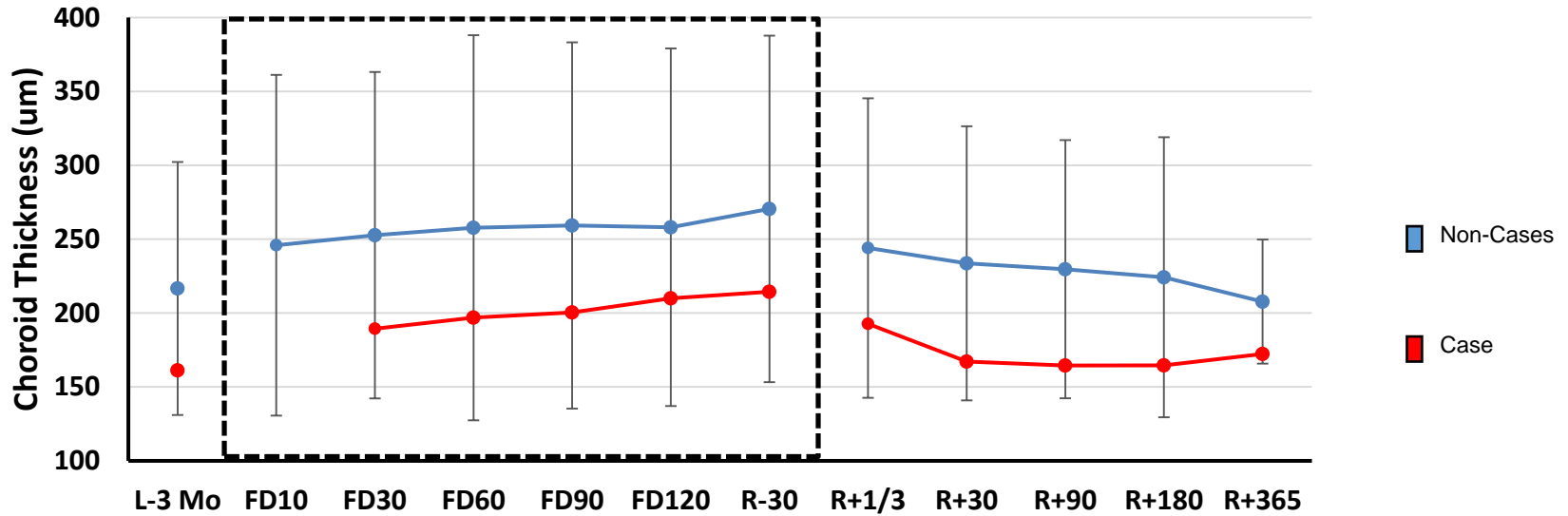


# Choroid Thickness

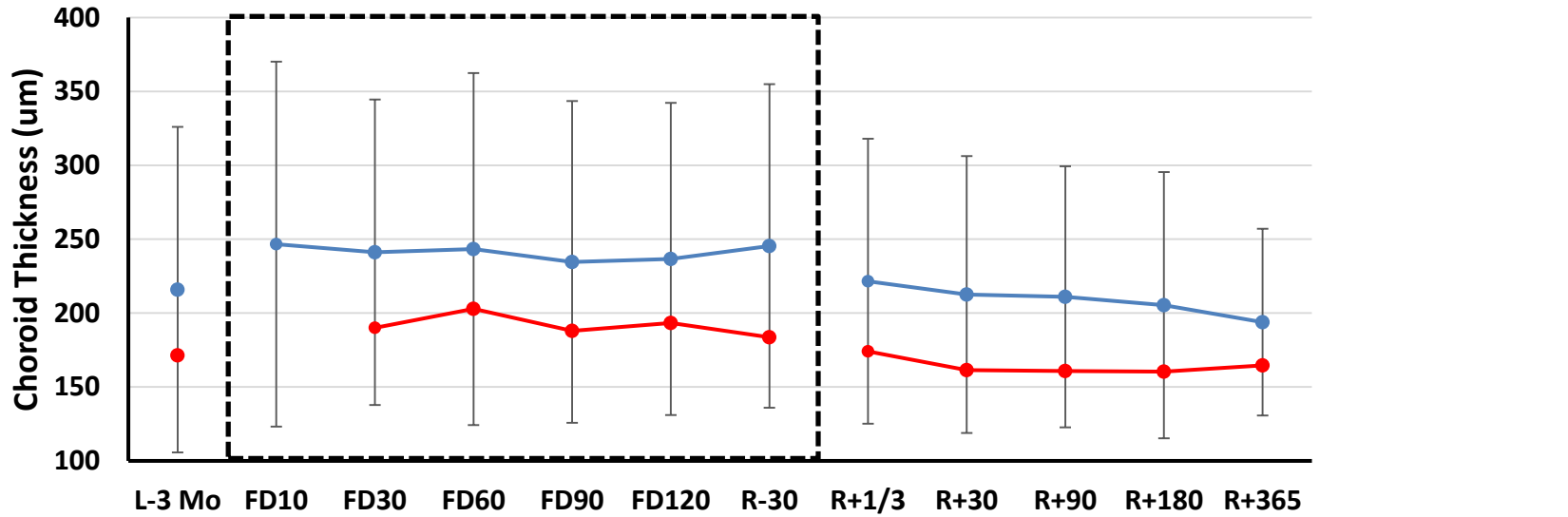
Preliminary Data



Right Eye



Left Eye



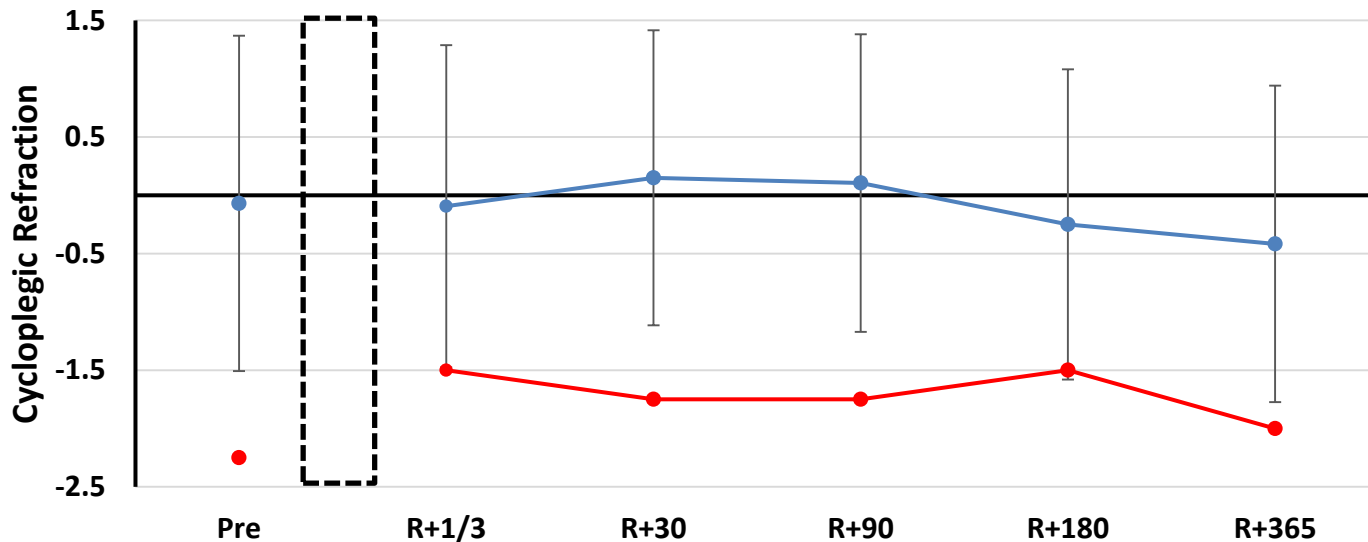


# Cycloplegic Refraction

Preliminary Data



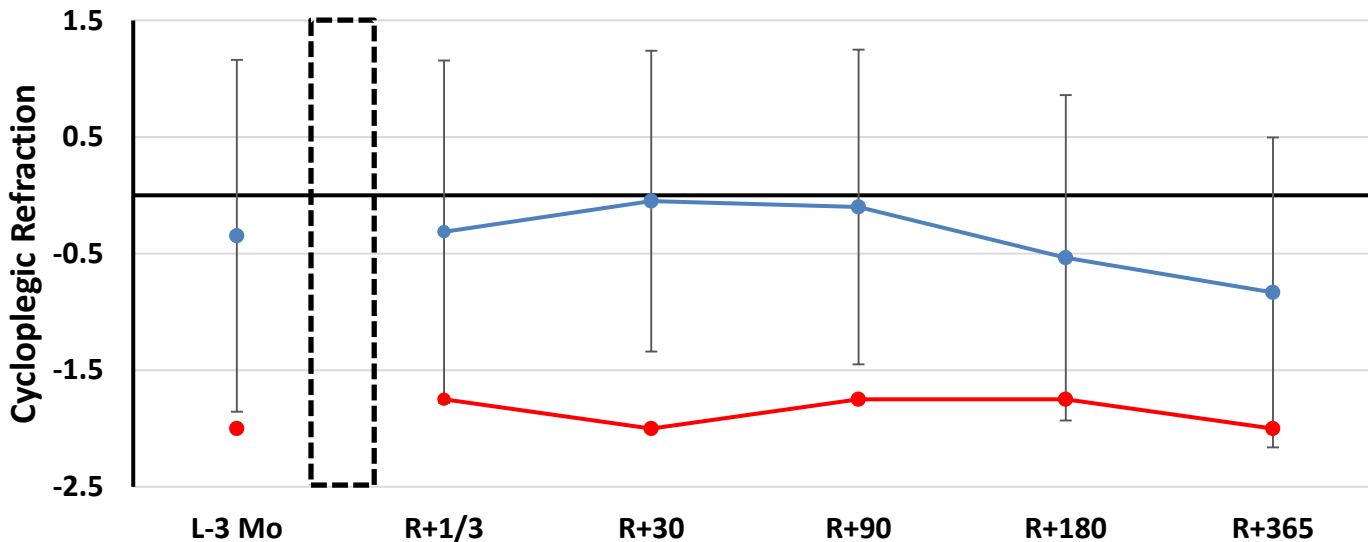
Right Eye



Non-Cases

Case

Left Eye



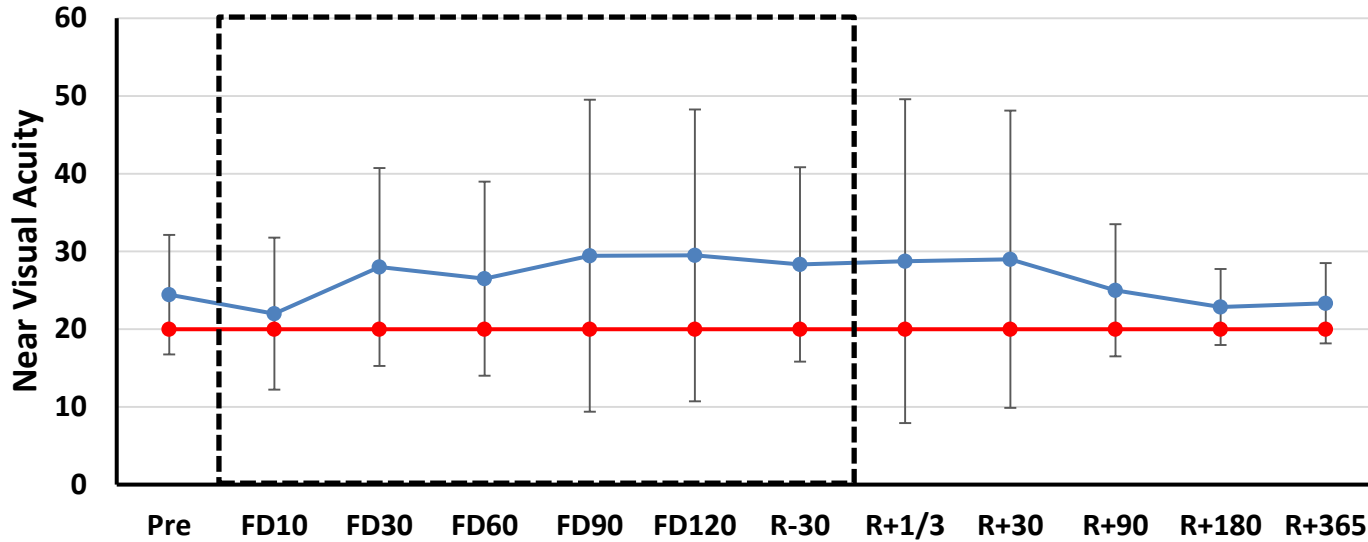


# Near Visual Acuity

Preliminary Data

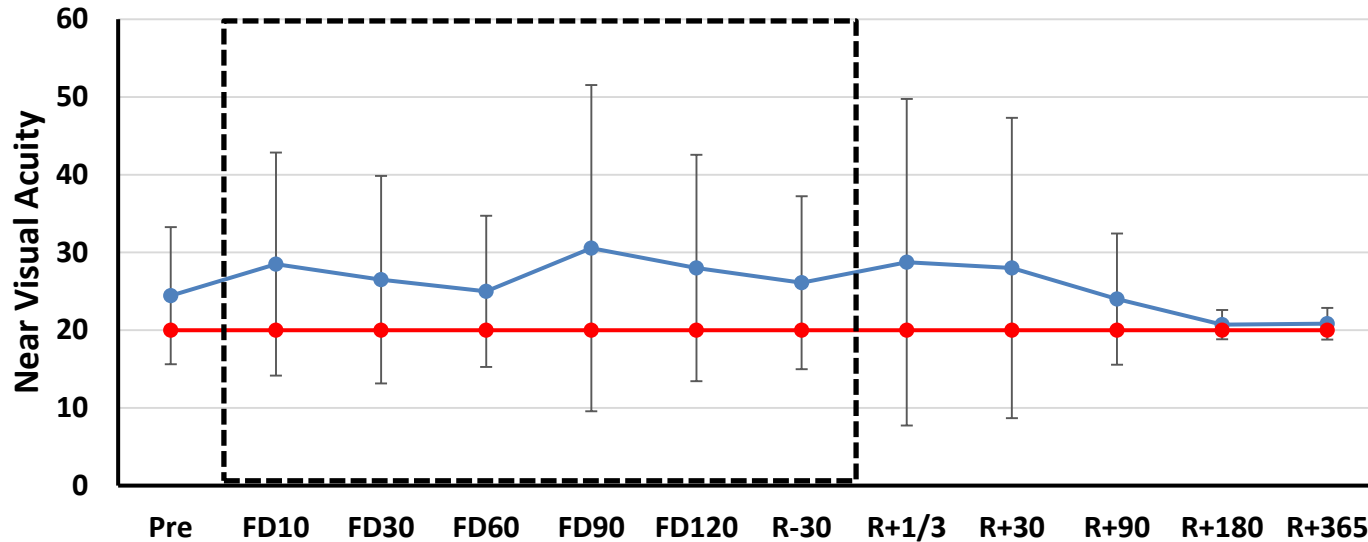


Right Eye



■ Non-Cases  
■ Case

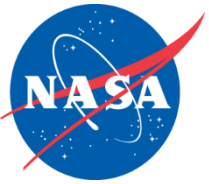
Left Eye



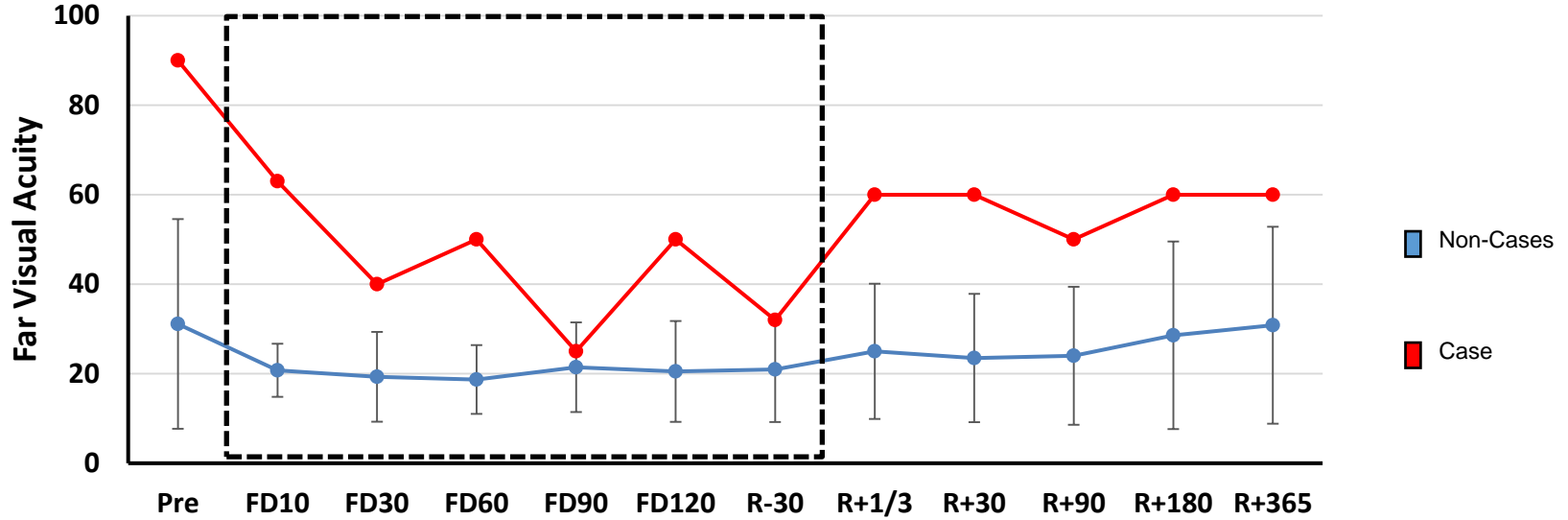


# Far Visual Acuity

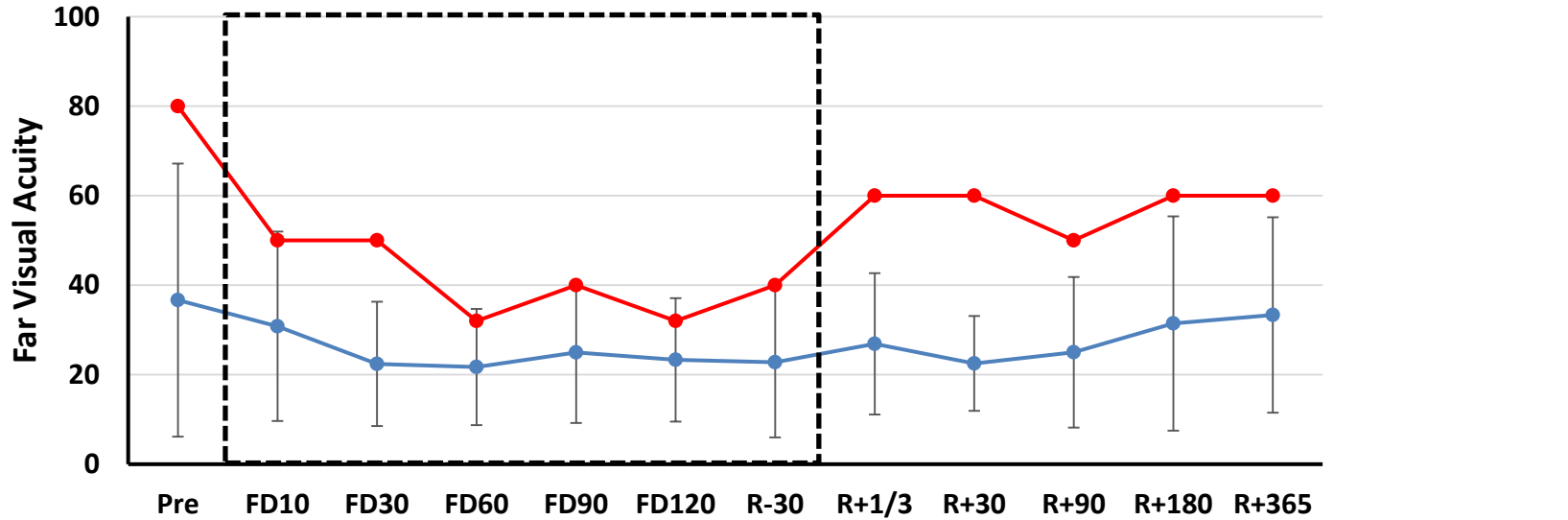
Preliminary Data



Right Eye



Left Eye



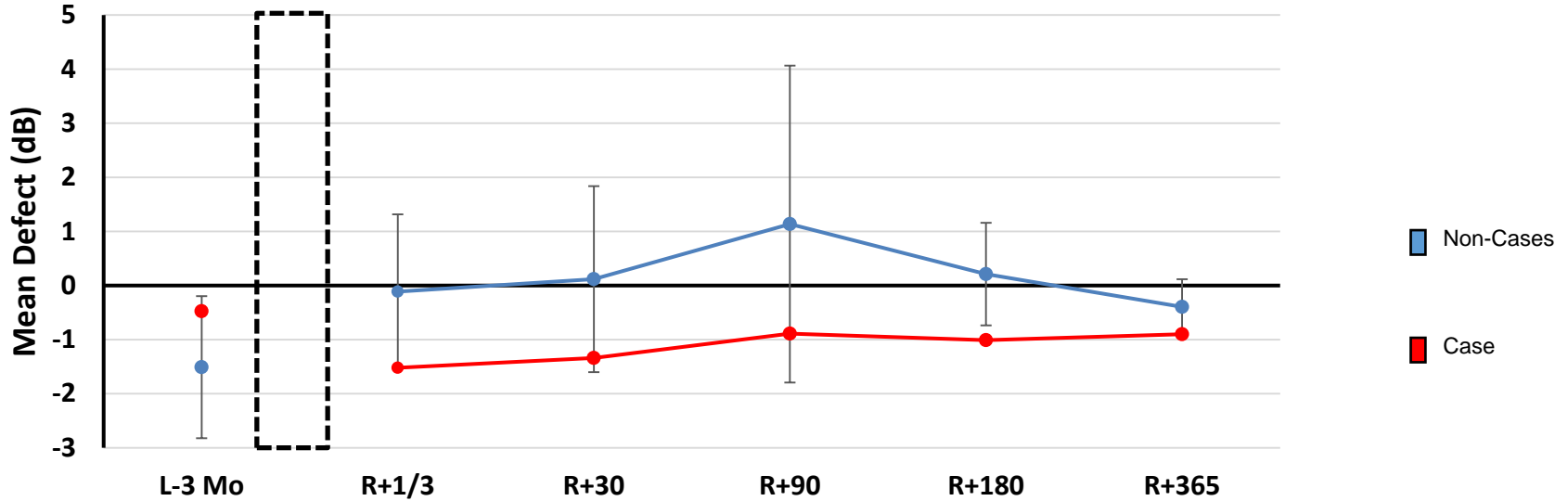


# Visual Field Mean Defect

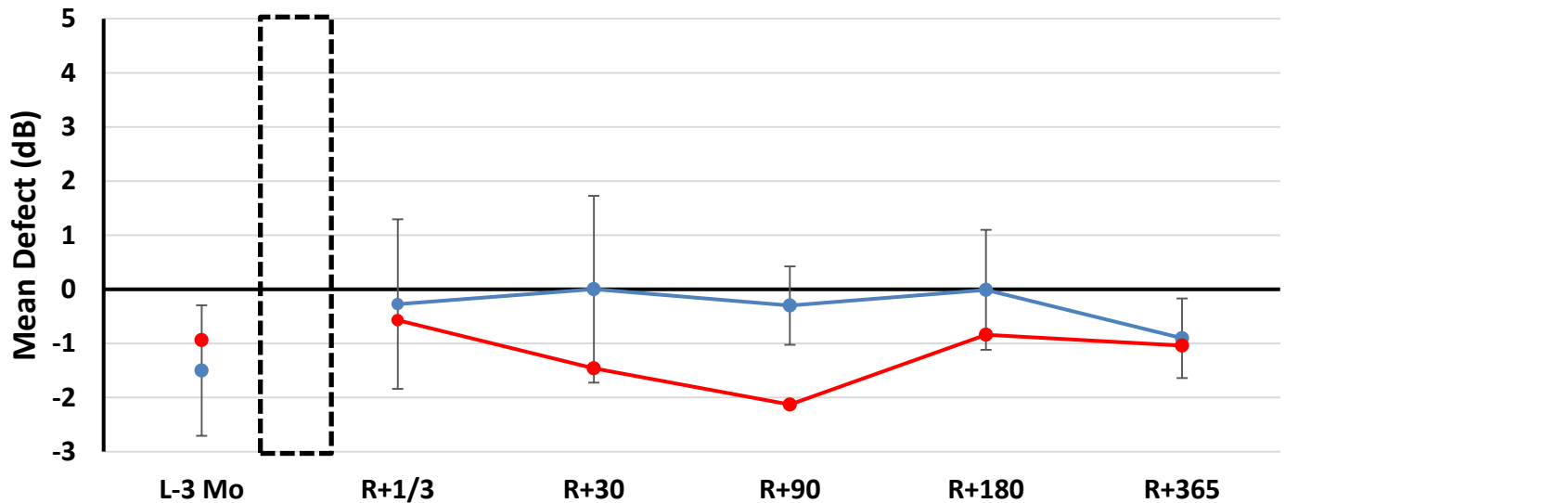
Preliminary Data



Right Eye



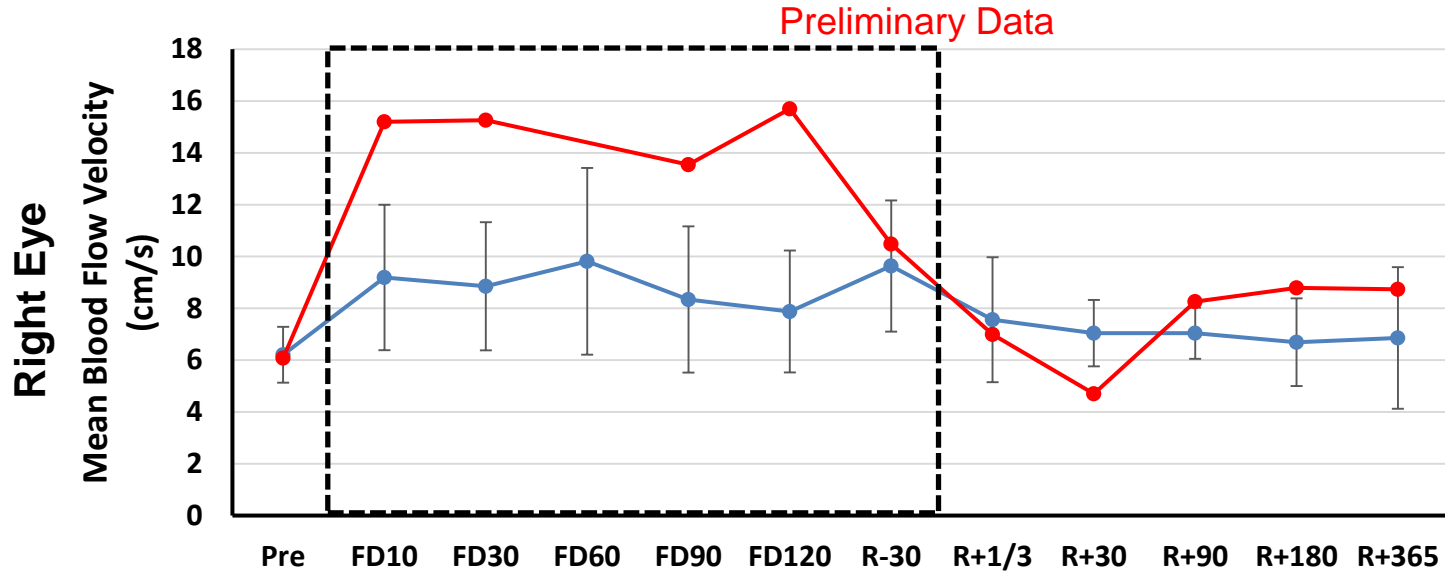
Left Eye



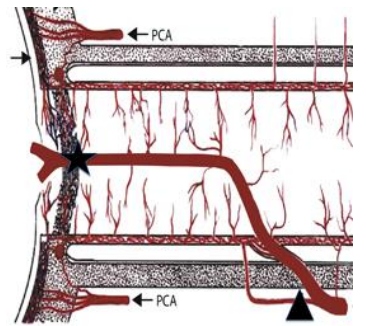
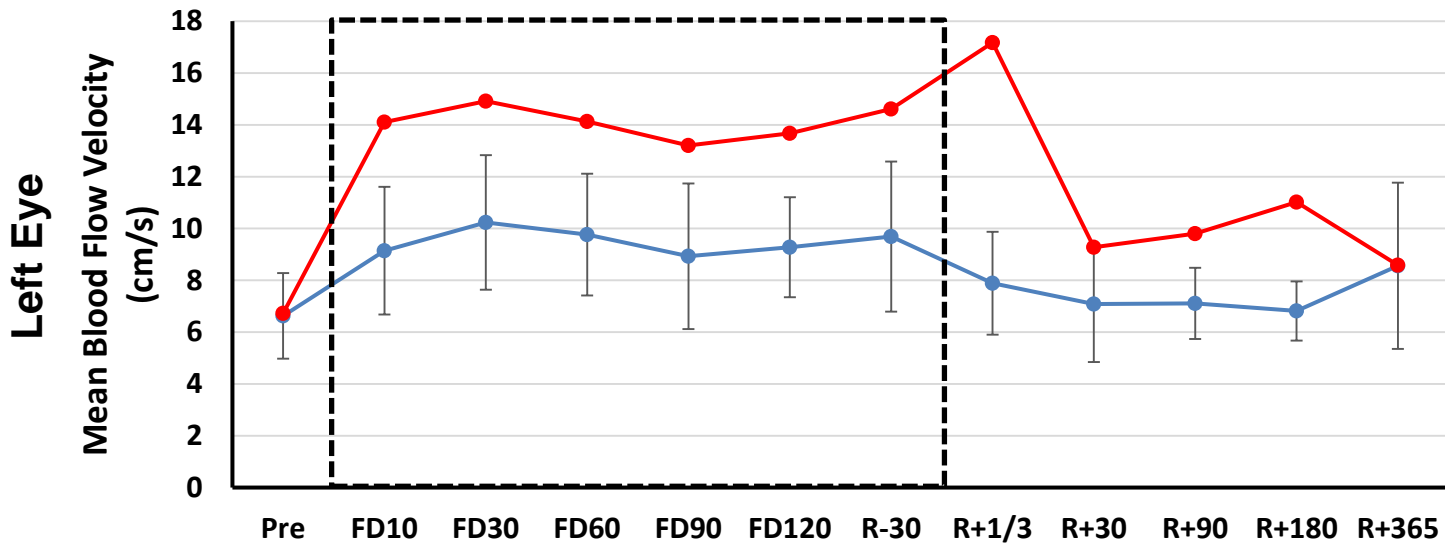




# Central Retinal Artery Mean Blood Flow Velocity



- Non-Cases
- Case



Central Retinal Artery  
Hayreh et al 1977

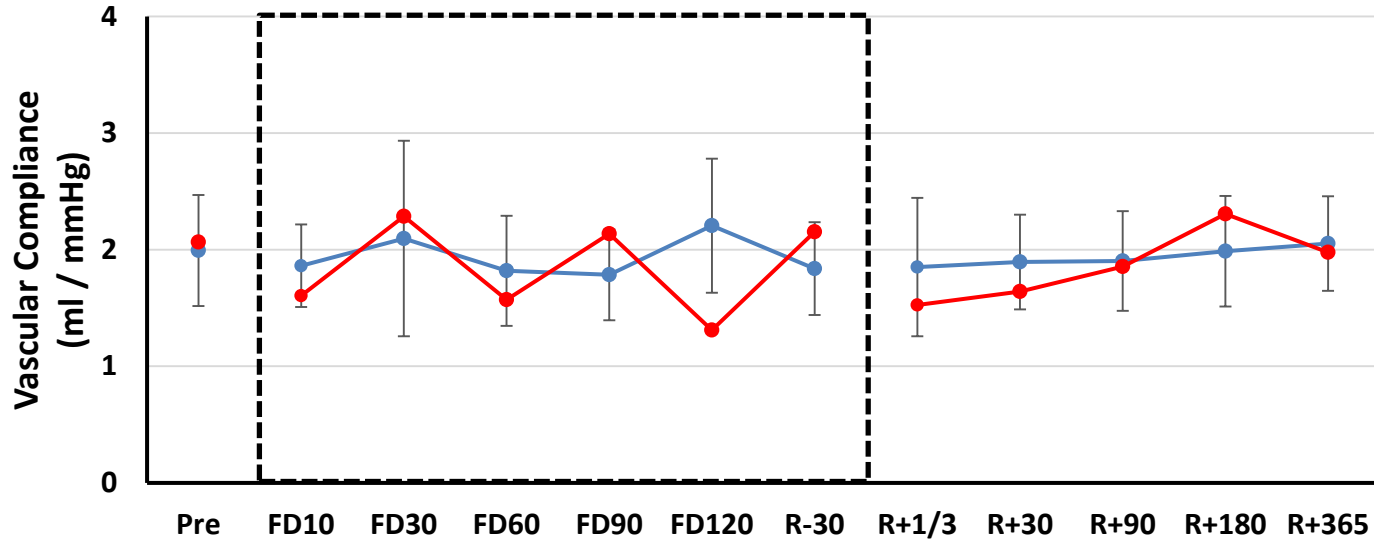


# Vascular Compliance

Preliminary Data



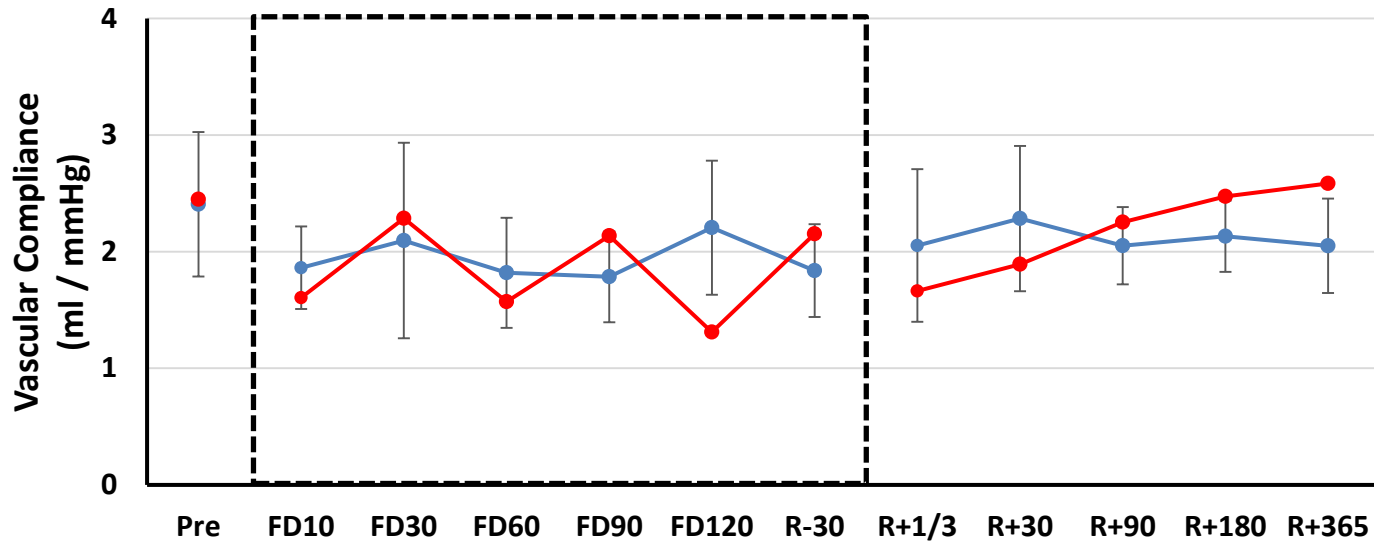
Seated



Non-Cases

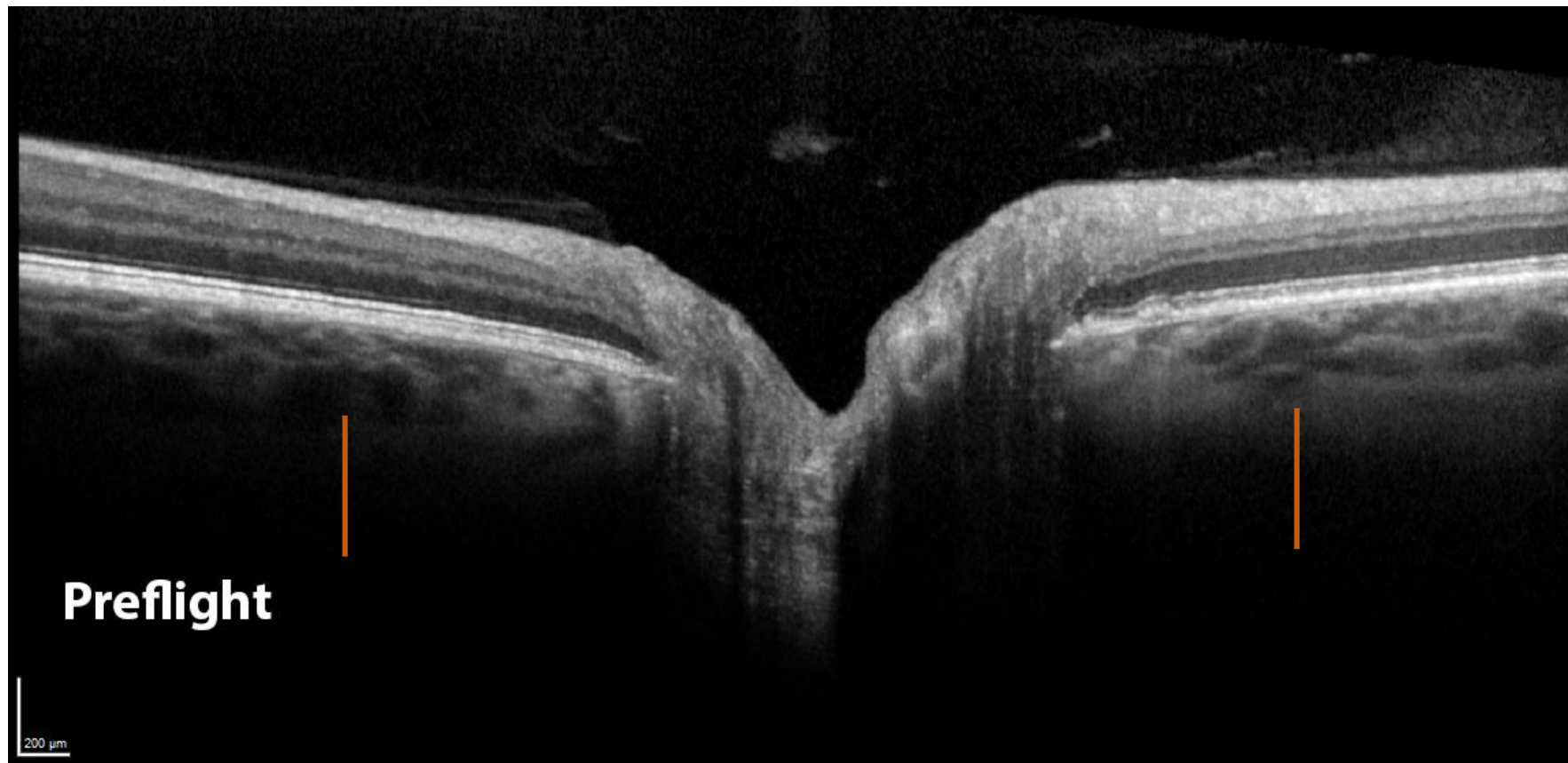
Case

Supine





# Optical Coherence Tomography



- Orange lines are approximate location of clinical circle scan.
- Note thickening and upward movement of optic disc.



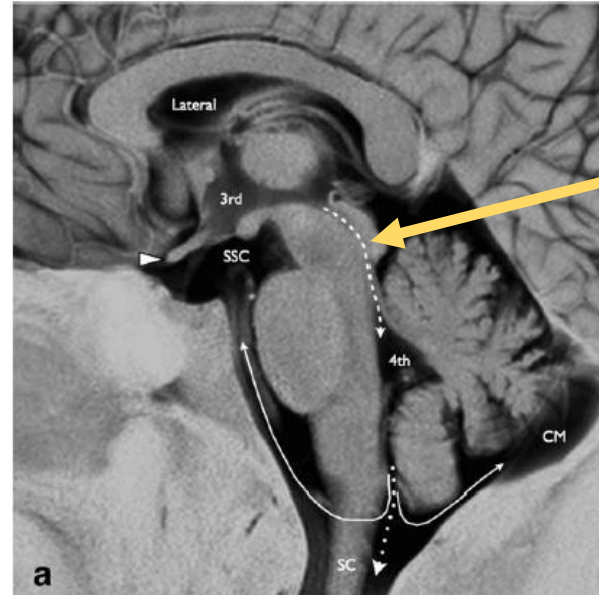
# Hydrodynamics of Cerebral Spinal Fluid Flow



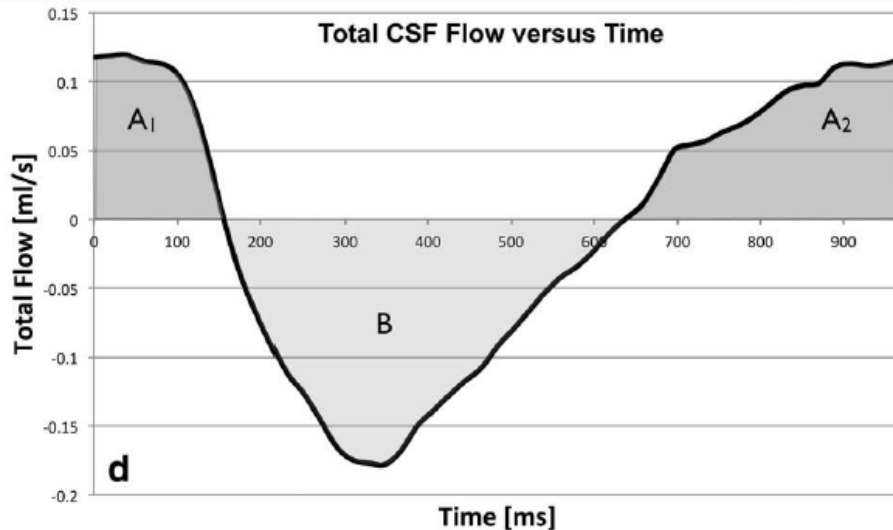
CINE phase-contrast MRI flow quantification used to assess cerebral spinal fluid flow hydrodynamics through the cerebral aqueduct.

**Key outcome measures:**

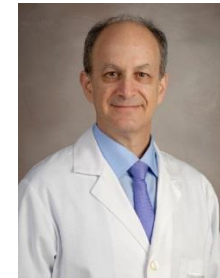
- Cerebral spinal fluid pulsatility
- Cerebral spinal fluid production rate



Cerebral Aqueduct



Kramer *et al.* J Magn Reson Imaging, 2015



Larry A. Kramer, M.D.  
Professor of Diagnostic Imaging and Intervention  
UTHSC, Houston, TX



# Future Work



- Cerebral blood flow regulation during tilt
- Total body vascular compliance
- Ocular structural (OCT) and functional (visual fields) relationships
- Clinical impression and grading of ocular and brain MRI
- Globe flattening quantification (MRI)



# Acknowledgments



International Space Station Medical Projects

Medical Operations

Remote Guiders

Ultrasound

OCT

Tonometry

Vision Testing