Aeromedical Consideration in Ophthalmology

A Case-based Approach

WG.CDR.TAECHIT MIRASENA, M.D.
CONSULTANT IN AVIATION MEDICINE AND OPHTHALMOLOGY

- Doctor of Medicine, Chulalongkorn University, 2008
- Certificate of Aviation Medicine, RTAF Institute of Aviation Medicine, 2009
- Certificate of Human Centrifuge (8G Profile), RSAF Aeromedical Centre, Singapore, 2011
- Flight Surgeon Training Program, Flugmedizinisches Institut der Luftwaffe, Germany, 2011-2013
- Diplomate Thai Board of Preventive Medicine (Aviation Medicine), 2014
- Residency Training in Ophthalmology, Chulalongkorn University, 2015-2018
- Diplomate Thai Board of Ophthalmology, 2018
- Certificate of Occupational Medicine, Nopparat Rachathani Hospital, 2021

Wg.Cdr. Taechit Mirasena M.D.

Certified Aviation Medical Examiner, CAAT

AeMC - RTAF Institute of Aviation Medicine, Samitivej Srinakarin Hospital

I have no conflicts of interest to disclose

Consent was given for educational purposes only

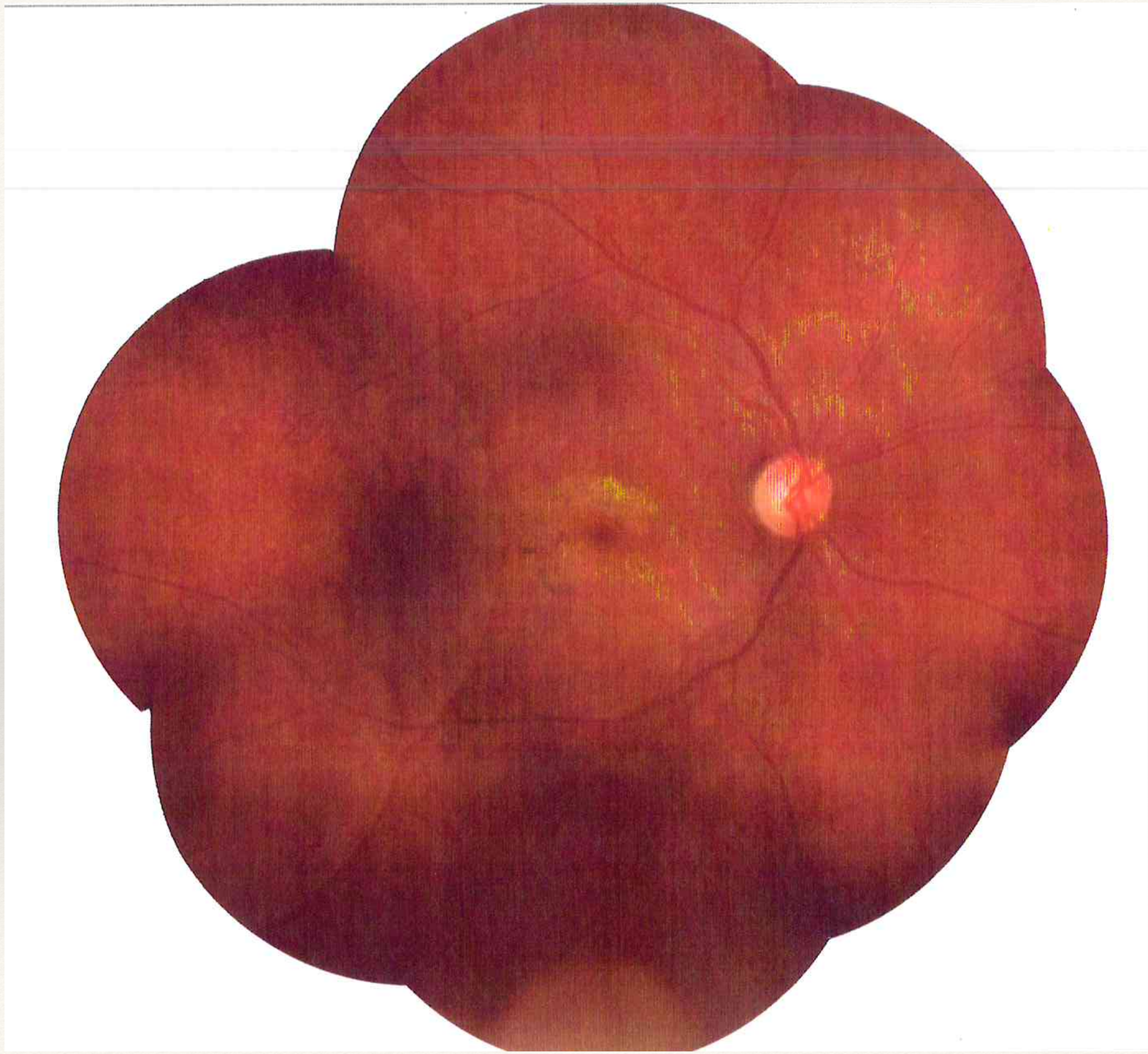
CASE 1 : Visual Acuity is not equal to Vision

General Information

- Thai male captain of airline, age 52 years
- Fleet Boeing-777, Total Flight Hours 18,000 Hrs
- ATPL, Class 1 Medical Certificate
- Apply for renewal of medical certificate at AeMC Samitivej Srinakarin Hospital
- Normal general physical examination

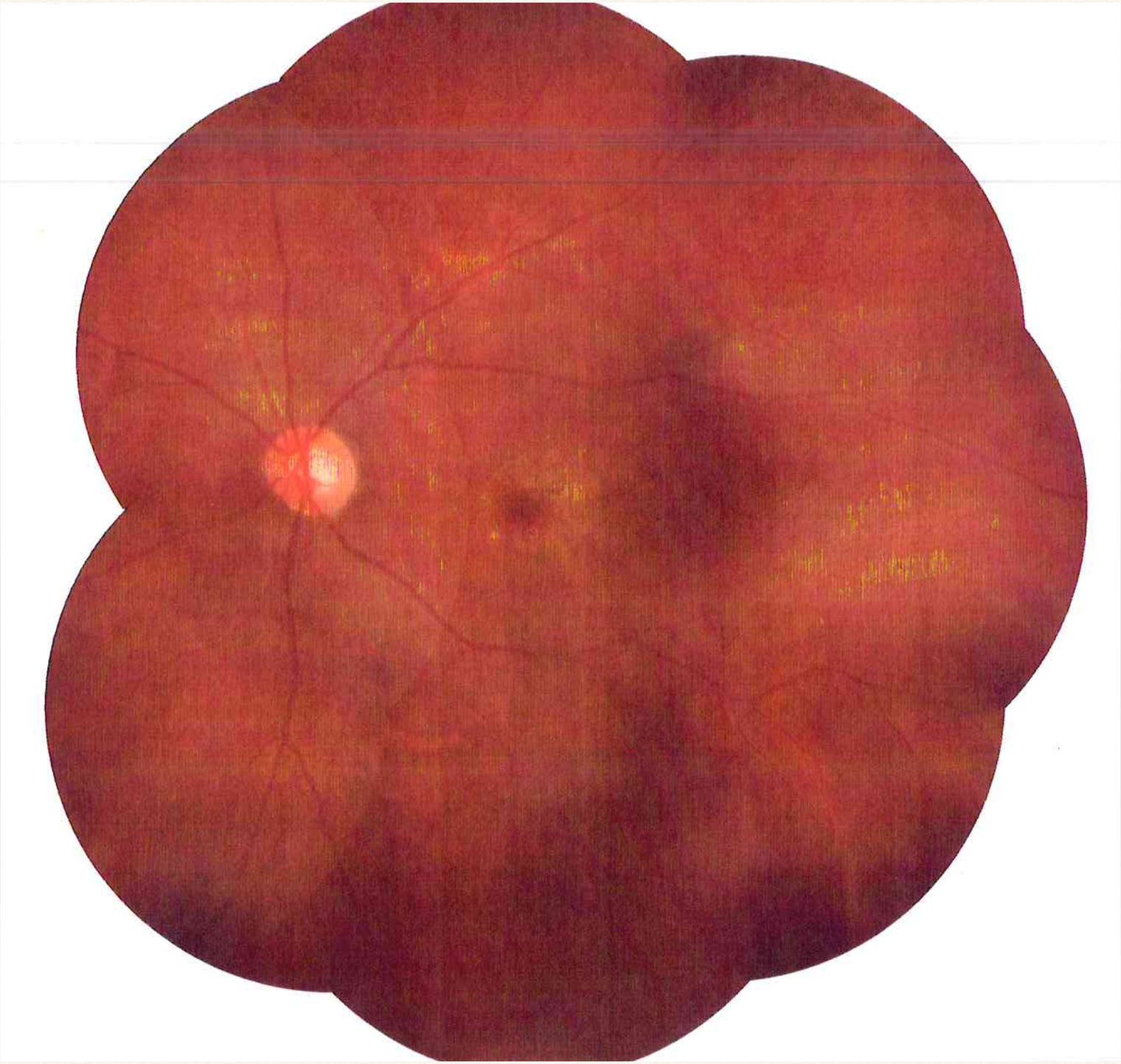
Ophthalmic History&Examination

- Hx. Cataract, S/P Phacoemulsification+IOL OD 15 Dec 2020, OS 22 Dec 2020
- No intra-op or post-op complications from cataract surgery
- No history of other eye diseases, no family history of any eye diseases
- Distant UCVA OD 20/20, OS 20/20, OU 20/20
- Near UCVA OD 20/20, OS 20/20, OU 20/20
- Color test - Ishihara 38 Plates edition: PASS
- AS: Good wound, Clear Cornea, A/C formed, IOL in place OU



OD

OS



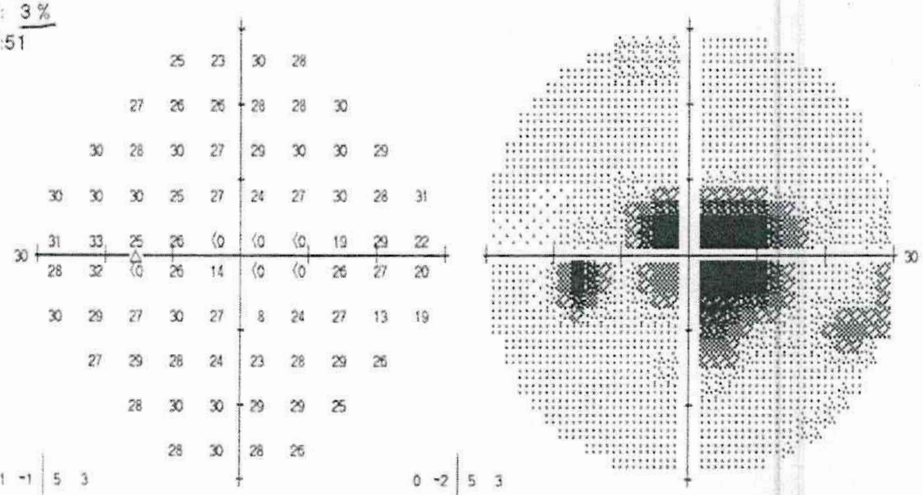
OS

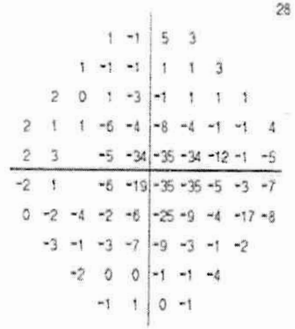
Fixation Monitor: Gaze/Blind Spot
Fixation Target: Central
Fixation Losses: 1/22
False POS Errors: 4 %
False NEG Errors: 3 %
Test Duration: 07:51

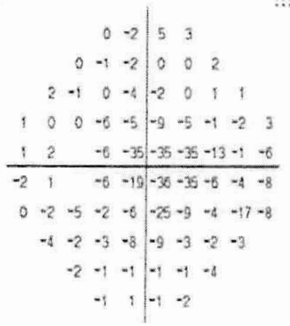
Fovea: 38 dB

Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter: 5.1 mm
Visual Acuity:
RX: +1.50 DS DC X





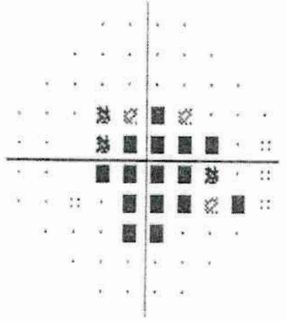


GHT
Outside Normal Limits

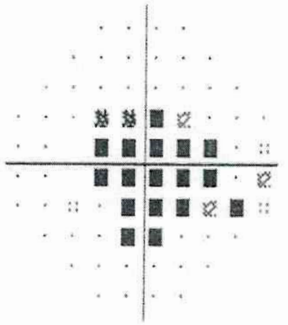
VFI 63%

MD -7.44 dB P < 0.5%
PSD 13.32 dB P < 0.5%

Total Deviation



Pattern Deviation



:: < 5%
▒ < 2%
▓ < 1%
■ < 0.5%

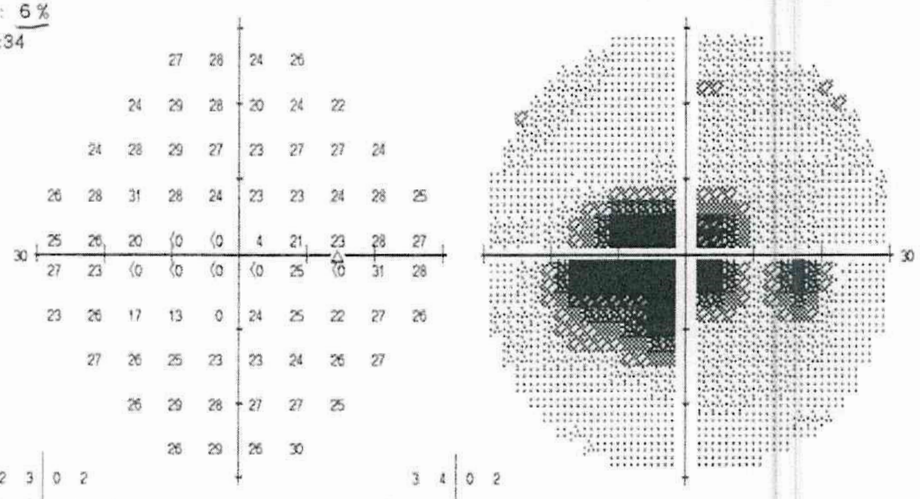
OD

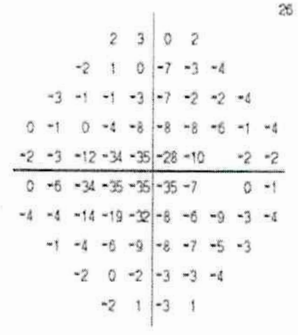
Fixation Monitor: Gaze/Blind Spot
Fixation Target: Central
Fixation Losses: 1/25
False POS Errors: 2 %
False NEG Errors: 6 %
Test Duration: 09:34

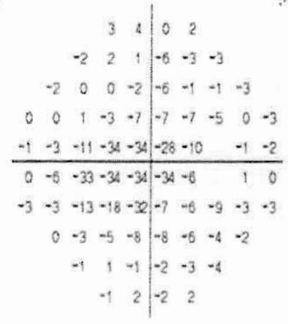
Fovea: 37 dB

Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter: 5.3 mm
Visual Acuity:
RX: +1.50 DS DC X





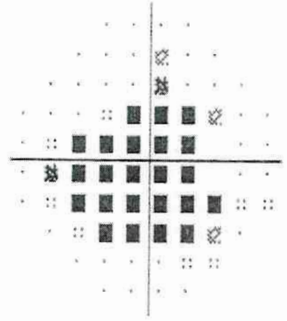


GHT
Outside Normal Limits

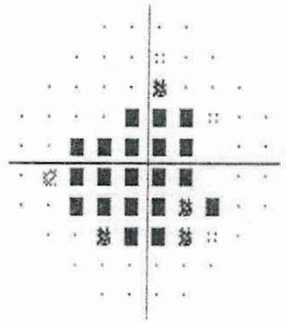
VFI 56%

MD -10.22 dB P < 0.5%
PSD 14.01 dB P < 0.5%

Total Deviation



Pattern Deviation



:: < 5%
▒ < 2%
▓ < 1%
■ < 0.5%

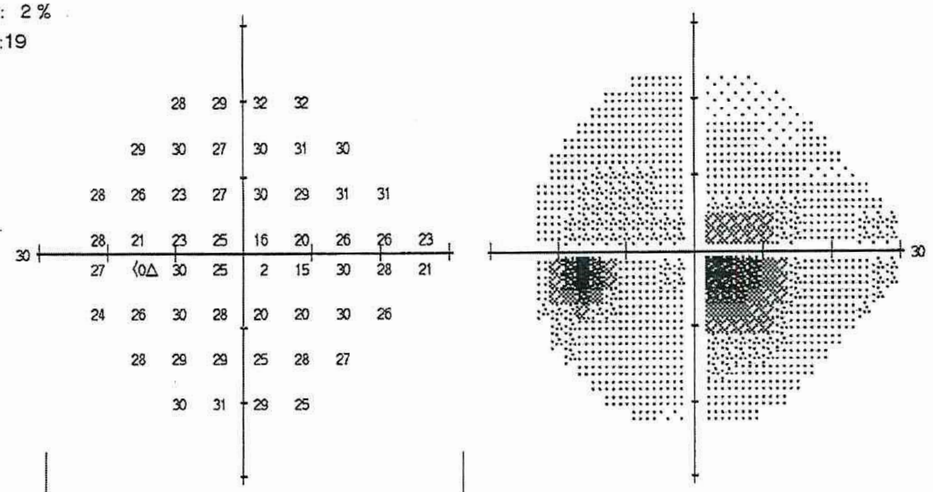
OS

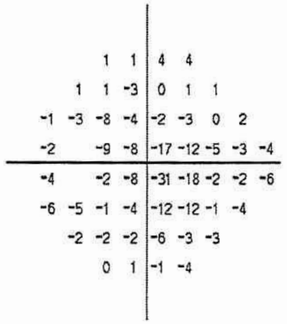
Fixation Monitor: Gaze/Blind Spot
Fixation Target: Central
Fixation Losses: 4/15 xx
False POS Errors: 2 %
False NEG Errors: 2 %
Test Duration: 06:19

Fovea: 39 dB

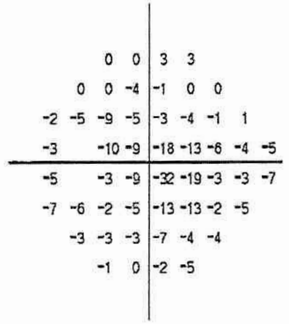
Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter: 6.1 mm
Visual Acuity:
RX: +2.00 DS DC X





Total Deviation



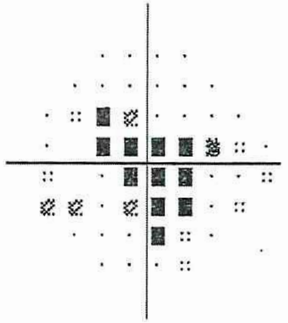
Pattern Deviation

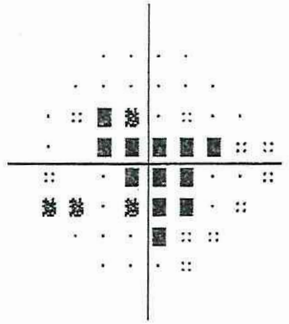
*** Low Test Reliability ***

GHT
Outside Normal Limits

VFI 79%

MD -5.14 dB P < 0.5%
PSD 7.15 dB P < 0.5%





:: < 5%
▒ < 2%
▒ < 1%
■ < 0.5%

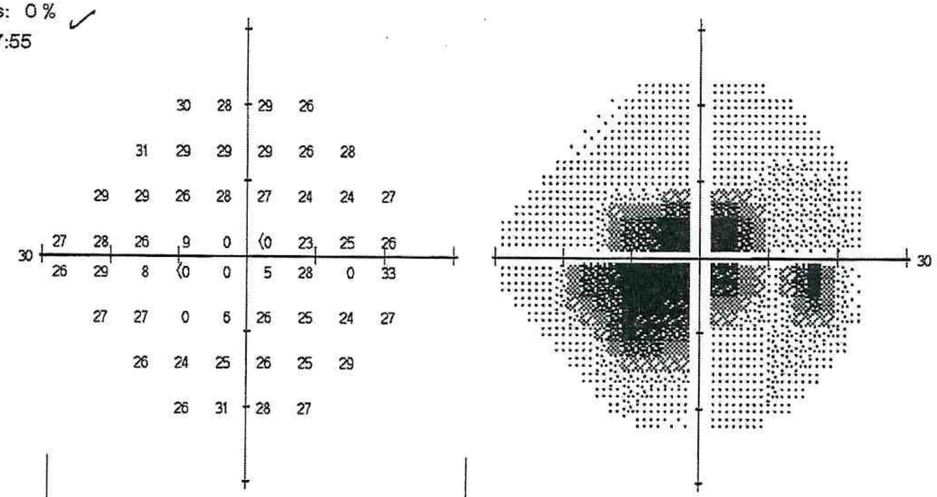
OD

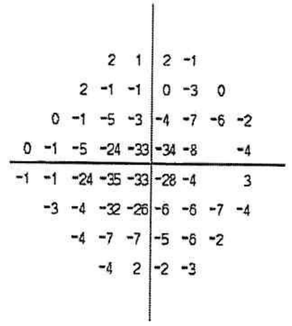
Fixation Monitor: Gaze/Blind Spot
Fixation Target: Central
Fixation Losses: 0/18
False POS Errors: 8 %
False NEG Errors: 0 %
Test Duration: 07:55

Fovea: 39 dB

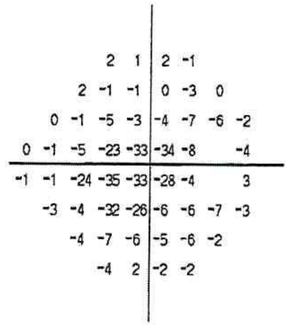
Stimulus: III, White
Background: 31.5 ASB
Strategy: SITA-Standard

Pupil Diameter: 6.7 mm
Visual Acuity:
RX: +2.25 DS DC X





Total Deviation

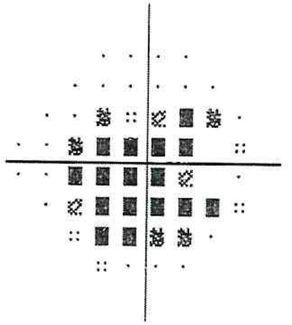


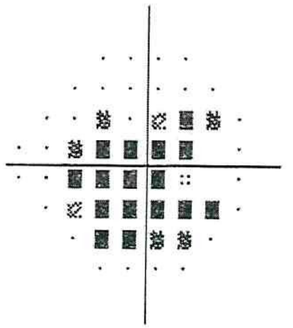
Pattern Deviation

GHT
Outside Normal Limits

VFI 61%

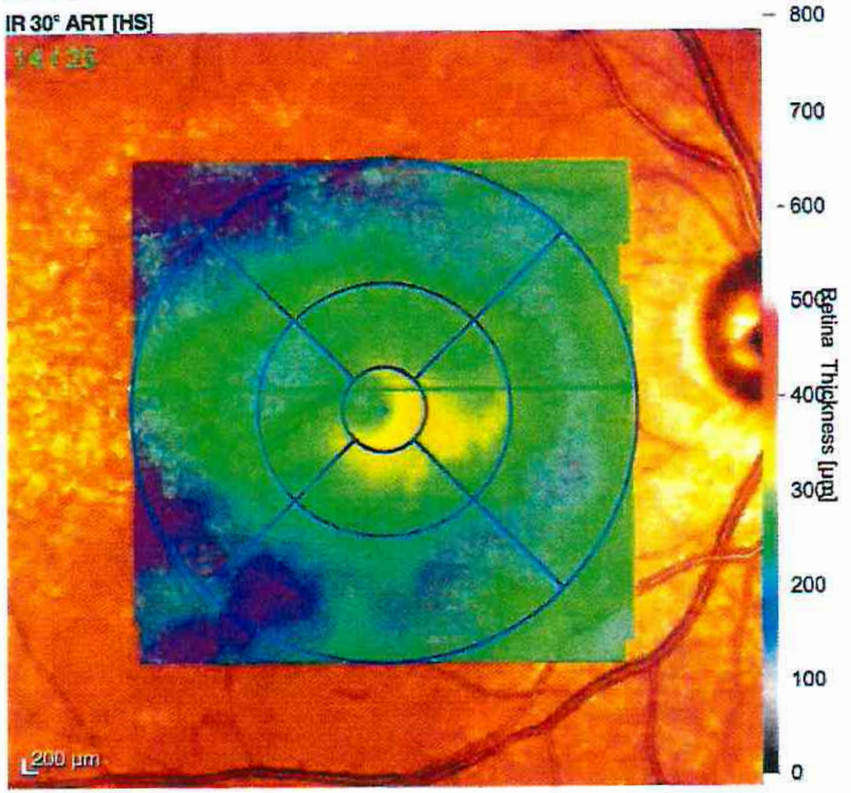
MD -9.90 dB P < 0.5%
PSD 12.91 dB P < 0.5%





:: < 5%
▒ < 2%
▒ < 1%
■ < 0.5%

OD



Average Thickness [µm]

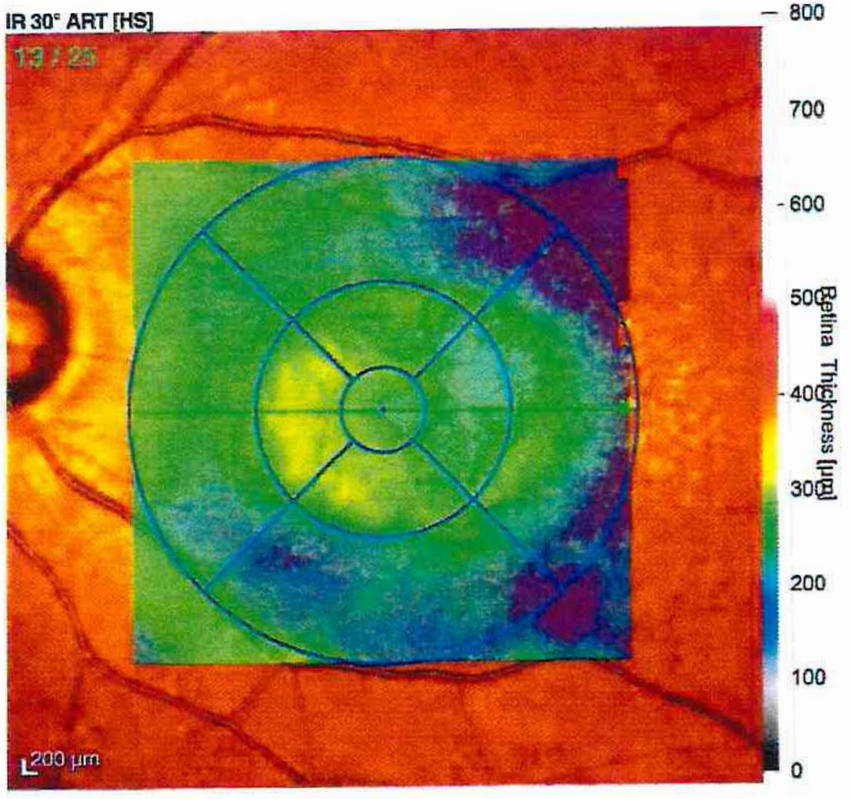
Vol [mm³]
6.45

	218 1.15			
	244 0.38			
220 1.16	233 0.37	272 0.21	267 0.42	229 1.22
	254 0.40			
	214 1.13			

Center: 254 µm
Central Min: 217 µm
Central Max: 301 µm

Circle Diameters:
1, 3, 6 mm ETDRS

OS



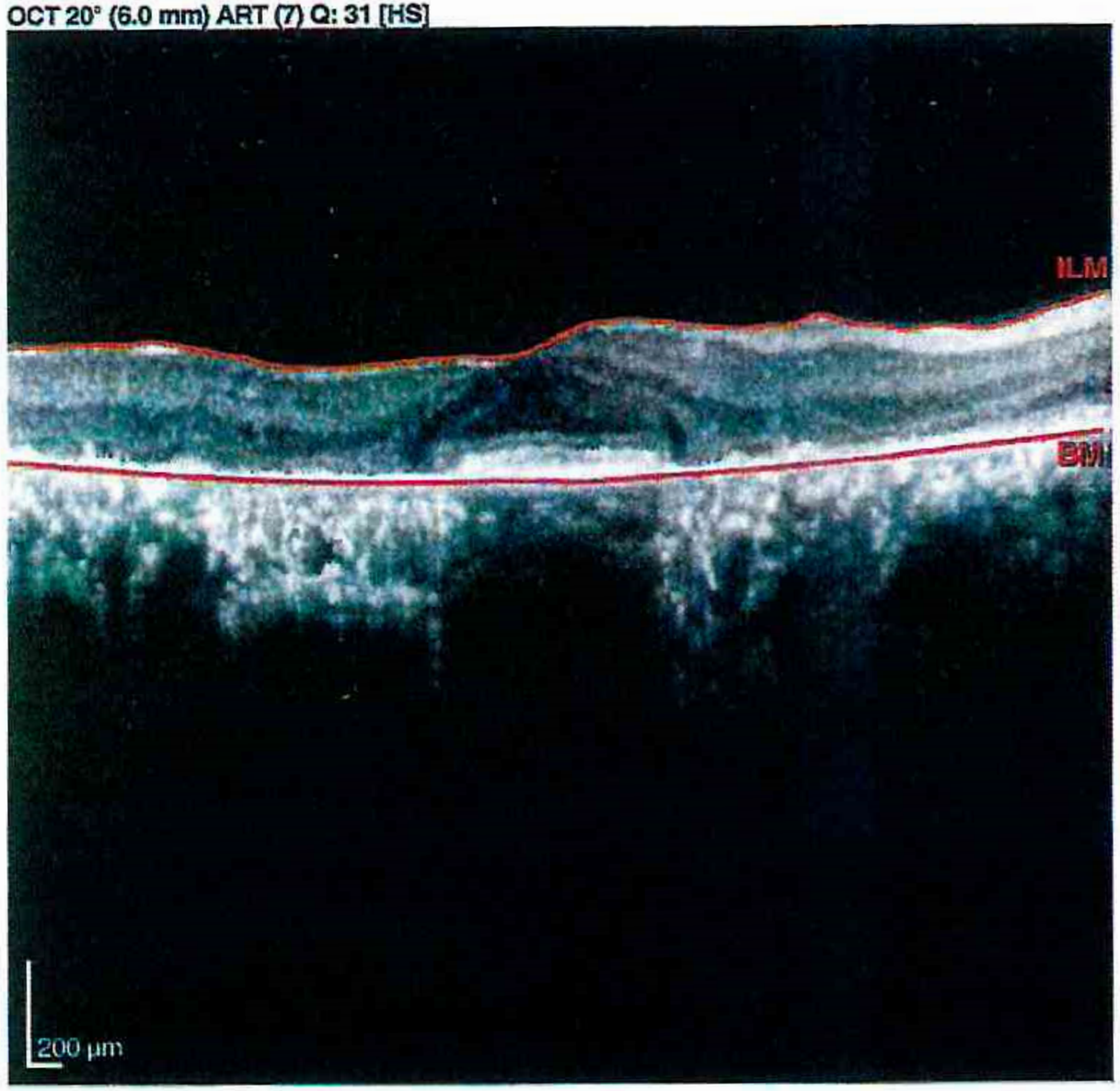
Average Thickness [µm]

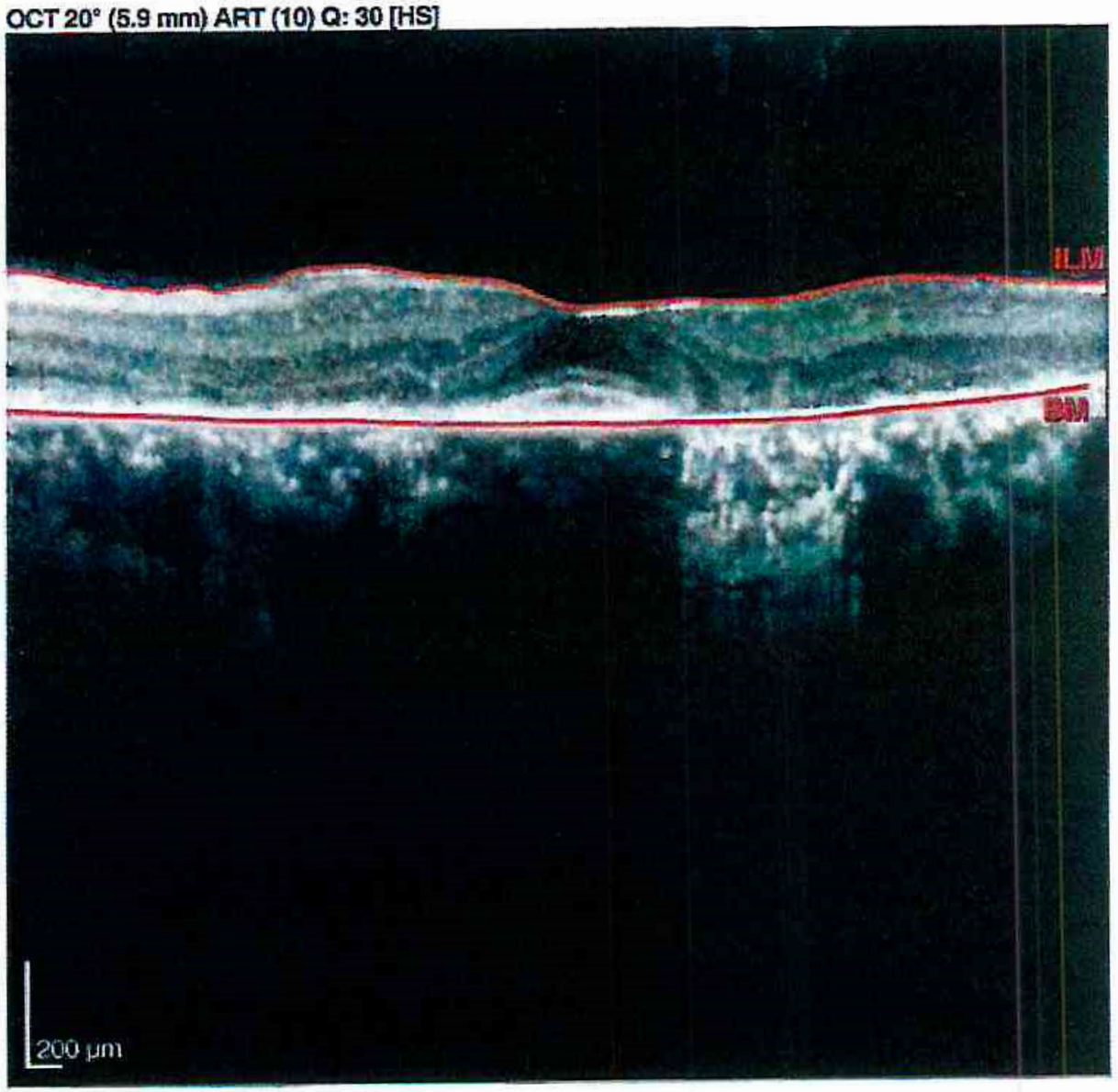
Vol [mm³]
6.40

	215 1.14			
	248 0.39			
233 1.24	271 0.43	245 0.19	229 0.36	212 1.12
	258 0.41			
	212 1.12			

Center: 220 µm
Central Min: 211 µm
Central Max: 271 µm

Circle Diameters:
1, 3, 6 mm ETDRS


OCT 20° (6.0 mm) ART (7) Q: 31 [HS]
ILM
BM
200 µm

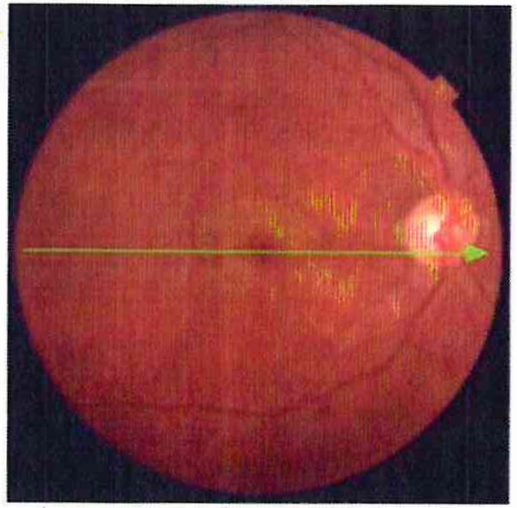

OCT 20° (5.9 mm) ART (10) Q: 30 [HS]
ILM
BM
200 µm

OCT OD

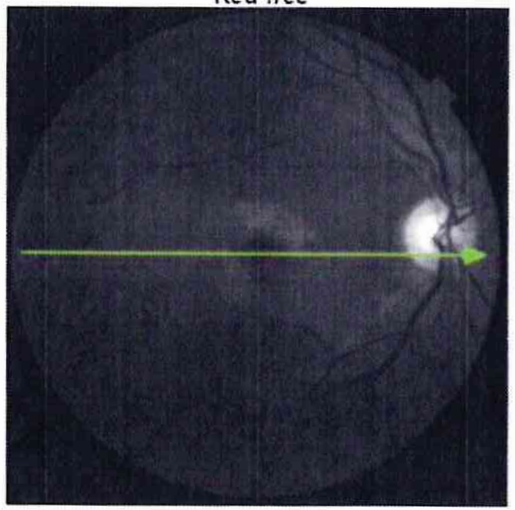
OD(R)

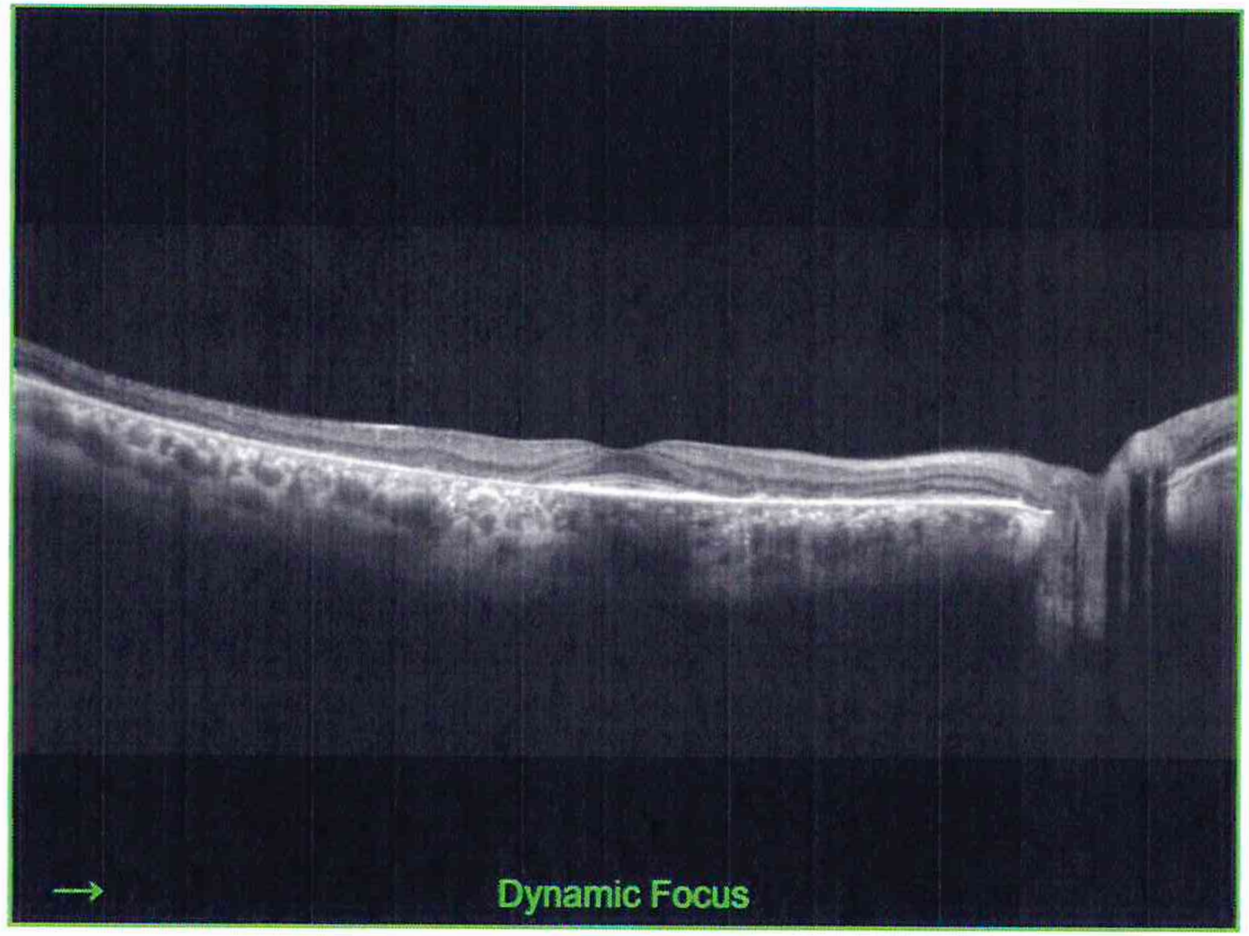
Image Quality 96 Analysis mode Fine (2 0 7)

Capture Date 27/05/2021

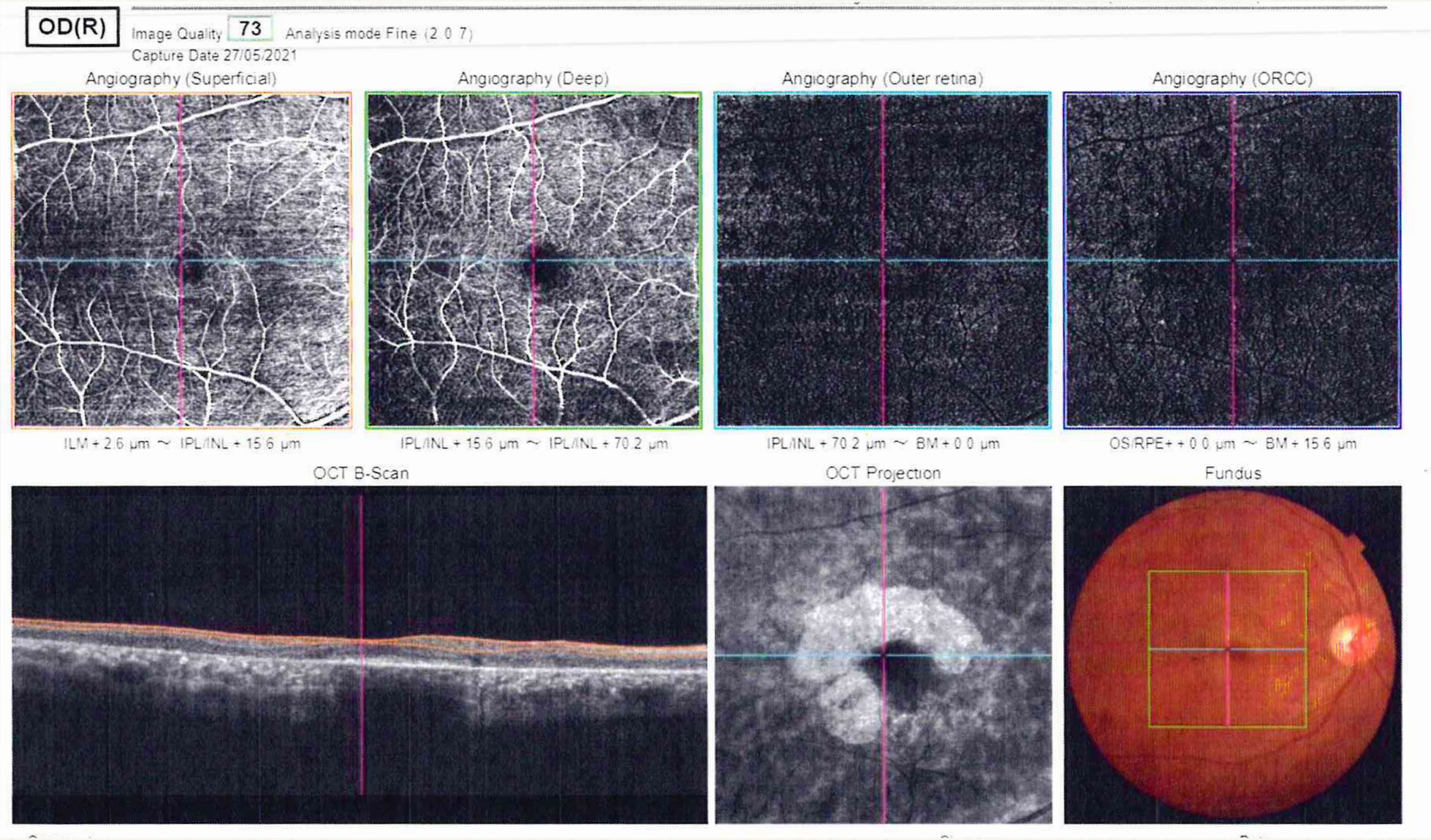


Red-free

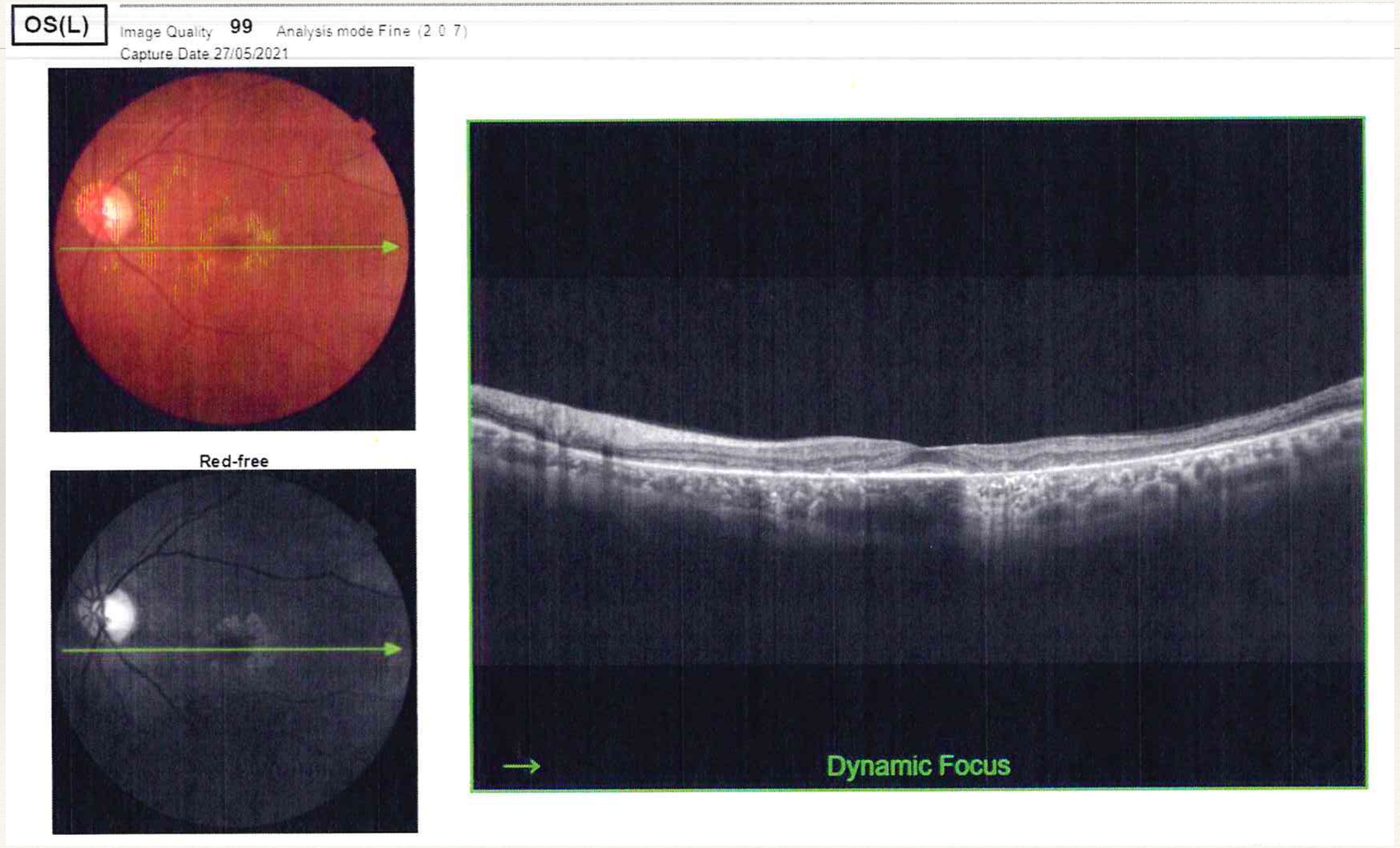




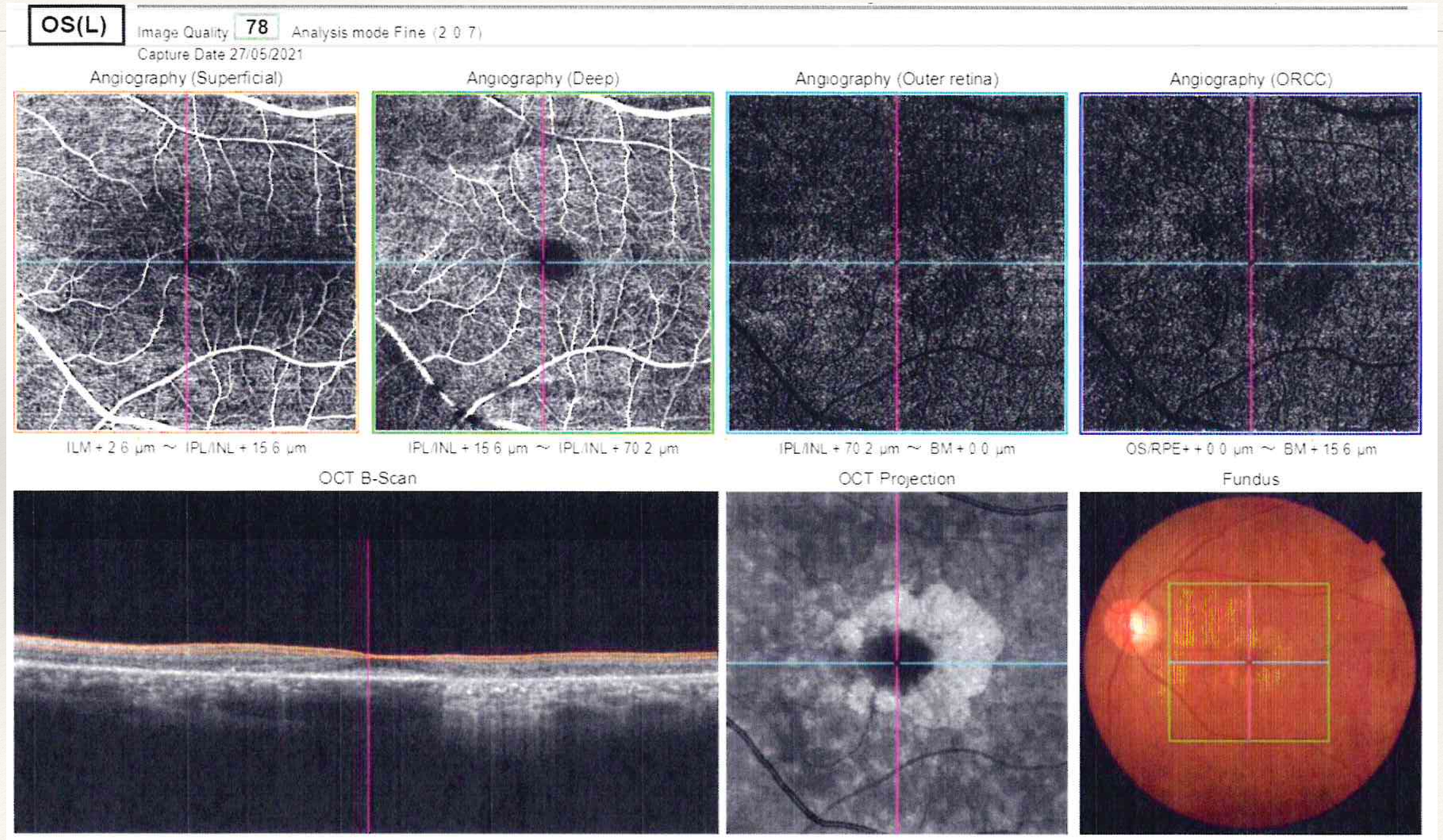
OCTA OD


OD(R)
Image Quality 73
Analysis mode Fine (2 0 7)
Capture Date 27/05/2021
Angiography (Superficial)
Angiography (Deep)
Angiography (Outer retina)
Angiography (ORCC)
ILM + 2 6 µm ~ IPL/INL + 15 6 µm
IPL/INL + 15 6 µm ~ IPL/INL + 70 2 µm
IPL/INL + 70 2 µm ~ BM + 0 0 µm
OS/RPE+ + 0 0 µm ~ BM + 15 6 µm
OCT B-Scan
OCT Projection
Fundus

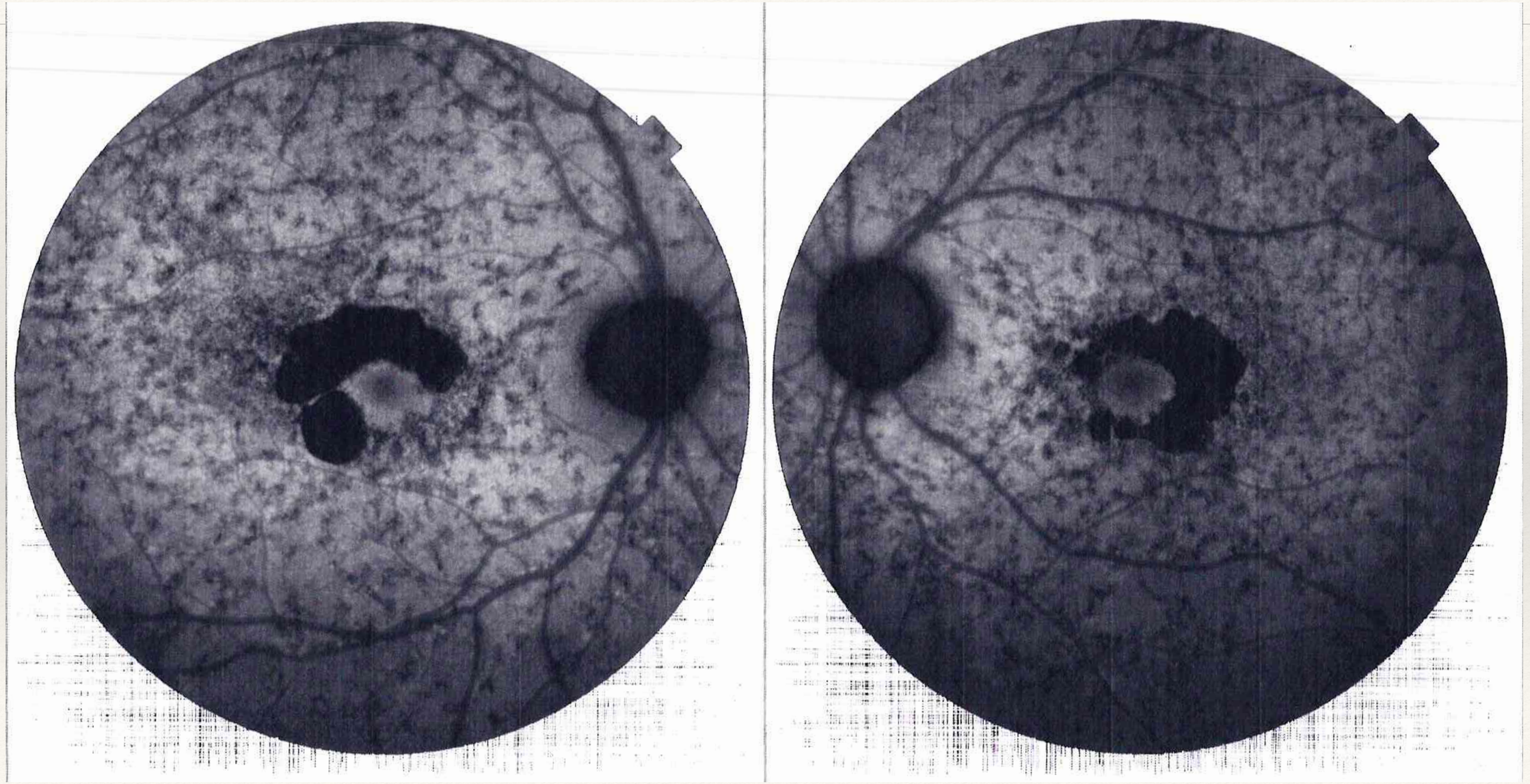
OCT OS


OS(L)
Image Quality 99 Analysis mode Fine (2 0 7)
Capture Date 27/05/2021
Red-free
Dynamic Focus

OCTA OS


OS(L)
Image Quality 78 Analysis mode Fine (2 0 7)
Capture Date 27/05/2021
Angiography (Superficial)
Angiography (Deep)
Angiography (Outer retina)
Angiography (ORCC)
ILM + 2 6 µm ~ IPL/INL + 15 6 µm
IPL/INL + 15 6 µm ~ IPL/INL + 70 2 µm
IPL/INL + 70 2 µm ~ BM + 0 0 µm
OS/RPE+ + 0 0 µm ~ BM + 15 6 µm
OCT B-Scan
OCT Projection
Fundus

Fundus Autofluorescene



Dx. Stargardt's Disease Stage I with Foveal sparing

Epidemiology&Genetic

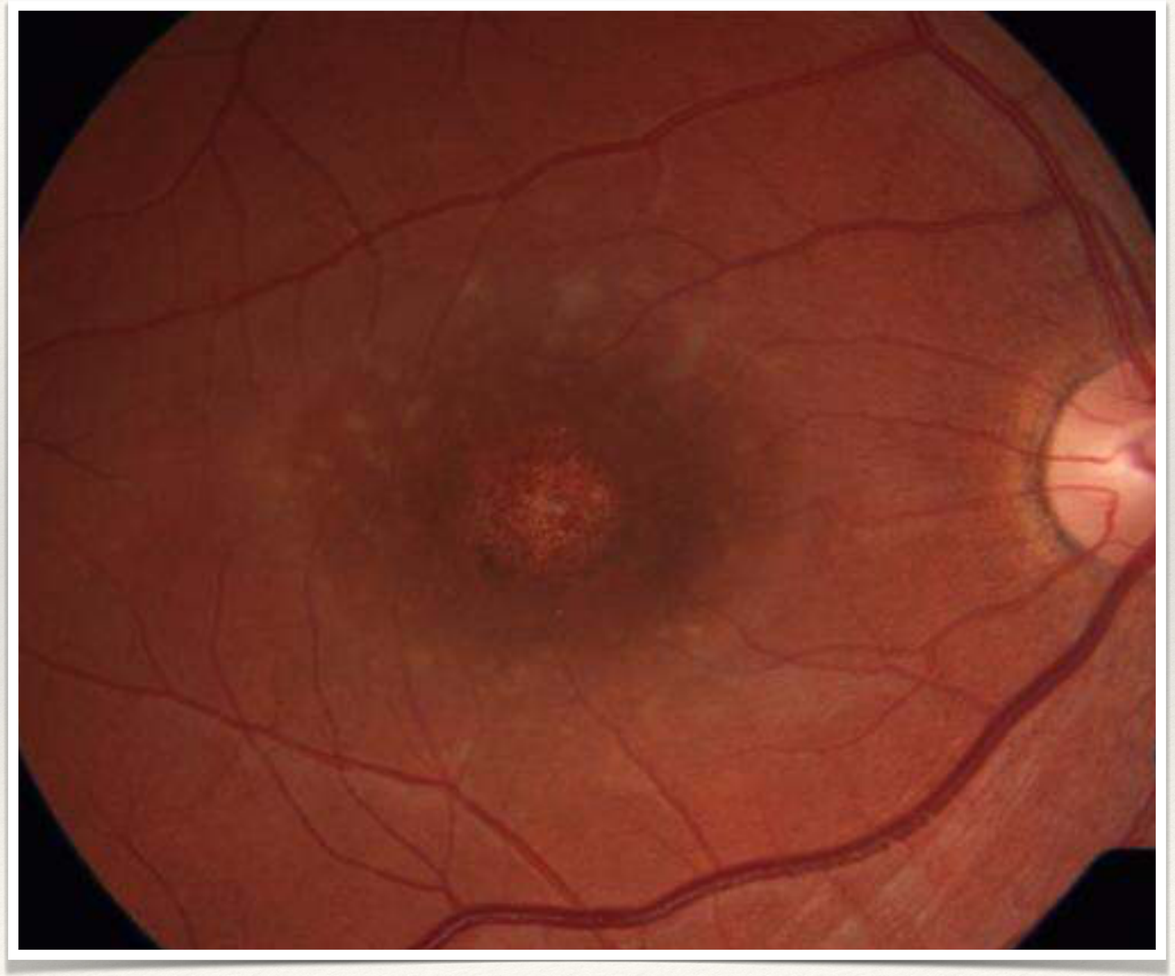
- STGD is the most commonly inherited childhood and adulthood maculopathy.
- It has a prevalence of 1 in 10,000.
- Stargardt Disease (STGD) is most commonly caused by mutations in the **ABCA4 gene** located on chromosome 1 and is inherited in an **autosomal recessive** manner.
- Mutations in this gene result in accumulation of N-retinylidene-N-retinyl-ethanolamine (A2E), a component of lipofuscin that is known to be toxic to RPE and photoreceptors.

Clinical Findings

- Patients with STGD typically present in childhood or early adolescence, but some may present in later adulthood.
- Initial symptoms include bilateral central visual loss characterized by blurred vision, central scotomas, and/or dyschromatopsia.
- The visual acuity (VA) at presentation **varies from 20/20 to 20/400**, with earlier age of onset having a worse visual prognosis.

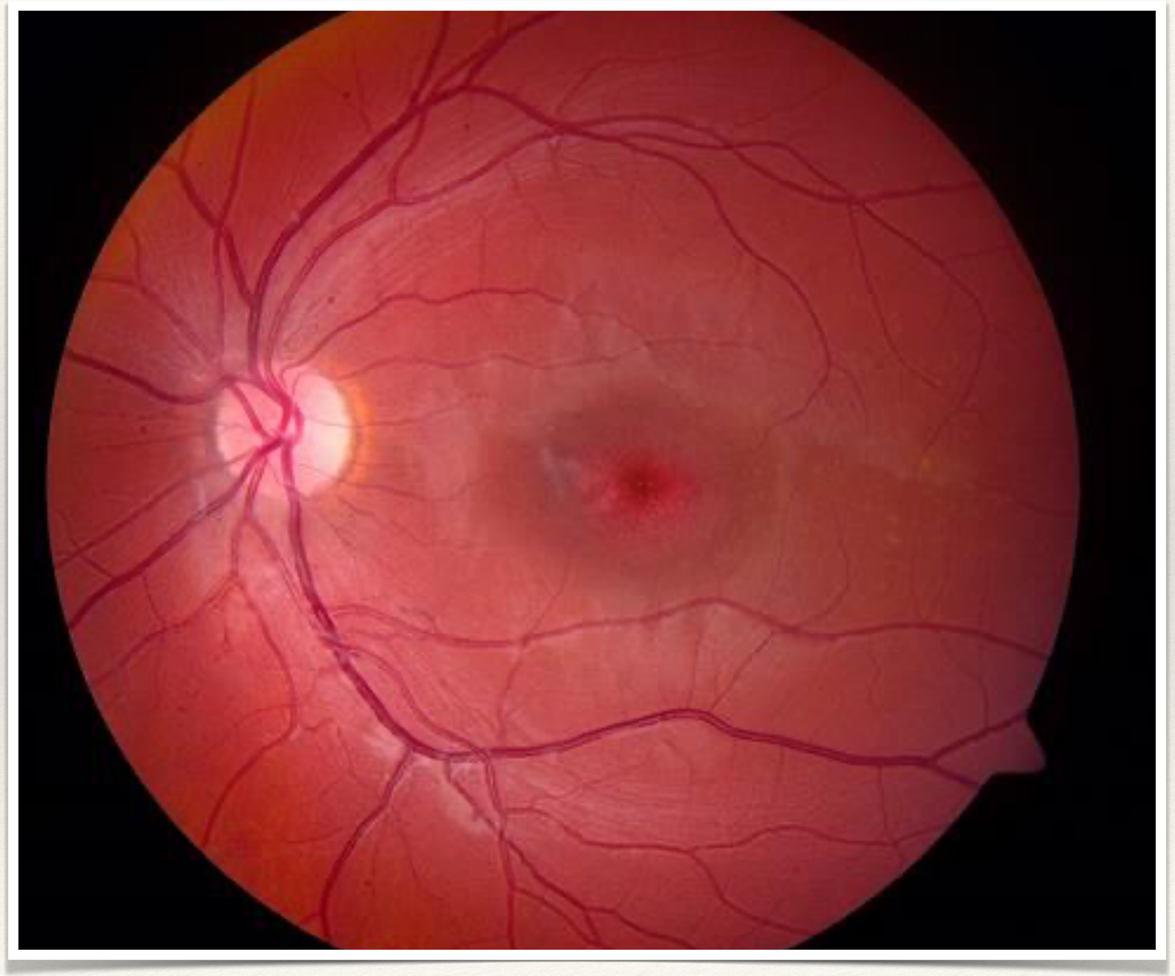
Clinical Findings

- In up to two-thirds of patients, the macula is classically described as “beaten bronze metal” appearance with yellowish, “fish-tail” or pisciform lesions in up to two-thirds of patients
- Interestingly, classic flecks are absent in approximately 30% of patients with childhood onset disease.



Clinical Findings

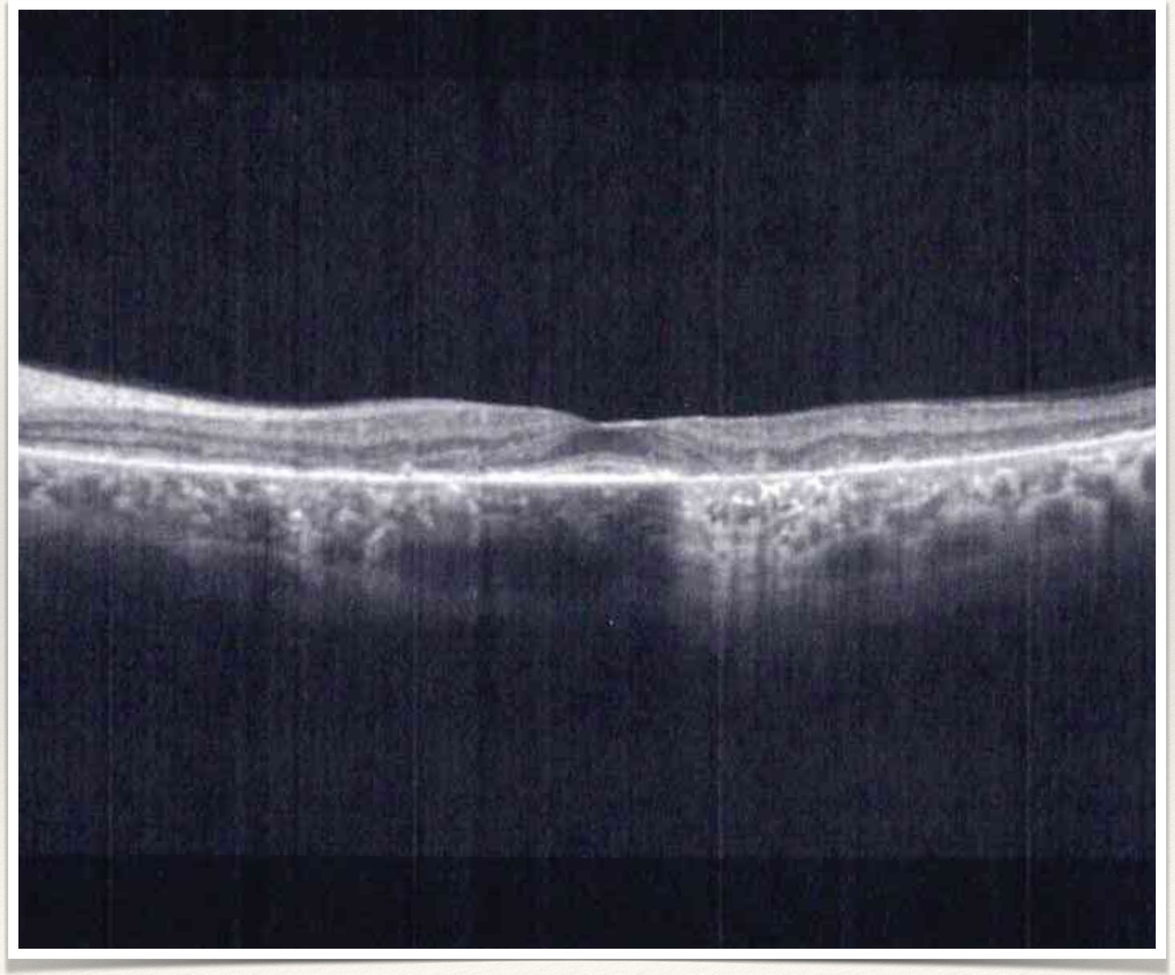
- The maculopathy then progresses slowly to a characteristic atrophic macular degeneration classically resulting in a “bull’s eye” pattern.



Investigation

Spectral-Domain Optical Coherence Tomography (SD-OCT)

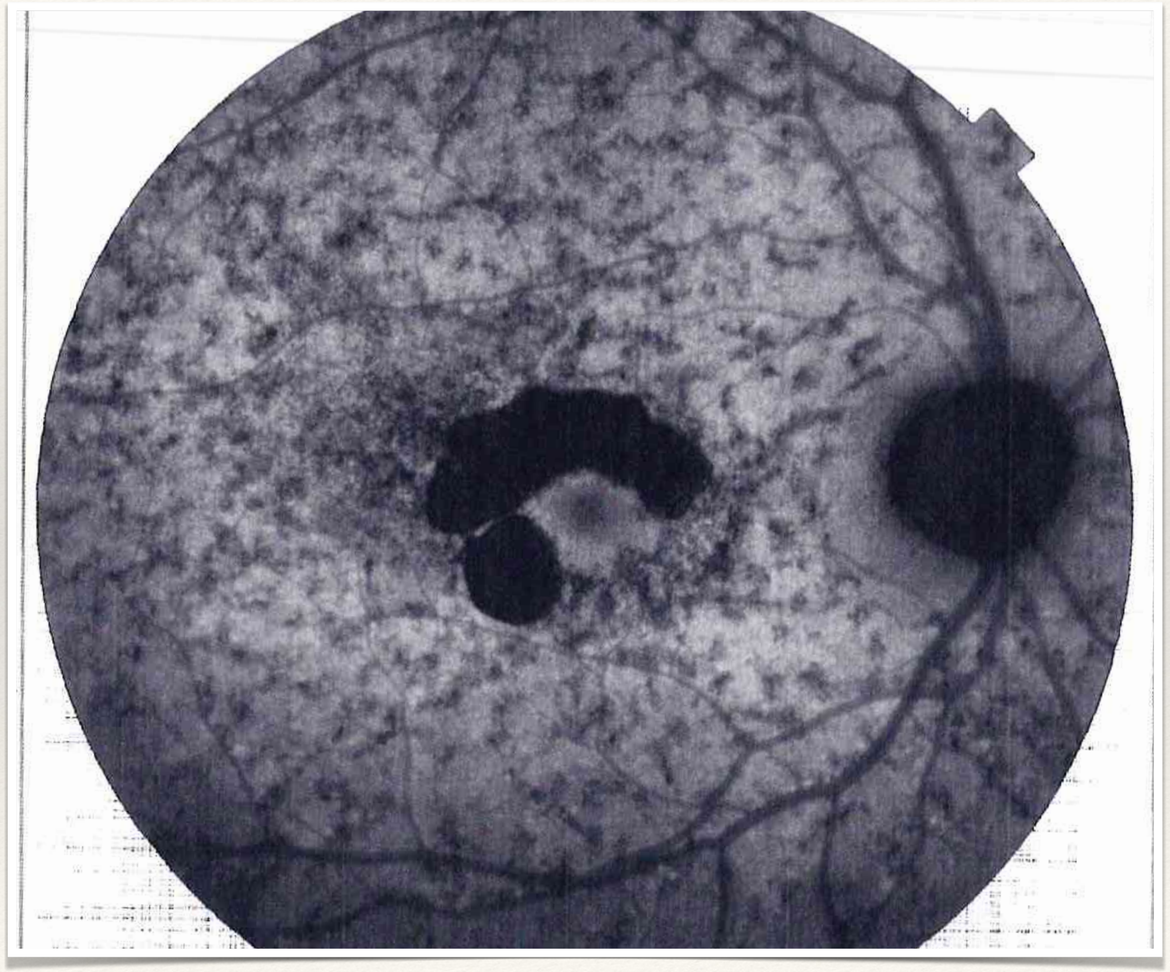
- The hallmark of STGD is outer retinal foveal atrophy and loss of the inner ellipsoid band
- The earliest OCT finding in children is thickening of the external limiting membrane prior to outer retinal atrophy.



Investigation

Fundus Autofluorescence (FAF)

- It allows early identification of RPE pathology prior to clinical manifestations.
- There is initially a hyperautofluorescent signal, which is likely due to lipofuscin accumulation in the RPE, progressing over the disease course to hypoautofluorescence, which is thought to result from RPE death.



Progression

- VA in STGD is highly correlated with both the diagnostic stage and the patient age at the initial diagnosis.
- In general, stage 1 STGD patients have VA better than 20/200, while those in stages 2, 3, and 4 have a VA of 20/200 of worse.
- In particular, patients initially diagnosed before the age of 20 years have an average VA decline from 20/ 40 to 20/200 over a follow-up period of 7 years.
- In contrast, VA decline is less progressive in those presenting between ages 21-40 and 41-60 years, whose VA declines over approximately 22 and 29 years, respectively.
- Not surprisingly, patients with foveal sparing have a VA of 20/40 or better.

Treatment

- Currently, **there is still no proven treatment** to halt or reverse STGD-related maculopathy.
- Early diagnosis is essential for low vision interventions, vocational and educational modifications, and family planning.
- Several promising treatment options are being investigated in humans. Essentially, the treatment options targeting STGD maculopathy are gene replacement therapies, stem cells therapies, or pharmacologic therapies.

Aeromedical Consideration

- **UNFIT for Class 1 Medical Certificate**
  - Due to Central Scotoma in Visual Field of Both Eyes
- Deferred to Board of Aeromedical Specialist for Special Issuance
  - Condition: Medical Flight Test

Medical Flight Test

Medical Assessor

- AM.Manop Chitcharas, M.D.
- Wg.Cdr. Taechit Mirasena, M.D.

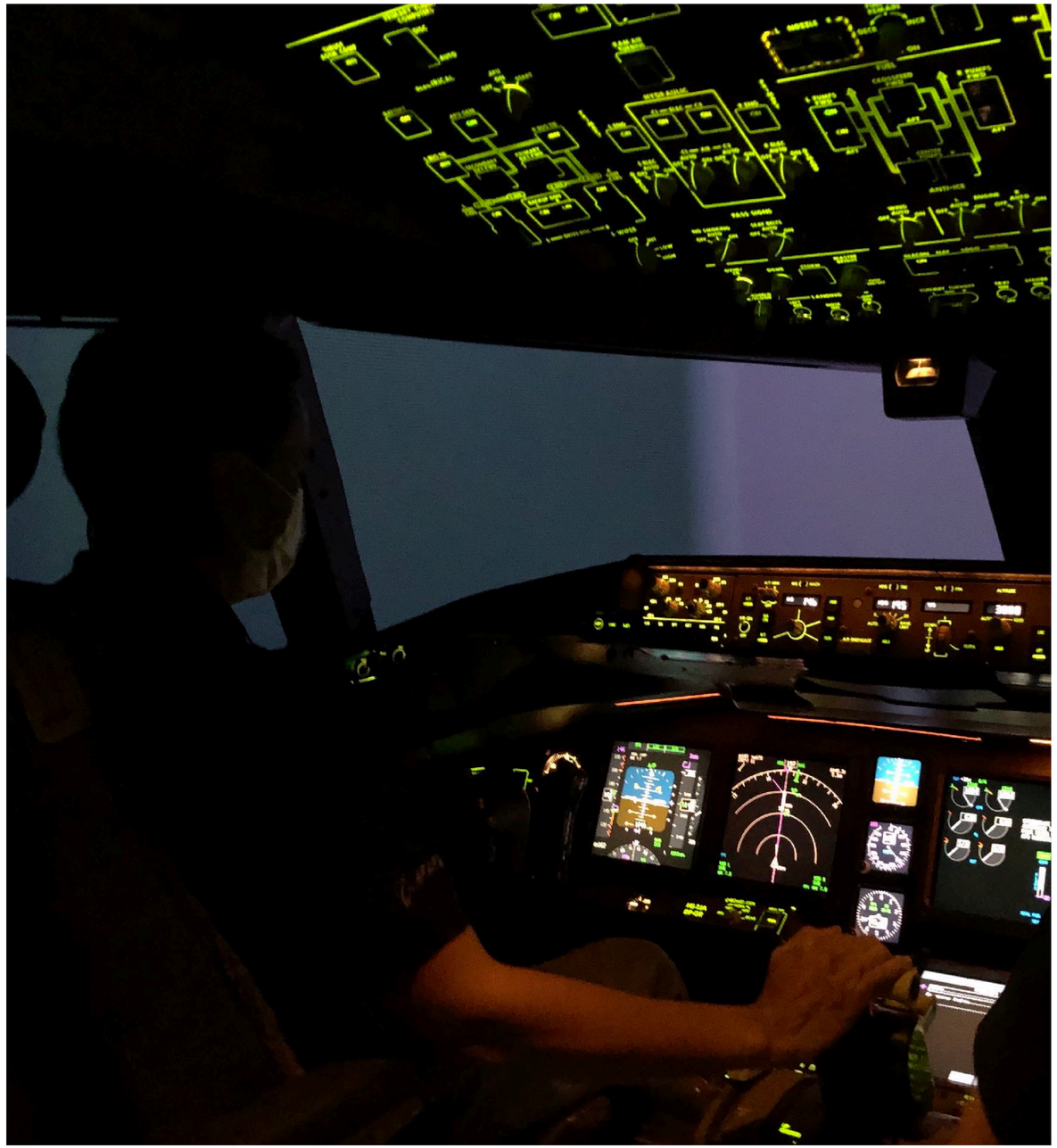
Flight Assessor

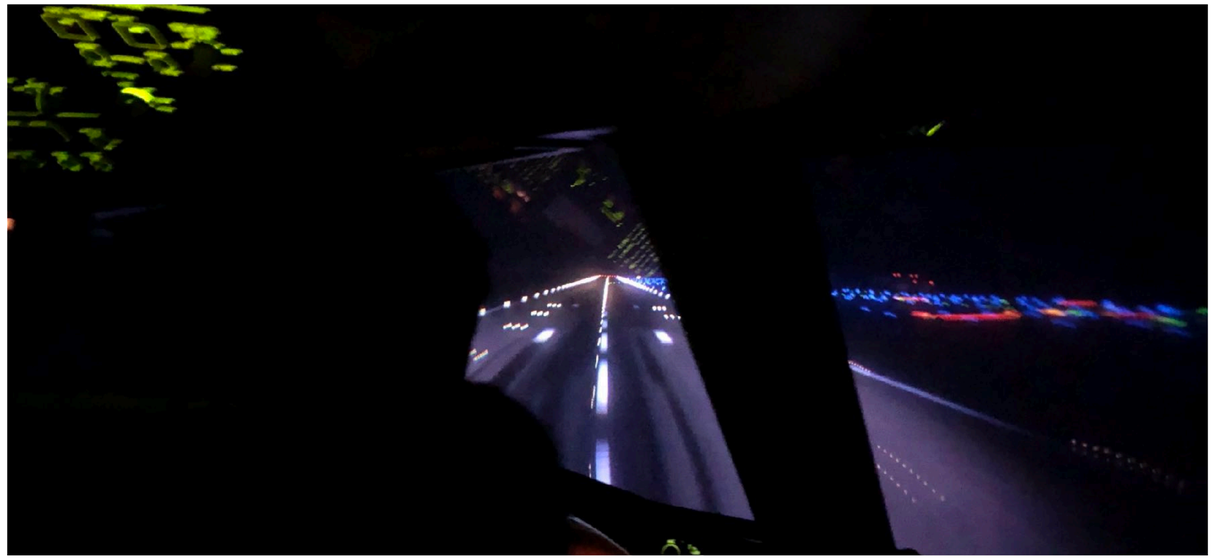
- Captain Noppon Wilairat, M.D.
- Chakatat Chiemchan, M.D.

Condition for testing

- Manual approach and landing in very low visibility&contrast
- Manual approach and landing in night


147
195
3000





Aeromedical Consideration

- **UNFIT for Class 1 Medical Certificate**
  - Due to Central Scotoma in Visual Field of Both Eyes
- Medical Flight Test: **PASSED**
- **Special Issuance with Limitations**
  - **OML (Valid only as or with qualified co-pilot)**
  - **RXO (Special ophthalmological examination) - CTVF, OCT, FAF q1yr**

Case 2: Be color safe in Aviation - How much?

6.2.4 Colour perception requirements

6.2.4.1 Contracting States shall use such methods of examination as will guarantee reliable testing of colour perception.

6.2.4.2 The applicant shall be required to demonstrate the ability to perceive readily those colours the perception of which is necessary for the safe performance of duties.

6.2.4.3 The applicant shall be tested for the ability to correctly identify a series of pseudoisochromatic plates in daylight or in artificial light of the same colour temperature such as that provided by CIE standard illuminants C or D_{65} as specified by the International Commission on Illumination (CIE).

6.2.4.4 An applicant obtaining a satisfactory result as prescribed by the Licensing Authority shall be assessed as fit. An applicant failing to obtain a satisfactory result in such a test shall be assessed as unfit unless able to readily distinguish the colours used in air navigation and correctly identify aviation coloured lights. Applicants who fail to meet these criteria shall be assessed as unfit except for Class 2 assessment with the following restriction: valid daytime only.

Note.— Guidance on suitable methods of assessing colour vision is contained in the Manual of Civil Aviation Medicine *(Doc 8984).*

ICAO Annex 1 12th Edition 2018
6.2 Requirements for Medical Assessments

History

Male Pilot age 73, PPL

- Initial examination on 26 March 1990, age 39, at IAM RTAF
- Record in initial examination Report
  - Color blindness
  - Lantern test pass, could differentiate emergency light
  - Color defect - SAFE
  - Fit for class 2
  - Limitation - corrective lens for distant and near vision are required

Lantern test

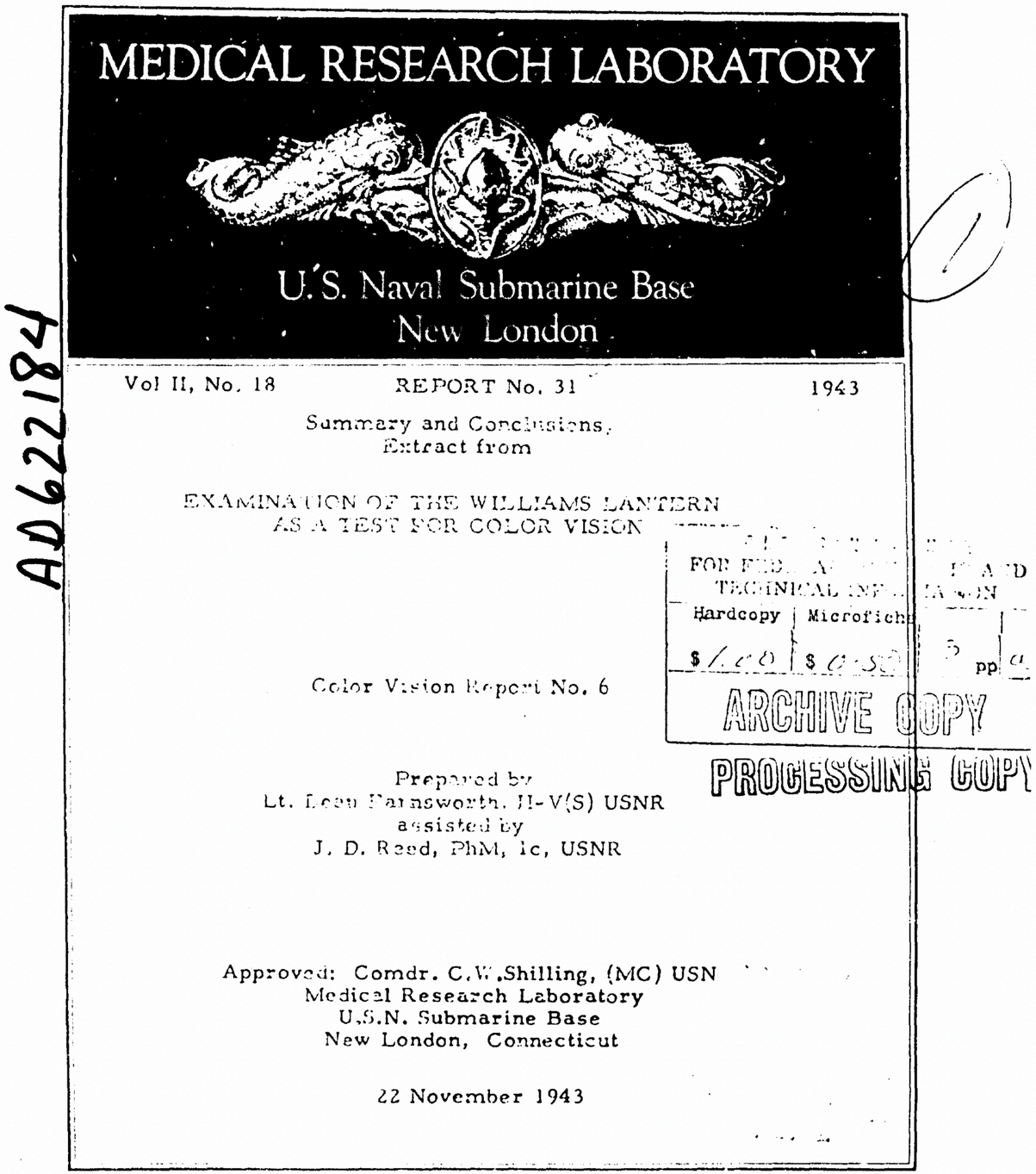
First color vision test ever

- In the second half of the 1800's, several spectacular train wrecks occurred
- This led to the discovery that some of the people responsible for these trains were color blind
- In 1899, ophthalmologist, Dr. Charles H. Williams of Boston constructed a lantern to test the color vision of railway men

Lantern test
Research study

- In 1943 the US Navy tested this lantern for suitability of detecting color deficiencies and found it
  - Difficult to interpret. Normal observers made similar responses
  - Possible correlated poorly with present standard tests
  - Awkward and confusing to opeate
- It is entirely unsuited for Navy use

Farnsworth D .*Examination of the williams lantern as a test for color vision.* US Naval Medical research laboratory report no.31;1943



MEDICAL RESEARCH LABORATORY

U.S. Naval Submarine Base
New London

AD622184

Vol II, No. 18 REPORT No. 31 1943

Summary and Conclusions,
Extract from

EXAMINATION OF THE WILLIAMS LANTERN
AS A TEST FOR COLOR VISION

Color Vision Report No. 6

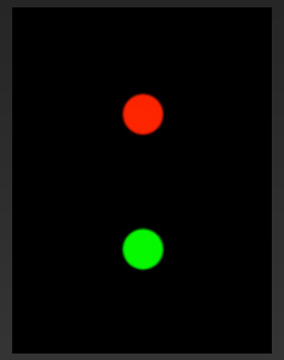
Prepared by
Lt. Dean Farnsworth, USNR-V(S) USNR
assisted by
J. D. Reed, PhM, 1c, USNR

Approved: Comdr. C.W.Shilling, (MC) USN
Medical Research Laboratory
U.S.N. Submarine Base
New London, Connecticut

22 November 1943

FALANT

Farnsworth Lantern Test



Farnsworth Lantern (FALANT)

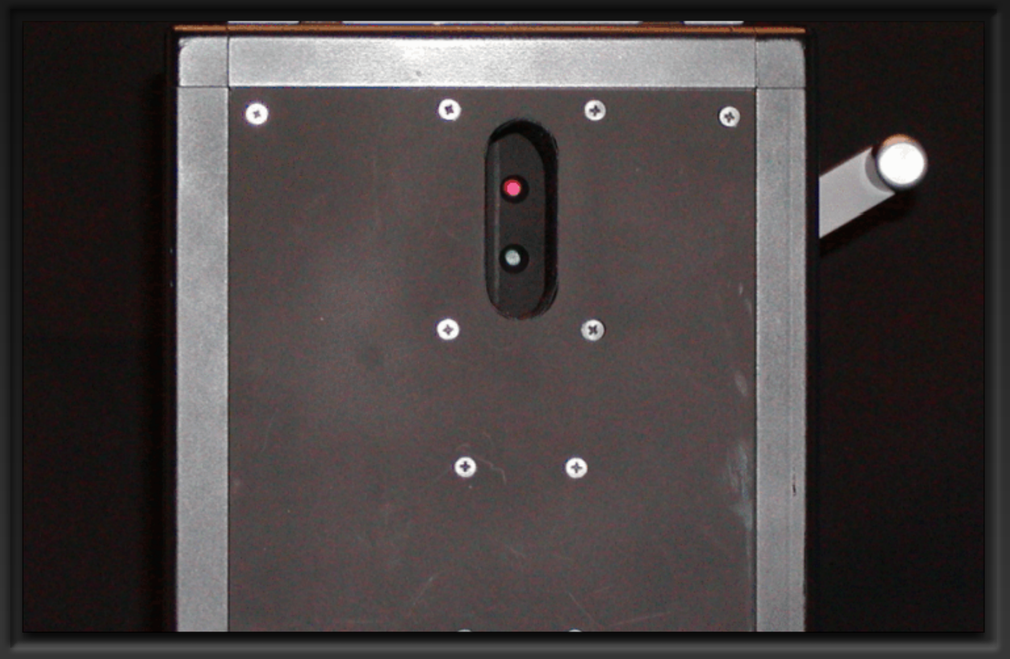
- After its adoption by the United States Navy in 1954 as the standard color vision test for seamen, it has additionally been used to screen pilots.
- It was designed to qualify 20% of color deficiencies but recent studies have shown it to pass much more severe defects
- The US Air Force discontinued use of the FALANT in 1993 due to its frequent failure to identify cases of color deficiency considerably more serious than the test was intended to let pass

Lantern testing with a Spectrolux, Beynes or Holmes-Wright lantern. This test is considered passed if the applicant passes without error a test with accepted lanterns.

EASA AMC to Part-MED 2019
AMC1 MED.B.075 Colour vision (Class 1)

Holmes Wright

Beynes



Spectrolux

The applicants who failed Ishihara test shall be evaluated with secondary tests approved by Aeromedical Department, CAAT (Anomaloscopy or **Color Lanterns**) to ensure that they have adequate color perception which is necessary for the safe performance of duties.

CAAT Standards for Medical Certificate 2019 (Old Version)
Appendix 2 Number 2.14 - Color vision standards

Application in real life!

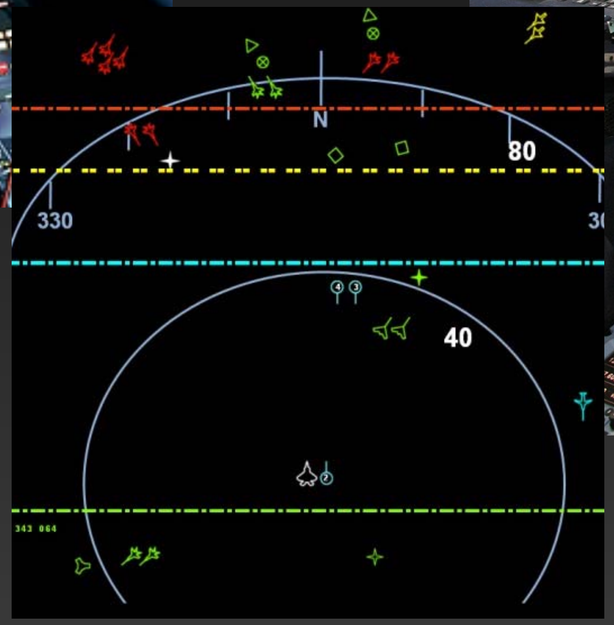
Is it safe enough???

The cockpit of the past

Only simple color indicator

...and Nowadays

Multispectral color display



Even in the private aircraft

Shark Aero - Diamond DA42

Airport Runway Lighting

Multicolor light signal

Airport Runway Lighting

The most important - PAPI

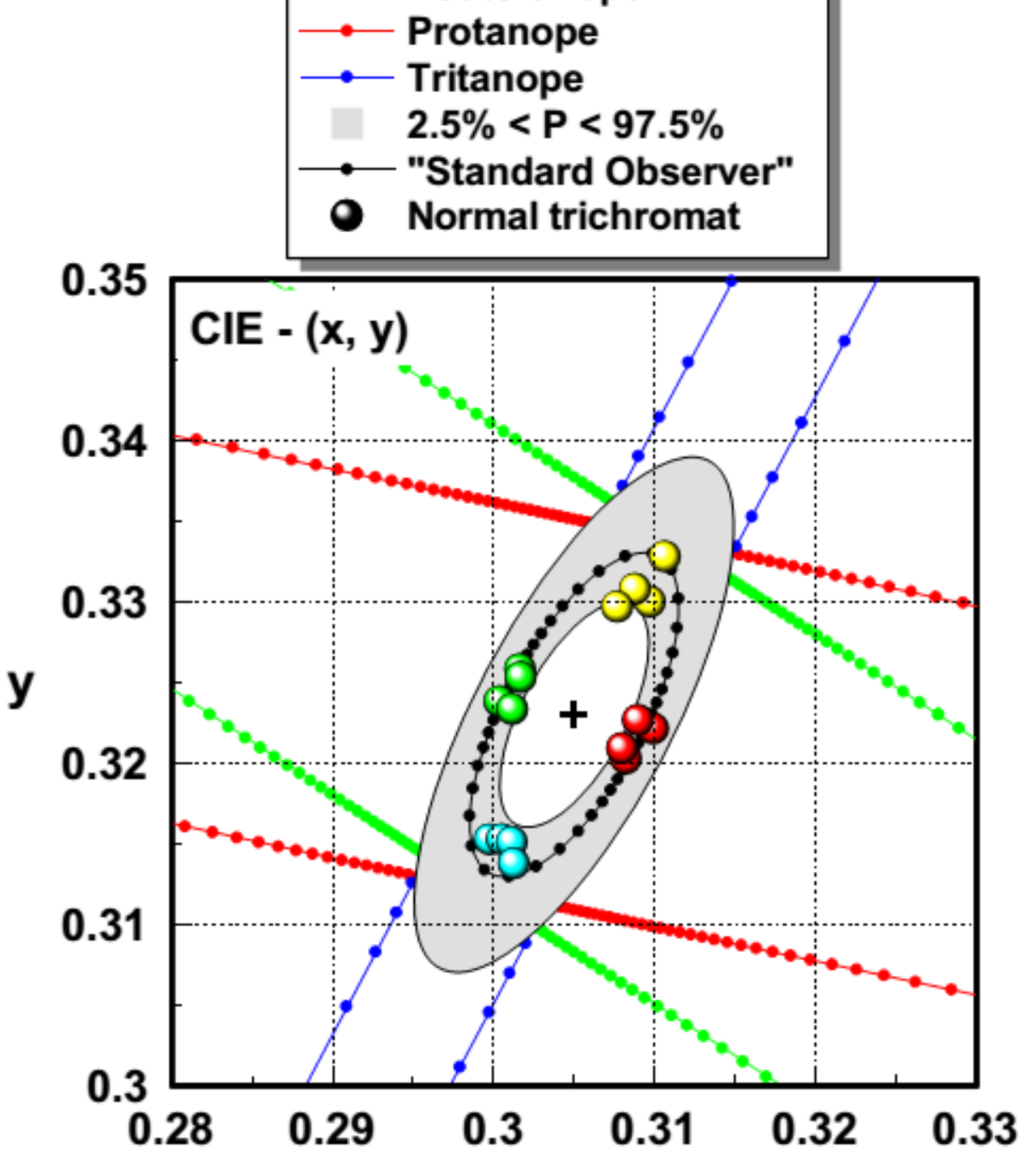
The crash of FedEx flight 1448 (a Boeing 727) in Tallahassee, Florida in July 2002

CAD Test

Color Assessment and Diagnosis Test

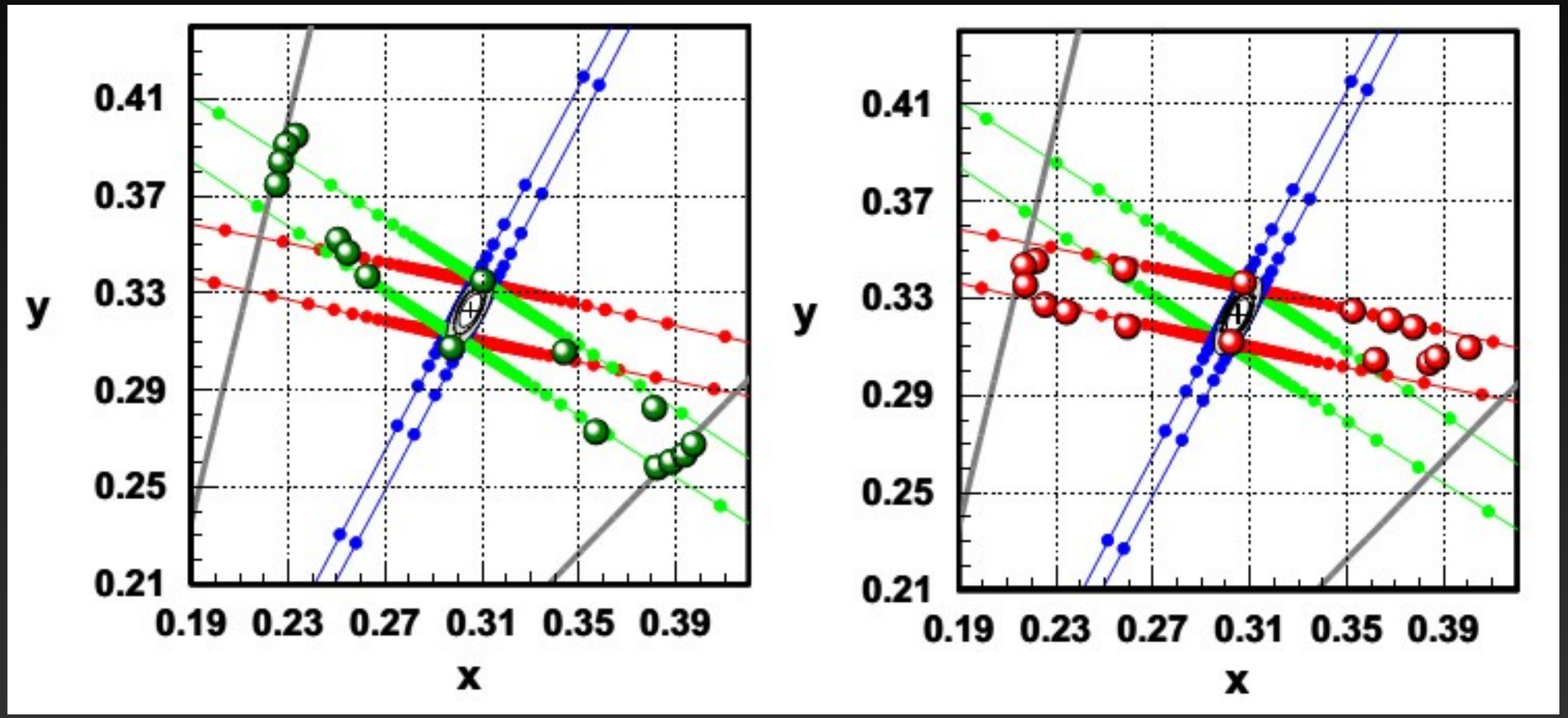
Scoring CAD
CIE 1931 Diagram

- Chromatic discrimination thresholds have been measured in 250 normal trichromats and 200 color deficiency observers
- The median threshold value is the **Standard Normal (SN)** observer
- A subject's thresholds can be expressed in SN units and this makes it possible to assess the severity of color vision loss



Interpretation of CAD

Severe deficiency



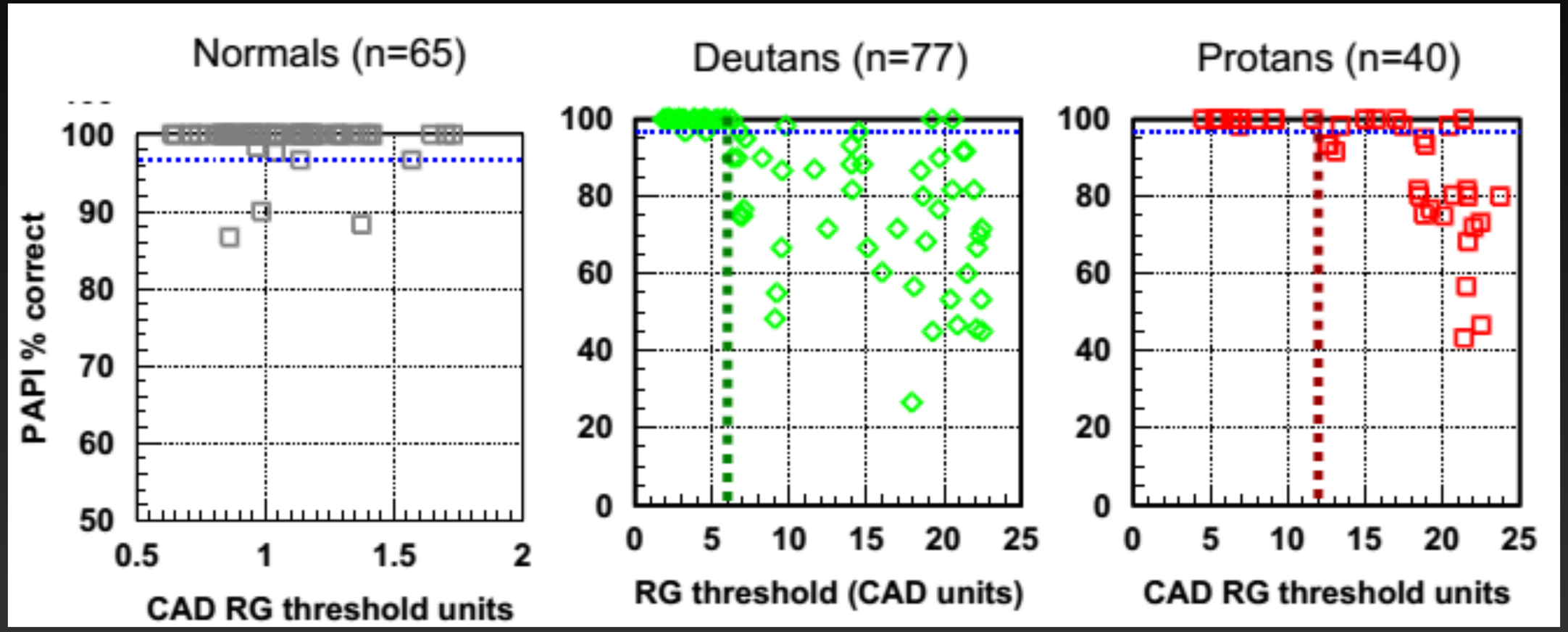
Deuteranopia

Protanopia

Civil Aviation Authority. *Minimum Colour Vision Requirements for Professional Flight Crew: Recommendations for new colour vision standards.* PAPER 2009/04. Medical Department, Safety Regulation Group, Civil Aviation Authority, West Sussex, UK: May 2009.

CAD Safety Threshold in Aviation

Critical color perception tasks (PAPI)



Approximate 35% of color deficient pilot applicants will pass the CAD test

Civil Aviation Authority. *Minimum Colour Vision Requirements for Professional Flight Crew - Part 2: Task Analysis.* PAPER 2006/04. Medical Department, Safety Regulation Group, Civil Aviation Authority, West Sussex, UK: 14 August 2006

Colour Assessment and Diagnosis (CAD) test. This test is considered passed if the threshold is less than 6 standard normal (SN) units for deutan deficiency, or less than 12 SN units for protan deficiency.

EASA AMC to Part-MED 2019
AMC1 MED.B.075 Colour vision (Class 1)

วันเกิด: 07 เม.ย. 2493
อายุ: 72-5-12 ปี
สิทธิ์ : เงินสด
ชุดตรวจ: 20105 A'S TEST 38 PLATES
เหล่า : นักบิน
สังกัด : ส่วนบุคคล (L/C Class II)
วันที่ตรวจ: 19/09/2565-08:26:11 Pers.

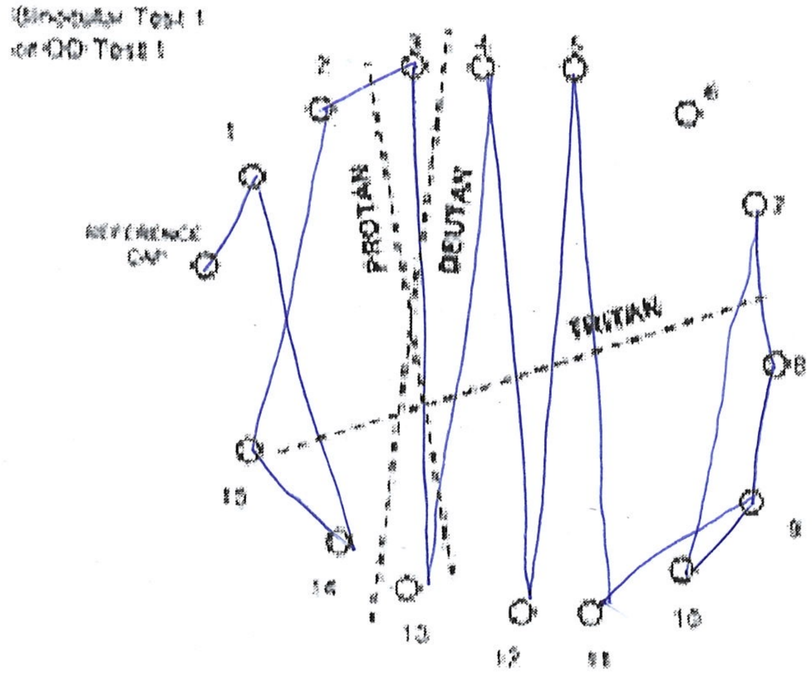
		RG Deficiencies	Person with total color blindness and weakness
1	12	12 ✓	
2	8	-	
3	6	6 ✓	
4	29	13	
5	57	-	
6	5	2	
7	3	3 ✓	
8	15	17	
9	74	21	
10	2	-	
11	6	-	
12	97	-	
13	45	-	
14	5	-	
15	7	-	
16	16	-	
17	73	23	
18	-	37	
19	-	8	
20	-	45	
21	-	23	
22	26	-	
23	42	30	
24	35	-	
25	96	-	

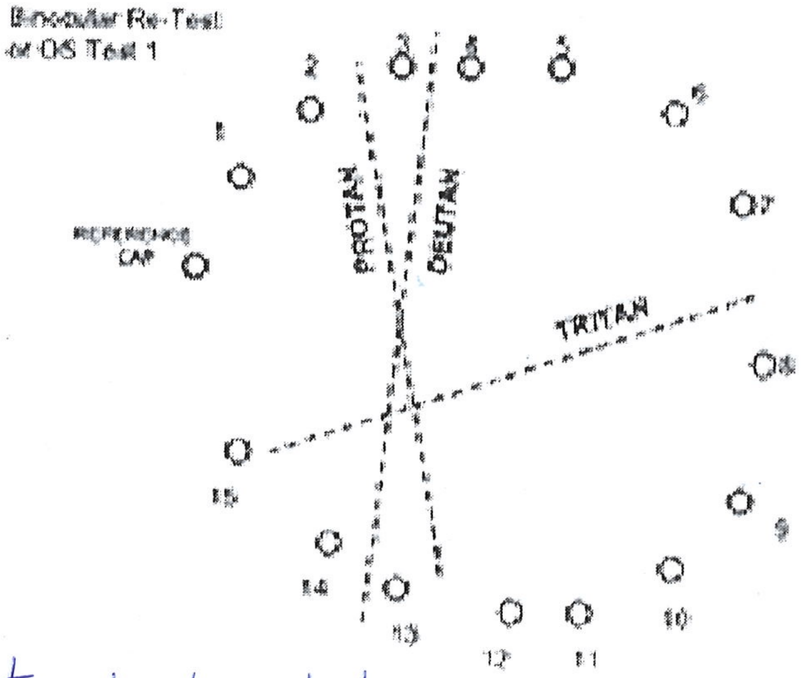
Score Sheet Template for 15 Disc Color Vision Test

Name: _____ DOB: 7/4/2493 Test Date: 21/3/65

Mode: Binocular ✓ or OD ___ OS ___ Tester: Photchara Bamrungrad.

Copy this template onto your medical history or plain paper





* but Lantern test pass

ผลการตรวจ plam ปกติ
OAD screening ปกติ
+ พยาธิสภาพของ

Richmond Products
1600 Silver Ave. SE Albuquerque NM 87106

Richmond Part Number 4478

Summary

Male Pilot age 73, PPL

- Last examination 30 Sep 2022 (Before new regulations was released)
- Record in eye examination report
  - Color deficiency - Failed Ishihara and Farnsworth D-15
  - **Lantern test passed**
  - Fit for class 2
  - Limitation - corrective lens for distant and near vision are required

Those failing the Ishihara test should be examined by Colour Assessment and Diagnosis (CAD) test. This test is considered passed if the threshold is less than 6 standard normal (SN) units for deutan deficiency, or less than 12 SN units for protan deficiency.

Applicants who fail to meet these criteria shall be assessed as unfit except for Class 2 assessment with the following restriction: valid daytime only.

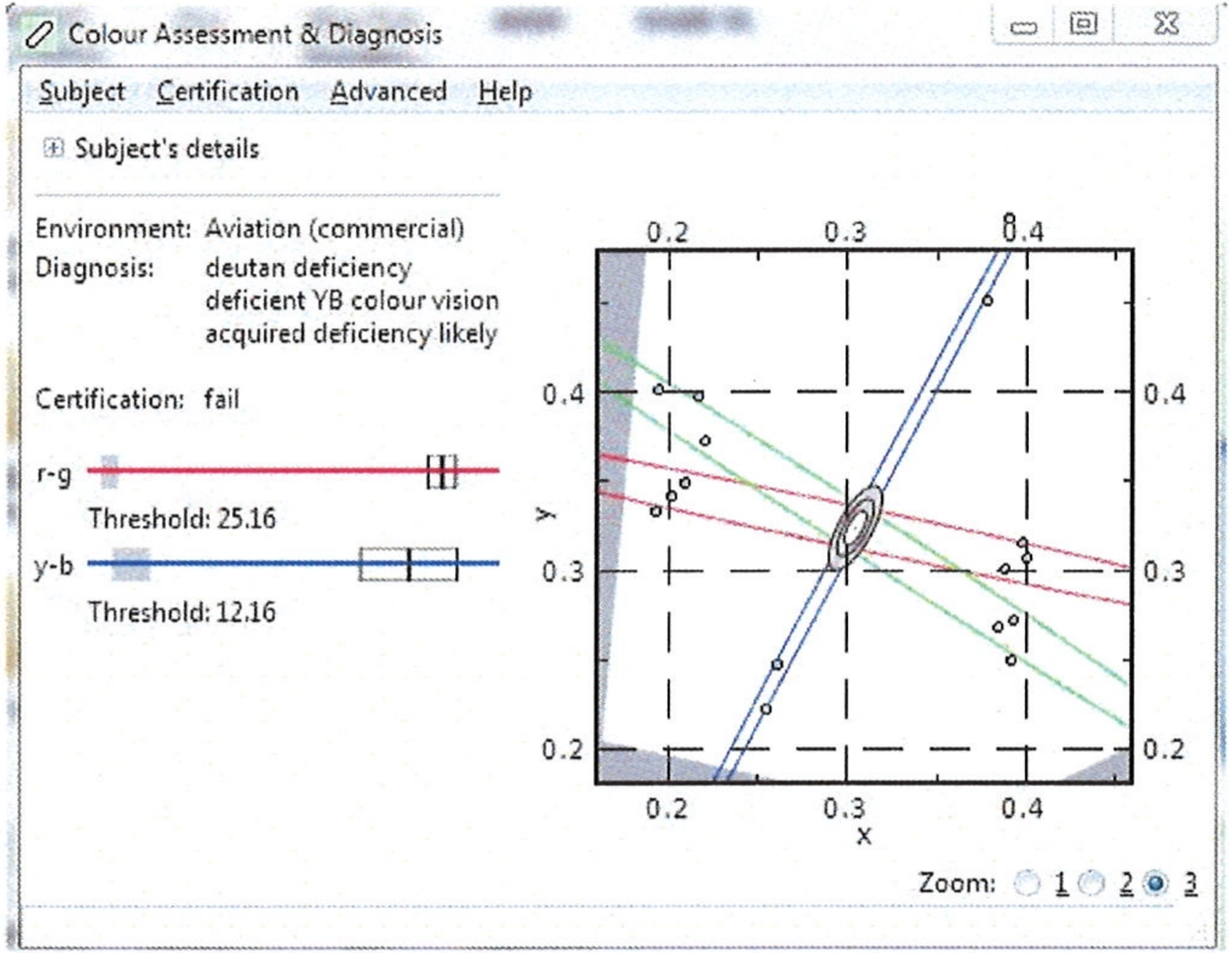
CAAT Standards for Medical Certificate 2022 (Current Version)
Appendix 5 Number 5.15 - Color vision standards

Lastest renewal examination: 29 Mar 2023

Telephone
Email
Comments
Date of test

Results

Environment Aviation (commercial)
Max. RG norm 2.200926018 (SNU)
Max. YB norm 2.371656275 (SNU)
Diagnosis deutan deficiency
deficient YB colour vision
acquired deficiency likely
Certification fail
r-g threshold 25.16 (SNU)
y-b threshold 12.15543556 (SNU)

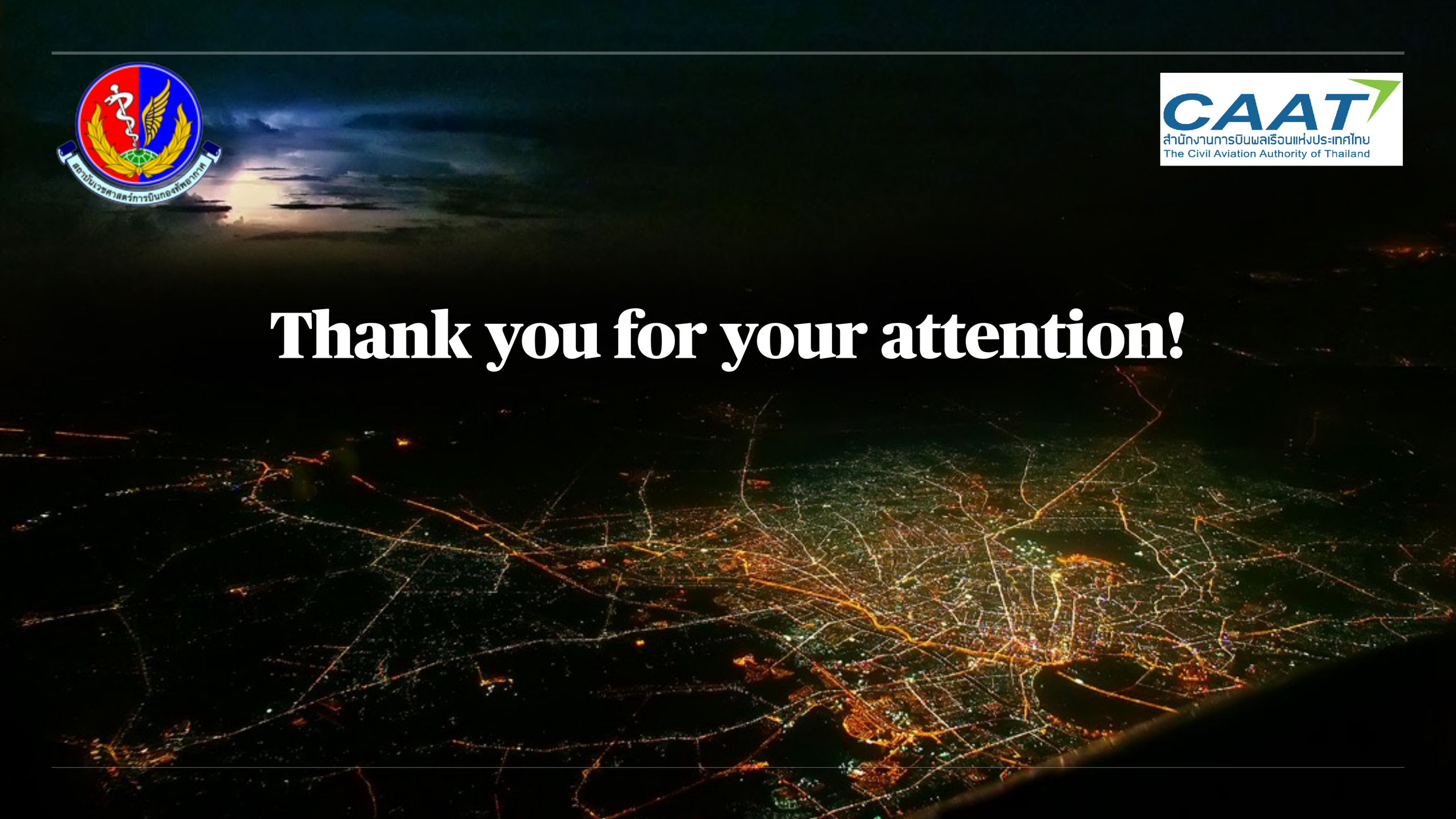


CAD Test - Deutan deficiency 25.16 SNU - Failed

Add Limitation: Valid Daytime Only

A gap between the regulations

Any Questions?



Thank you for your attention!