The Schwind Amaris 1050RS 7D Predictive EyeTracking and its Influence on Clinical Results

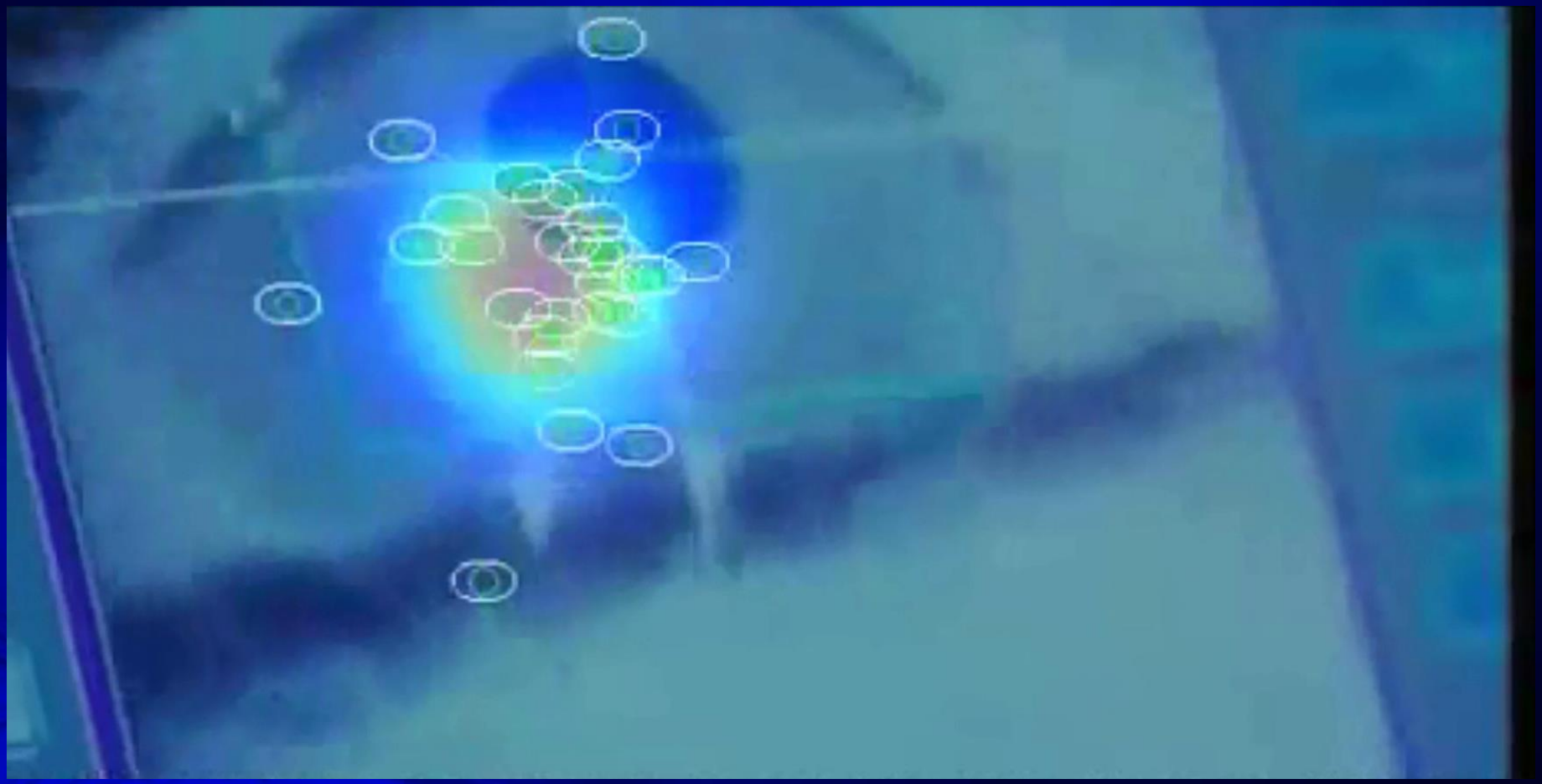
I am a Consultant for
Schwind Eye-Tech-Solutions

What Does Speed Give You?

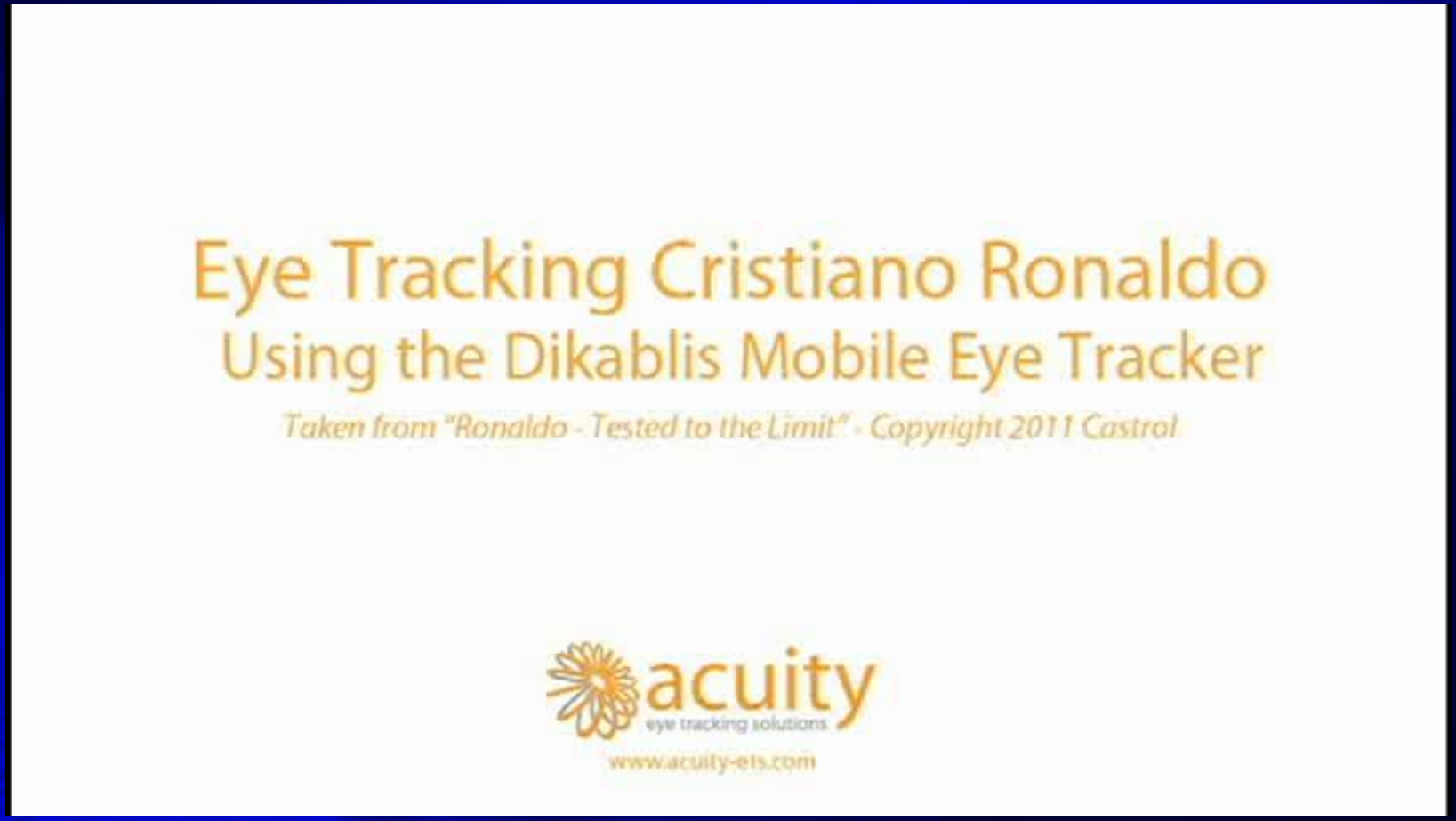
- Shorter Treatments Times
  - Better Comfort
  - Keeping Still for a Short Time is Easy
- Less Dehydration of the Cornea
  - Less Environmental Influence
  - Better Consistency of Results (?)

But You Need a Super Eye Tracker!

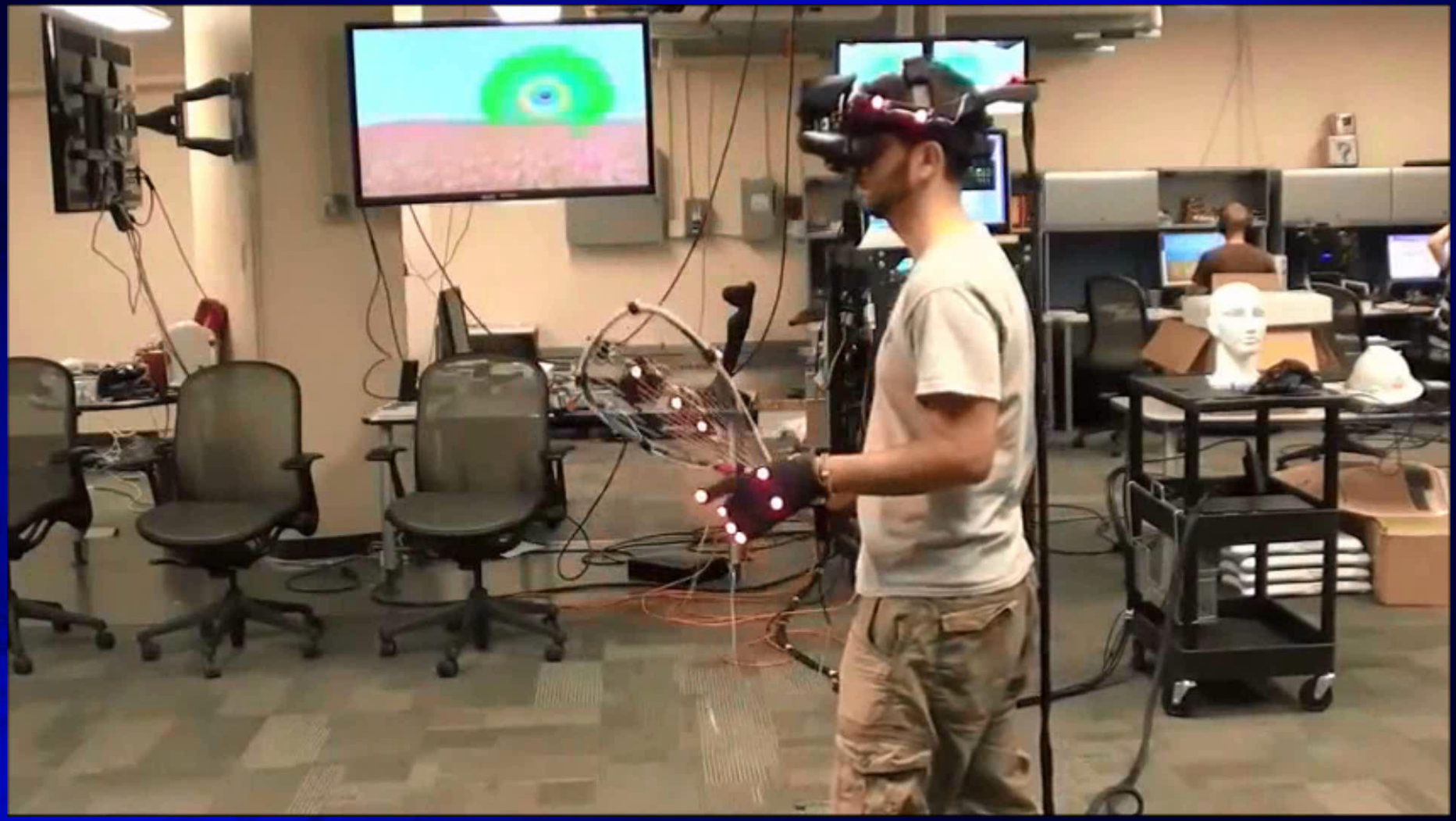
How the Eyes Move

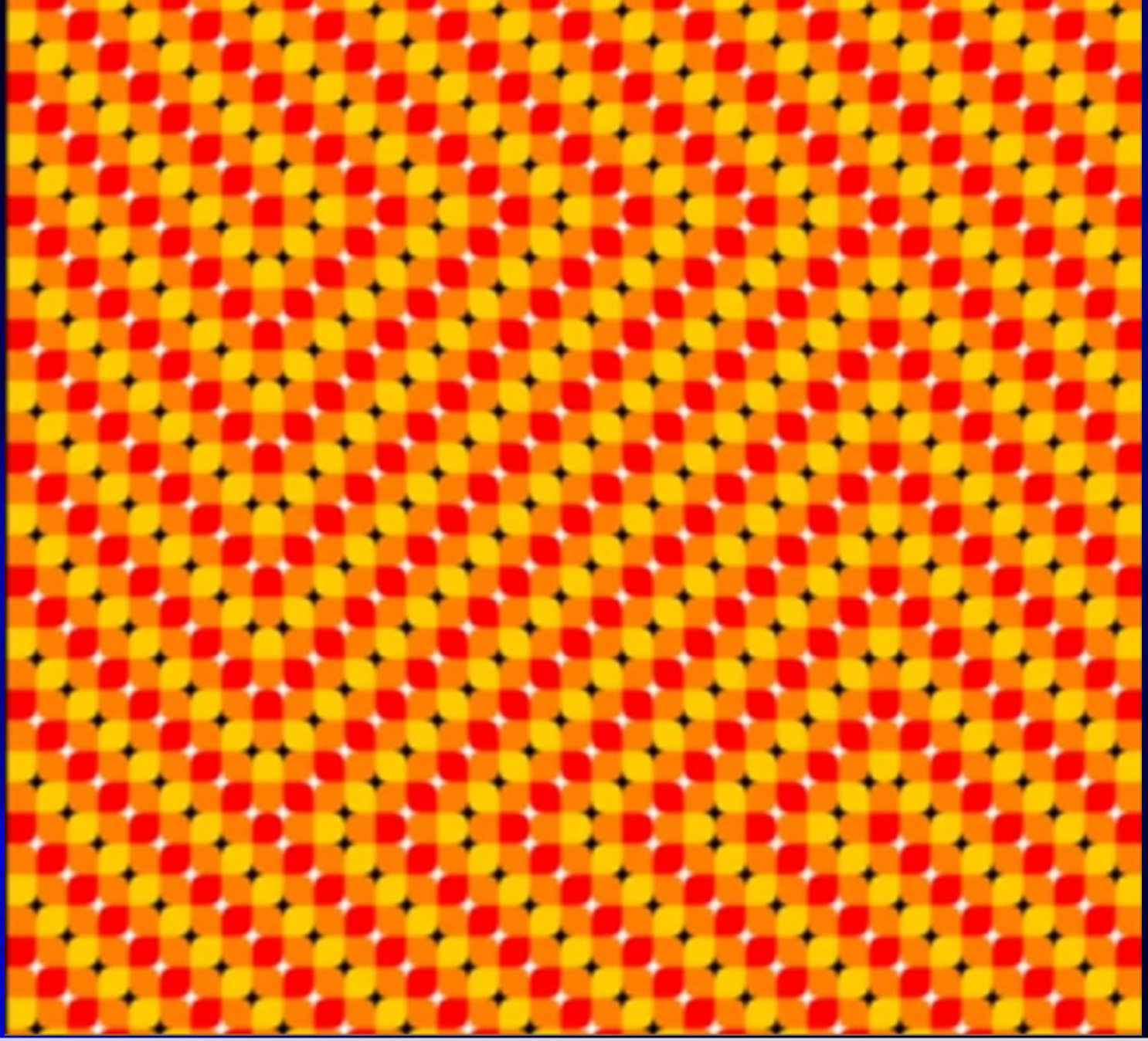


Cristiano Ronaldo

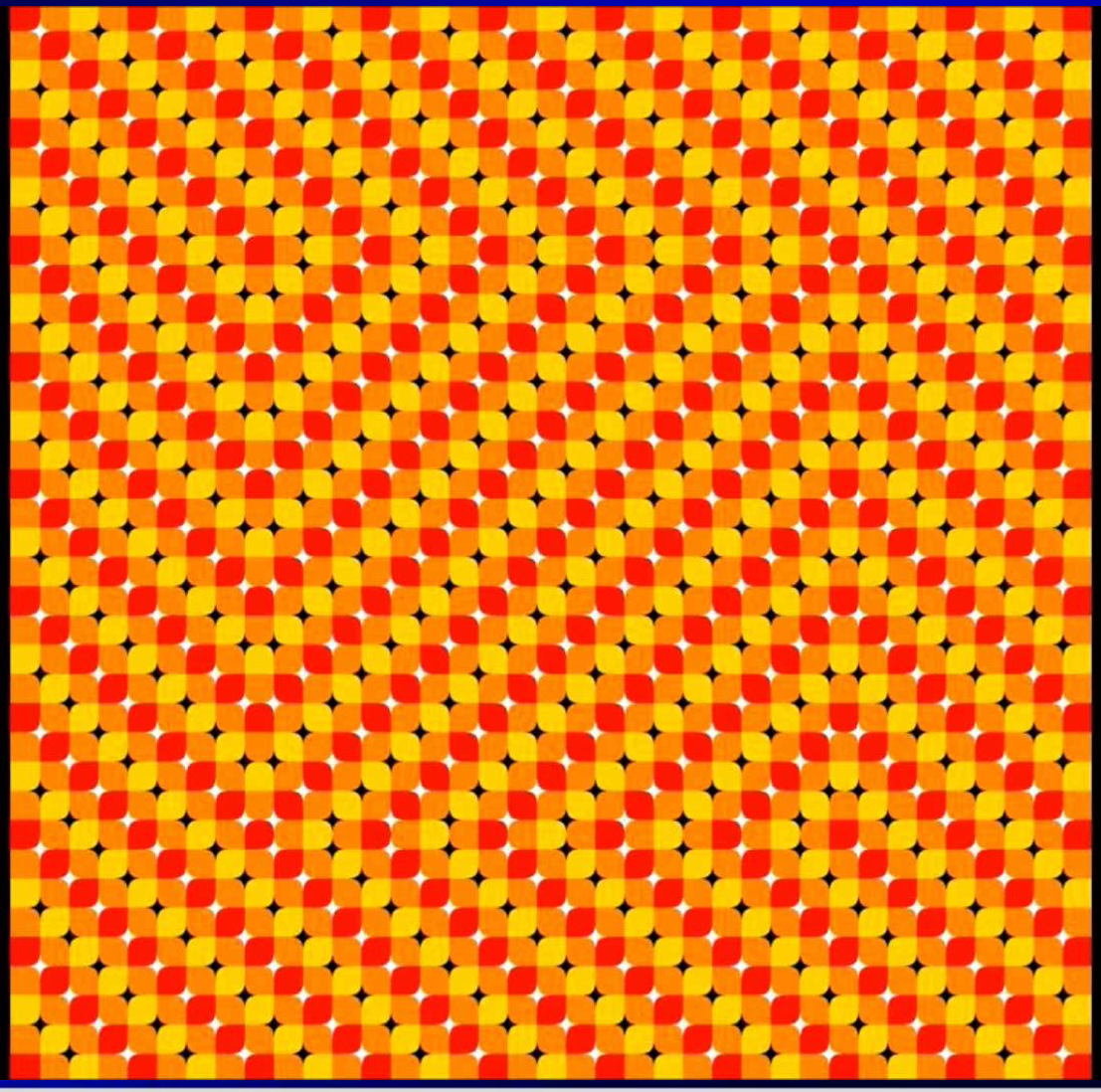


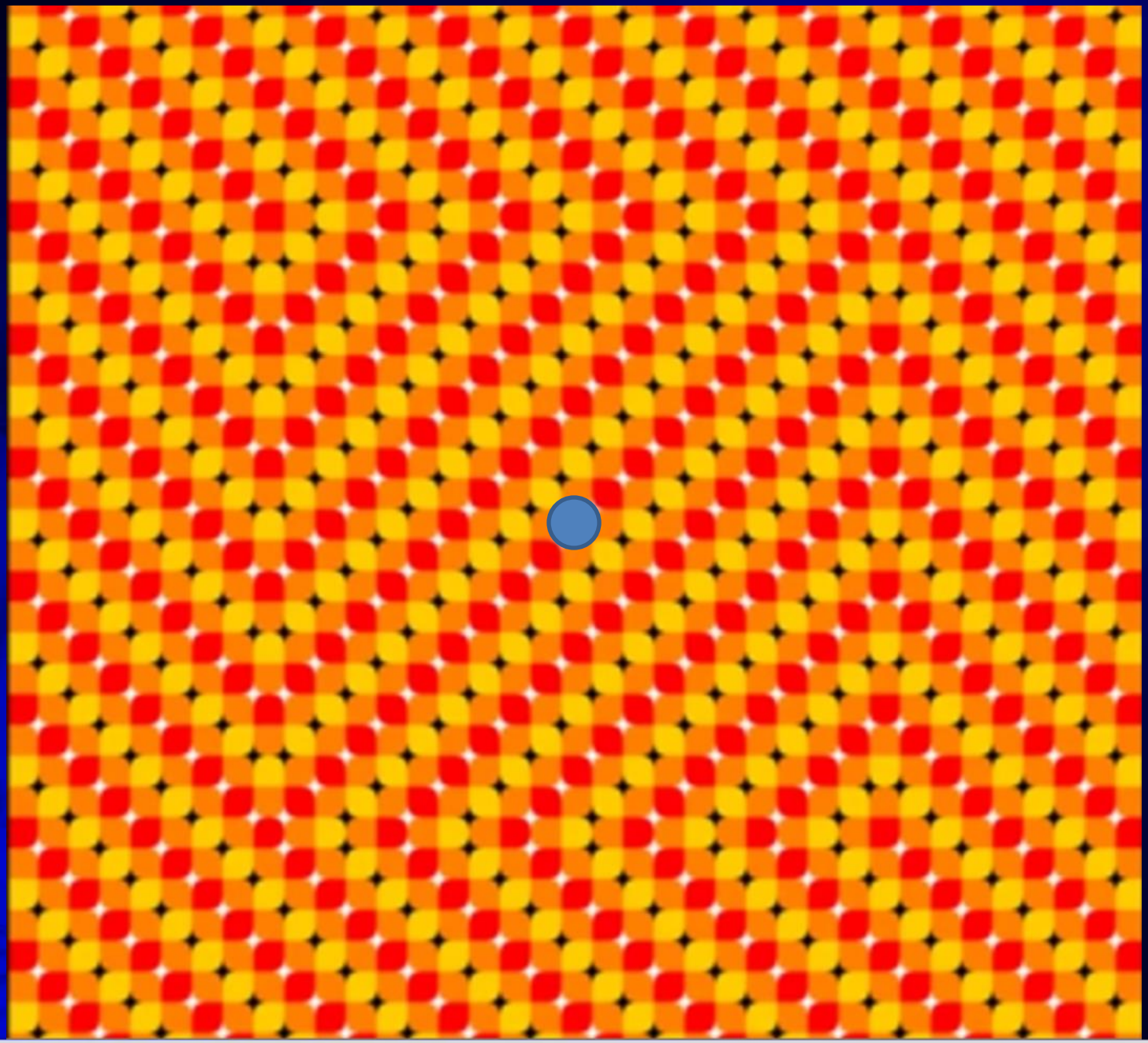
Fixation of the Eye



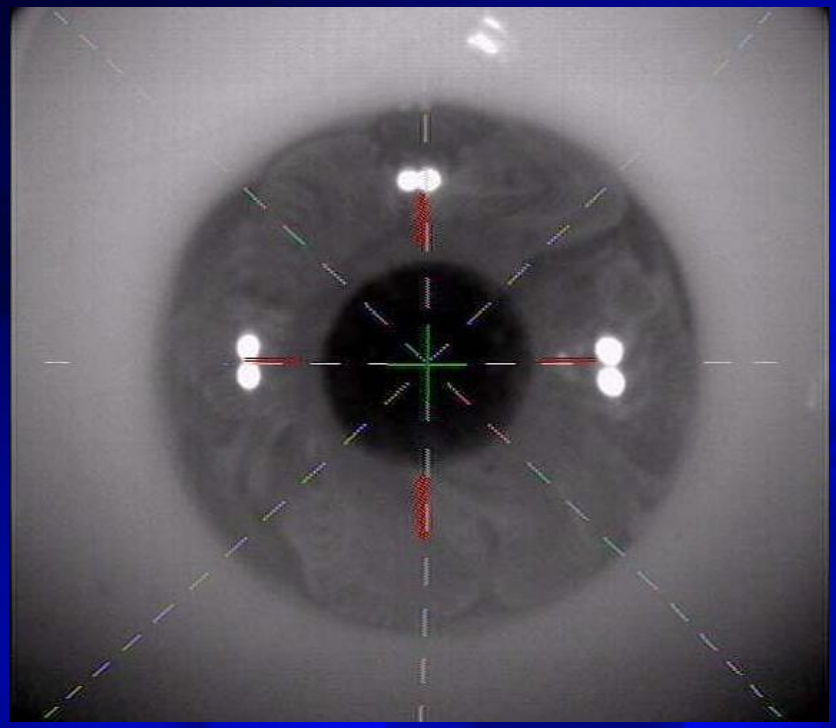


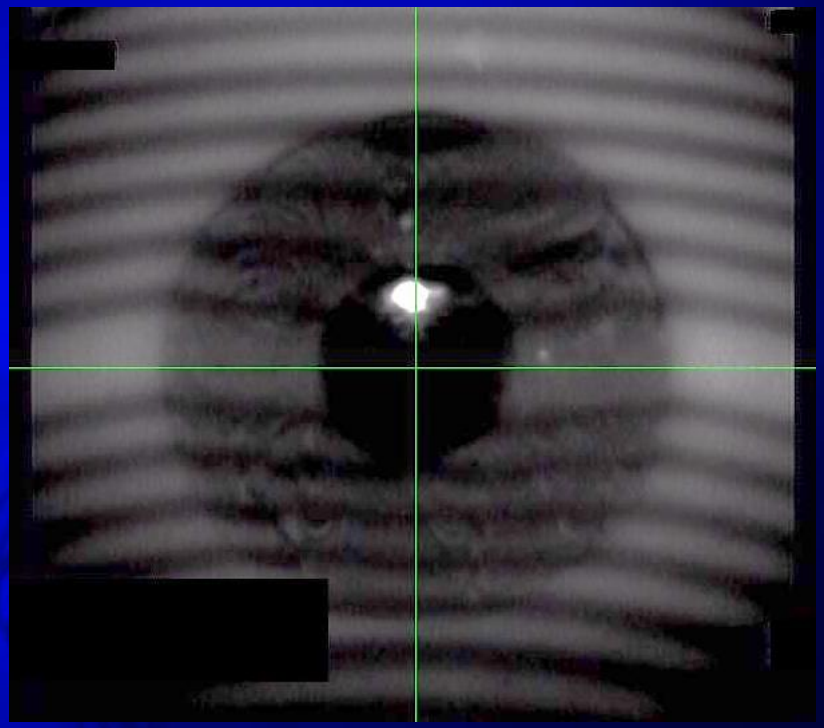
Follow the dot





AMARIS – 7D- Eye-Tracking System Basics





Crosshairs and meridional Sections:

- green: ablation center
- red: pupil center
- white: meridians for 3D- effect

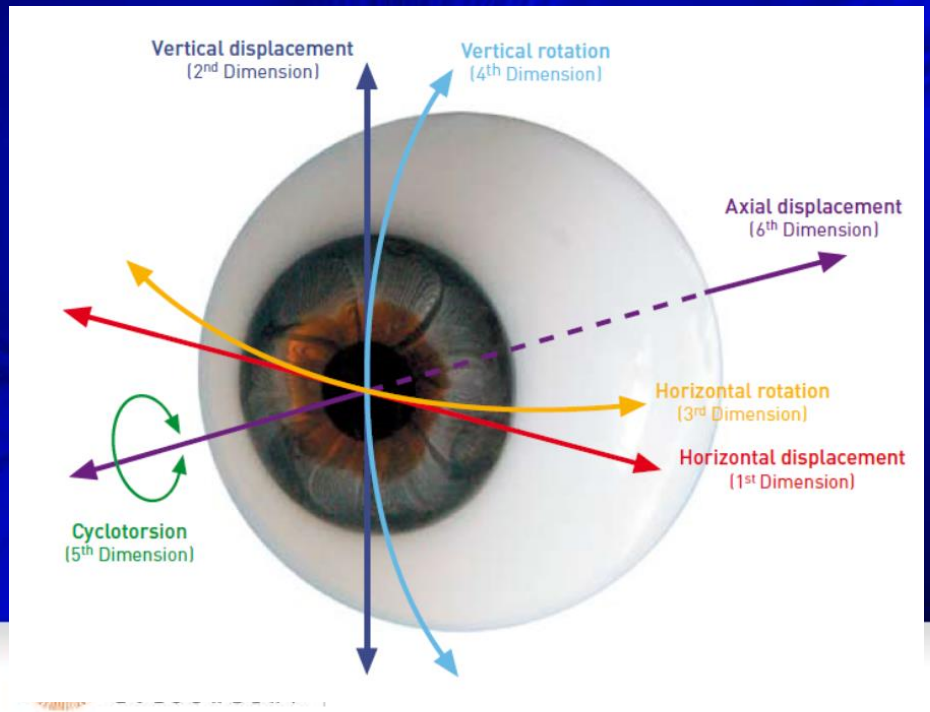
Stripe projection (invisible infra red illumination):

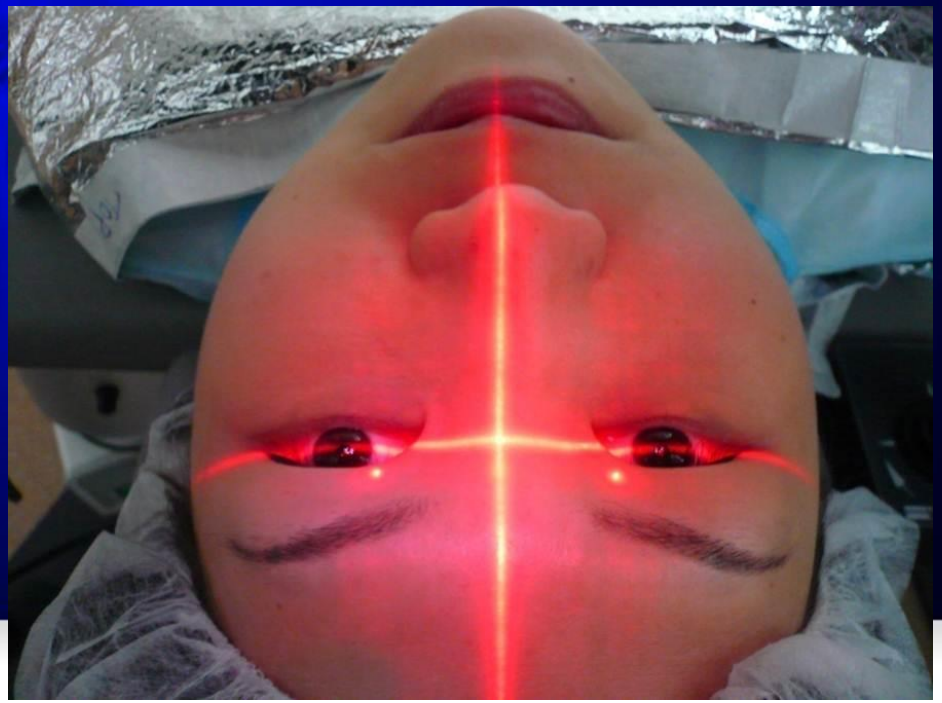
- for height tracking (z-axis)
- for dynamic rolling compensation

Amaris 1050s vs Amaris 750s

Accuracy - Eye Tracker

- Amaris 750s
  - 6D
  - Everything automatic
  - Also has alignment cross option
- Amaris 1050RS
  - 7D Eye Tracking which is necessary to help cut treatment times and even improve accuracy





The Old 6D Software

- In 6D Eye Tracking the linear movements (1st and 2nd dimensions) are tracked
- It also compensates rolling movements of the eye (3rd and 4th dimensions)
- Compensation of the eye's rotation around its optical axis is achieved with the static and dynamic Advanced Cyclotorsion Control (5th dimension)
- Movements along the z-axis (sixth dimension) are actively compensated by means of the z-tracking
- Automatic pupil size control and pupil centroid shift compensation ensure additional safety (Some Laser manufacturers call this another Dimension)

The 7th Dimension (Degrees of Freedom)

- The new, ground-breaking Latency-Free Tracking considers the time factor, i.e. the 7th “dimension”/Degree of Freedom
- Latency-Free Tracking compensates for eye movements that occur in the period between acquisition of the eyetracker image and triggering of the subsequent laser pulses

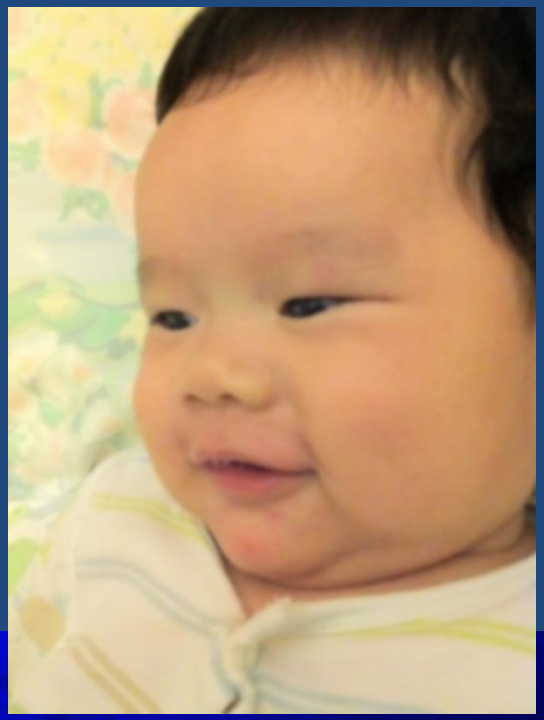
How to Create a Perfect 1050 tracker

Its in the Software!!

Just like how your mobile phone takes such beautiful pictures!

How to Make a 1050Hz tracker to Track a 1050Hz Laser?

Its in the Software!!



Why Does Our Lousy Phone cameras Take Such Good Photos!

- The HDR process takes the "proper" exposure, maps the luminance of each pixel, then uses that luminance data to create a weighted average for that pixel from the under, proper, and over exposed images.

  So, if a pixel in the "proper" exposure has a luminance of say, 30%, the HDR software would average the values of the three exposures, putting more weight on the RGB values in the over-exposed image to bring back detail into the final HDR image.

It’s All in the Software

Nikon Predictive Autofocus System

Other Predictive Focus Systems
(Nikon Camera Brochure)

- Continuous-servo AF (AF-C)" maintains continuous focus on a moving subject, but this is not sufficient for taking a sharply focused picture.
- A short time lag occurs between when the shutter is pressed and when the picture is actually taken, RELEASE TIME LAG
- "PREDICTIVE FOCUS TRACKING SYSTEM" uses special algorithms to forecast subject's position at the moment the image is captured based on measurement of the subject's movement, and moves the lens accordingly
- This system detects the subject's speed of motion and adjusts the focus by taking the release time lag into consideration.
- based on the locus of the subject's motion
- Nikon used extensive data obtained by photographing numerous moving subjects for the development of the PREDICTIVE FOCUS TRACKING SYSTEM "

Laser Tracking and Baseball

Dan Reinstein

As a rule of thumb, it is necessary to accurately position a laser spot within at least one-third of the diameter of the spot. Therefore, the complete eye-tracking loop must be fast enough to enable a shot to be fired before the eye can move more than one-third of the spot diameter away from the detected position. This is a similar situation to baseball batsmen predicting the flight of a pitch. A batsman must judge the flight of the ball; they swing the bat based on this judgment. The batsman cannot—realistically—change the course of the swing once committed, so a thrown ball may lead to a strike. The time between deciding where the ball is going (ie, position detection), activating the right muscle groups (ie, mirror alignment), and swinging (ie, laser shot) is the latency

Predictive Algorithms

journal of vision
an ARVO journal
Exploring all aspects of biological visual function
ARVO

J Vis. 2013; 13(8): 27.
Published online 2013 July 31. doi: 10.1167/13.8.27
PMCID: PMC3730983

Trajectory prediction of saccadic eye movements using a compressed exponential model

Peng Han,[1,2] Daniel R. Saunders,[2] Russell L. Woods,[2] and Gang Luo[2]

SPIE Digital Library

SPIE is a not-for-profit international professional society for optics and photonics technology, founded in 1955

Proceedings Home | Browse Proceedings > | by Conference | By Year | by Volume No.

SPIE Proceedings | Volume 2056 | Active Vision for Intelligent Robots II >

< Previous Article | Next Article >

Proceedings Article

Predictive visual tracking

Albert J. Wavering ; Ronald Lumia
[+] Author Affiliations

Proc. SPIE 2056, Intelligent Robots and Computer Vision XII: Active Vision and 3D Methods, 86 (August 6, 1993); doi:10.1117/12.150188

Text Size: A A

From Conference Volume 2056

Intelligent Robots and Computer Vision XII: Active Vision and 3D Methods
David P. Casasent
Boston, MA | September 07, 1993

Predictive Mathematics

FIR Smoothing of Discrete-Time Polynomial Signals in State Space

Yuriy S. Shmaliy, *Senior Member, IEEE* and Luis J. Morales-Mendoza

$$a_{03}(p) = 8\frac{\begin{array}{c}2N^6 - 15N^5 + 47N^4 - 90N^3 + 113N^2 - 75N + 18\\ +5(6N^5 - 42N^4 + 107N^3 - 132N^2 + 91N - 30)p + 5(42N^4 - 213N^3 + 378N^2 - 288N + 91)p^2\\ +10(71N^3 - 246N^2 + 271N - 96)p^3 + 5(246N^2 - 525N + 271)p^4 + 1050(N-1)p^5 + 350p^6\end{array}}{N(N^2-1)(N^2-4)(N^2-9)}, \quad (72)$$

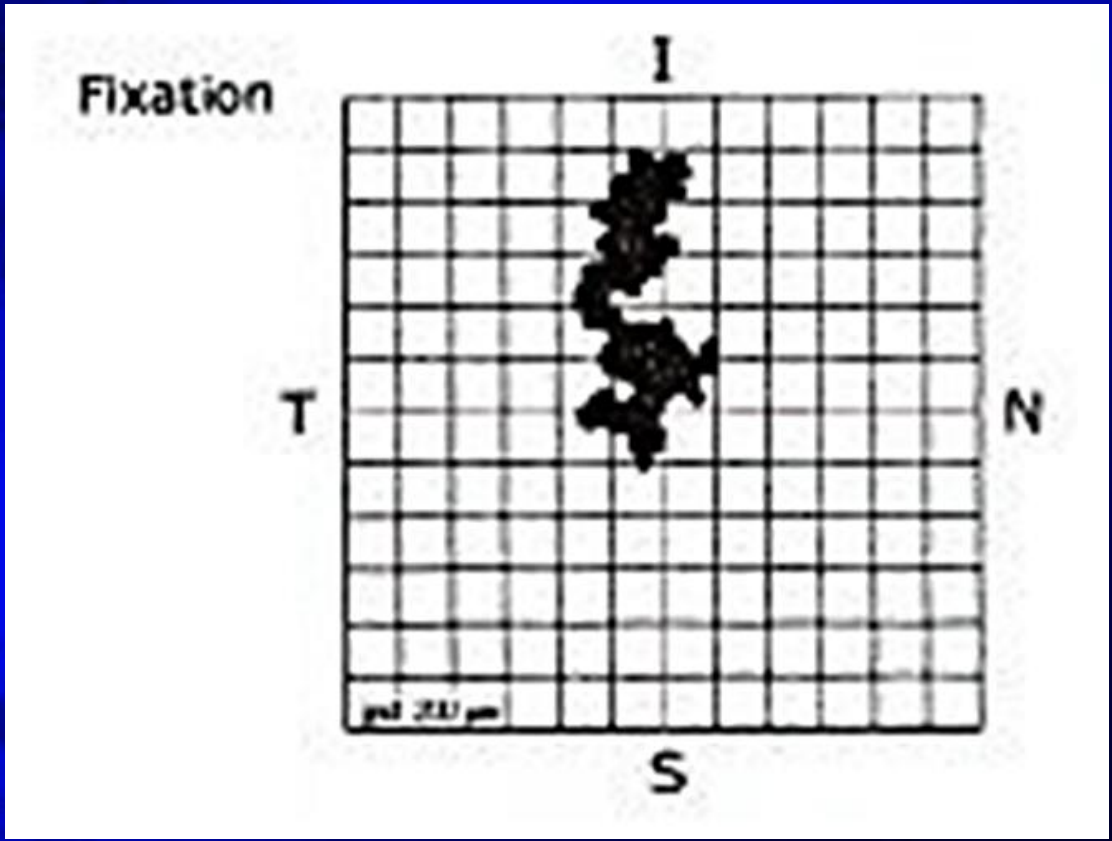
$$a_{13}(p) = -20\frac{\begin{array}{c}6N^5 - 42N^4 + 107N^3 - 132N^2 + 91N - 30 + 2(42N^4 - 213N^3 + 378N^2 - 288N + 91)p\\ +2(213N^3 - 738N^2 + 813N - 288)p^2 + 4(246N^2 - 525N + 271)p^3 + 1050(N-1)p^4 + 420p^5\end{array}}{N(N^2-1)(N^2-4)(N^2-9)}, \quad (73)$$

$$a_{23}(p) = 120\frac{\begin{array}{c}2N^4 - 13N^3 + 28N^2 - 23N + 6\\ +2(13N^3 - 48N^2 + 58N - 23)p + 2(48N^2 - 105N + 58)p^2 + 140(N-1)p^3 + 70p^4\end{array}}{N(N^2-1)(N^2-4)(N^2-9)}, \quad (74)$$

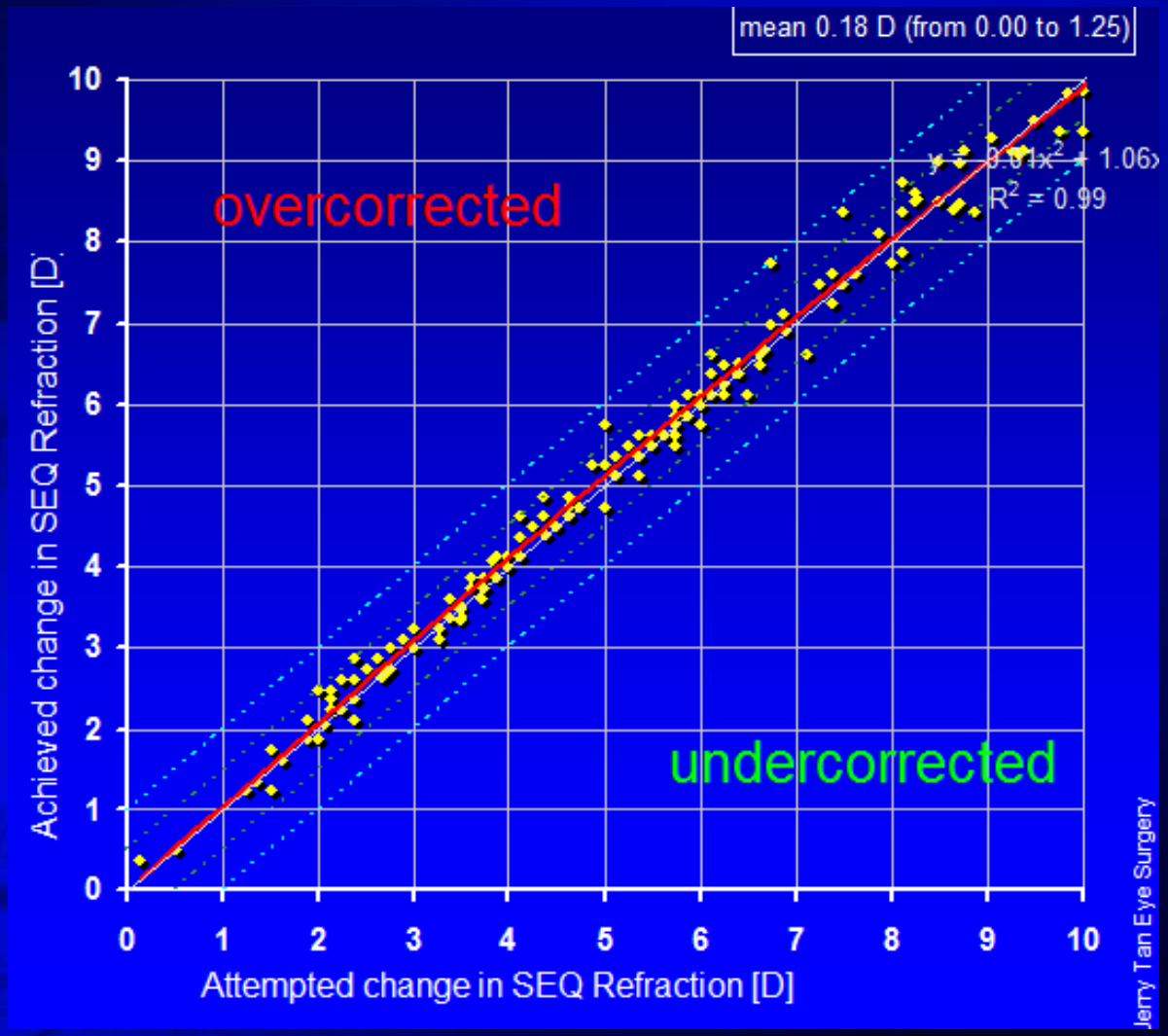
$$a_{33}(p) = -140\frac{N^3 - 6N^2 + 11N - 6 + 2(6N^2 - 15N + 11)p + 30(N-1)p^2 + 20p^3}{N(N^2-1)(N^2-4)(N^2-9)}, \quad (75)$$

The More the Patient moves..

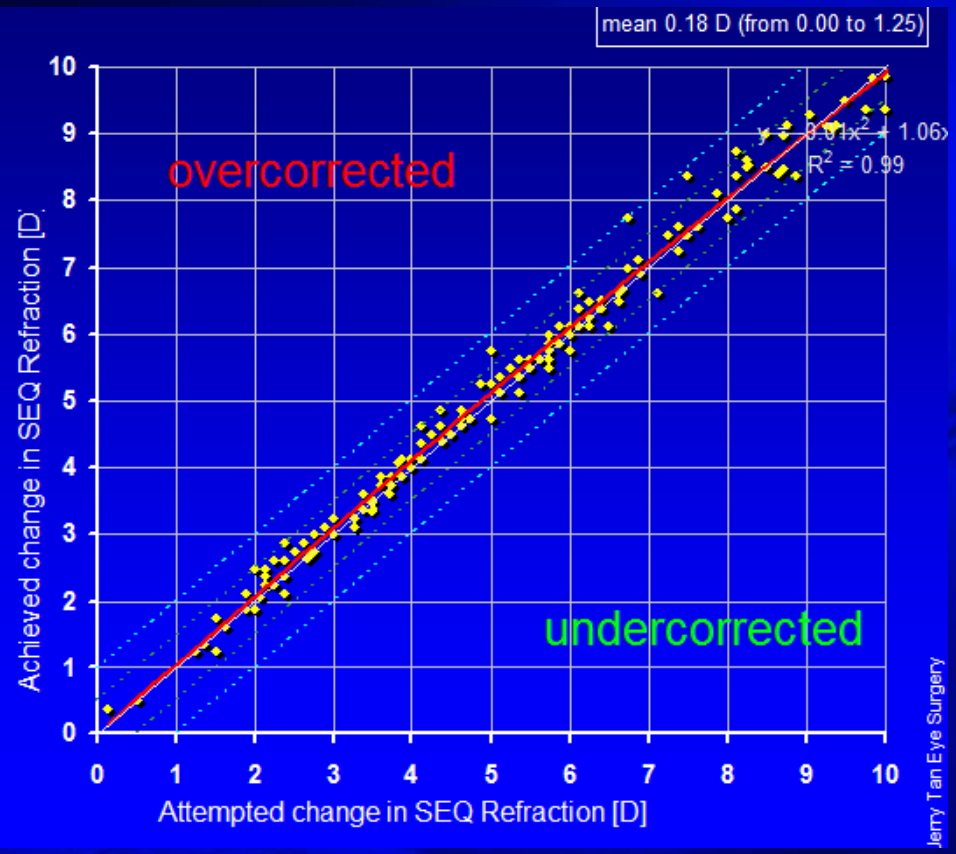
The more beneficial this 7D tracker is!!

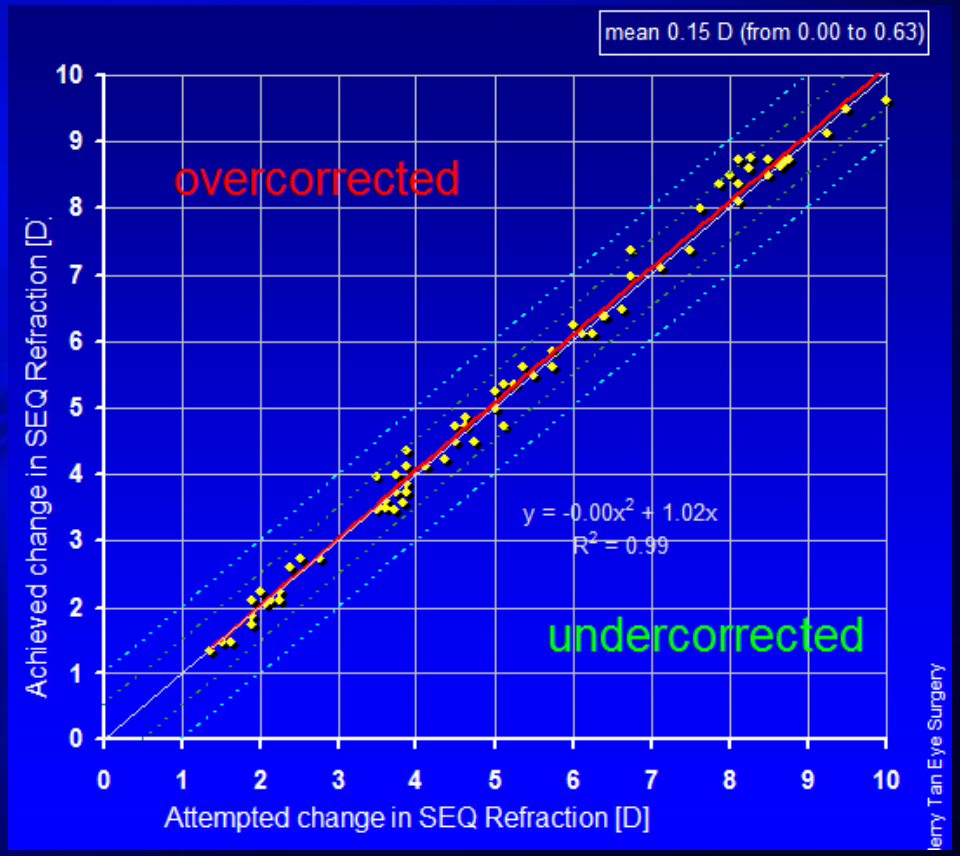


750S Results



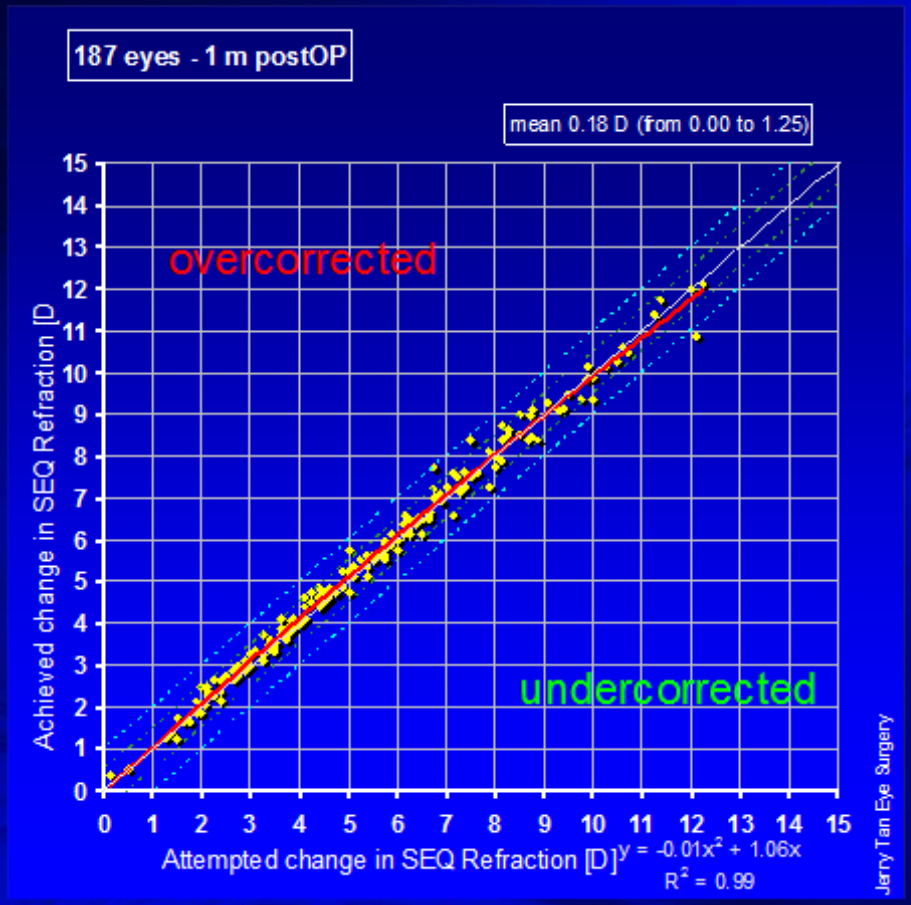
750S vs 1050Rs Results



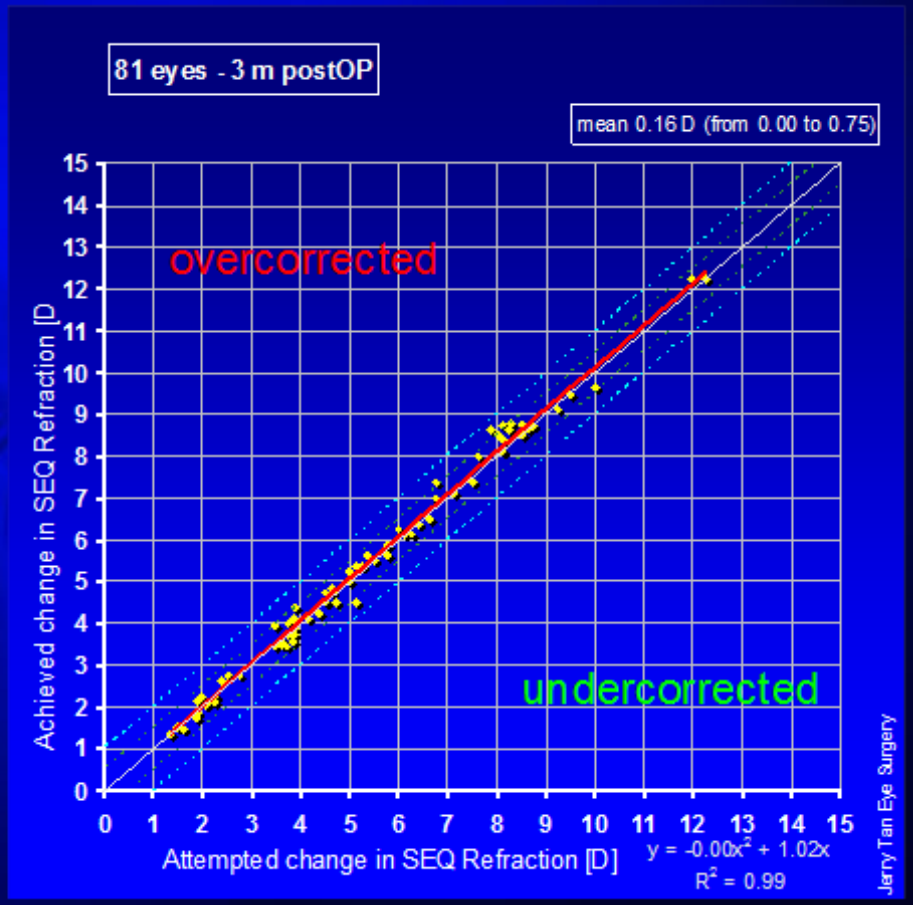


The Results – 1 Month & 3 Months

Our Results seem to get Better – even up 12D



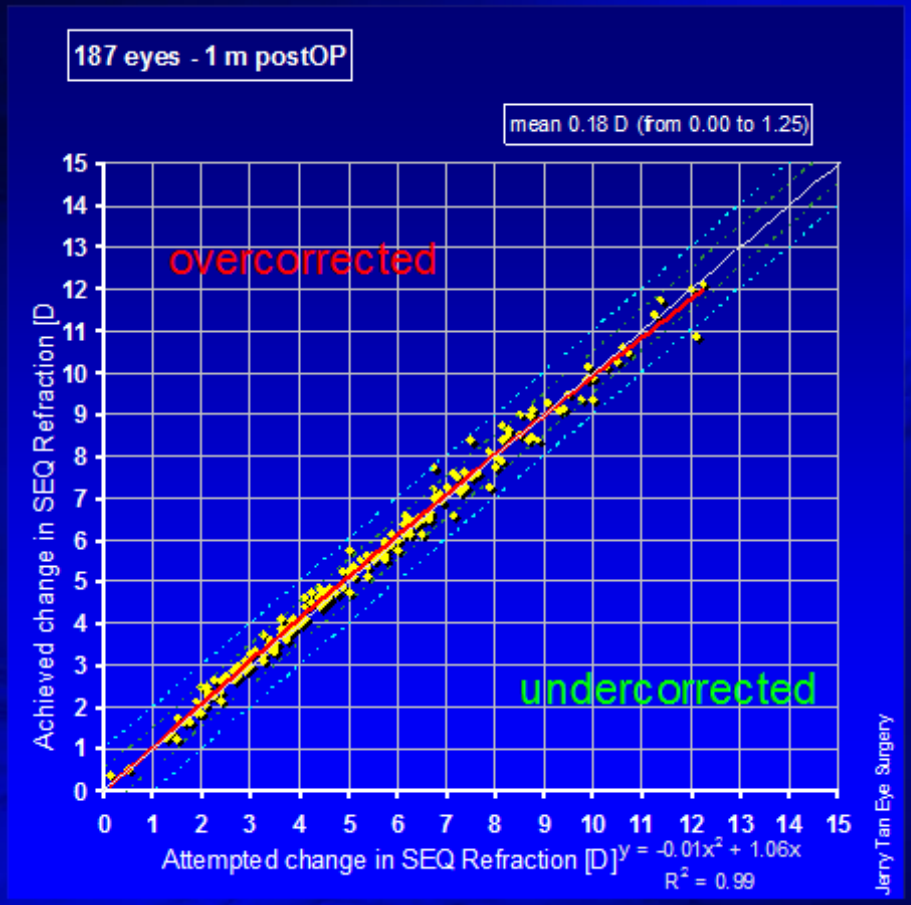
One Month

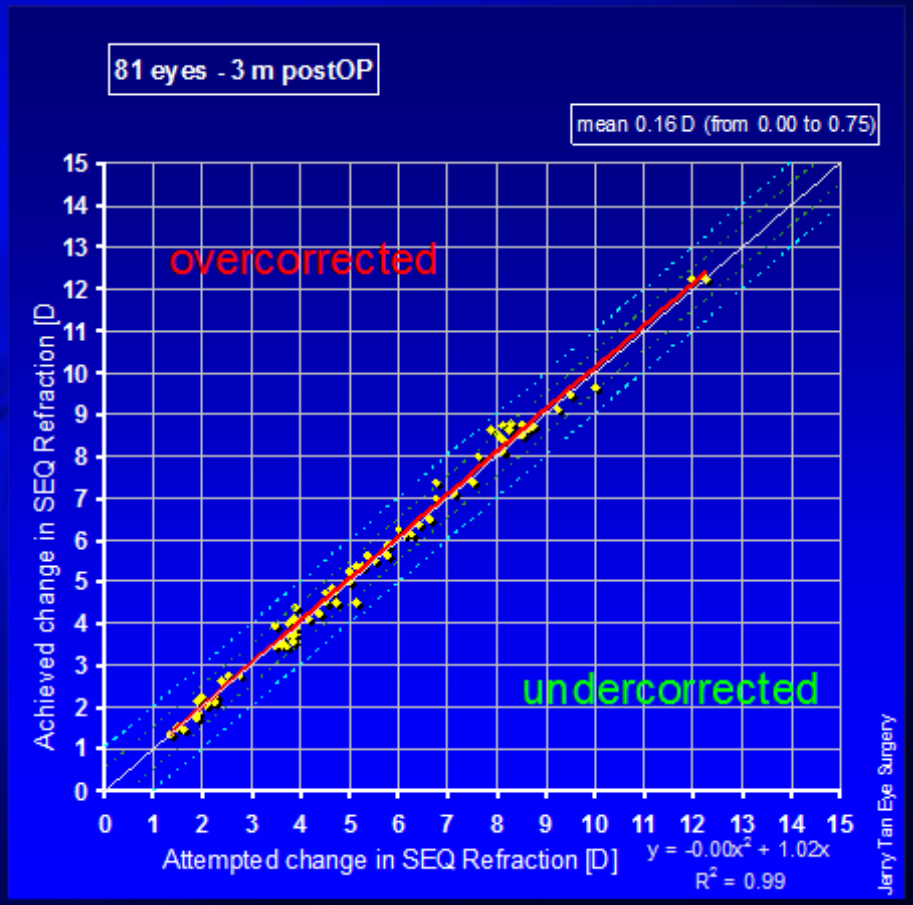


Three Months

The Results

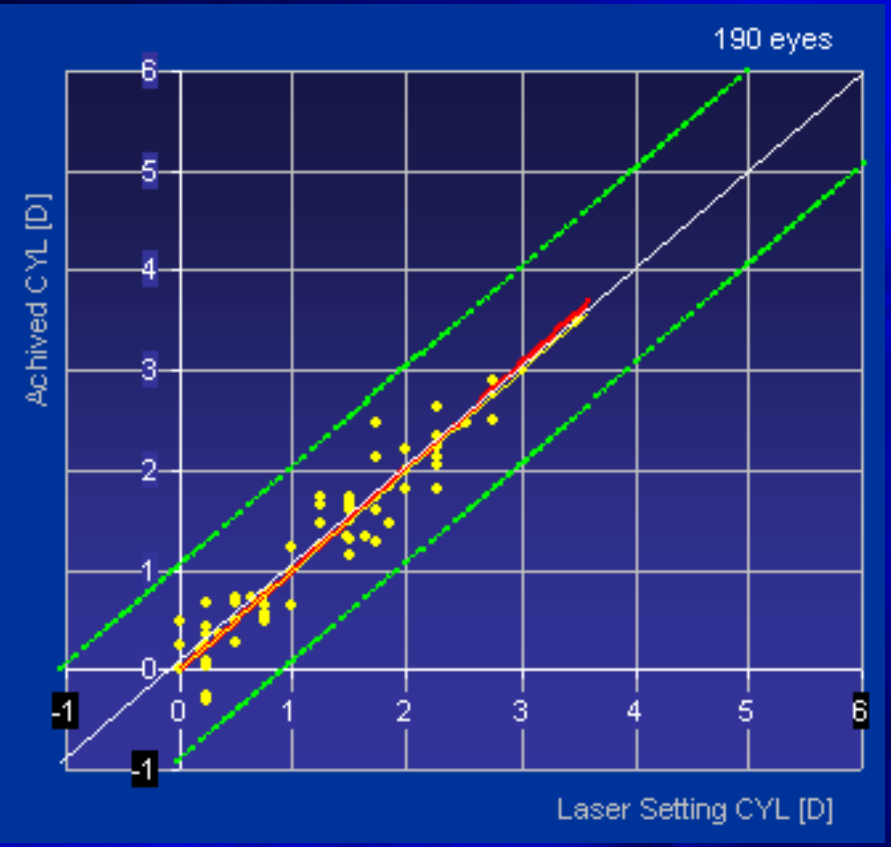
Our Results seem to get Better & definitely not worse!



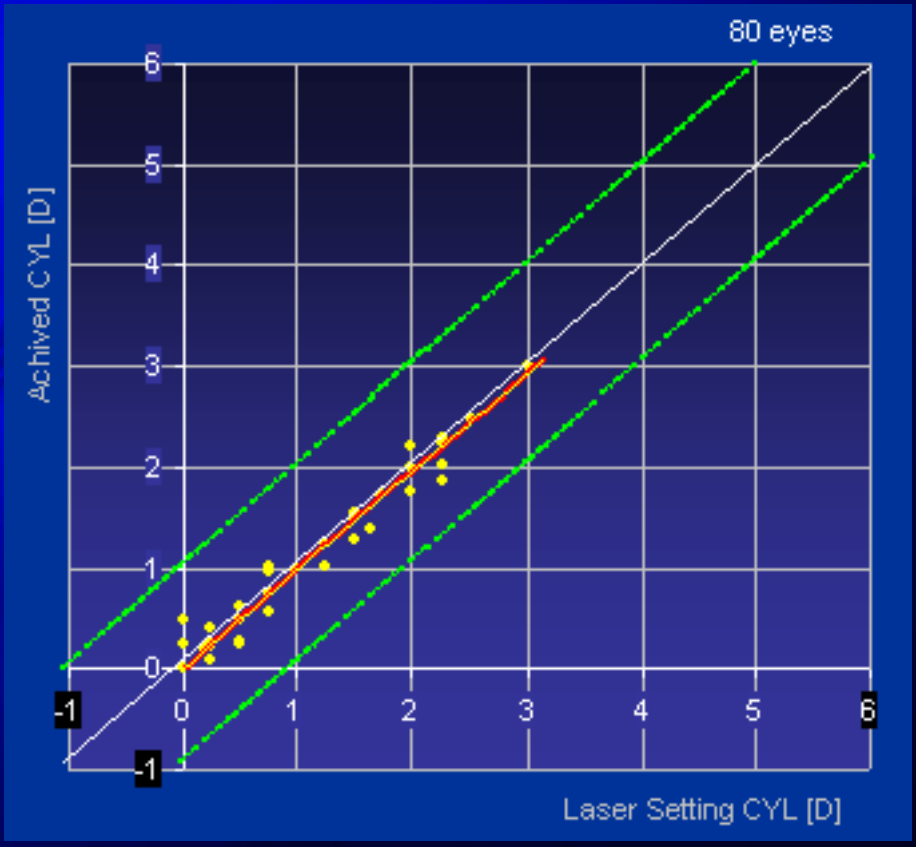


1050RS Astigmatic CWFG results

1 month post-LASIK

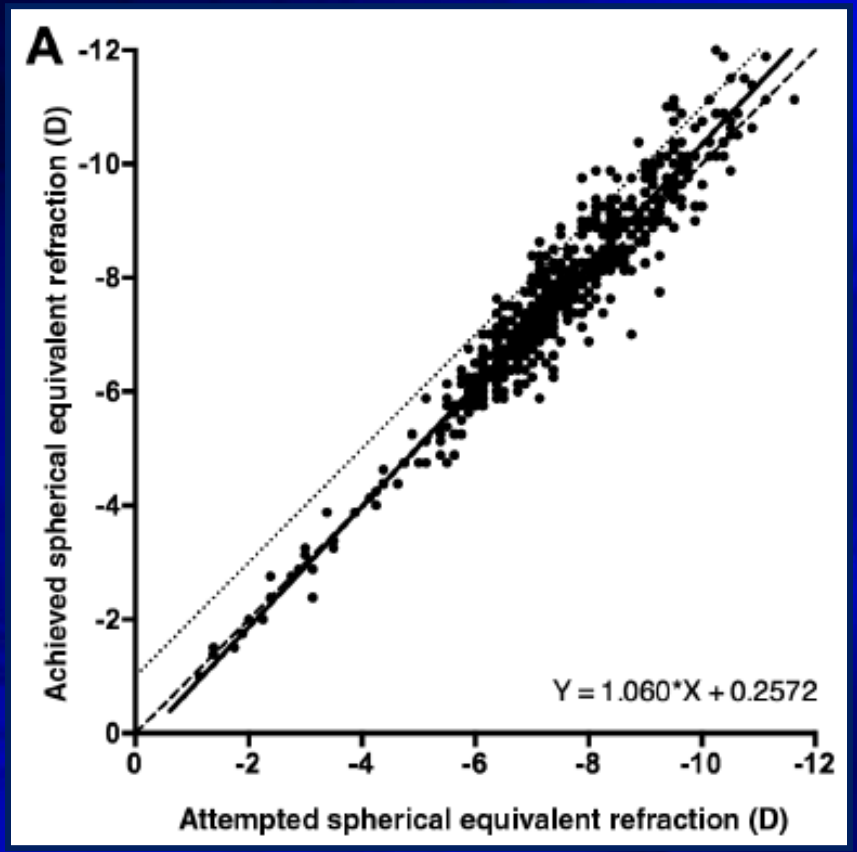


3 months post-LASIK

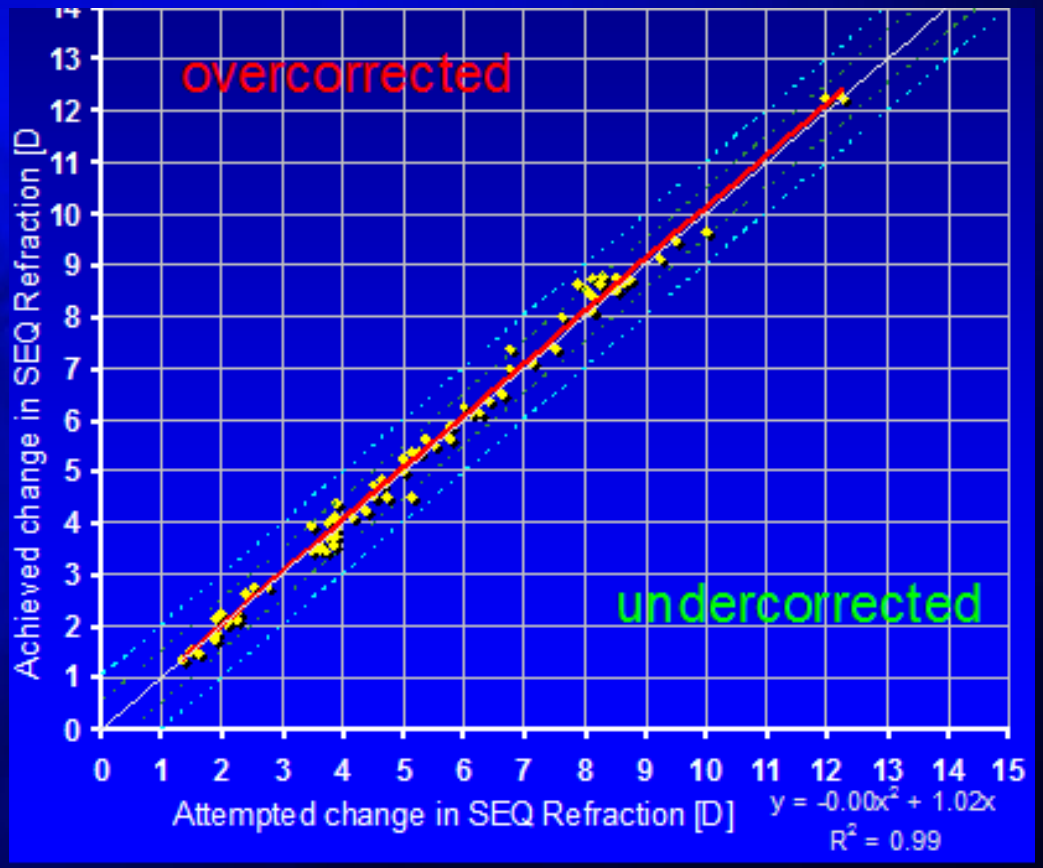


Results: Smile vs Amaris1050 RS

- Smile

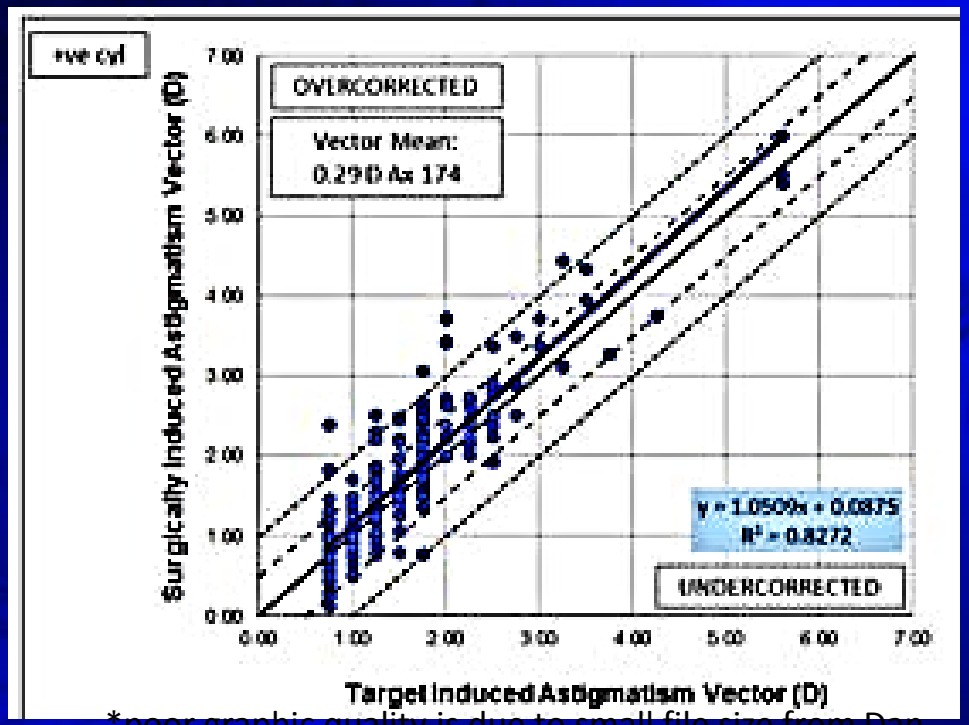


- Amaris 1050RSLasik



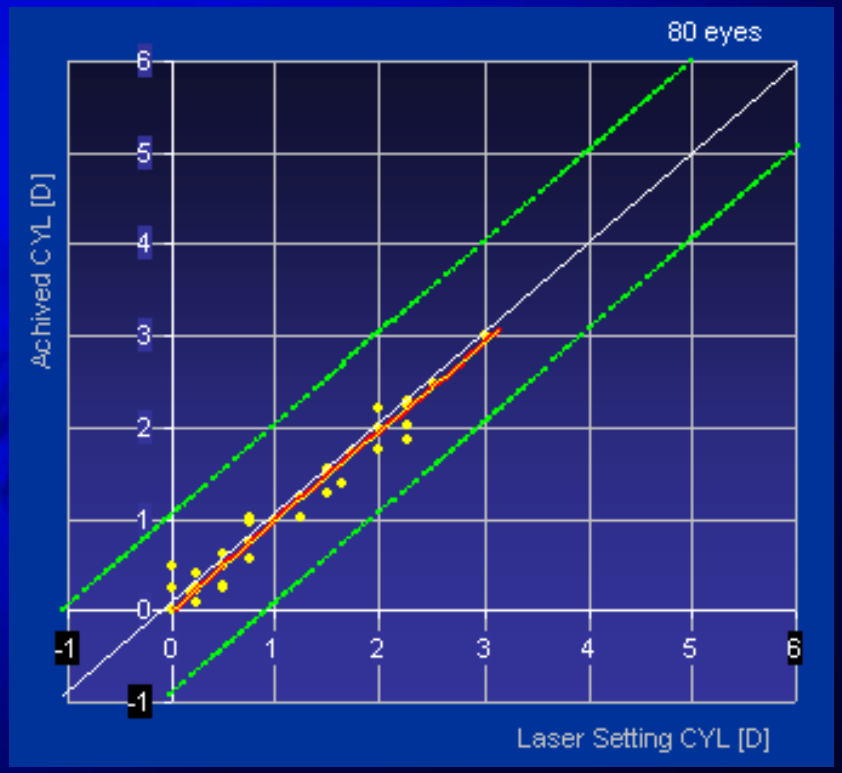
Smile vs Astigmatic CWFG results

Smile

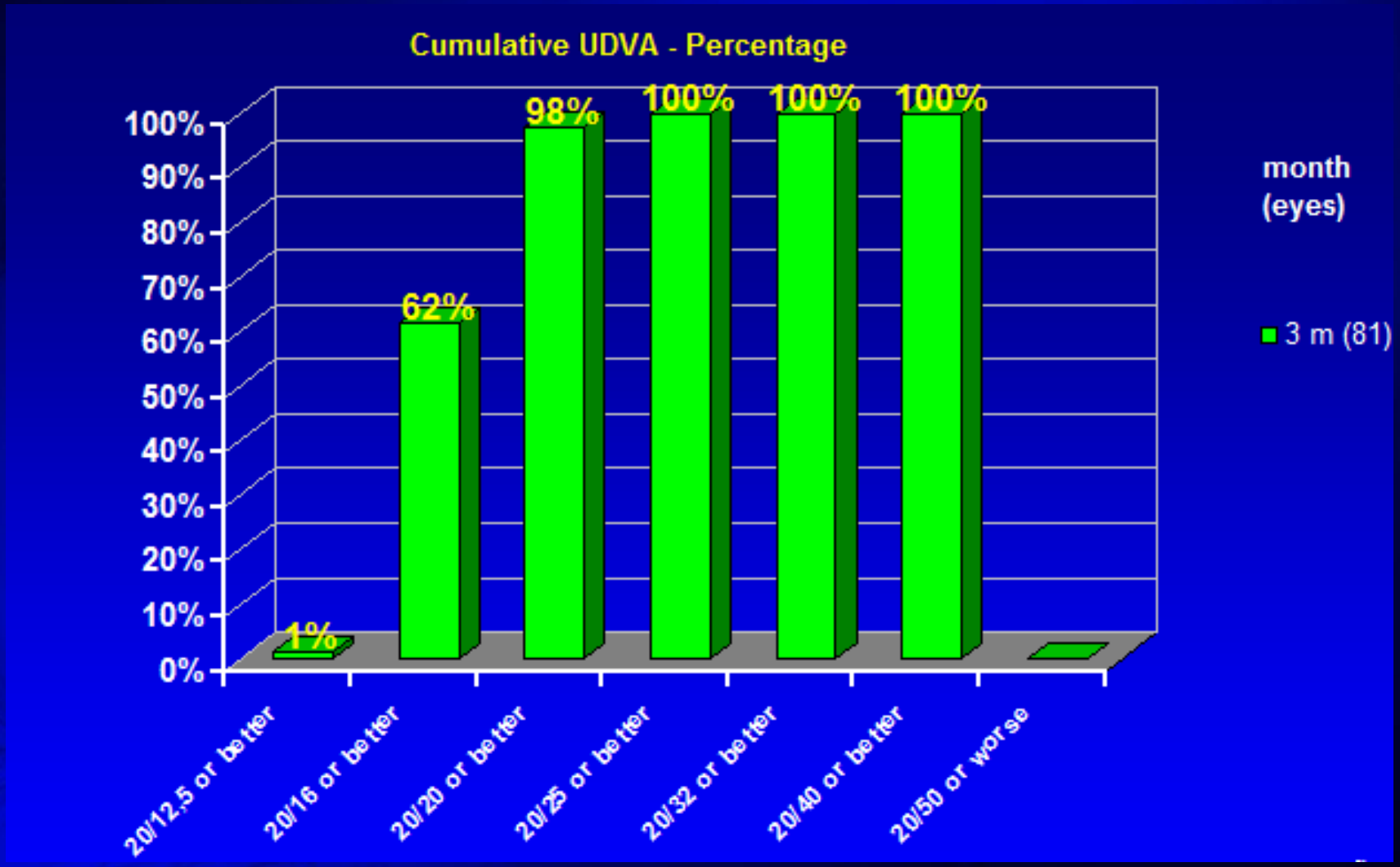


*poor graphic quality is due to small file size from Dan

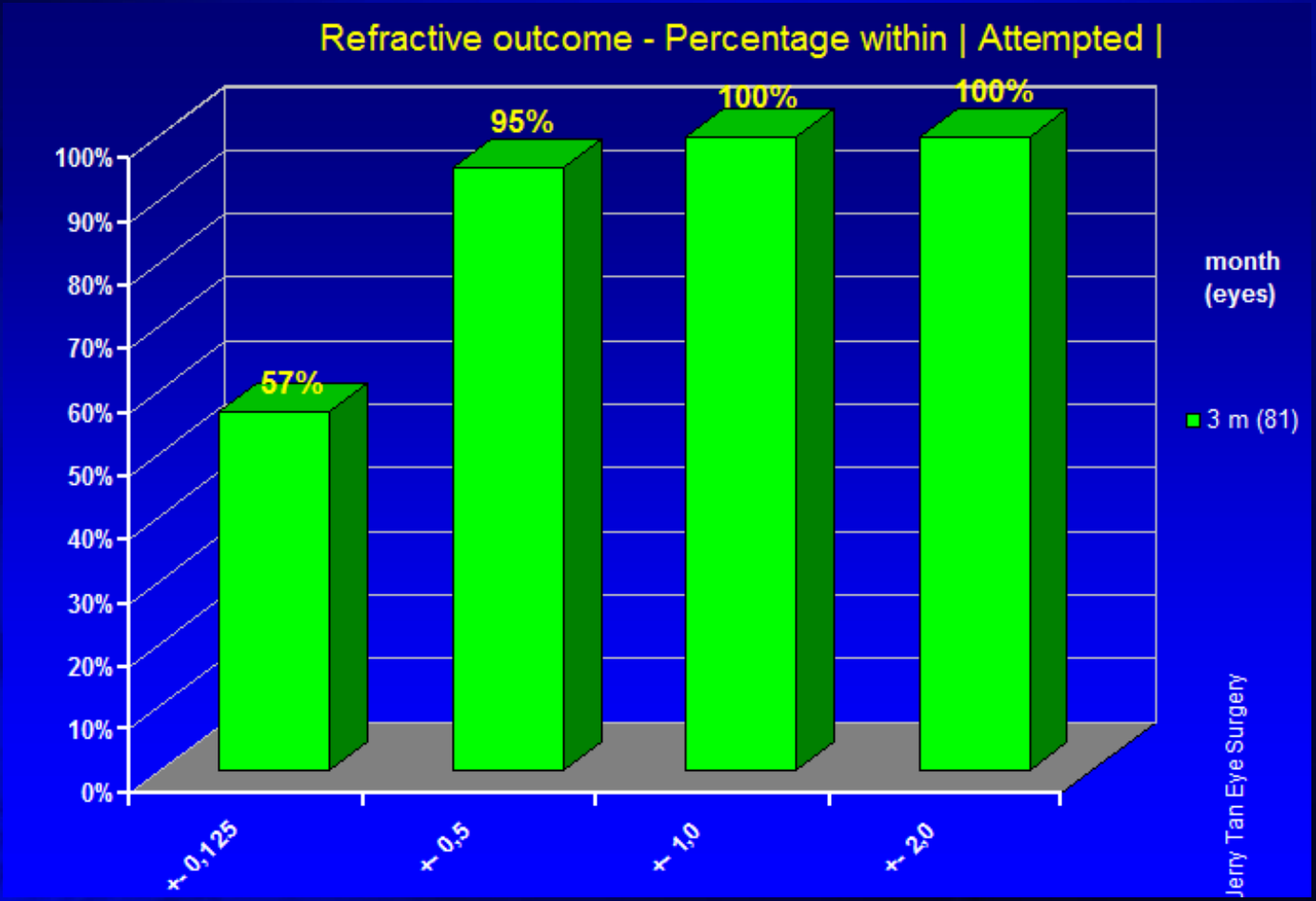
Amaris 1050RS



Unaided Va – 98% 20/20!

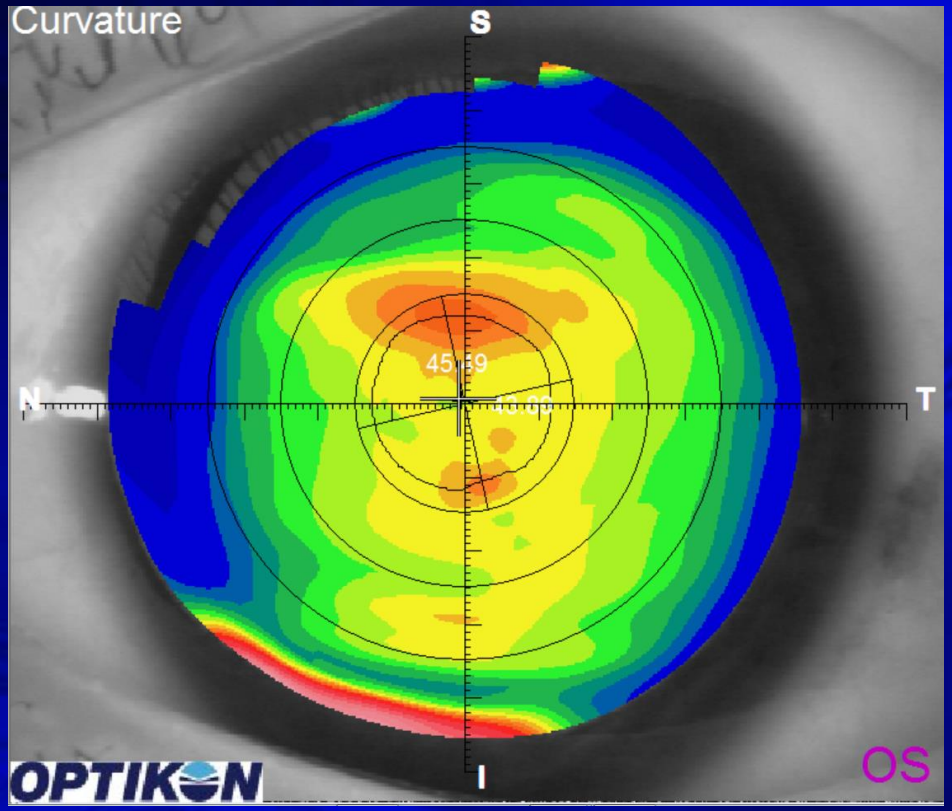


Refractive Outcomes – 95% +/- 0.5D

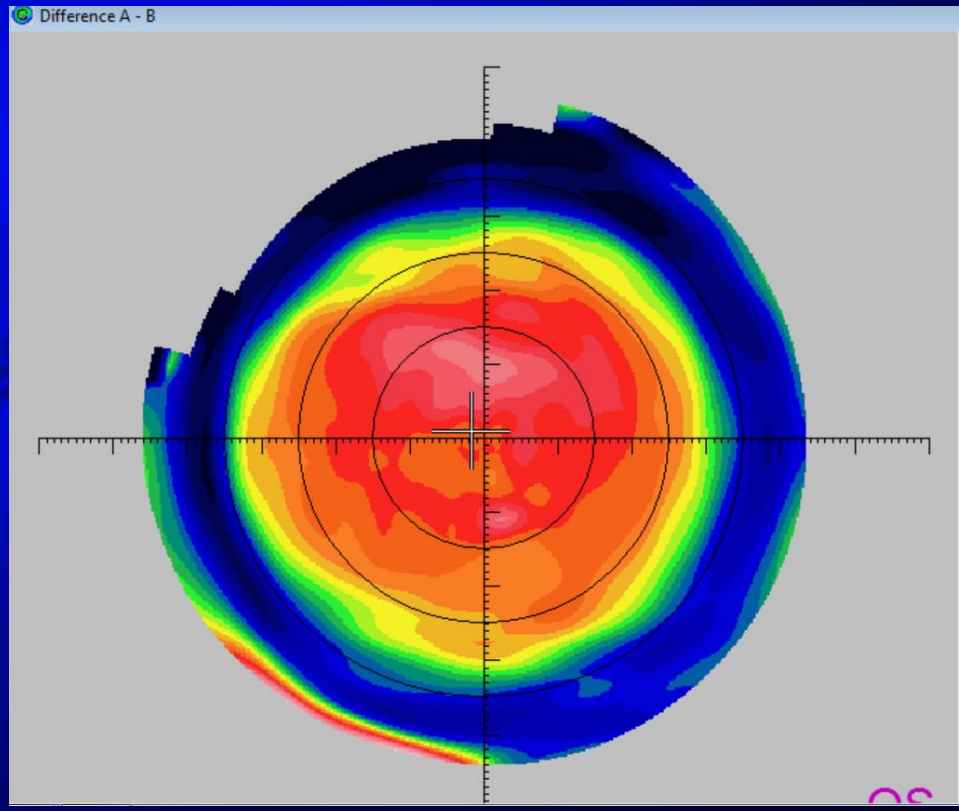


Centration of Ablation

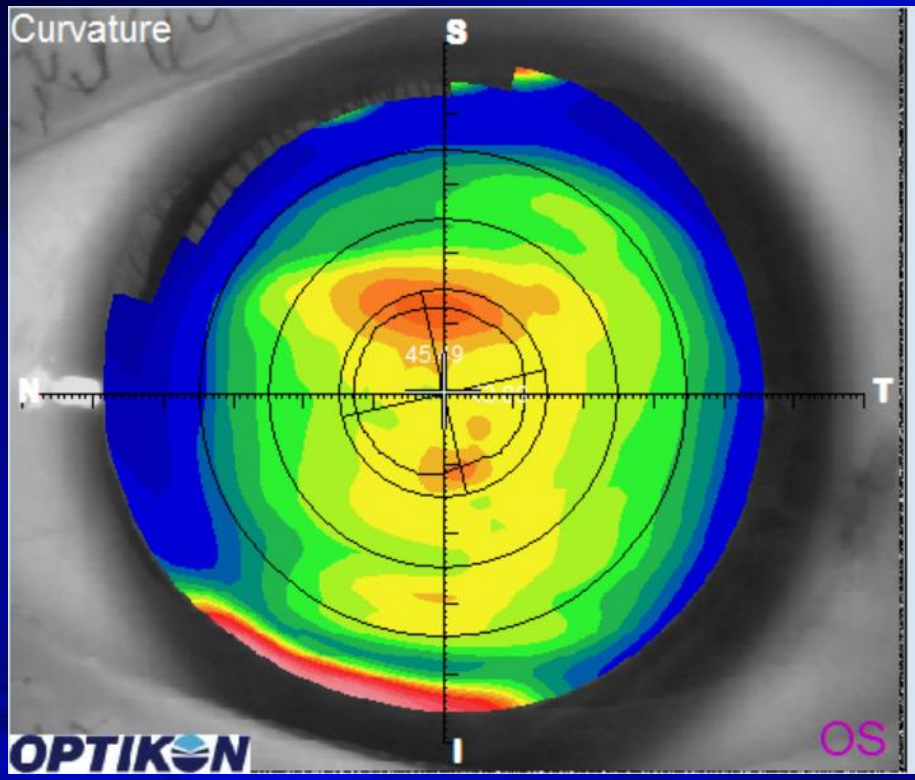
X :-0.1 , Y : +0.1

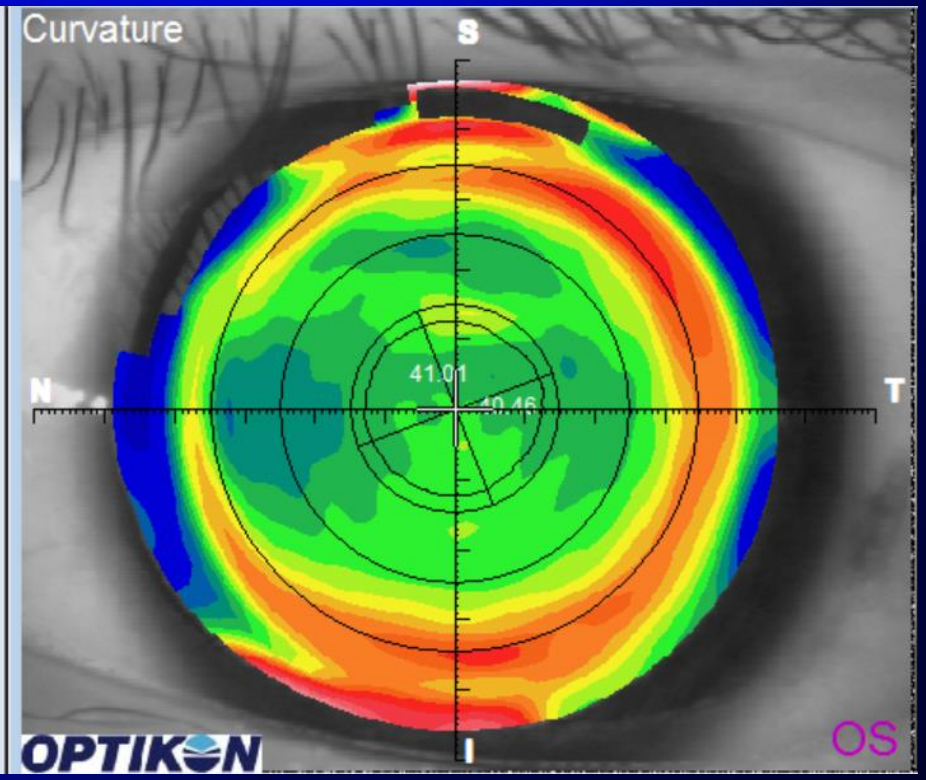


X : -0.25, Y :+0.15

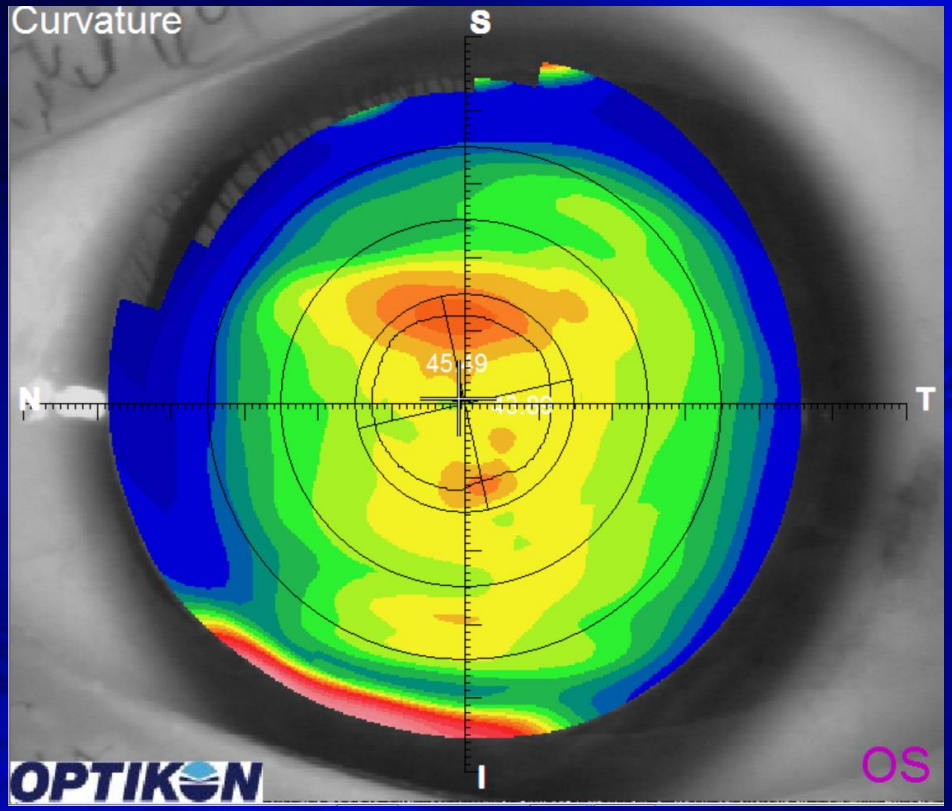


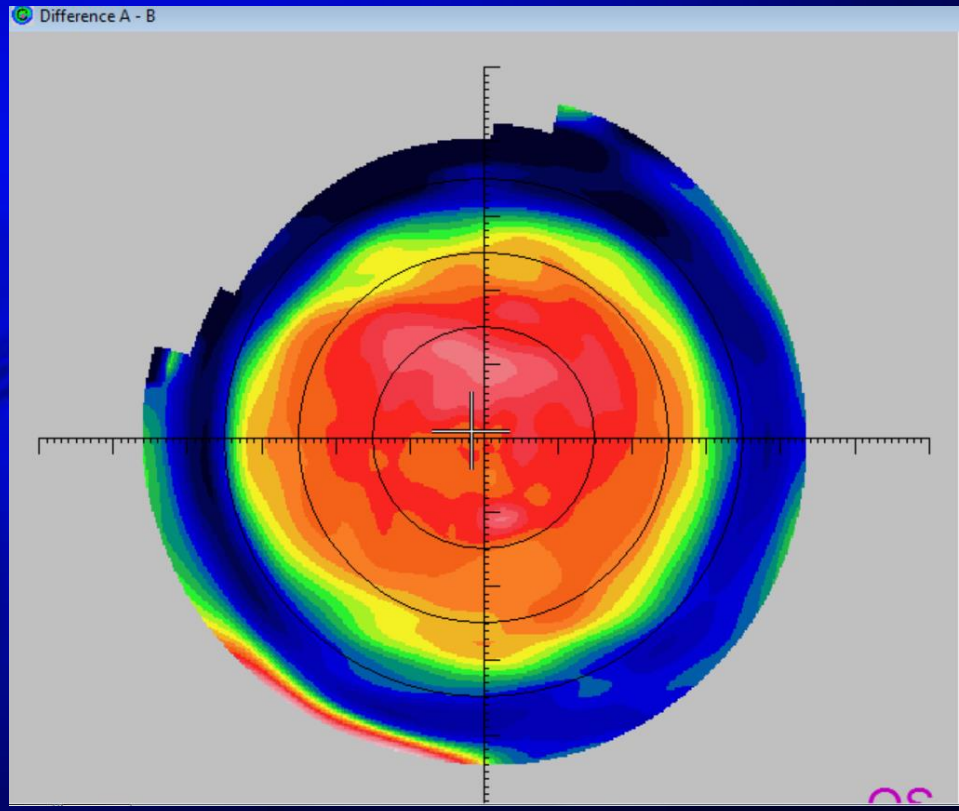
Pre and Post Op





Center of Ablation to Vertex





X,Y Distance from

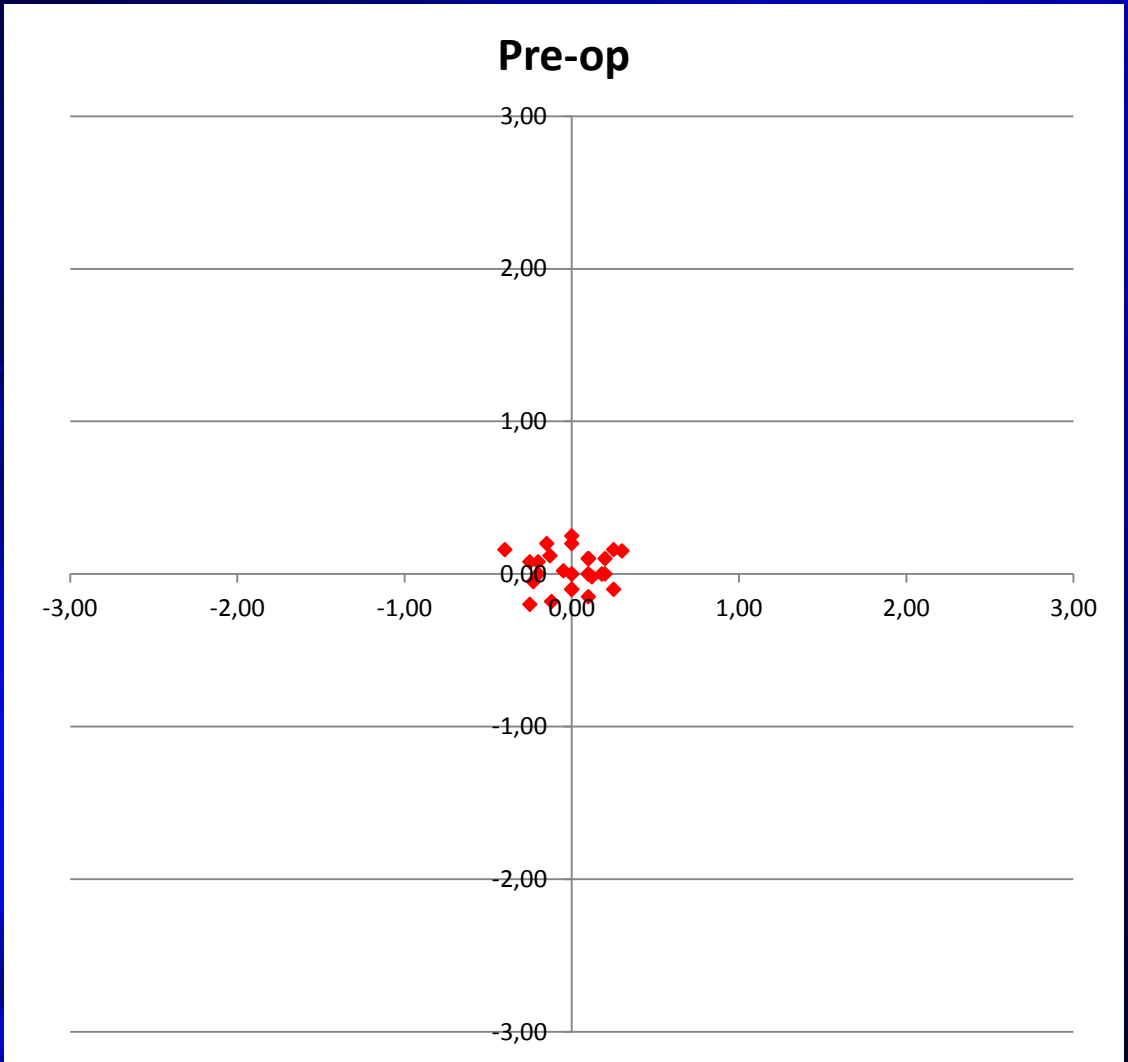
Pupil Centre to Vertex

Compared to

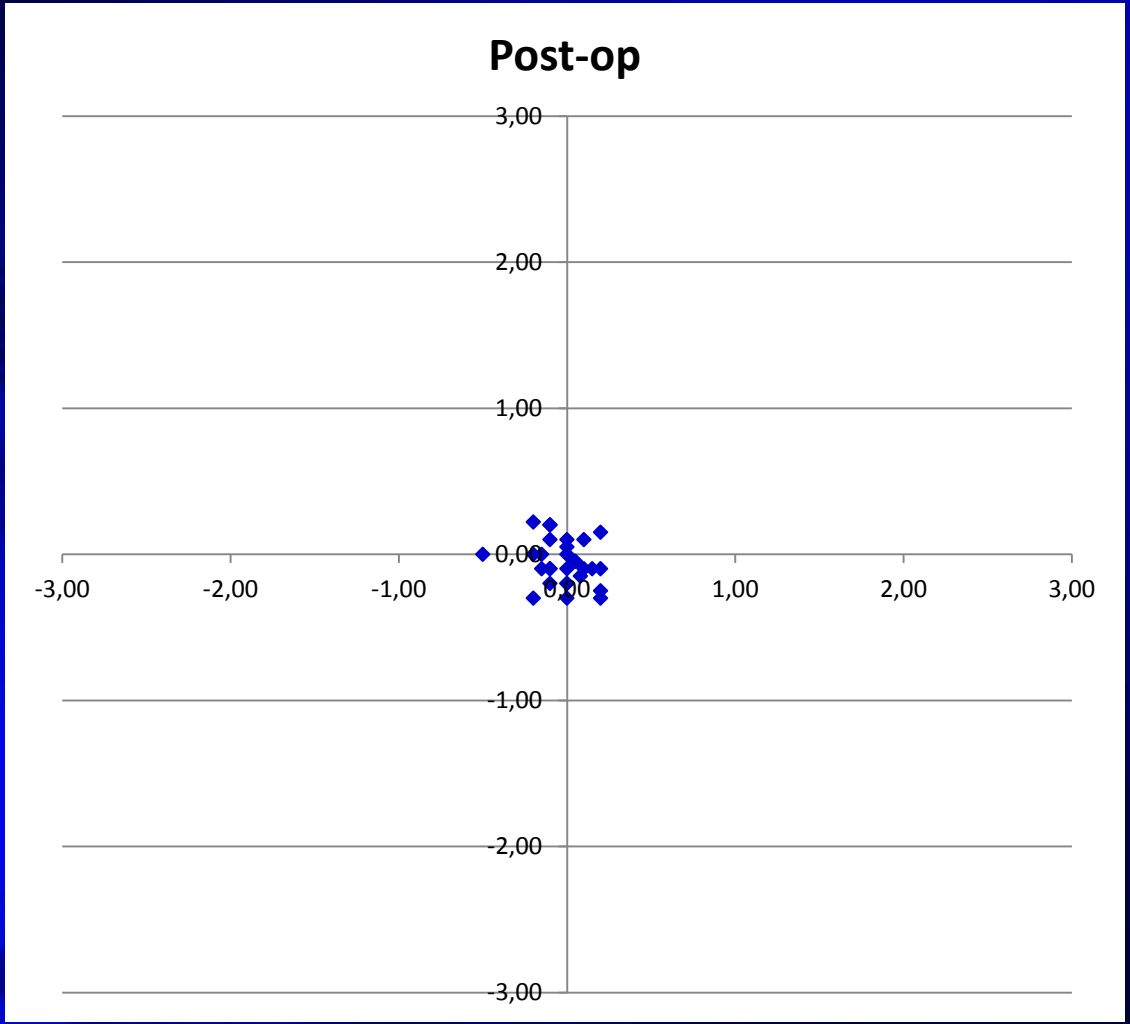
Vertex to Ablation Centre

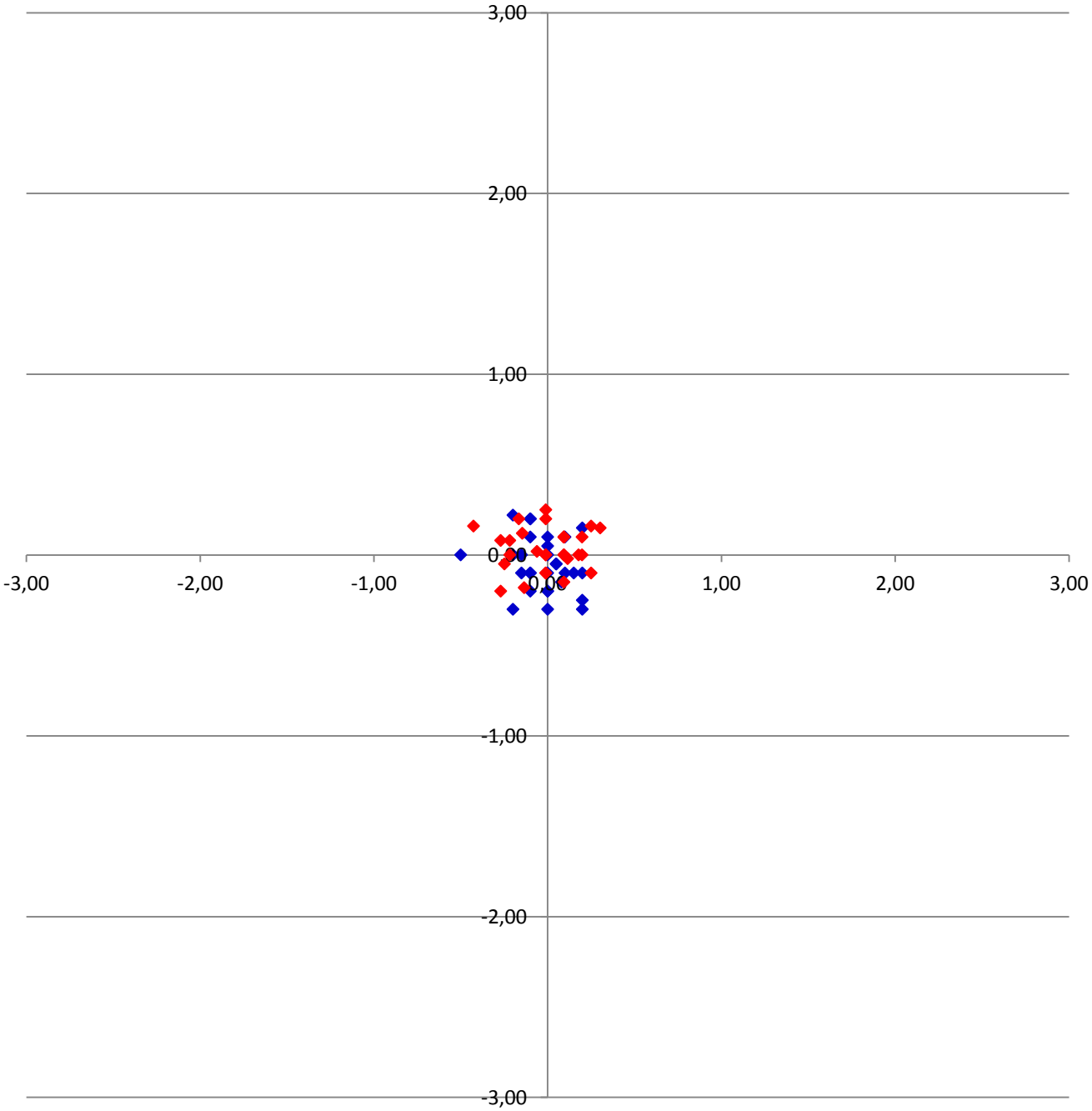
		Name of Patient	Right eye							Left eye						
4			pre-op			post-op				pre-op			post-op			
5			X (mm)	Y (mm)	Amt. of decentration to pupil centre(mm)	X (mm)	Y (mm)	Amt. of decentration to pupil centre(mm)	Difference bet. Pre & post-op decentration	X (mm)	Y (mm)	Amt. of decentration to pupil centre(mm)	X (mm)	Y (mm)	Amt. of decentration to pupil centre(mm)	Difference bet. Pre & post-op decentration
6	1	Lim Chuan Loong Brian	0.12	-0.02	0.122	0.08	-0.15	0.170	0.048	-0.05	0.02	0.054	-0.15	-0.10	0.180	0.126
7	2	Magnier Maurice John	0.00	0.25	0.250	-0.20	0.22	0.297	0.047	0.25	-0.10	0.269	0.20	-0.25	0.320	0.051
8	3	Tan Lay Hoon Jasmine	-0.23	-0.05	0.235	-0.10	0.20	0.224	-0.012	0.10	0.10	0.141	0.10	0.10	0.141	0.000
9	4	Tan Ee Lyn Jacqueline	0.20	0.10	0.224	0.05	-0.05	0.071	-0.153	-0.25	0.08	0.262	-0.15	0.00	0.150	-0.112
10	5	Jones Nicholas Peter								0.00	-0.10	0.100	0.00	-0.20	0.200	0.100
11	6	O'Neill Michelle	-0.40	0.16	0.431	-0.50	0.00	0.500	0.069	0.25	0.16	0.297	0.20	-0.30	0.361	0.064
12	7	Sudirman Utomo	0.30	0.15	0.335	0.20	0.15	0.250	-0.085	-0.20	0.08	0.215	-0.10	0.10	0.141	-0.074
13	8	Wibowo Muhammad Ridzki	0.10	0.10	0.141	0.00	0.00	0.000	-0.141	0.00	-0.10	0.100	0.00	0.10	0.100	0.000
14	9	Wibowo Muhammad Haqi	0.18	0.00	0.180	0.15	-0.10	0.180	0.000	-0.12	-0.18	0.216	-0.20	-0.30	0.361	0.144
15	10	Tan Teng Teng Jolene	0.10	0.00	0.100	0.10	-0.10	0.141	0.041	0.00	0.00	0.000	0.00	-0.30	0.300	0.300
16	11	Nair Sandhya	-0.25	-0.20	0.320	-0.10	-0.20	0.224	-0.097	0.20	0.00	0.200	0.20	-0.10	0.224	0.024
17	12	Ng Zu Xiang	0.10	0.00	0.100	0.00	-0.10	0.100	0.000	-0.20	0.00	0.200	-0.20	0.00	0.200	0.000
18	13	Hastings Warren Kenneth	-0.13	0.12	0.177	-0.10	0.20	0.224	0.047	0.10	0.10	0.141	0.05	-0.05	0.071	-0.071
19	14	Hartono Norman	-0.15	0.20	0.250	0.00	0.05	0.050	-0.200	0.00	0.20	0.200	0.00	-0.20	0.200	0.000
20	15	Tham Feng Keng Jamie	0.00	0.00	0.000	-0.10	-0.10	0.141	0.141	0.10	-0.15	0.180	-0.10	-0.10	0.141	-0.039

First 39 Eyes with 7 Dimensional Tracker



First 39 Eyes with 7 Dimensional Tracker




3,00
2,00
1,00
0,00
-1,00
-2,00
-3,00
-3,00
-2,00
-1,00
0,00
1,00
2,00
3,00

Conclusion

- The Mean Error was found to be 0.075mm
- Anything less than 0.2mm has been deemed to be clinically insignificant (Reinstein)
- The Amaris 1050 RS shows Excellent Centration using the Predictive Latency Free Eye Tracking System even at such High Frequencies

The Future & Eye Tracking!

Tom Cruise aka Mr. Yakamoto