Understanding the Tools in Refractive Surgery: The First Fifteen Years

Mark E Johnston MD FRCSC

Nebraska Optometric Association

Omaha, April 14,2012

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Mark E. Johnston
MD, FRCSC

Welcome to MEJ
Education and Profile
Presentations
Surgery Presentations

Presentations

Presentations

- **Diffuse Lamellar Keratitis related to intermittent blockage of a humidifier drain** DOWNLOAD
  Presented ASCRS Paper, San Diego 2011
- **Laser in Situ Keratomileusis Decentration With and Without Active Eye-Tracking System** DOWNLOAD
  Presented ASCRS Poster , San Diego, ASCRS, 2011
- **An outbreak of Diffuse Lamellar Keratitis (DLK) related to waste gas and an improperly mounted air conditioner** DOWNLOAD
  Presented ASCRS Boston 2010
- **Refractive outcome six months after LASIK with a mechanical microkeratome or femtosecond laser** DOWNLOAD

Maximized Blend and Optical zone for astigmatism DOWNLOAD

Presented: Chicago ASCRS, April 2008

Prevention of Epithelial ingrowth DOWNLOAD

Presented at ASCRS in Chicago,April 2008

American Academy of Ophthalmology 2007 DOWNLOAD

Sporadic Diffuse Lamellar Keratitis related to a Steam Humidifier, New Orleans, Nov 2007

ASCRS 2007 DOWNLOAD

Best Paper of Session,

ASCRS Paper Session 3-C: KERATOREFRACTIVE Cornea Metrics:
Best fit regression modeling of excimer lasers profiles

ASCRS Poster 2007 DOWNLOAD

Effect of excimer laser ablation decentration on refractive sphere, cylinder and coma

ASCRS Course Outline 2007 DOWNLOAD

Biophysics and Molecular Biology in Understanding LASIK Sequelae

Wavefront ablation of with the rule astigmatism DOWNLOAD

Note the relative over-correction at the three and nine position and the relative under-correction at the six and twelve position

Biology and Physics of LASIK DOWNLOAD

Presented to the Nebraska Optometric Association Oct 20, 2006

Biophysics of LASIK DOWNLOAD

American Society of Cataract and Refractive Surgery 2006

Hansatome and Zyoptix XP Keratome for LASIK DOWNLOAD

American Society of Cataract and Refractive Surgery 2006

Refractive Shift (Coupling) with Standard and Wavefront

American Society of Cataract and Refractive Surgery 2005

Use Tax DOWNLOAD

Use tax is not applicable in LASIK

Mechanics of Flap Wrinkling DOWNLOAD

American Society of Cataract and Refractive Surgery 2004

Oral Presentation: Mechanics DOWNLOAD

American Society of Cataract and Refractive Surgery 2004

Prevention of Microstriae DOWNLOAD

American Society of Cataract and Refractive Surgery 2003

ASCRS Course Outline DOWNLOAD

American Society of Cataract and Refractive Surgery 2003

Overhydration in LASIK Complications DOWNLOAD

American Society of Cataract and Refractive Surgery, June 2002.
1109

Epithelial Ingrowth with Hypertonic Saline DOWNLOAD

International Society of Refractive Surgery, Nov. 2001

Optisol (Corneal Preservation Media) in LASIK Surgery

First Place , Best Paper
Fall 2000 World Refractive Symposium

Aspiration into the LASIK Interface DOWNLOAD

Selected as a Highlight of the1999 Meeting of the American Society of Cataract and Refractive Surgery (ASCRS)

Cause and Prevention of Microkeratome Jamming Related to Lid Squeezing

Mark E Johnston MD FRCSC

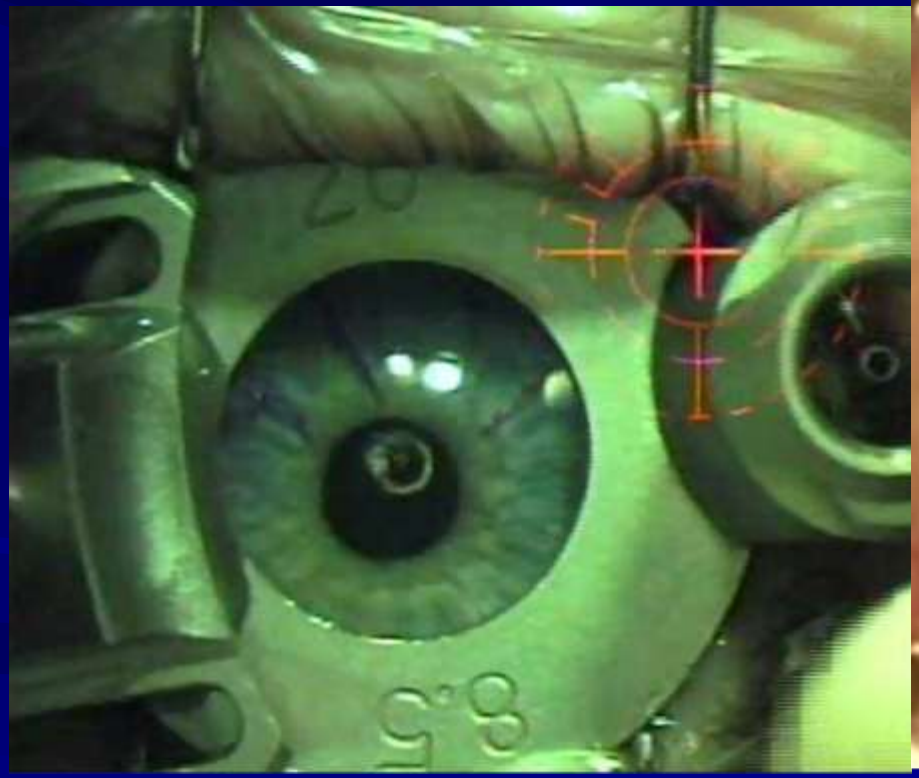
nebraskaeye.com

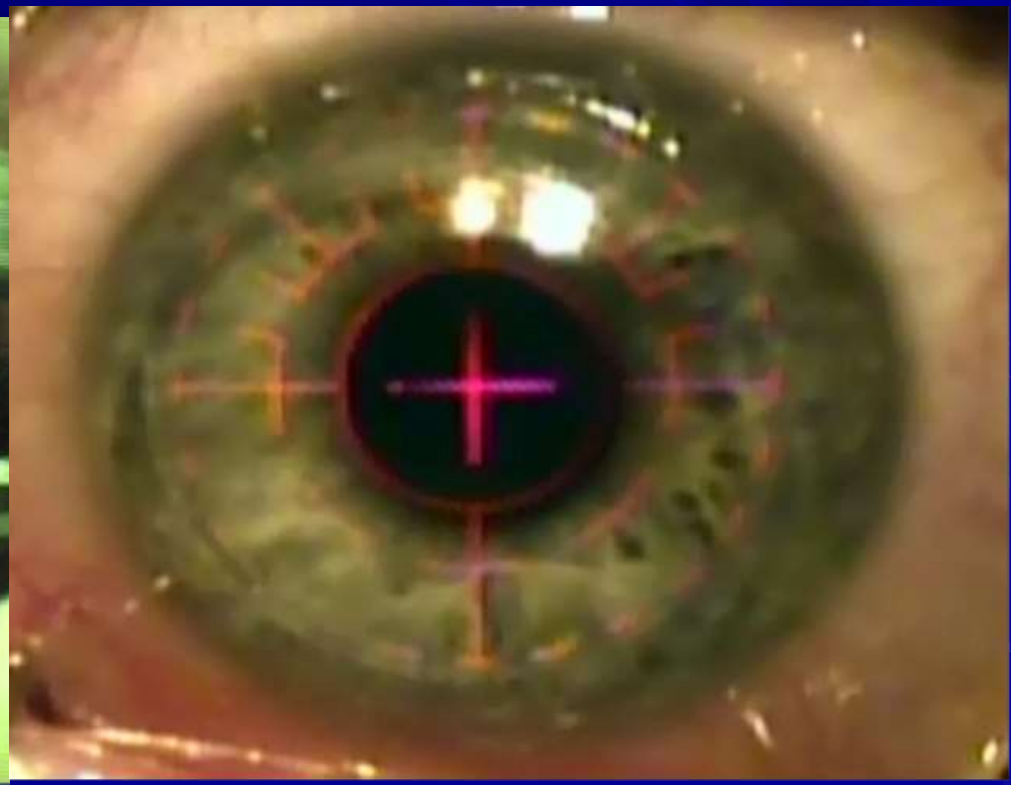
The authors have no financial interest in the subject matter of this paper.

The Zyoptix XP microkeratome has been used in our center for the past seven years in over 15,000 eyes.

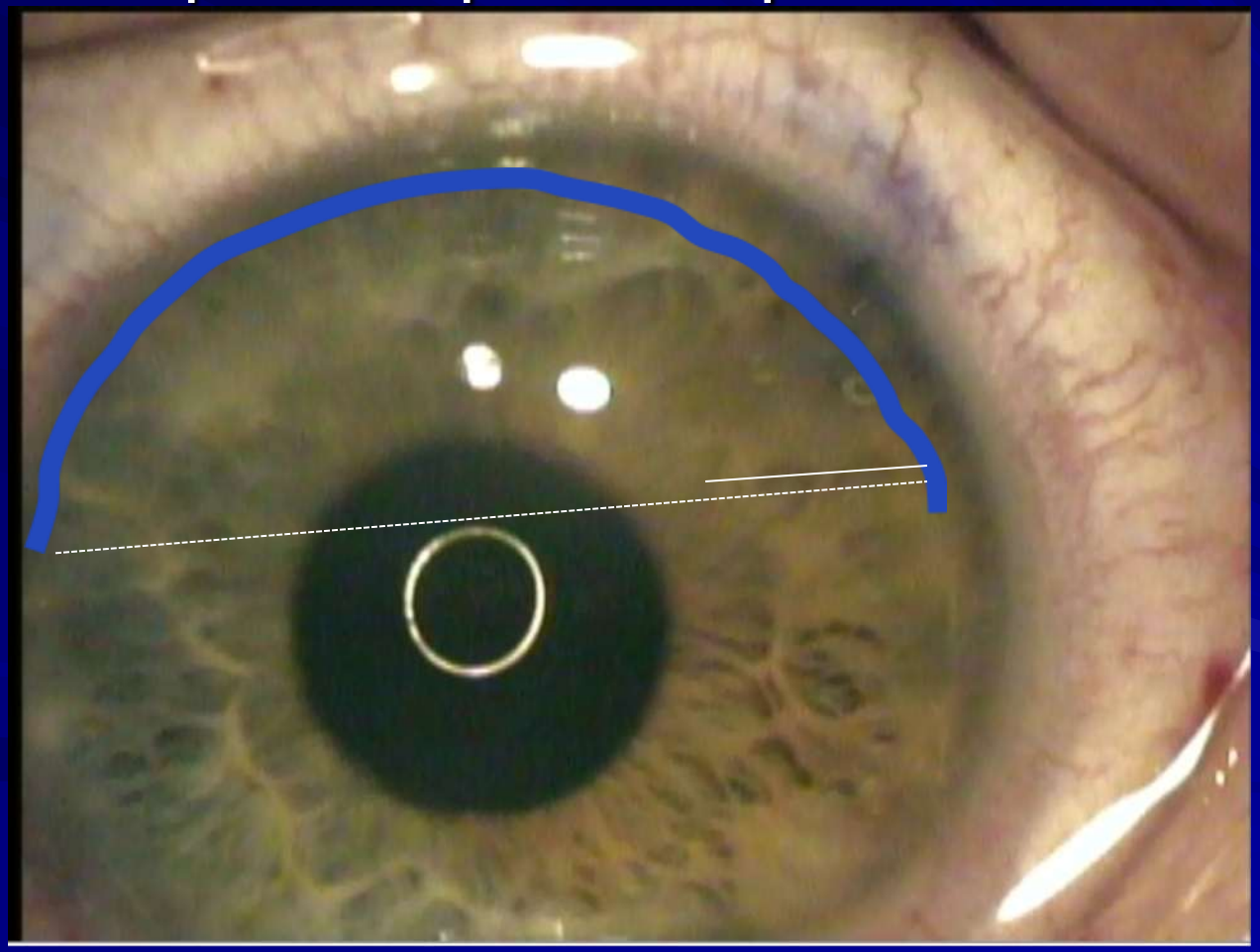
Three cases of jamming of the Technolas Zyoptix XP® microkeratome related to patient squeezing resulted in partial flap formation,

all in the first eye attempted and in males with deep set eyes and strong lids.





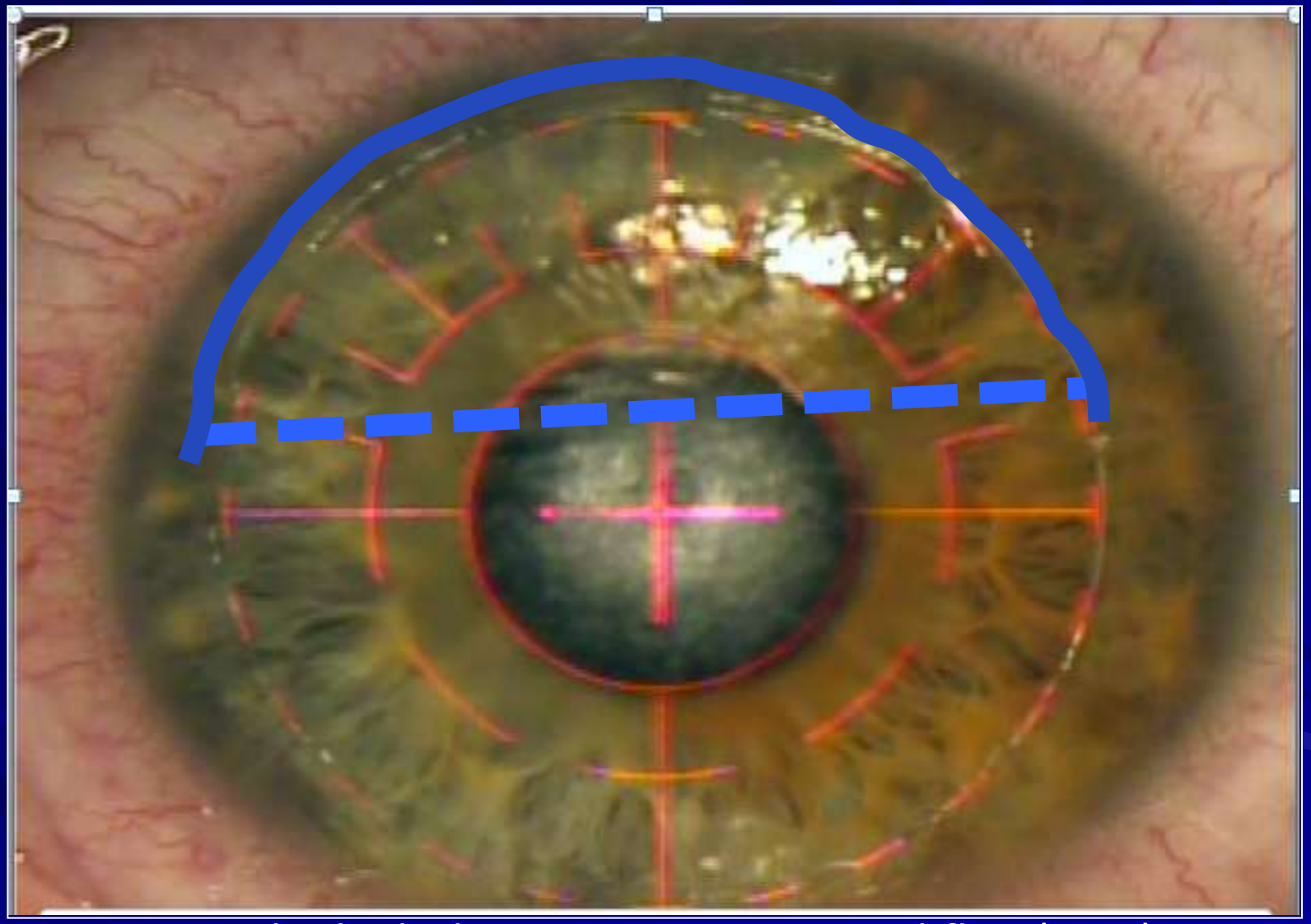
In the third case the microkeratome could not be reversed. The assembled suction ring-microkeratome was removed after suction was released, resulting in a partial flap with a partial flap tear.



Contact in place with flap repositioned

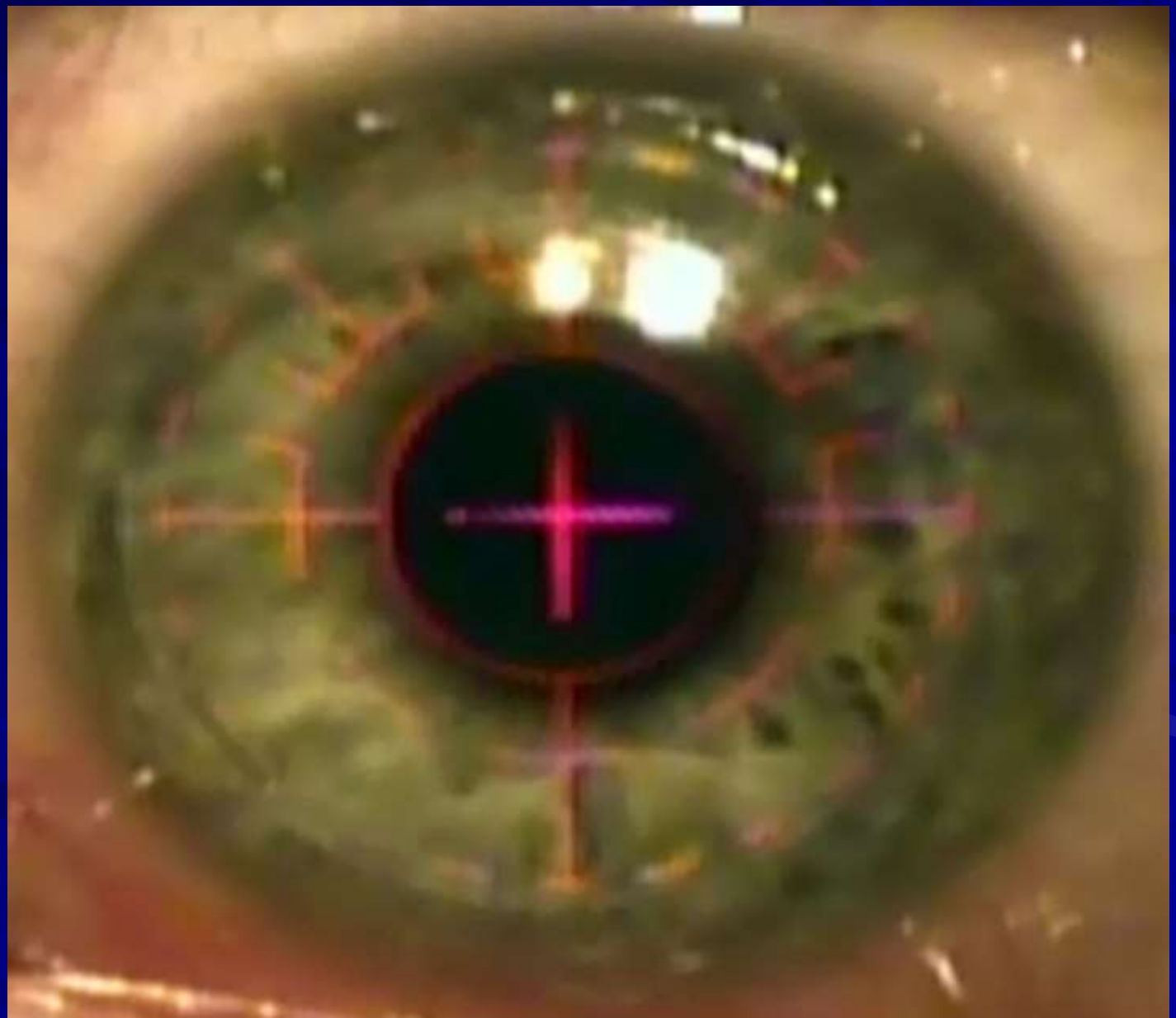
The mechanism for the first two cases was unclear. The microkeratome would not reverse during the third case, thereby allowing inspection and documentation of the mechanism.

All patients had successful photorefractive keratectomy at a later date.

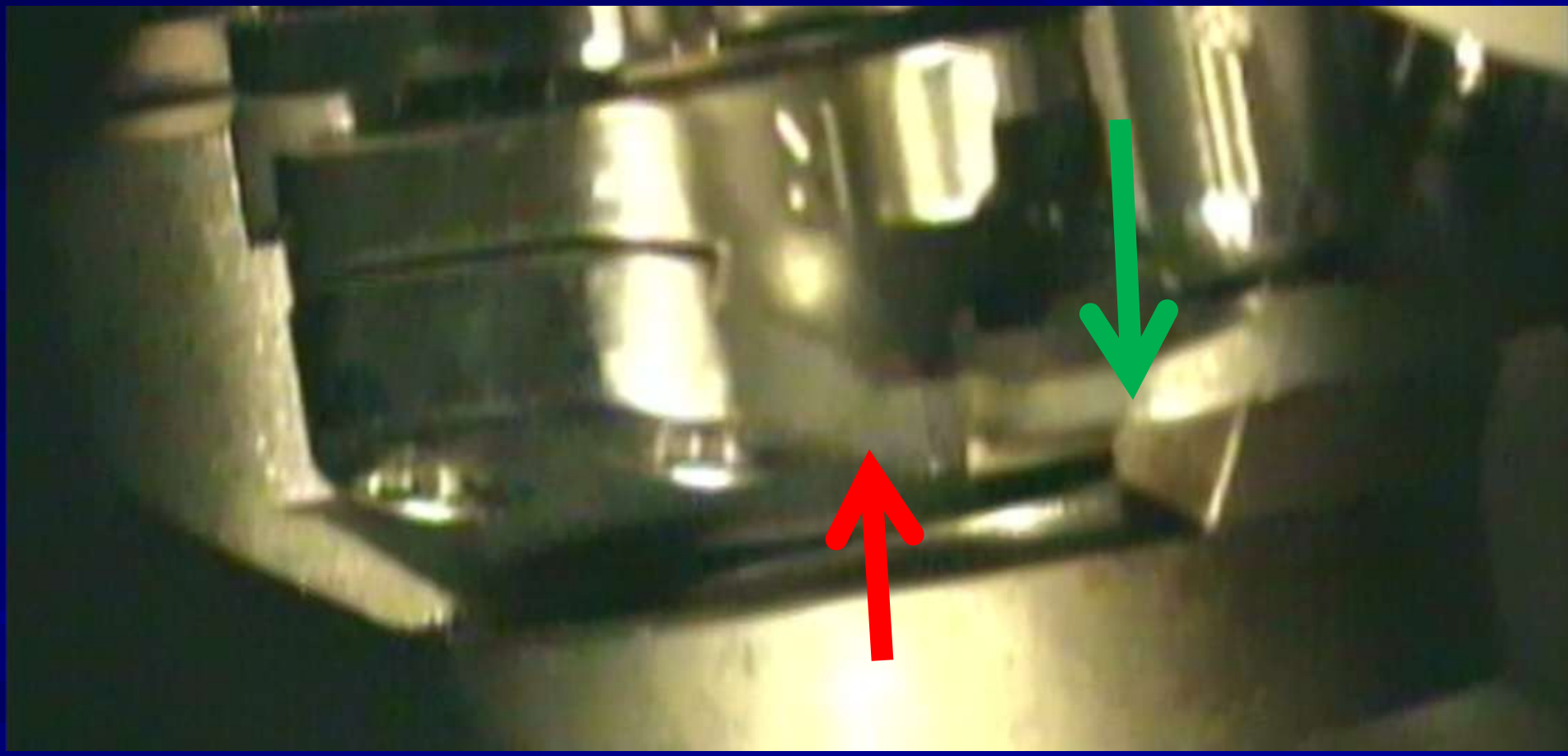


PRK with alcohol over previous partial flap (40%)

PRK (alcohol) over partial flap

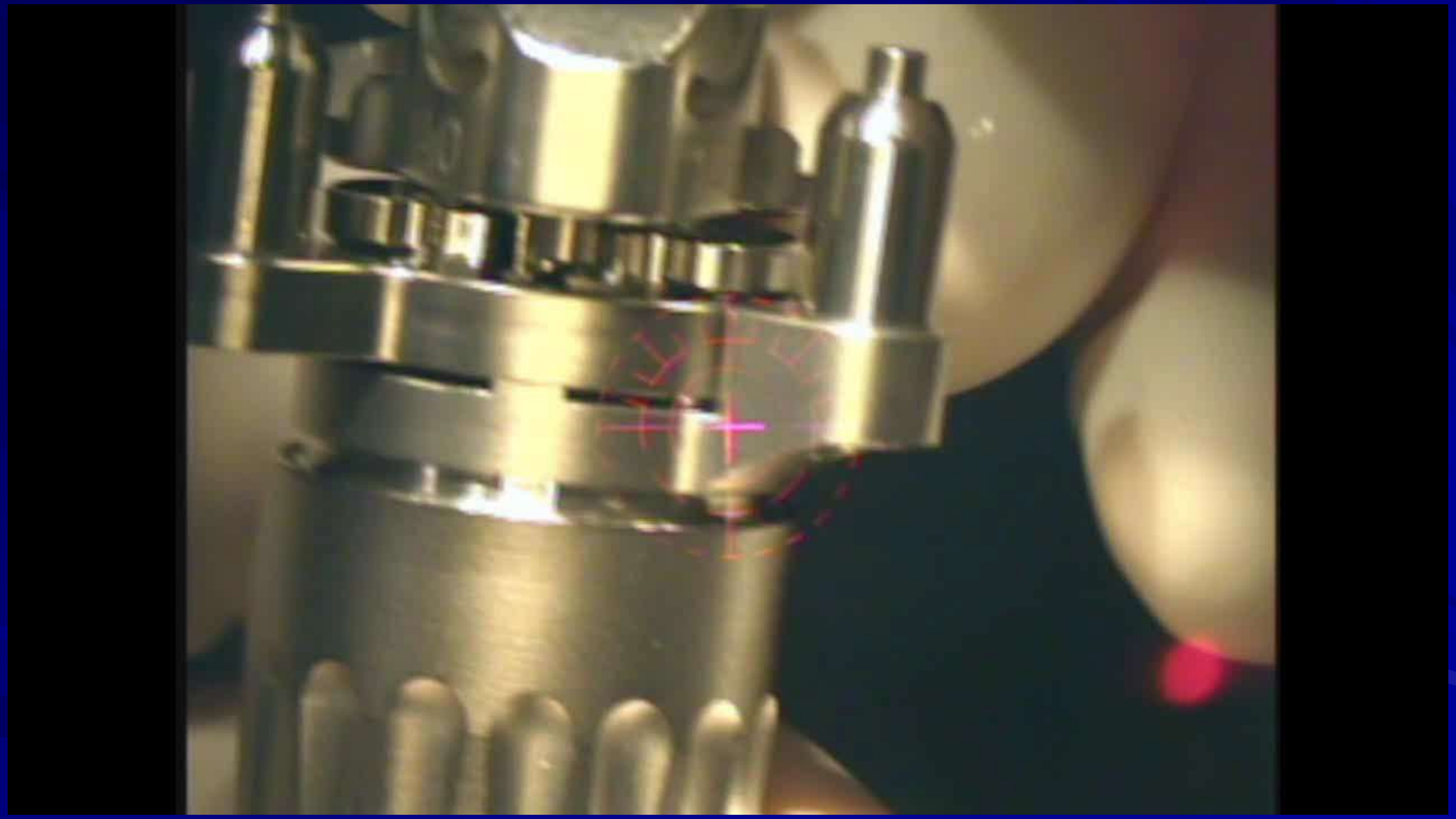


The jammed microkeratome from the third case showed that the guide on the microkeratome head which normally slides under the overhang of the microkeratome ring had instead advanced against this overhang and jammed.

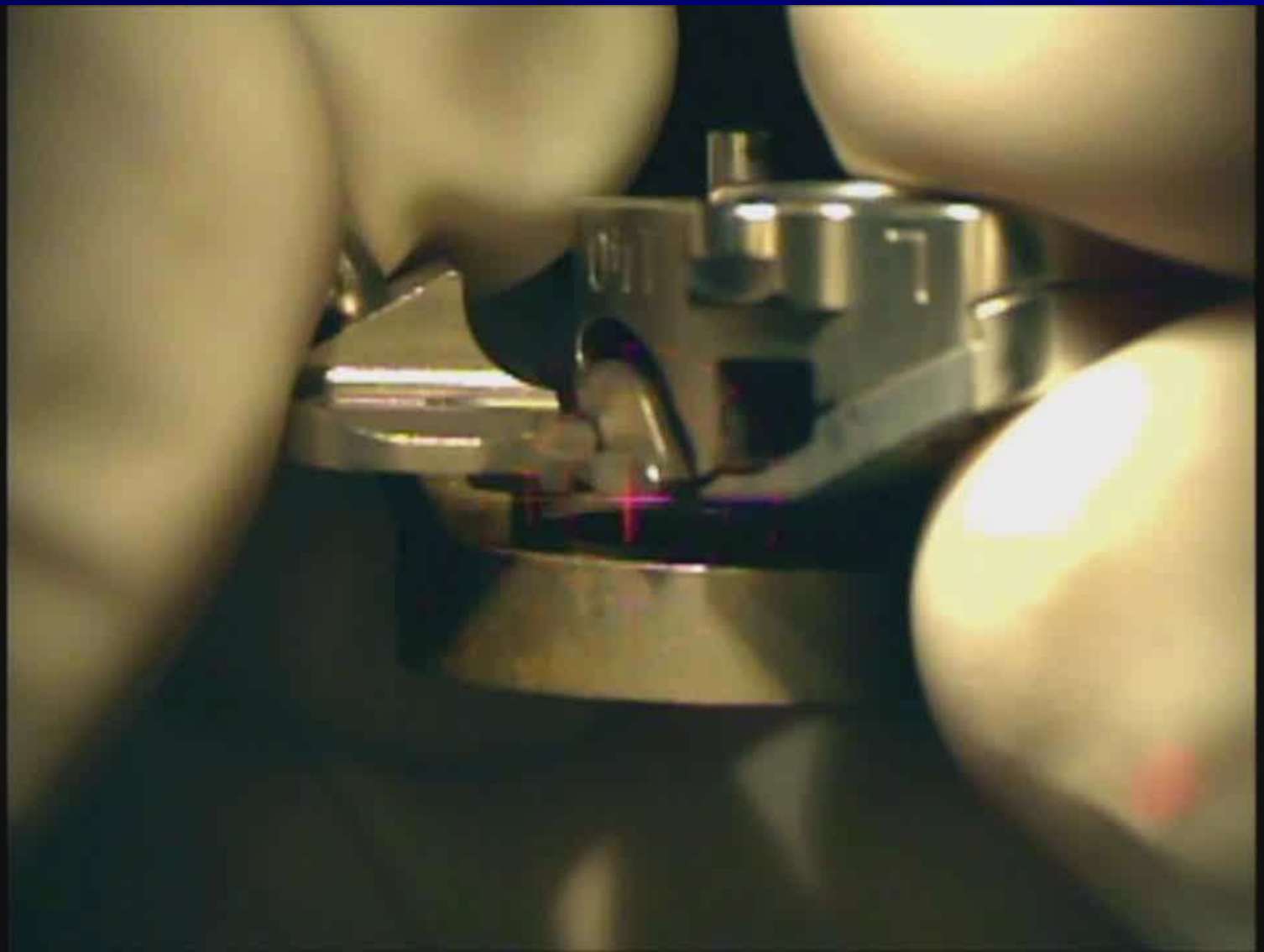


Glide (red) is jammed into the ring overhang (green)

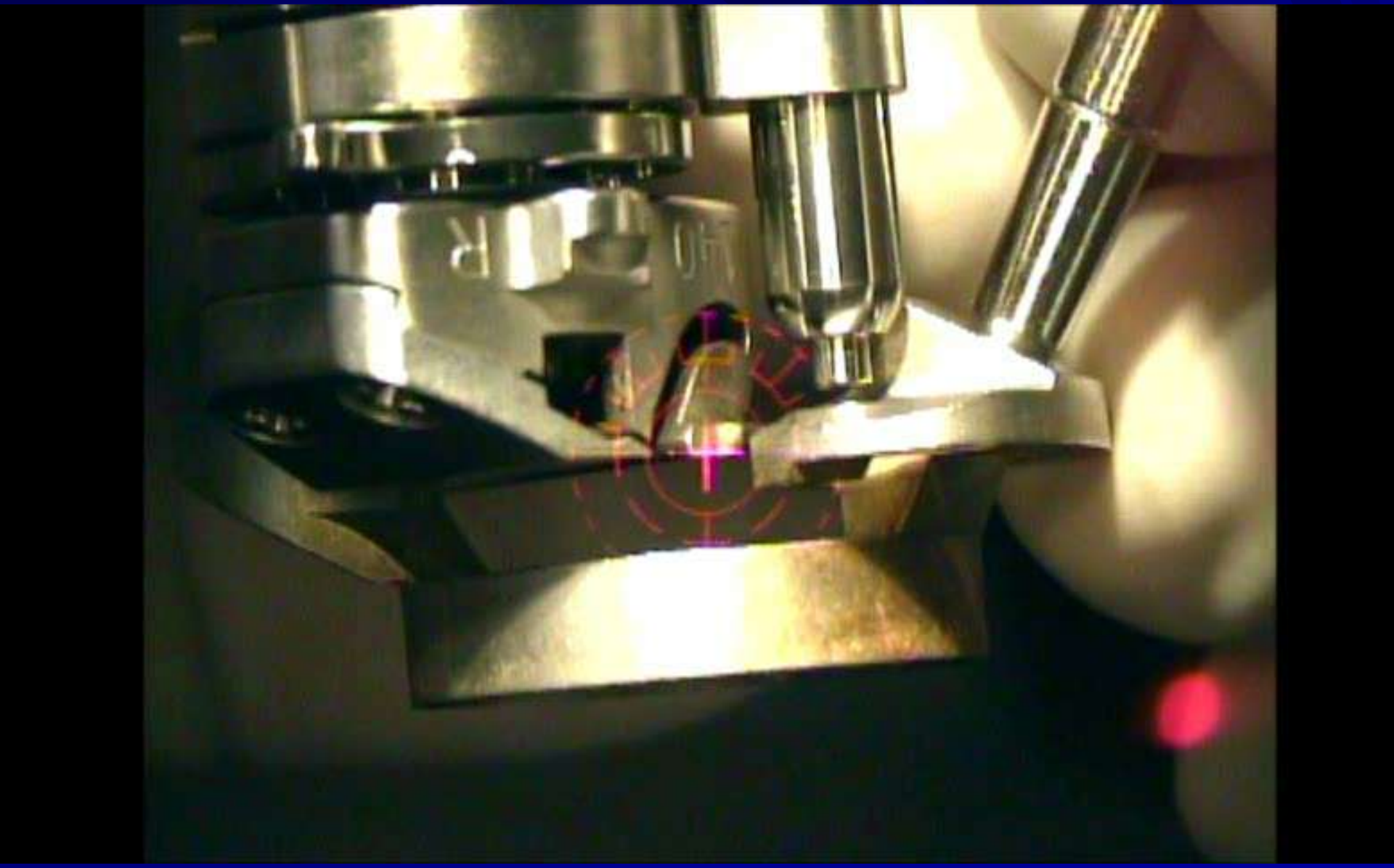
This jam can only be reproduced if the microkeratome head is first knocked slightly off angle and then advanced with the head not fully seated down into the microkeratome ring.



The off-angle head can then advance such that the microkeratome head guide is on the same plane as the overhang on the microkeratome ring and will jam at 40% excursion

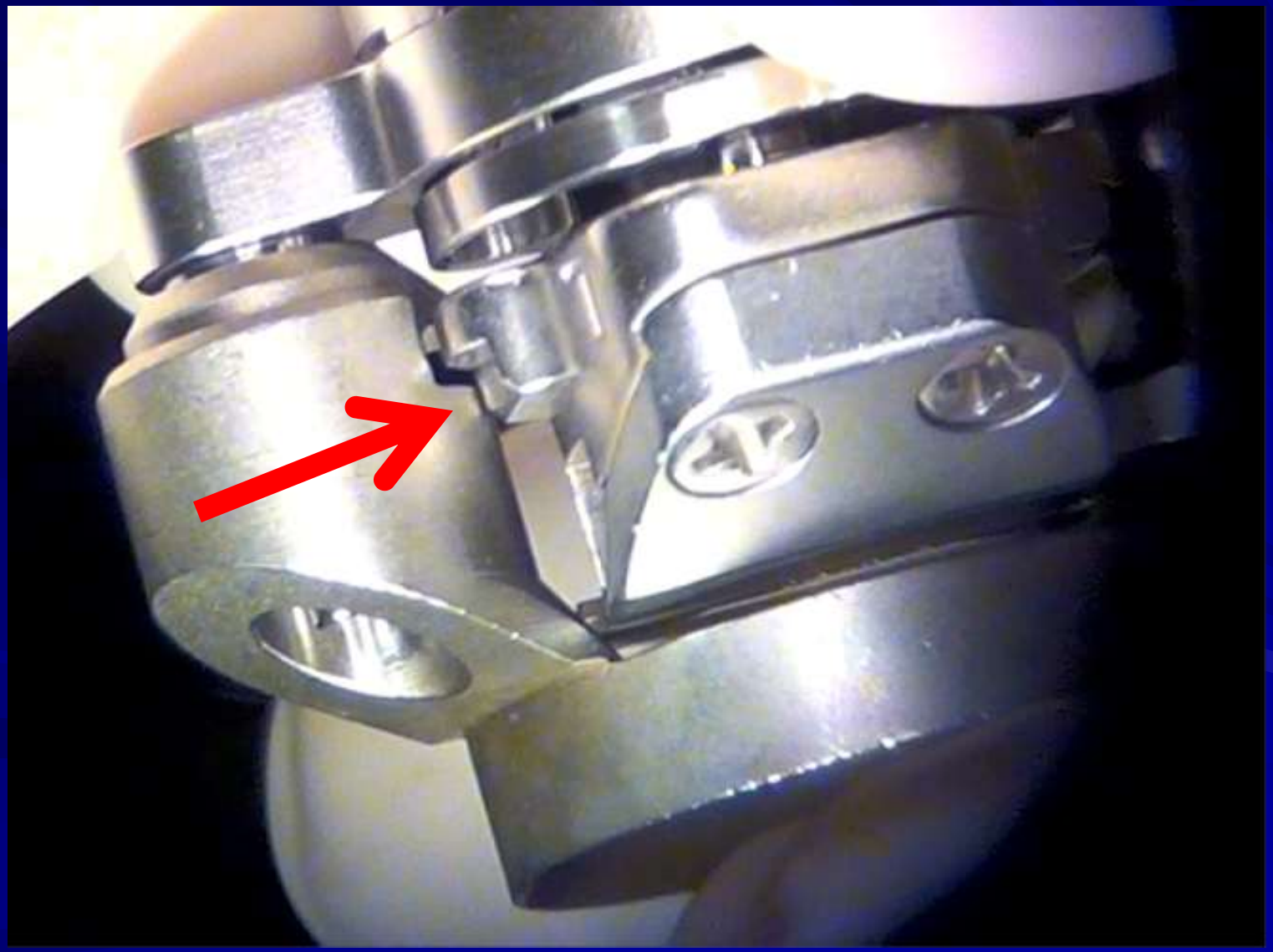


Demonstration: jamming



Caution: It may be difficult to unjam the keratome

Upper guide displacement makes the keratome difficult to unjam



No further cases have been noted for the last two years (over 3500 eyes)

Since the mechanism of this jamming has been understood, extra care is taken, especially in squeezers, to assure that the microkeratome head guide is properly seated and lower than the ring overhang before advancing the head

Laser in Situ Keratomileusis Decentration With and Without Active Eye-Tracking System

Mark Edmund Johnston MD
FRCSC

www.nebraskaeye.com

ASCRS Poster , San Diego, 2011

A subset of patients presenting for enhancement surgery following LASIK with the AMO-VISX ActiveTrak system were noted to have superior decentration.

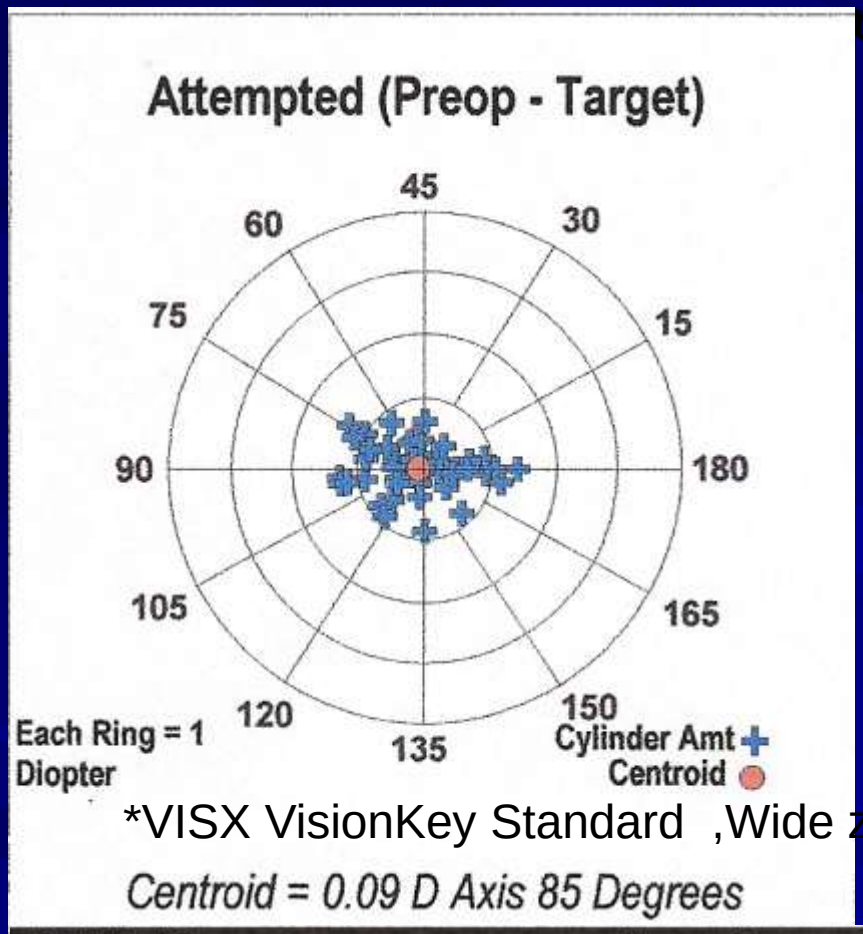
(Mark E .Johnston, Laser in Situ Keratomileusis Decentration with Active Eye-Tracking System ASCRS Poster , 2010)

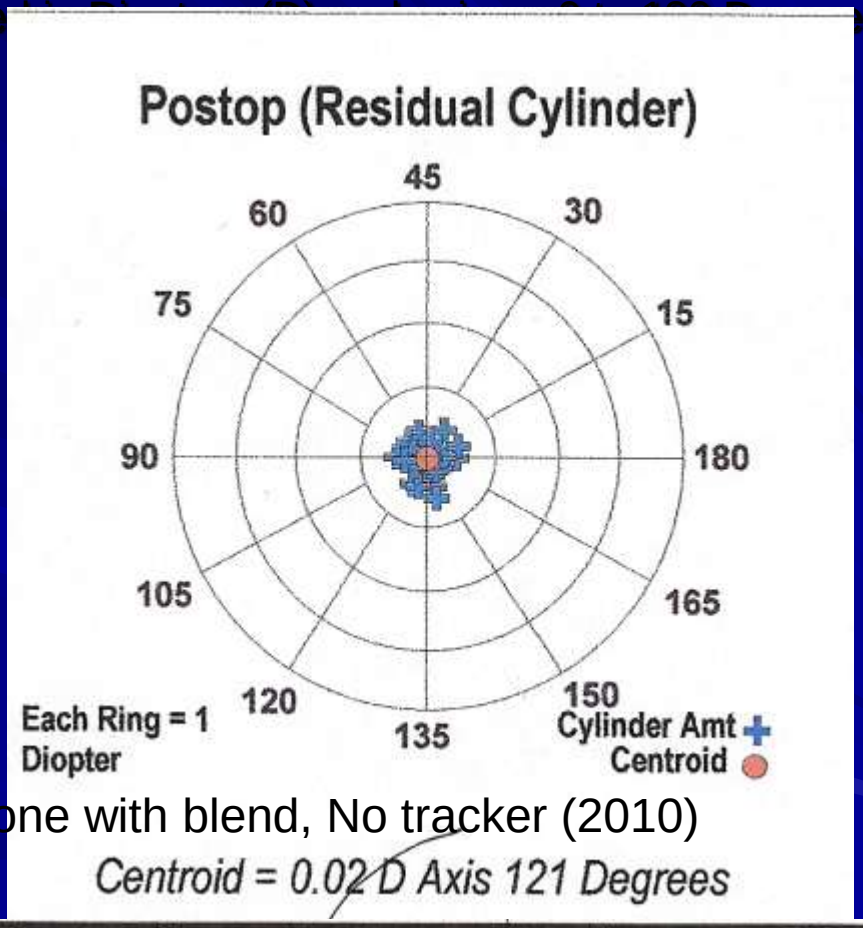
The ActiveTrak system video output feed can be recorded and/or monitored during surgery

Purpose

- Based on historic data without a tracker from our center and a pilot study we discontinued the routine use of the tracking device.
- This study was done to compare our results with and without a tracker.

We used astigmatism as a marker of decentration utilizing the Refractive Surgical Consultant© as our database.





*VISX VisionKey Standard ,Wide zone with blend, No tracker (2010)

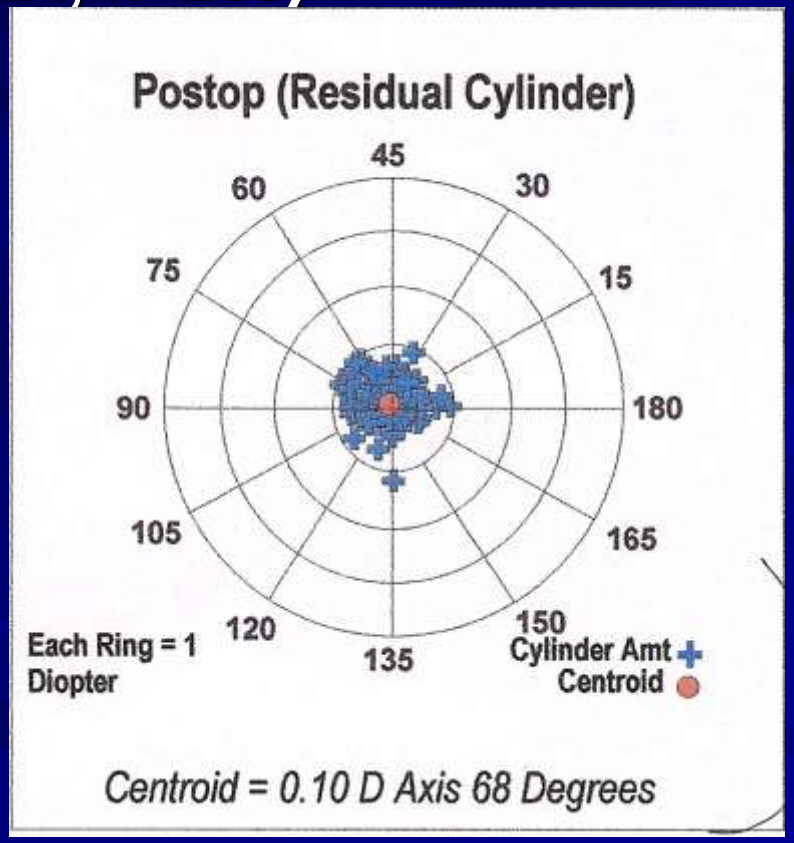
Statistical Summary	N	Mean	St Dev	Min	Max	Centroid	St Dev
Attempted Correction (Preop - Target)	76	0.44	0.43	0.00	1.45	0.09 D Axis 85 Degrees	0.40
Postoperative (Residual Cylinder)	76	0.12	0.18	0.00	0.66	0.02 D Axis 121 Degrees	0.15

Methods

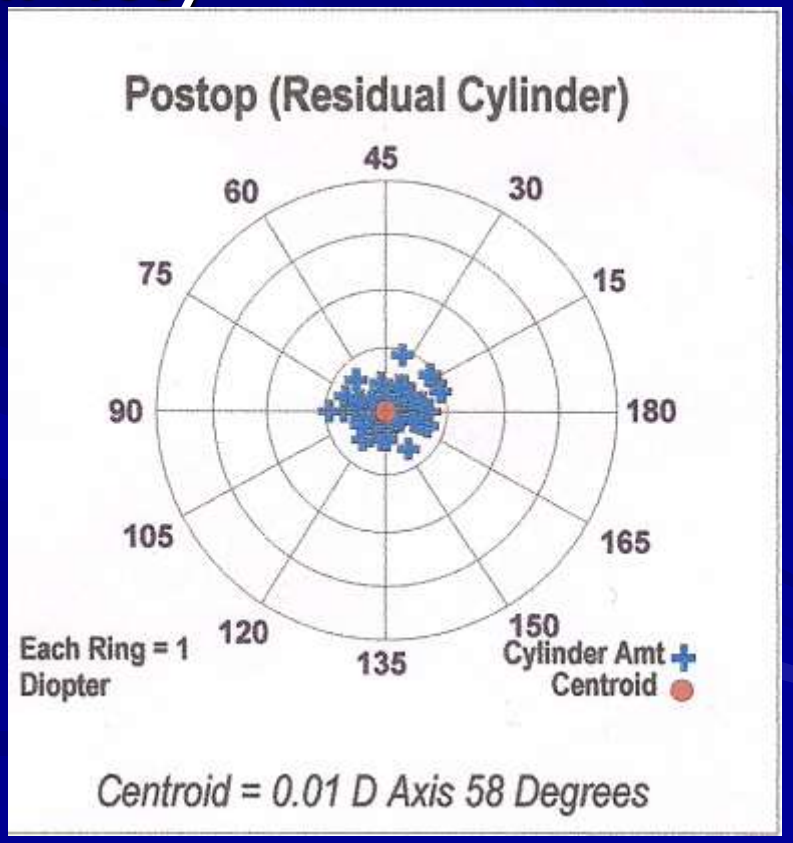
- A retrospective analysis was done on all myopic patients (0-10D) with less than 1.5 D cylinder treated with AMO-Visx CustomVue over a one year period.
- Corrections above (high) and below (low) 6.0 diopters spherical equivalent were analyzed separately.
- Ablations both with and without the tracker were centered on the pupil in low illumination

Results for low myopia:

WITH the tracker 0.10 Diopters at 68 Degrees (SD 0.24, n=288)



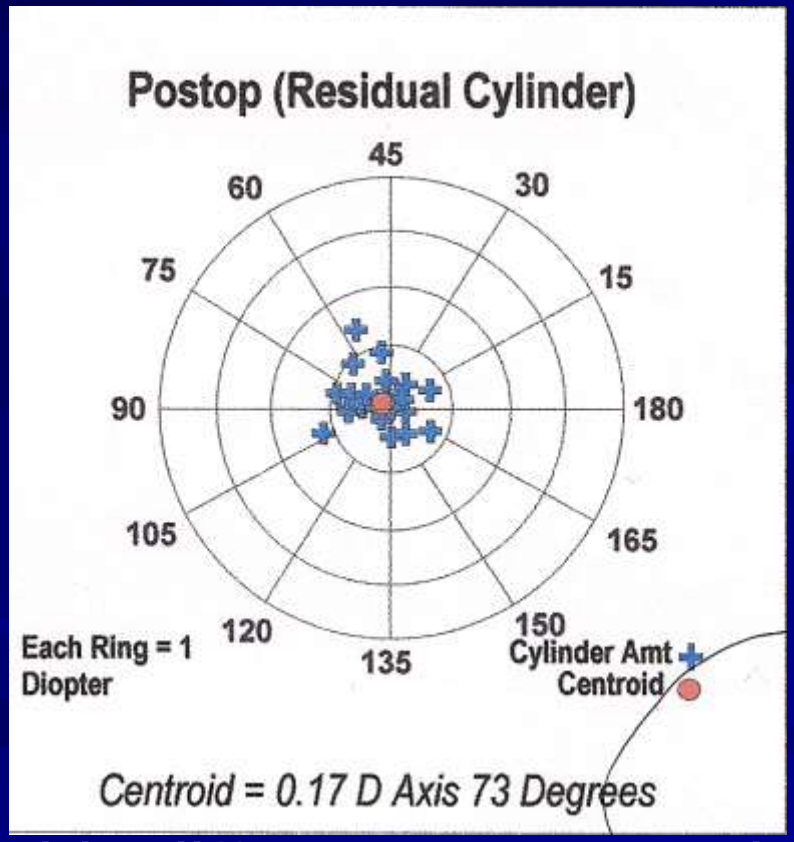
WITHOUT the tracker 0.01 D at 58 Degrees (SD 0.23, n=160)



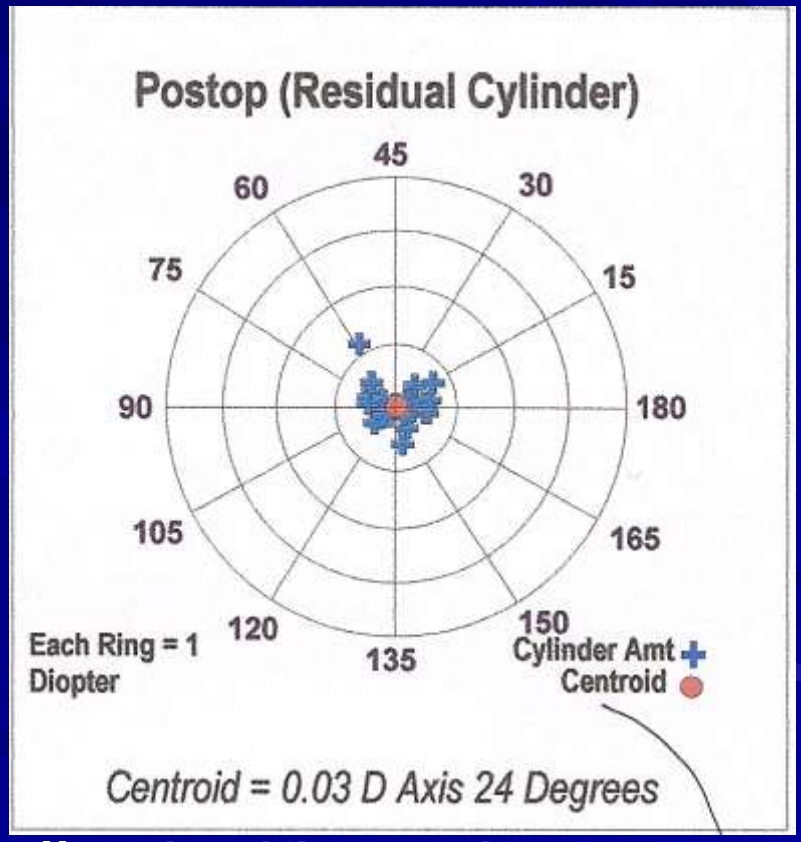
This difference was highly statistically significant (P=0.0001)

Results for high myopia:

WITH the tracker 0.17 D at 73 degrees (SD 0.36, n=43);



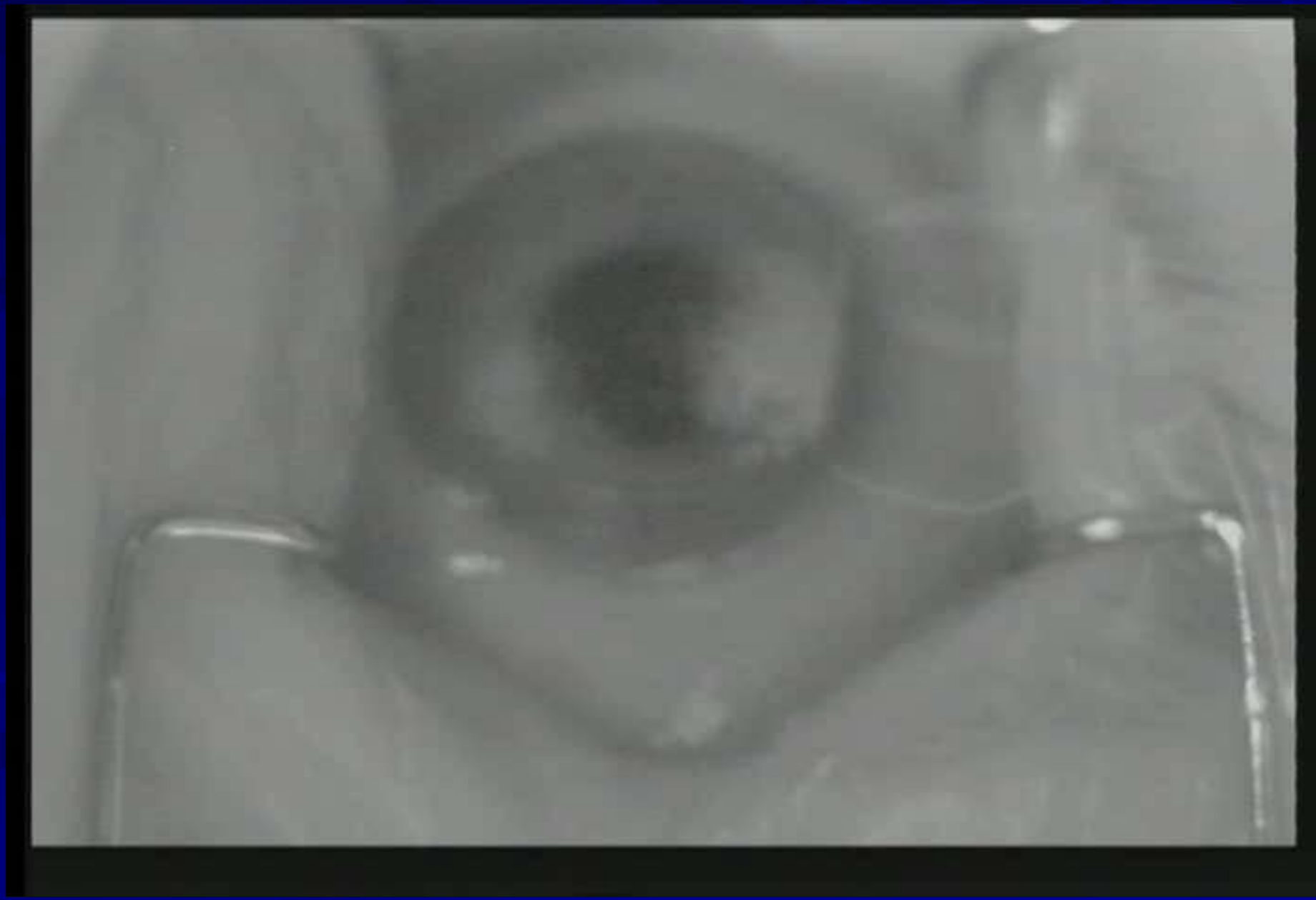
WITHOUT the tracker 0.03 D at 24 degrees (SD 0.24, n=56).

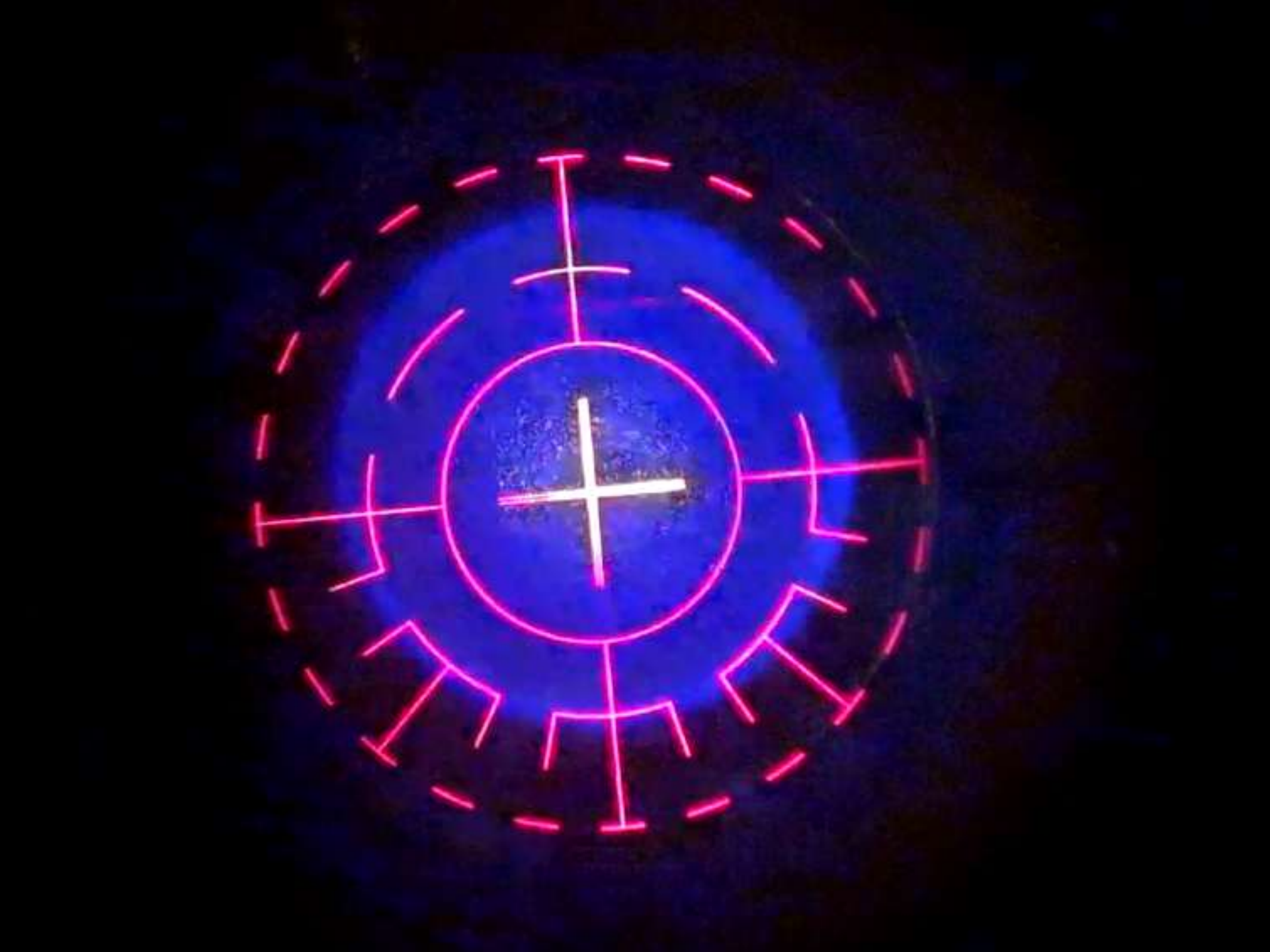


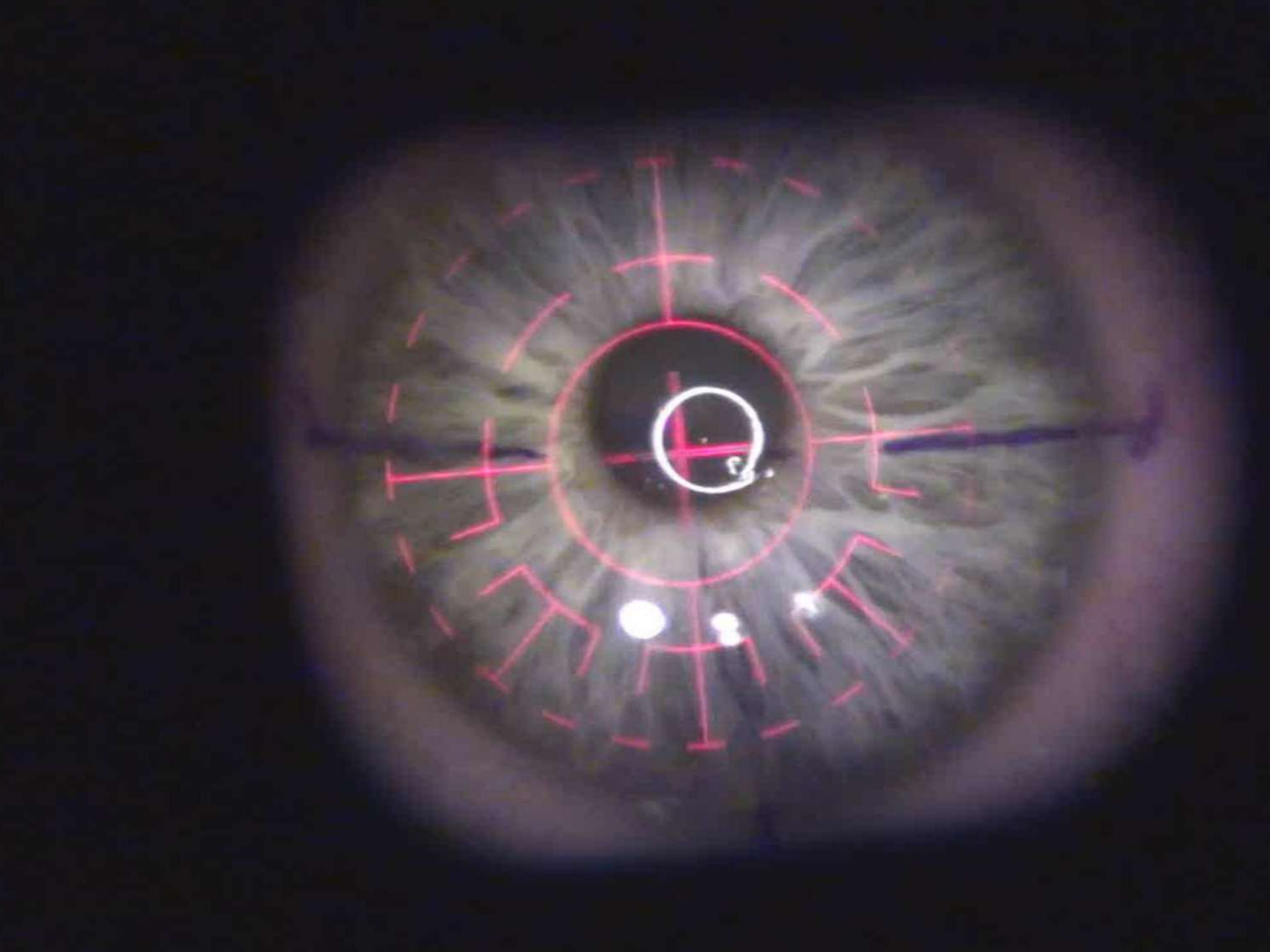
This difference was statistically significant (P=0.0226.)

Conclusion

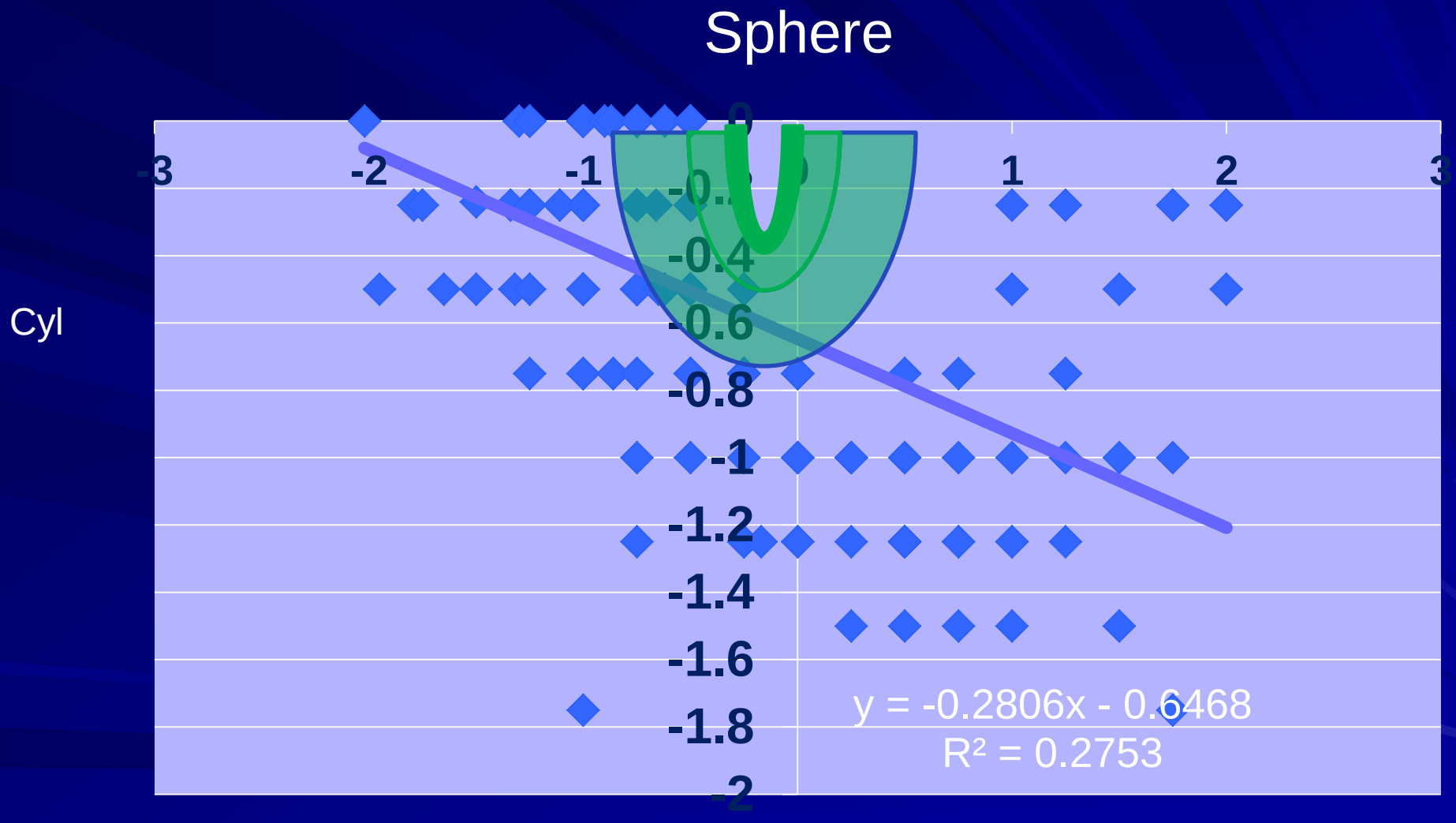
- While in general the ActiveTrak system performs well, with careful attention to fixation, superior results were noted without the tracker, even with the longer treatment times with higher corrections.





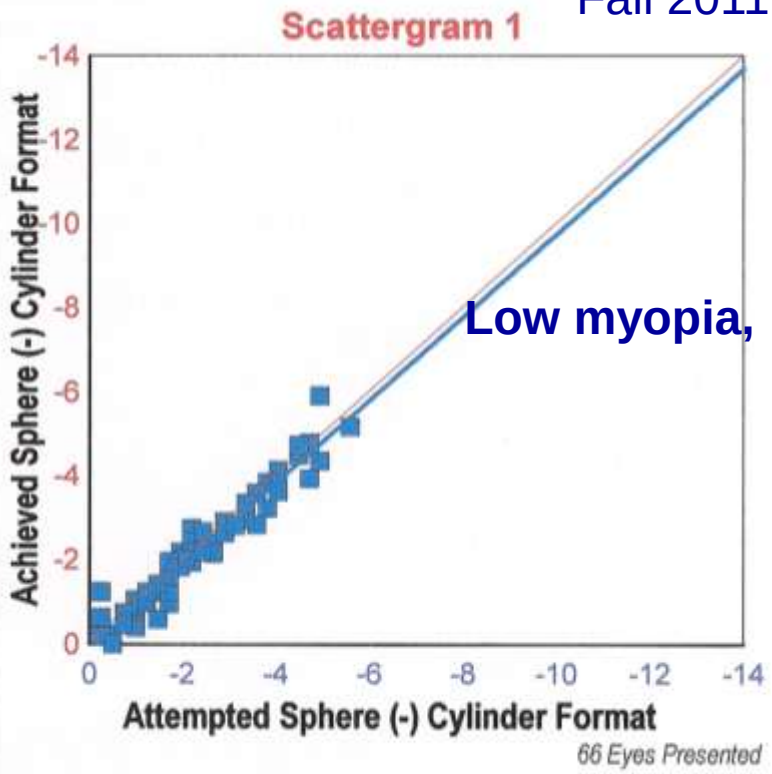


Pre-Enhancement 2011:

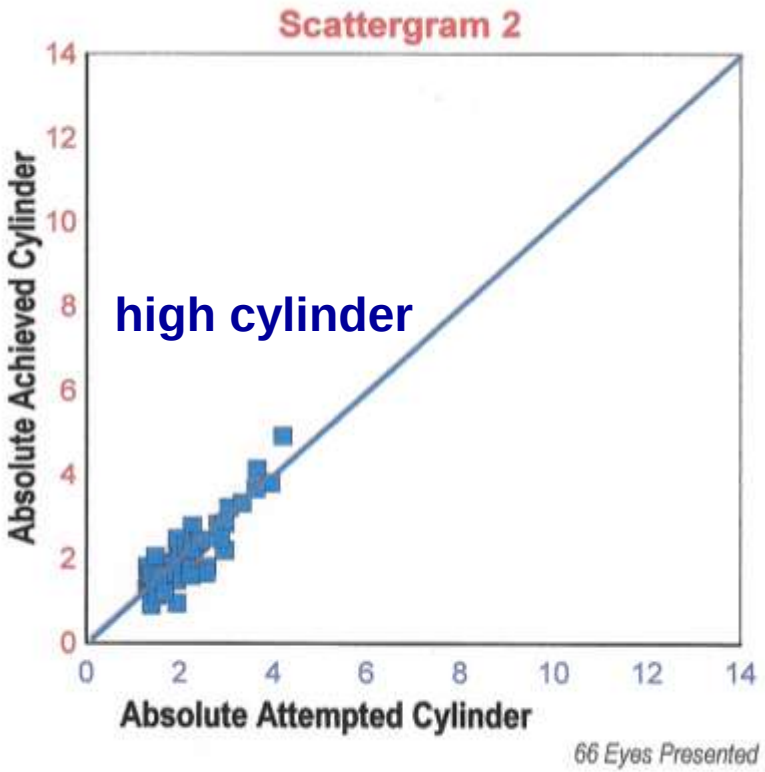


1 Month

Fall 2011



Low myopia,

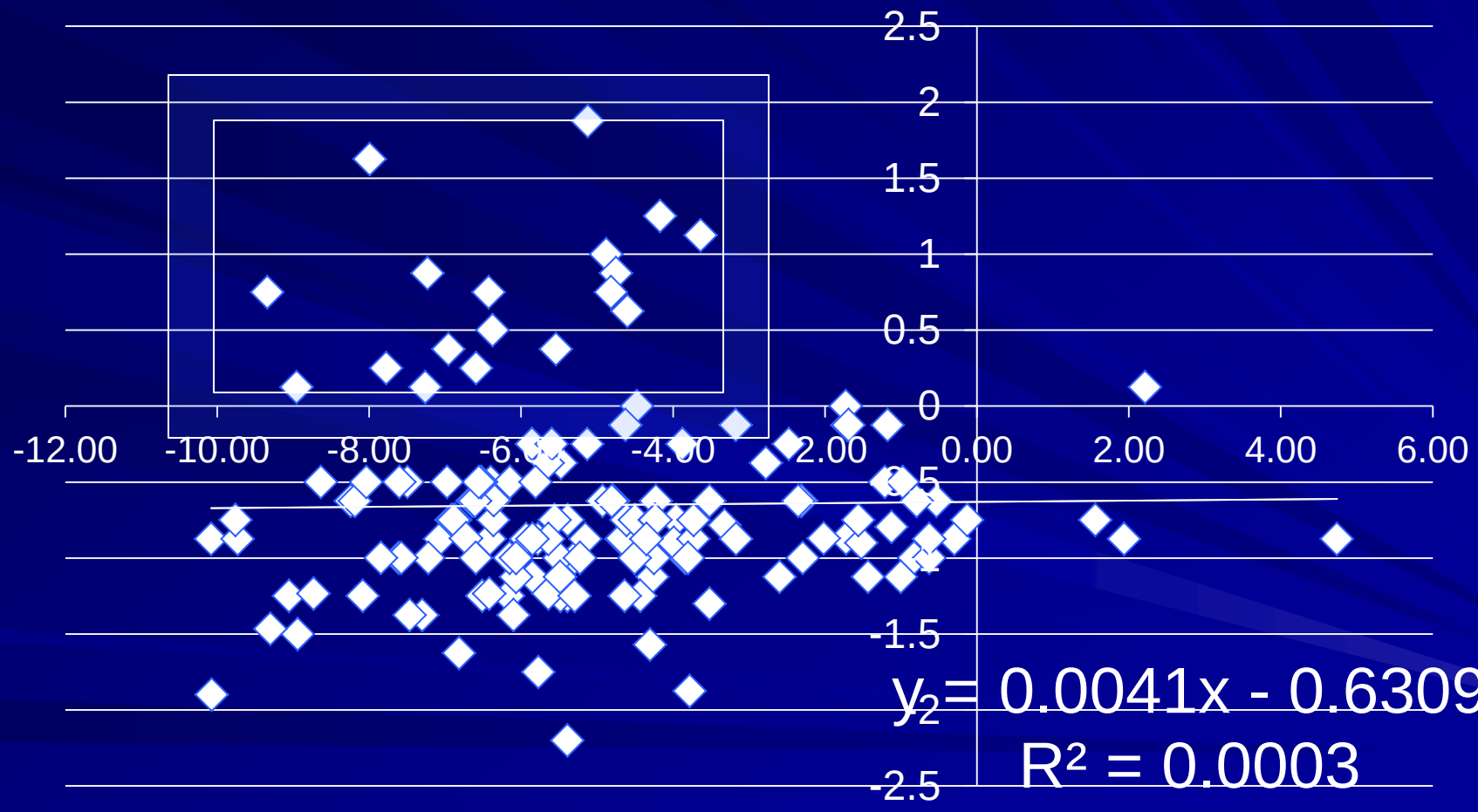


high cylinder

Achieved Sphere (-) Cylinder Format v. Attempted Sphere (-) Cylinder Format				
Statistics	Mean	Standard Deviation	Minimum	Maximum
Attempted Sphere (-) Cylinder Format	**-2.36**	**1.42**	**-5.58**	**-0.25**
Achieved Sphere (-) Cylinder Format	**-2.23**	**1.45**	**-5.91**	**0.04**
Linear Regression	Regression Formula		P Value	R Value
	Y=0.96 X		**0.000**	**0.982**

Absolute Achieved Cylinder v. Absolute Attempted Cylinder				
Statistics	Mean	Standard Deviation	Minimum	Maximum
Absolute Attempted Cylinder	**2.02**	**0.69**	**1.30**	**4.20**
Absolute Achieved Cylinder	**1.98**	**0.76**	**0.90**	**4.92**
Linear Regression	Regression Formula		P Value	R Value
	Y=0.98 X		**0.000**	**0.976**

Pre-post SE for cases that required Enhancement 2011:



An outbreak of Diffuse Lamellar Keratitis (DLK) related to waste gas and an improperly mounted air conditioner.

Mark Edmund Johnston MD FRCSC
www.nebraskaeye.com

Paper presented at ASCRS Boston 2010

- Five patients, in the middle of eleven patients, at a satellite surgery center developed Diffuse Lamellar Keratitis (DLK).
  - Three patients had minimal inflammation
  - Two patients had moderate central involvement (Grade 3) with delayed return to normal visual function.

Investigation

- As the same equipment, staff, reusables, medications and solutions were in use in our main surgery center, the major focus was on air quality.

- The outbreak occurred two days after a tornado caused street flooding , malfunction and noxious odor from a nearby waste treatment facility

The staff was asked to identify any unusual factors the day of the outbreak.

- The laser technician had noted a “rotten egg” odor from the air ducts.

Air duct in laser room

- The pre-op nurse had an abnormal cough, noted by the surgeon, during the time interval in question

Air duct in Pre-op

- One week later a single blast of a “sulfuric” odor was noted from the suspected air conditioner duct as the unit turned on.

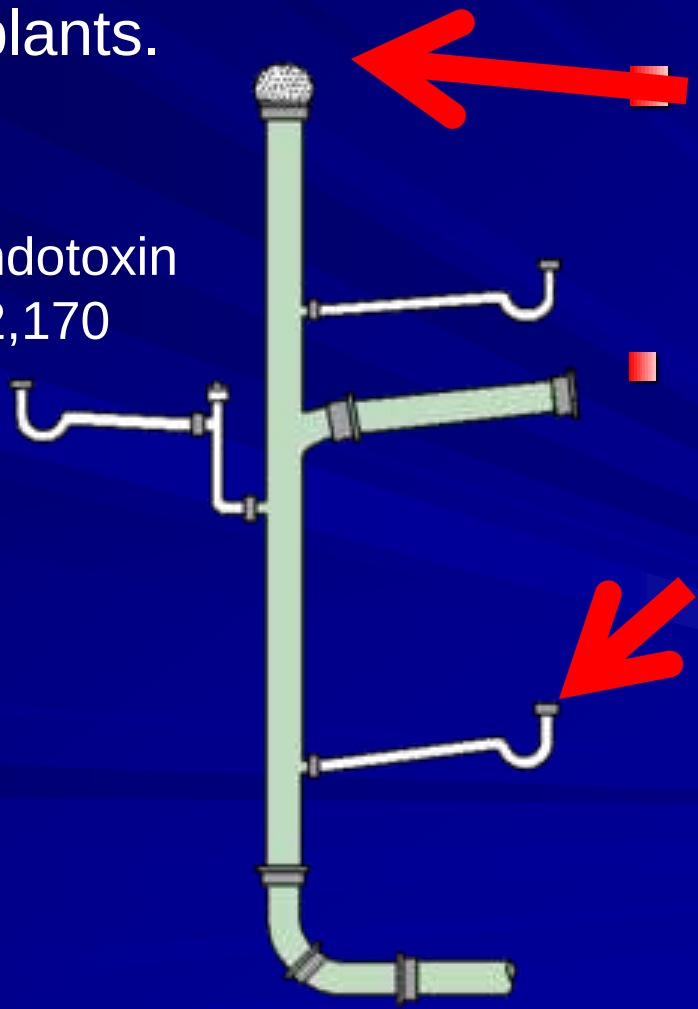
Instrument Prep Area

Initially the suspected cause was noxious waste gas, known to contain significant endotoxin and sulfur compounds.

Health effects among workers in sewage treatment plants.

The amount of airborne endotoxin varied between 3.8 and 32,170 ng/m3.

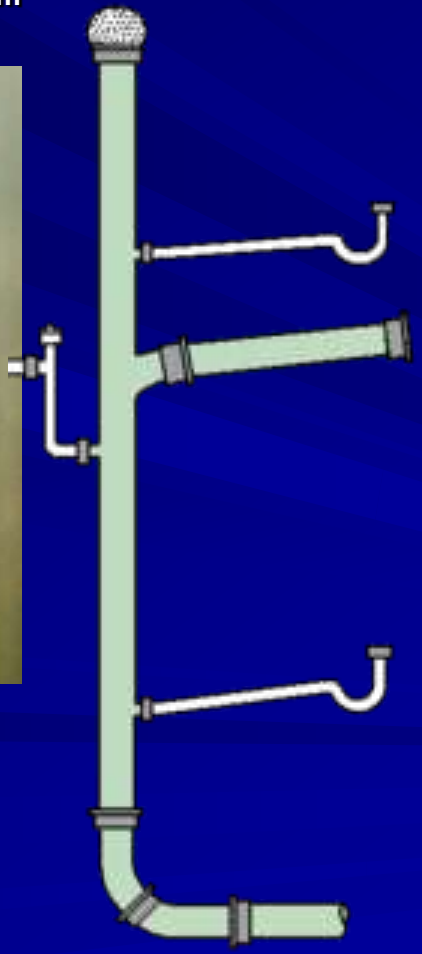
Rylander R.
Occup Environ Med. 1999 May;56(5):354-7.



- Any pressure surge should be released by the waste vent
- A water trap prevents waste gas from entering the air-conditioning unit.

An initial inspection was negative

A remote air conditioner did not meet code:
- **It was more than 20 feet from the drainage waste system**
- **did not have a proper vent**



Water heater

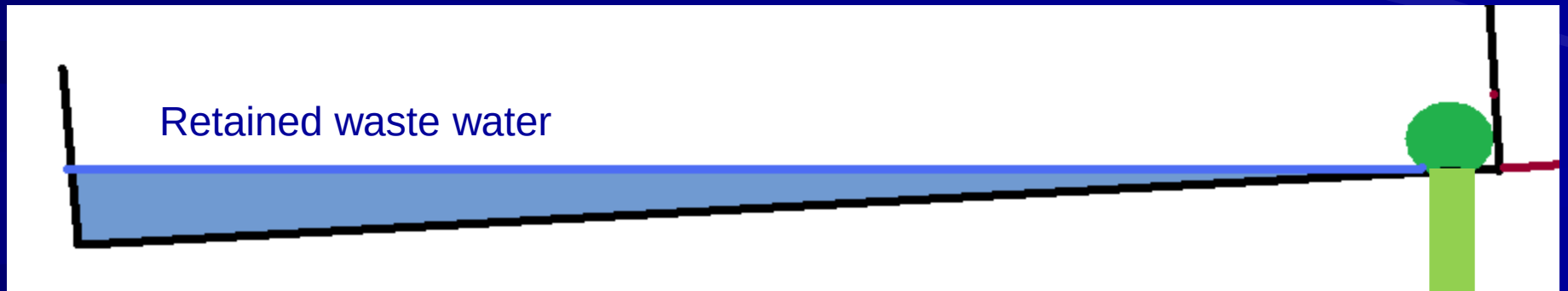
Airborne endotoxin assays two weeks after the outbreak were normal.

ENDOTOXIN ANALYSIS

Location:	1: Sioux city (7-21) fan on	2: Sioux city (7-18) 24 hours	3: Sioux city (7-18) 1-hour
Comments (see below)	A	A	A
Lab ID-Version‡:	2533739-1	2533740-1	2533741-1
Sample Type:	Dust sample	Dust sample	Dust sample
Measurement:	1 sample	1 sample	1 sample
1 EU* conversion:	0.091 ng	0.091 ng	0.091 ng
Reporting Unit:	EU/sample	EU/sample	EU/sample
RESULT:	**0.064**	**0.034**	**< 0.025**

- New external sewer vents were installed at one week

Internal inspection after the OR unit was removed showed rusting of the drainage pan consistent with an improper reverse slant, away from the water trap.



The abnormal unit drained in the middle, making it easy to tilt in the wrong direction during installation

A new air-conditioner system was installed and no further episodes occurred.

Volatile organic compounds associated with microbial growth in automobile air conditioning systems

Curr Microbiol. 2000 Sep;41(3):206-9. Links
Rose LJ, Simmons RB, Crow SA, Ahearn DG.
Department of Biology, Georgia State University, Atlanta, GA 30303, USA.

- Biofilms of M. mesophilicum on aluminum evaporator components produced mainly dimethyl disulfide.
- Reduction of retained moisture in the air conditioning system is advised for remediation of the noxious odors.

Conclusion

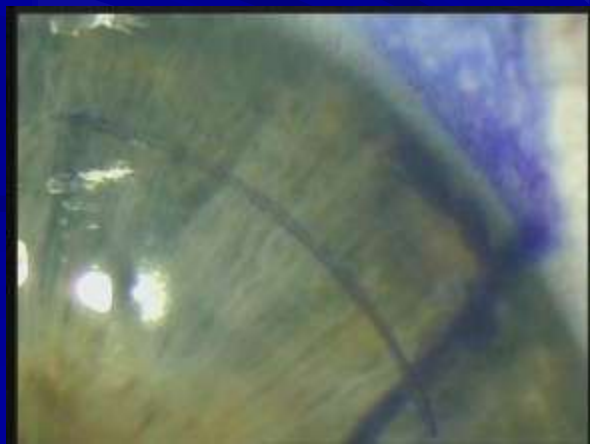
- We found improper installation of an air conditioner with retained waste water and secondary noxious odor , consistent with bacterial endotoxin as the cause of our cases of DLK.

Debris from LASIK Sponges 2011

Refractive outcome after myopic LASIK with a mechanical microkeratome or a femtosecond laser keratome

Mark E Johnston, MD, FRCSC
www.nebraskaeye.com

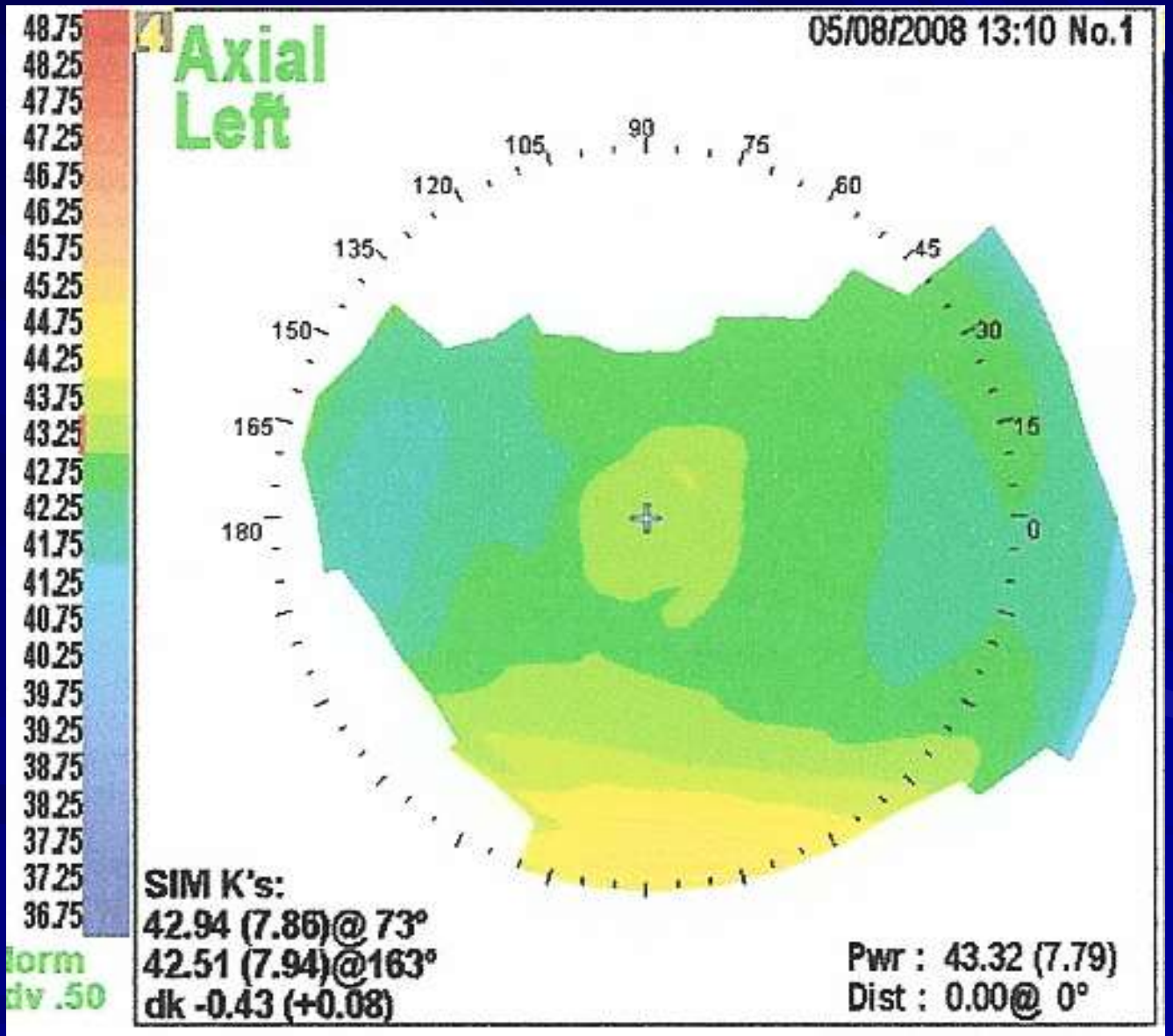
Presented San Francisco ASCRS 2009



Purpose:

- An increased number of myopic enhancements were noted following Lasik with a femtosecond keratome.
- This study was undertaken to refine our nomogram; particularly to differentiate between
  - low myopia vs high myopia
    - spherical equivalent under/over -6.00 Diopters
  - younger vs older patients
    - under / over age 40

Central island and undercorrection with IntraLase



Corneal incisions can create a myopic refractive error

Corneal flattening by shallow circular trephination in human eye bank eyes.

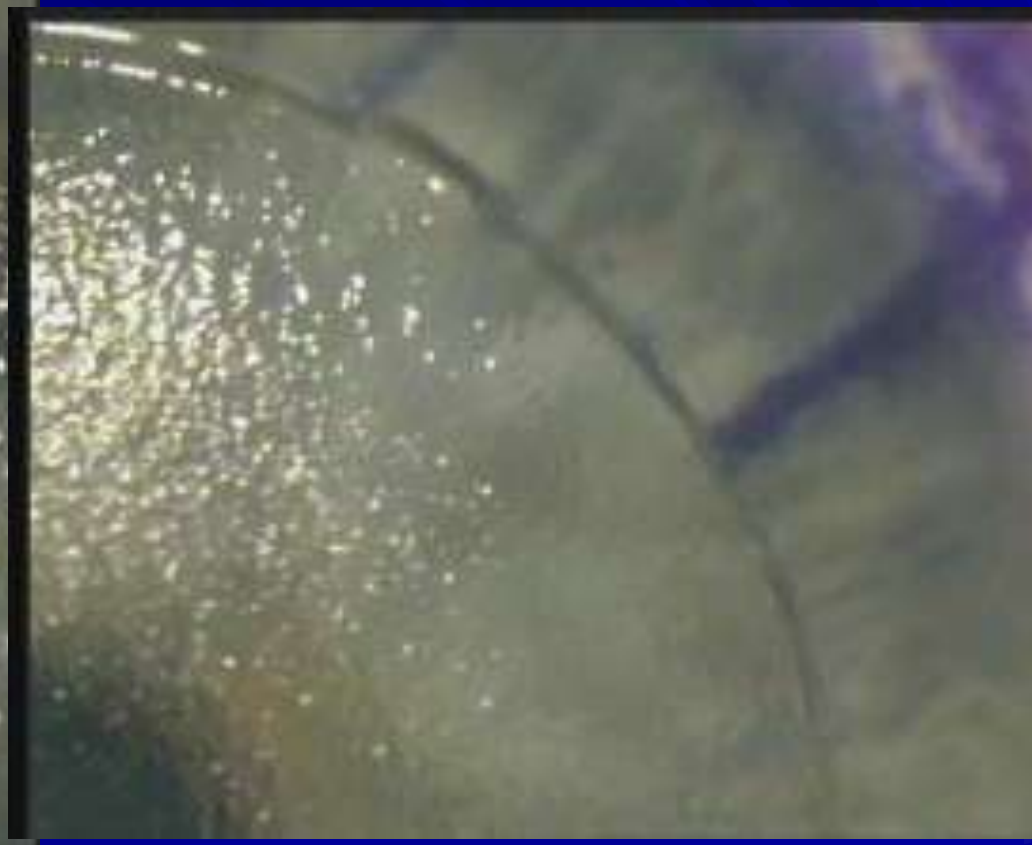
Gilbert ML, Roth AS, Friedlander MH.
Refract Corneal Surg. 1990 Mar-Apr;6(2):113-6.

- **The mean acute central keratometric flattening from the shallow trephine incision was 2.81 D (SD 2.28, P = .017)**

Clinical: Edge profile

Microkeratome:
Stepped / beveled

IntraLase:
Sharp edge / steep



METHODS:

- Lasik flaps were made with a Zyoptix XP microkeratome® 140 micron blade (MK) or IntraLase® 130 micron (IL).
- VISX® wavefront guided ablations were done.
- During the study period we treated 1081 eyes in the microkeratome group and 644 eyes in the IntraLase group.
- Small target adjustments were made for age, spherical aberration and cylinder.
- IntraLase was done if preferred by the patient or when recommended by the surgeon, most commonly older patients (over 40) and patients with higher corrections.
- The Refractive Surgical Consultant® was used to analyze all available results at one, three and six months after surgery.
- Statistical analysis was done with two-tailed p value, statistical significance at $p<0.05$.

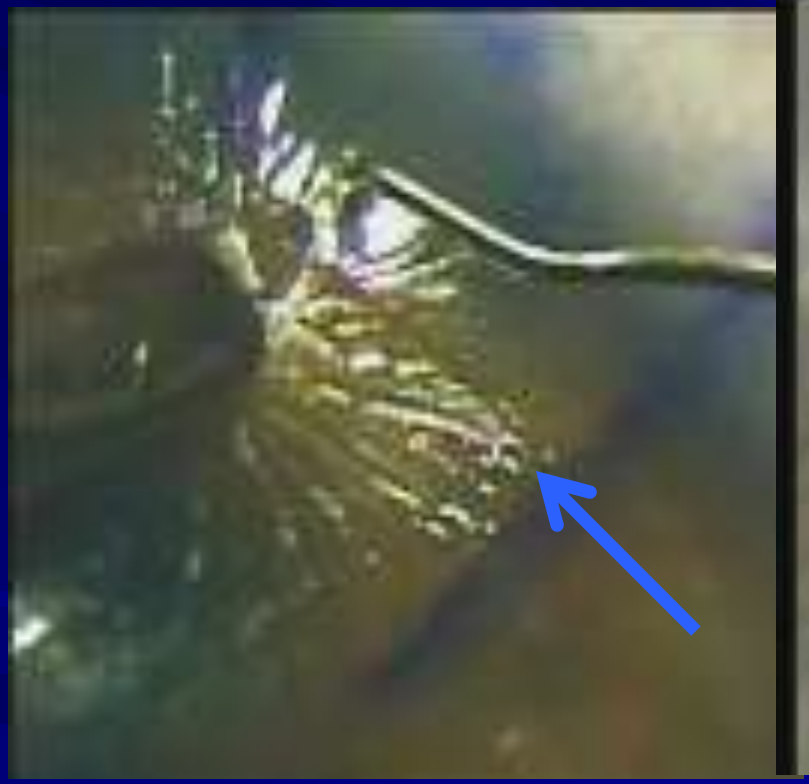
Results:
Difference between spherical equivalent (SE) outcome and predicted SE outcome with standard deviation (SD)

	Zyoptix XP			IntraLase			P value
	Sph Eq	St Dev	#	Sph Eq	St Dev	#	
All patients							
1 mo	-0.05	0.41	915	-0.14	0.48	521	0.0002
3mo	-0.12	0.44	411	-0.21	0.52	292	0.0135
6mo	-0.16	0.43	333	-0.28	0.55	248	0.0035
*The subsets of under/over age 40 with low myopia showed similar trends							
High myopia & under 40							
1 mo	+0.08	0.52	56	-0.29	0.59	63	0.0005
3 mo	-0.04	0.80	23	-0.45	0.59	29	0.0384
6 mo	-0.13	0.50	22	-0.55	0.90	32	0.0589^

*There were an insufficient number of cases in the over 40/high myopia subset for clinical significance
^Borderline statistically significant

Clinical observations

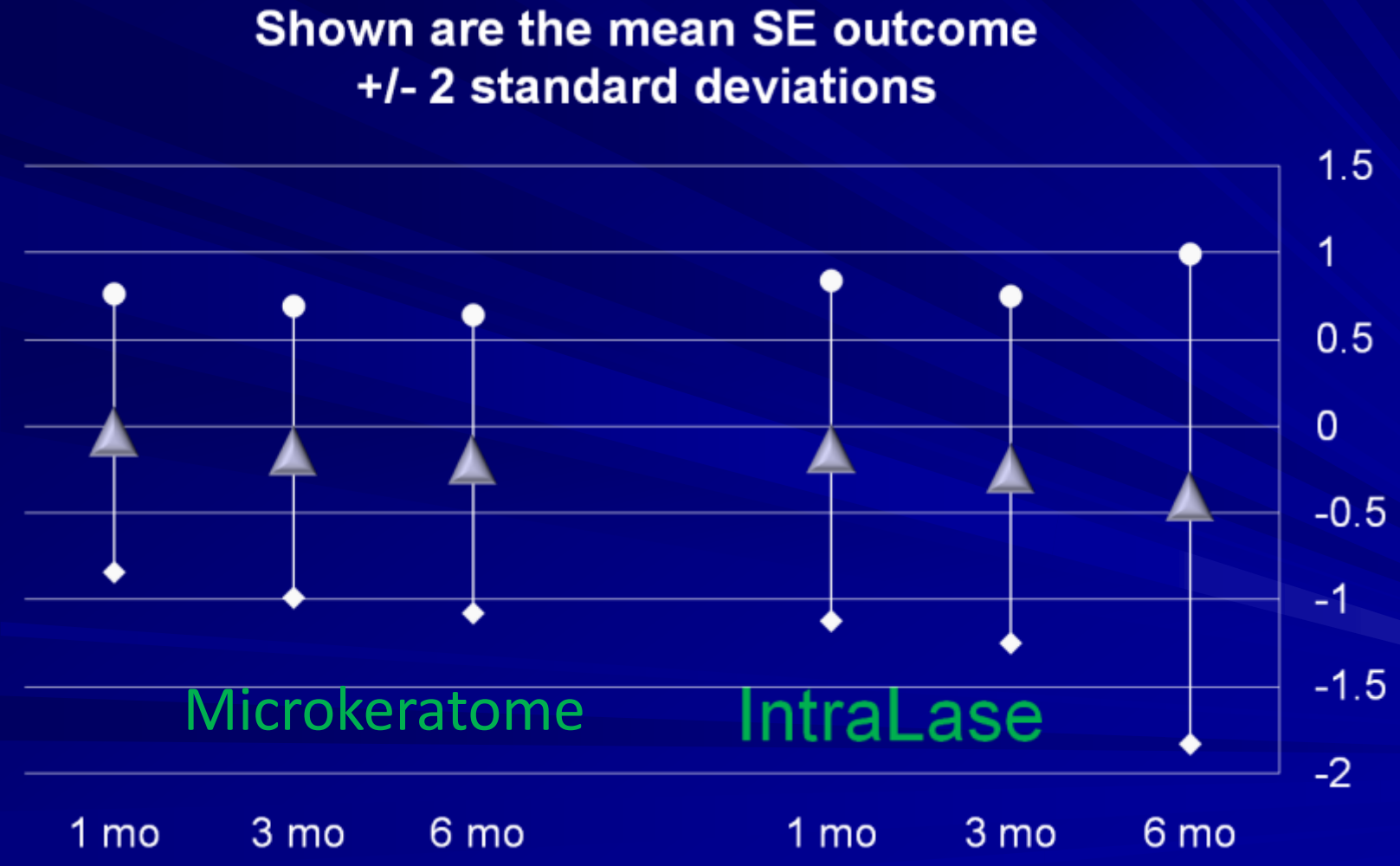
Hansatome: Gutter usually only visible with manipulation



Intralase: Gutter usually visible with the microscope

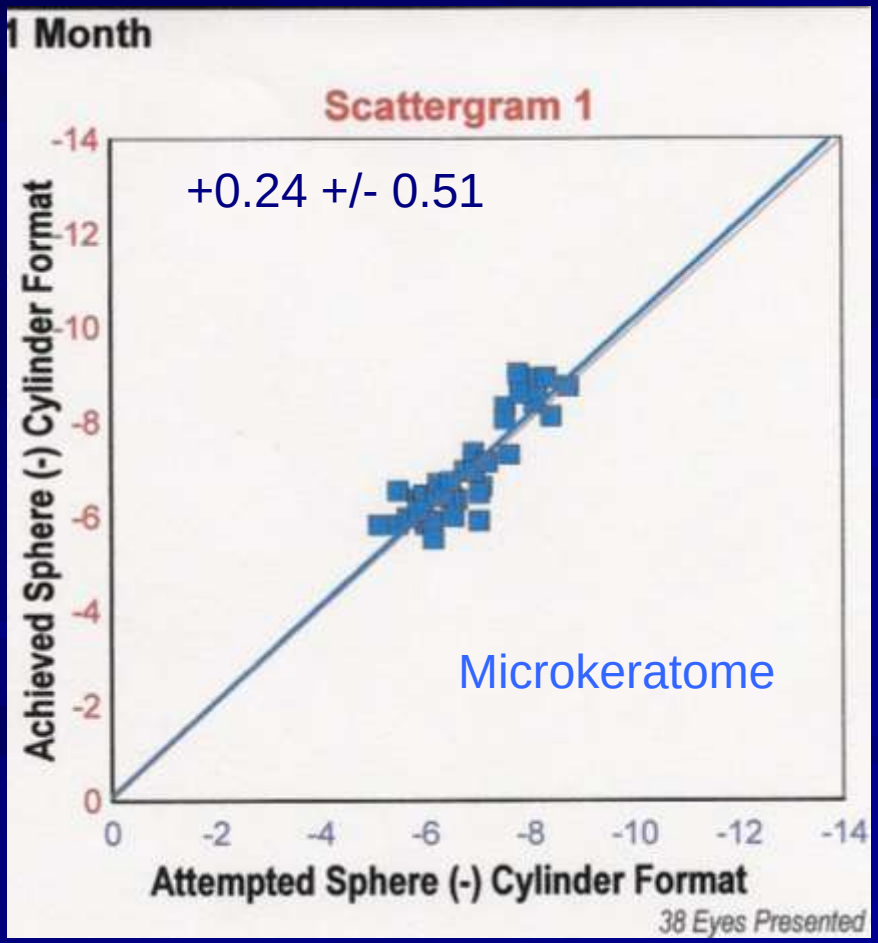
IntraLase gutter : depressed scar with pooling of stain

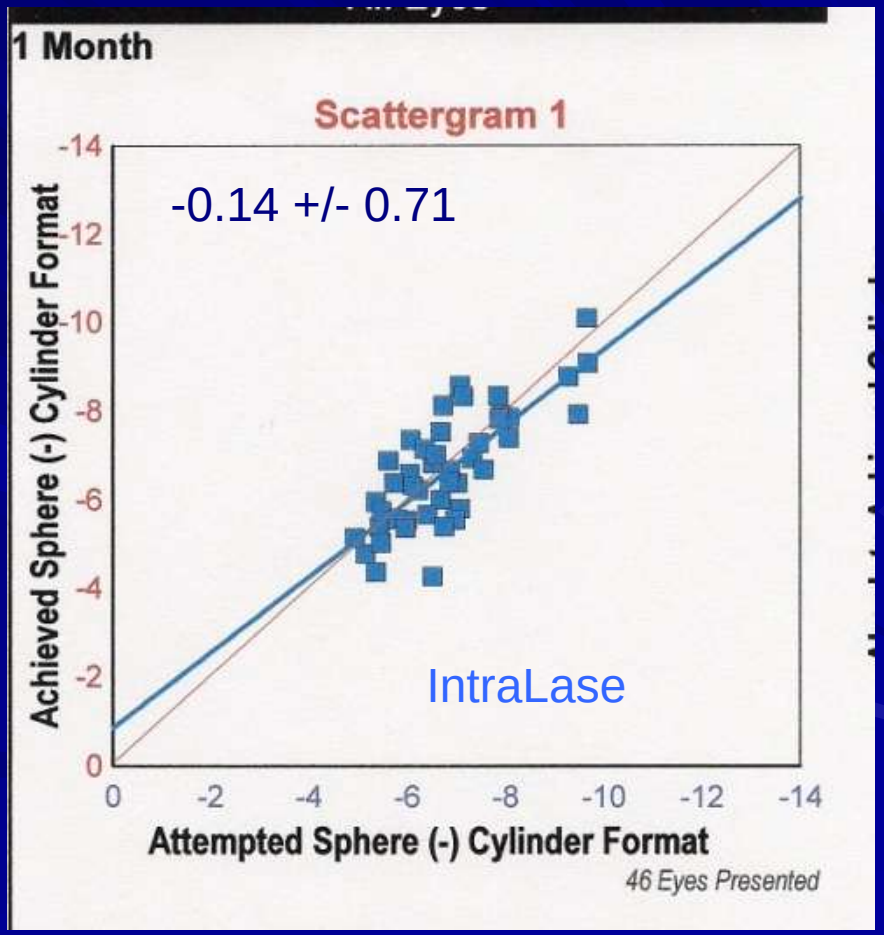
Myopic shift: Zyoptix XP vs IntraLase



Zyoptix XP vs IntraLase:
over age 40, high myopia*

Initial study with additional cases for 6 months : P=0.0071
(The initial study had an insufficient number of cases in the over 40 / high myopia subset for statistical significance)

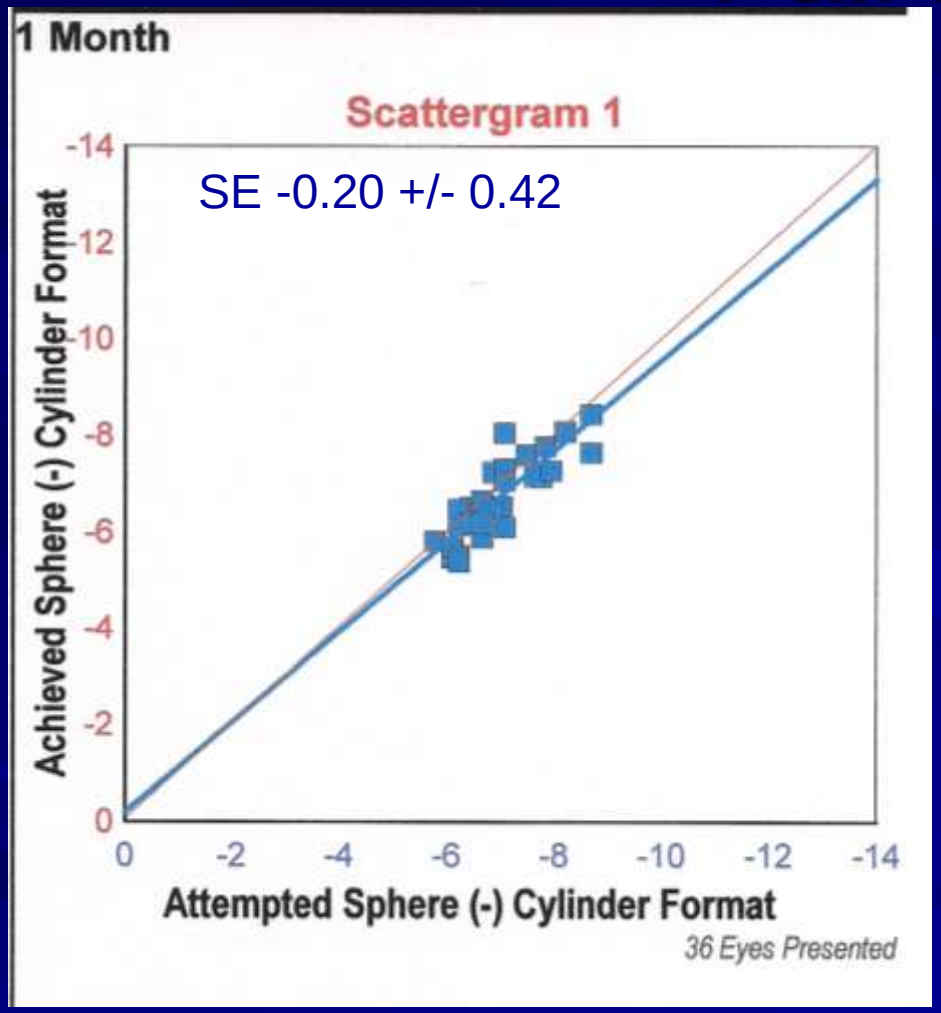


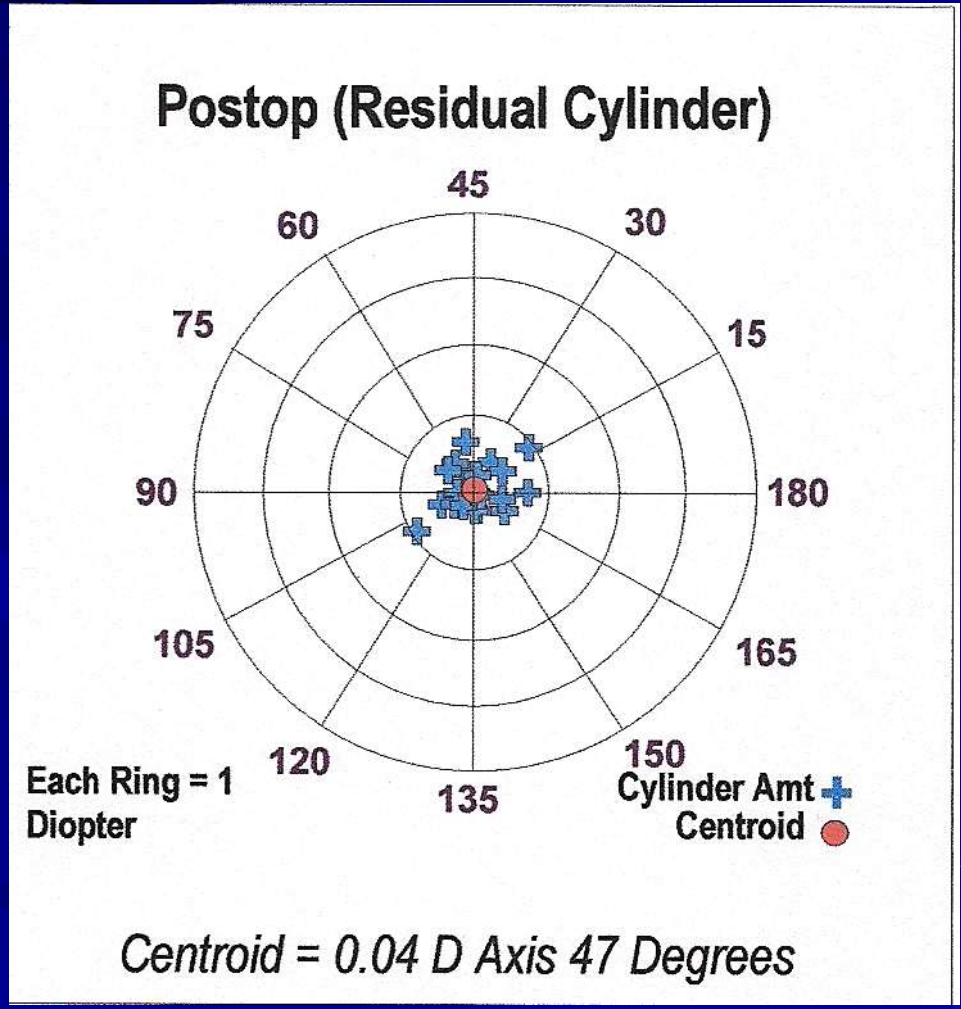


Conclusion:

- When compared to the Zyoptix XP microkeratome, IntraLase is associated with a greater average myopic shift and a higher standard deviation. Using these results, adjustments have been made to our treatment nomogram, especially for patients with higher corrections

High myopia Standard with MK Fall 2011





Improved astigmatism outcomes for VISX CustomVue ™ with Maximized optical zone and blend size

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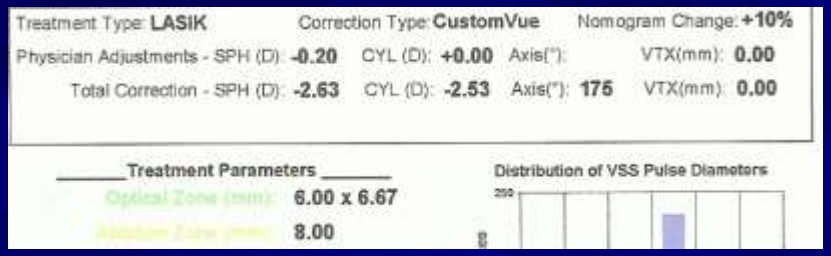
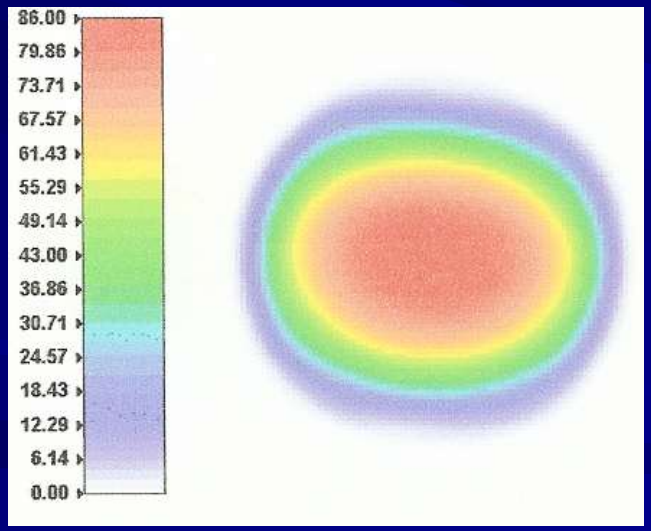
Nebraska Laser Eye Associates, Omaha, NE
www.nebraskaeye.com

Presented Chicago ASCRS, April 2008

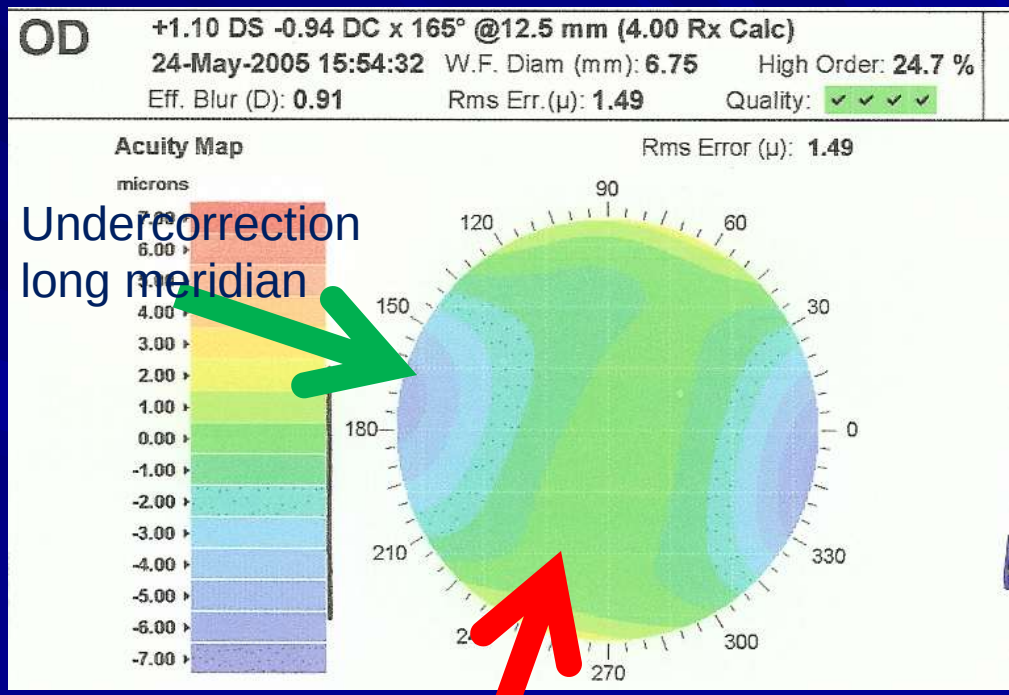
In 2005 & 2006 we noted that VISX Wavefront treatment of myopic astigmatism resulted in significant overcorrection

-2.63 -2.53 x 175





+1.10 – 0.94 x 165

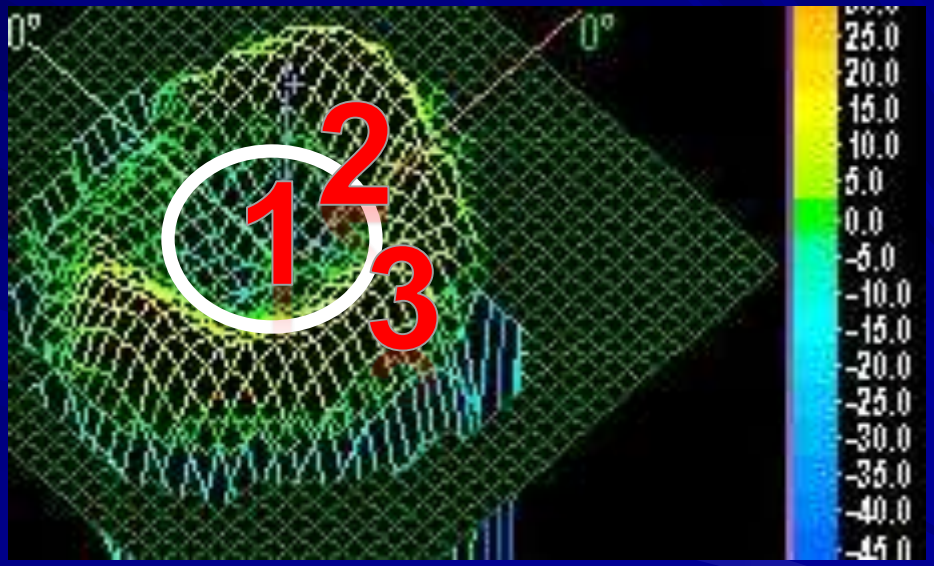


Undercorrection long meridian

Overcorrection short meridian

- *Previous studies have shown that increasing the depth of spherical and cylinder laser ablation results in an exponential :
  1. Increase in overcorrection
  2. Decrease in effective optical zone,
  3. Increase in induced spherical and toric aberrations

Theoretically, we would expect the same effects with any decrease in the width of ablation.



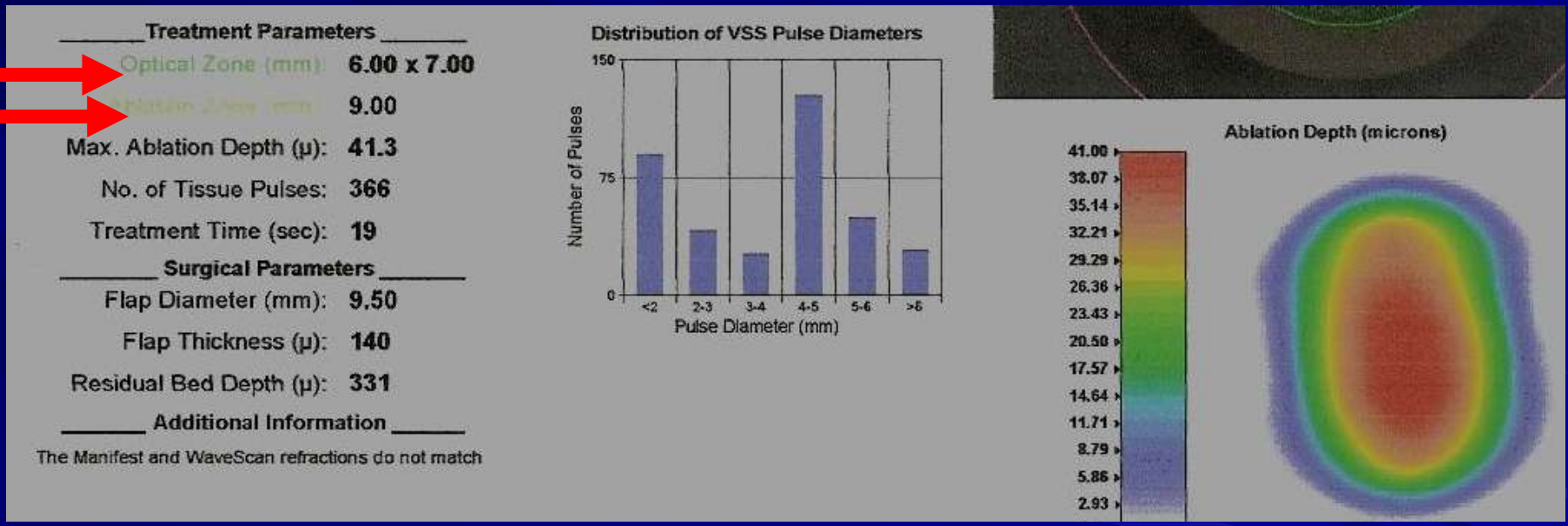
Effective Optical Zone (EOZ) is the area within one diopter of central power

*Best fit regression modeling of excimer lasers profiles ,
M E Johnston, ASCRS, 2007

Assuming that increasing the width of the ablation would result in less overcorrection, beginning in July 2006, all eyes with more than 1.5 Diopters of astigmatism were treated with:

a blend zone adjusted to the Maximal 9.0 mm

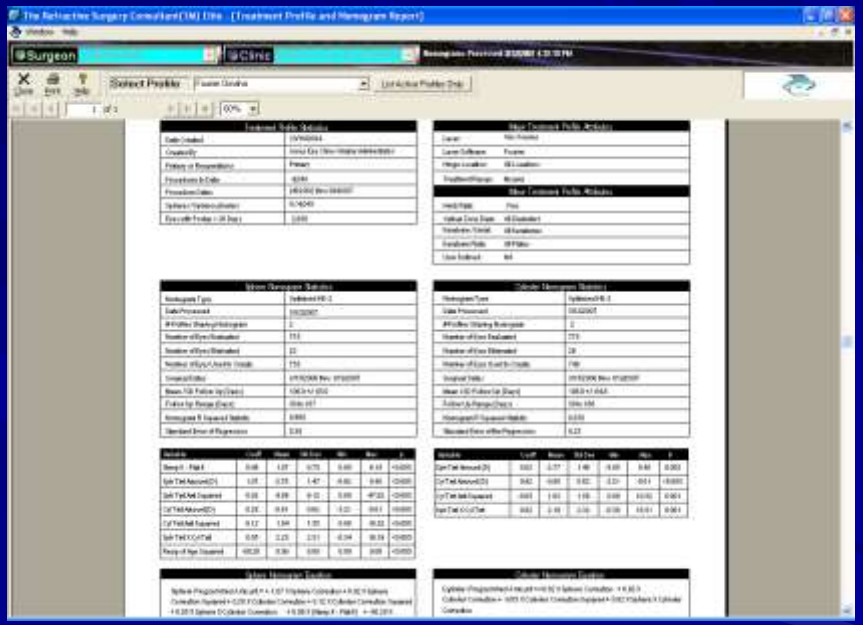
thereby maximizing the optical zone to 6.00 by 7.00 mm



VISX CustomVue ™ was used to perform excimer laser ablations on patients with one to six diopters spherical equivalent using either the standard 8.0 mm blend zone (Standard) or maximal 9.0 mm blend zone(Maximized)

Method

- Refractive outcomes were analyzed using a commercial outcome software program, the Refractive Surgery Consultant ™ (RSC), which provides a best fit regression nomogram equation for both sphere(S) and cylinder(C).

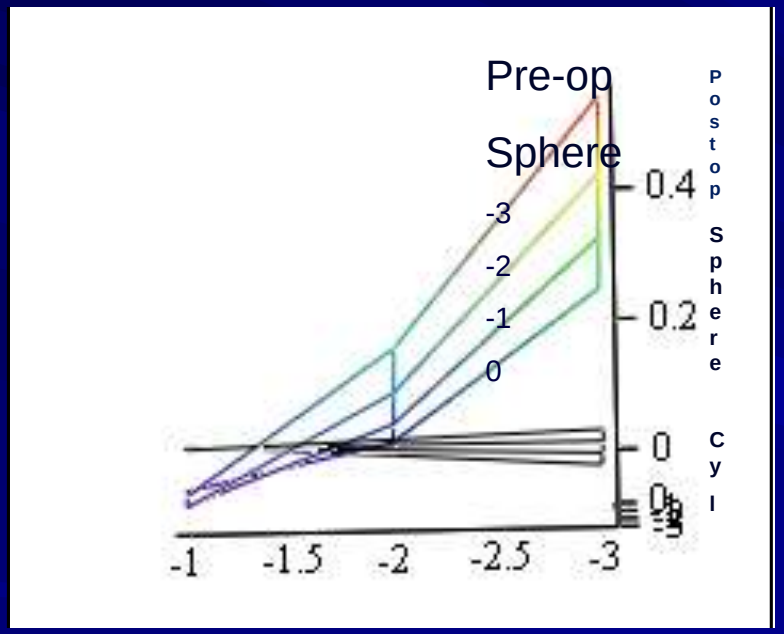


Program developed by Dr Jack Holladay and Dr Guy Kezirian

RSC Nomogram Results: Normal vs. maximized optical zone (MOZ)

Best fit regression RSC for Standard (1044 eyes) is $S=1.07s +0.01s^2 +0.17c +0.08c^2 +0.05sc$ (r^2 0.97) $C=1.02c +0.01sc$ (r^2 0.85).

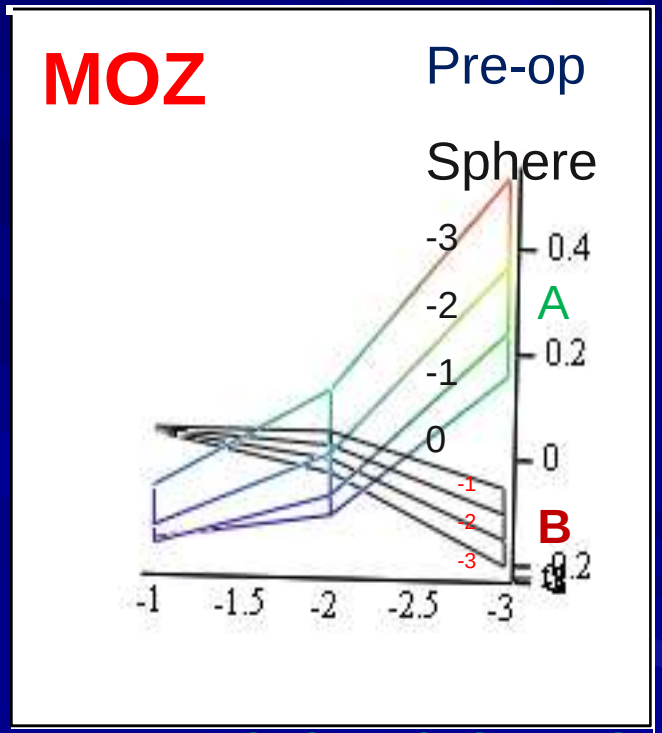
Standard WF



Pre-op cylinder

July 2006 n=1044

Best Fit Regression (RSC) for Maximized (753 eyes) is : $S=1.07s +0.02s^2 +0.29c +0.12c^2 +0.05sc$ (r^2 0.96) $C=0.92c-0.05sc +0.02s$ (r^2 0.97).



Post op

Sphere

Cylinder

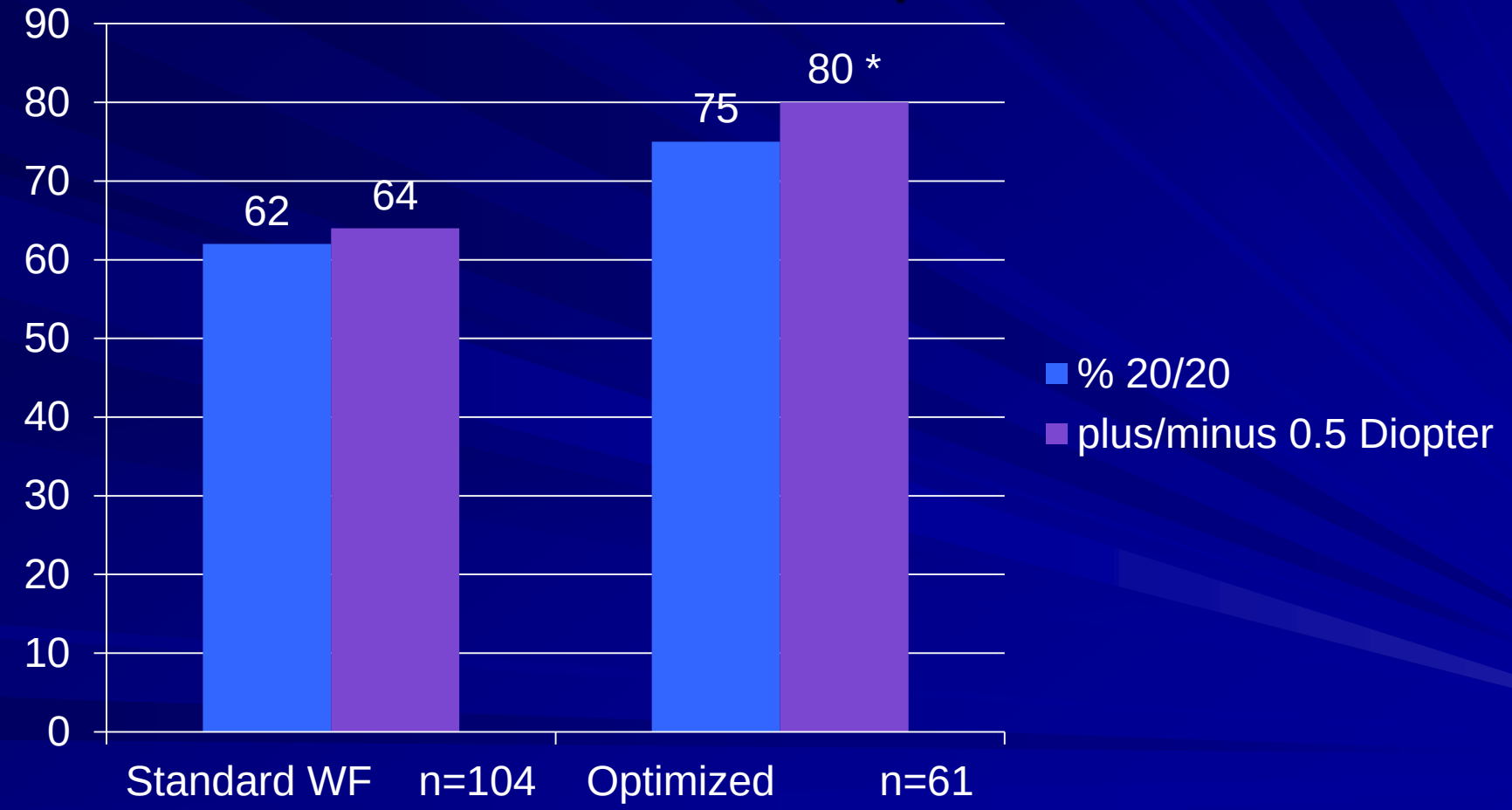
A:Less induced plus sphere

B: Under-correction of cylinder

• Normalized spherical equivalent

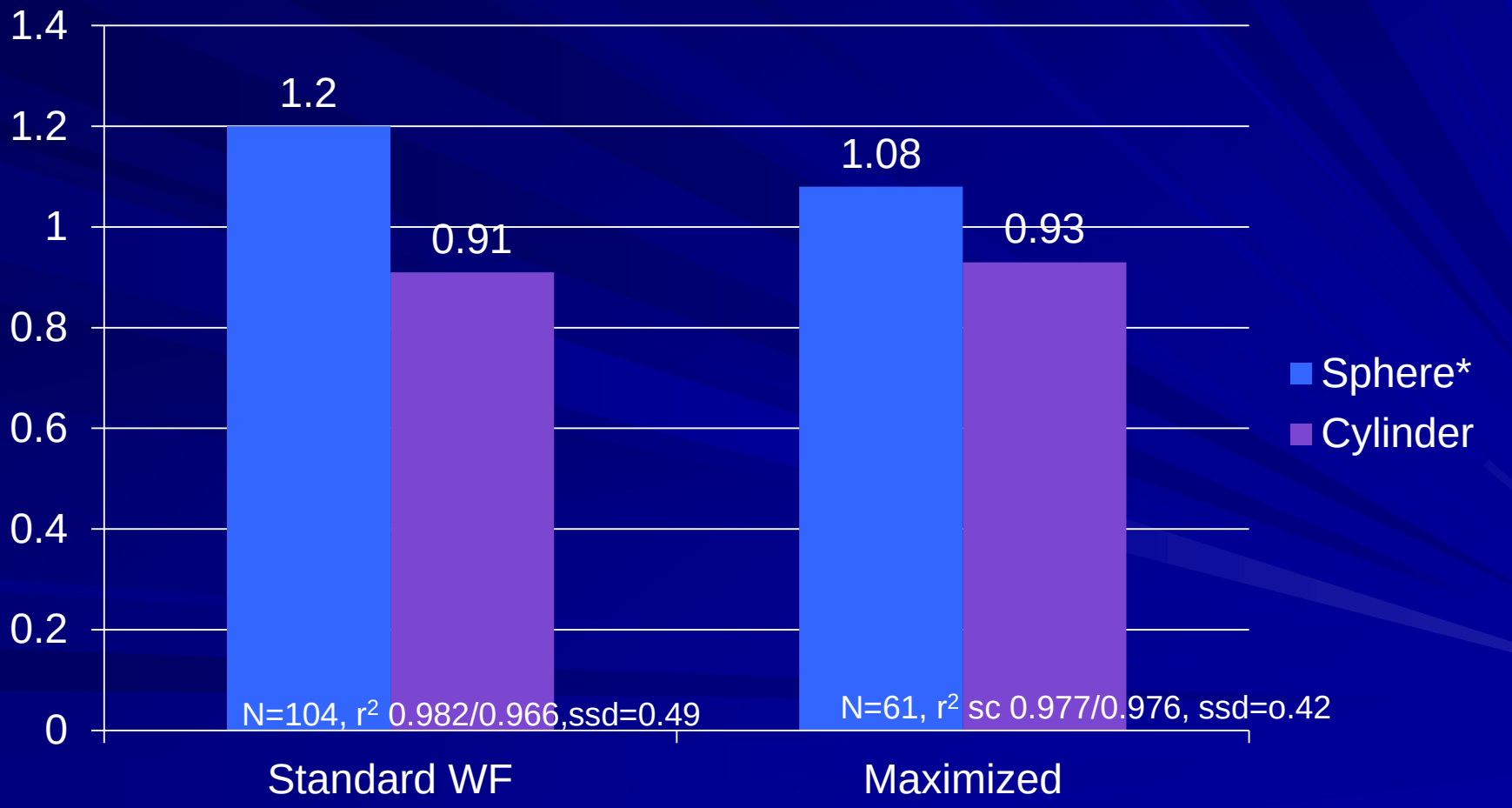
March 2007 n=753

When pre-op Cylinder is over 2.00 Diopters, better visual and optical results were noted with Maximized Optical Zone



*Statistically significant p=0.0001

With Cylinder greater than 2.00 D, the achieved versus attempted ratio for sphere and cylinder was normalized for Maximized OZ



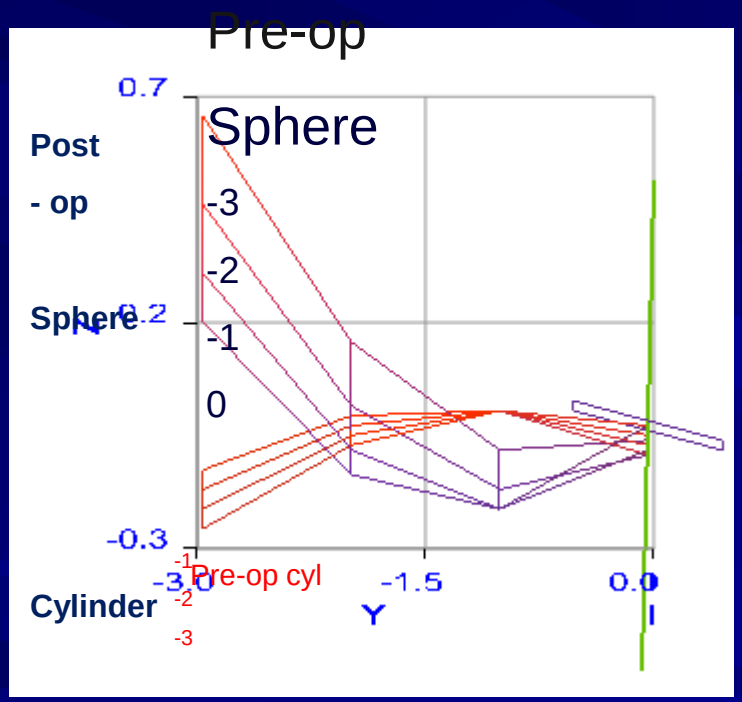
*Statistically significant (p=0.0003)

No statistically significant difference was noted between Standard and Maximized for Low Cylinder

Current (2008) VISX Myopic Wavefront nomogram using maximized optical zone

(Some of the improvement noted may be related to an averaging effect from including high myopia wavefront cases)

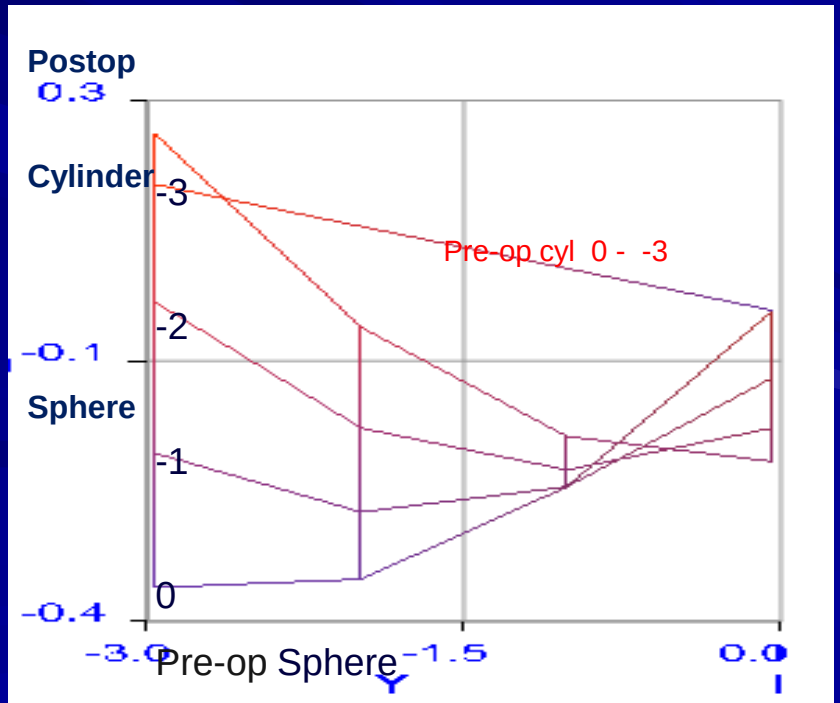
March 2007



March 2008

S=1.09s+0.01s2=0.26c+0.05c2+0.08sc
(r2=0.95,se=0.37,n=666

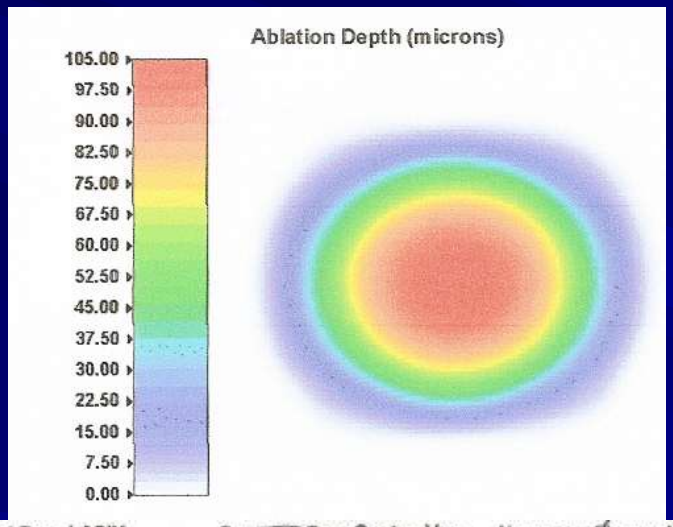
c=0.95c
(r2=0.97,se=0.21,n=666)



Conclusion

For patients with Cylinder over 2 Diopters, Maximized Optical Zone:

- requires less nomogram adjustment
- provides superior clinical outcomes



Treatment Type: **LASIK** Correction Type: **CustomVue** Nomogram Change: **+0%**

Physician Adjustments - SPH (D): **+0.20** CYL (D): **+0.00** Axis(°): VTX(mm): **0.00**

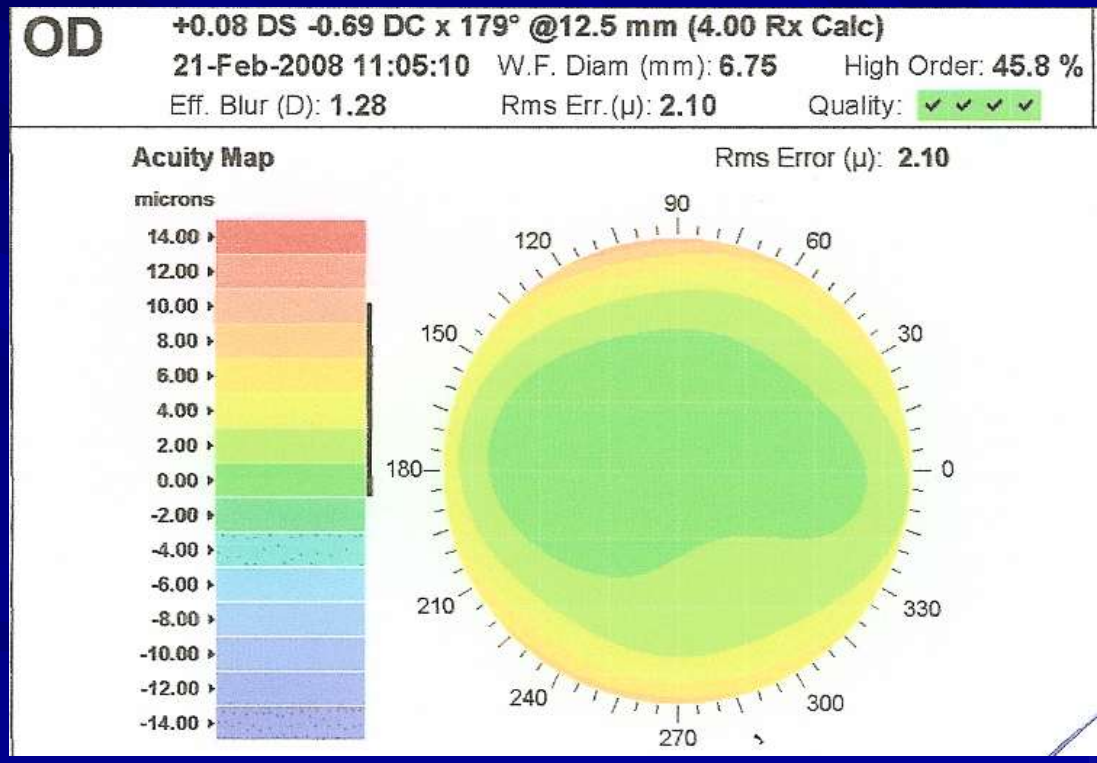
Total Correction - SPH (D): **-4.38** CYL (D): **-2.10** Axis(°): **1** VTX(mm): **0.00**

Treatment Parameters

Optical Zone (mm): **6.00 x 7.00**

Ablation Zone (mm): **9.00**

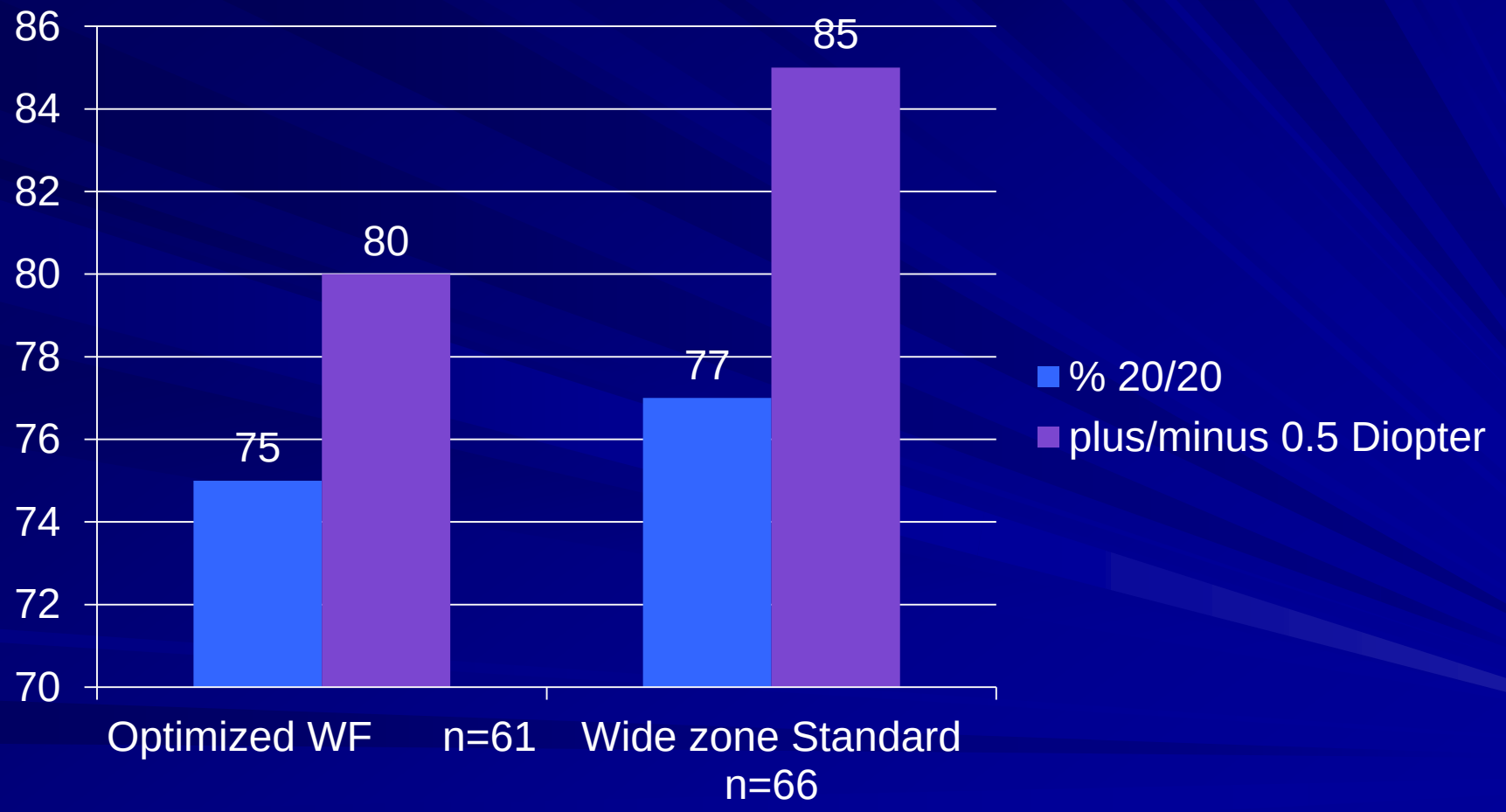
Distribution of VSS Pulse Diameters



-4.38 -2.10 x 1

+0.08 – 0.69 x 179

When pre-op Cylinder is over 2.00 D(Wavefront) or 1.50 D Standard, better visual and optical results were noted with Larger Optical Zone



*Statistically significant p=0.0001

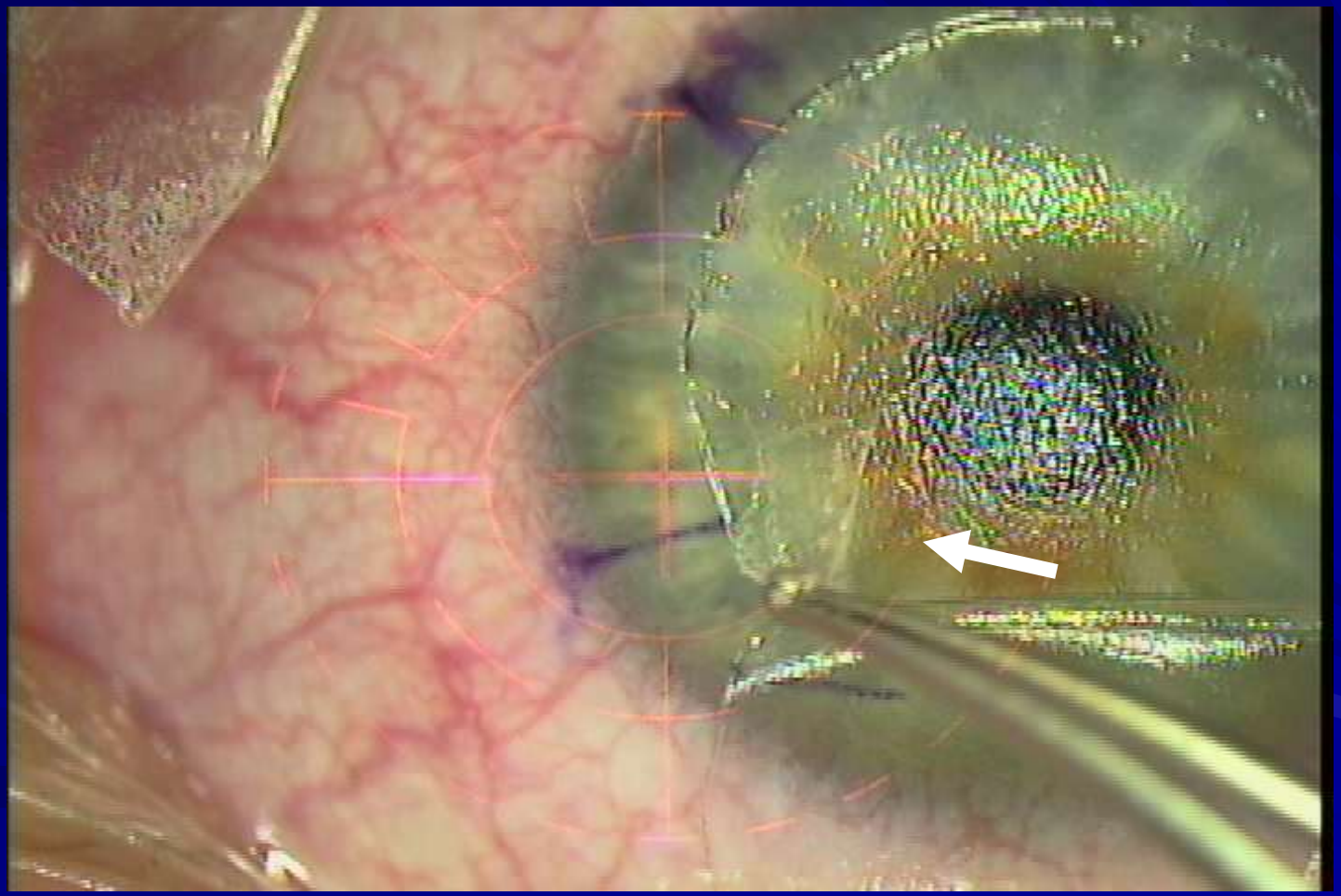
Prevention of epithelial in-growth following LASIK enhancement surgery

Mark E Johnston MD FRCSC
www.nebraskaeye.com
Omaha NE
NO FINANCIAL INTERESTS

Purpose

- Previous studies have shown that excimer laser ablation of the corneal surface increases adhesion of epithelium to the corneal stroma.
- This study was designed to study the rates of epithelial in-growth following LASIK enhancement surgery when the peripheral LASIK bed is protected from excimer laser ablation at the time of enhancement surgery.

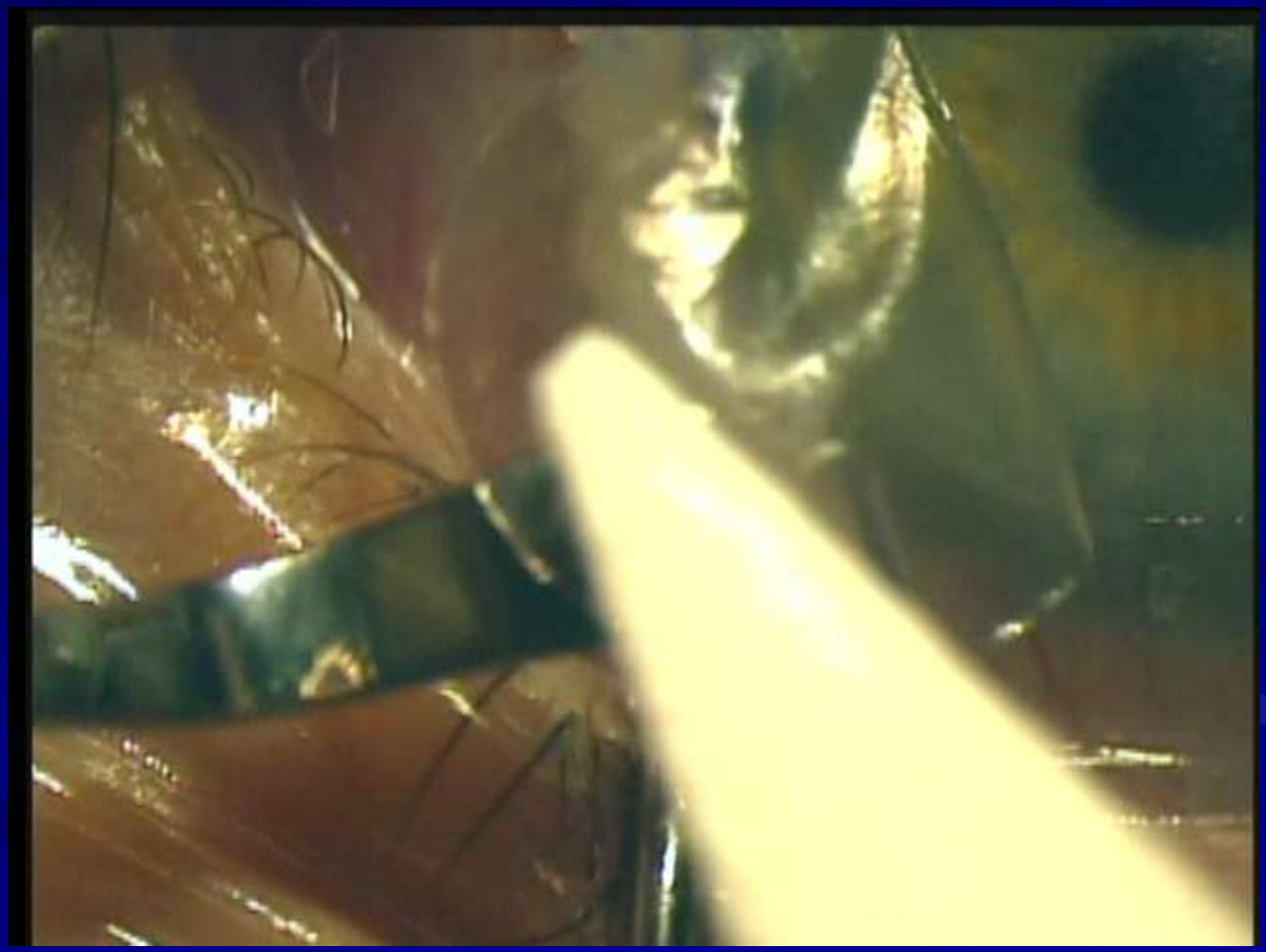
Sheet of epithelial in-growth removed with Burrato forceps



Methods

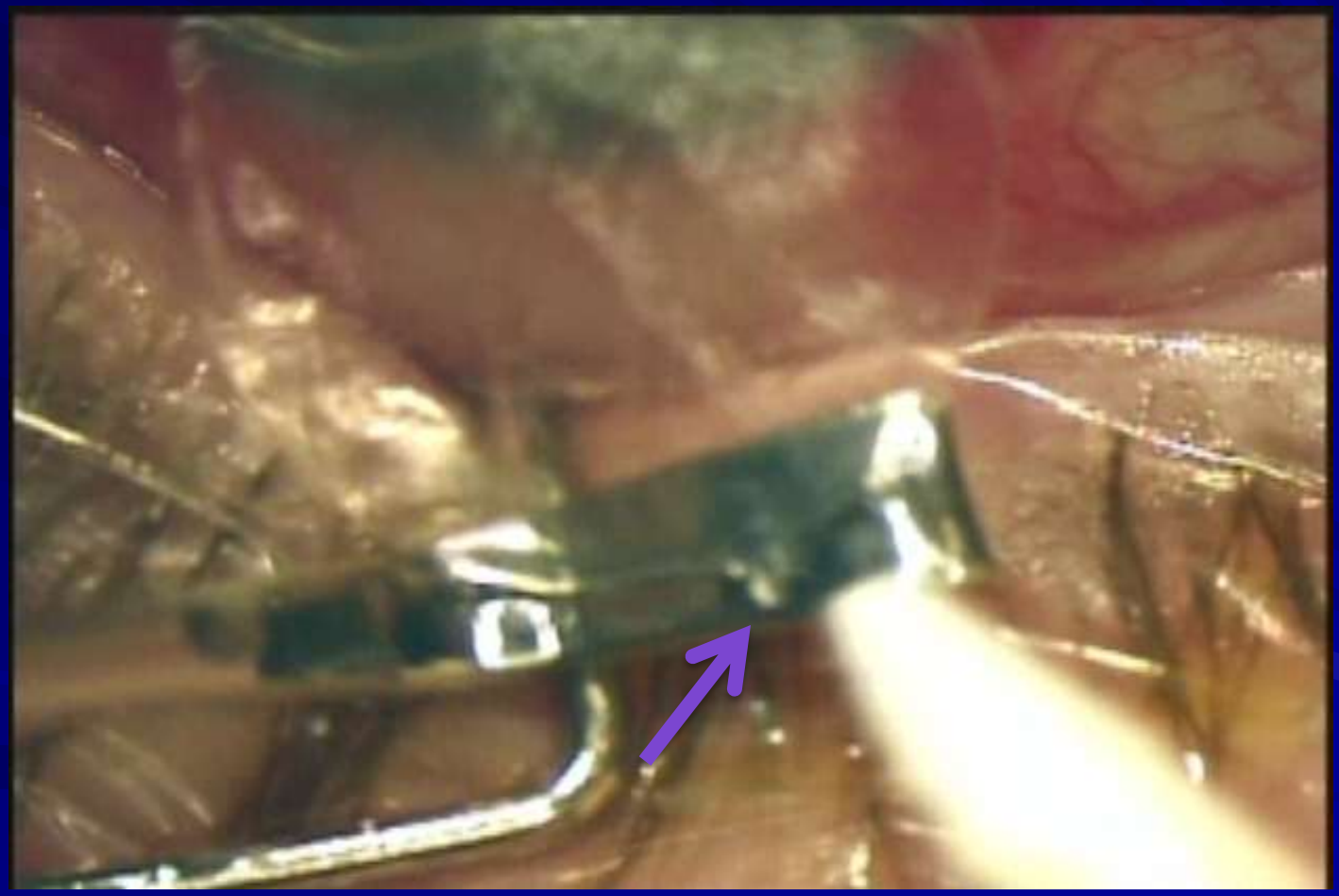
- Clinically significant epithelial in-growth following LASIK enhancement was defined as those cases in which a decision was made to surgically remove the epithelial in-growth.
  - This decision was usually made because of induced astigmatism and decreased uncorrected visual acuity.
- Original surgery was with a Hansatome
- Beginning in November 2005, all patients undergoing Lasik enhancement surgery had the peripheral 1.0 mm of the LASIK bed protected with a BD Visitec ™ Lasik eye drain (Chayet) lightly moistened with BSS.

Use a moist spatula to support the flap while forceps or a microsponge is used to remove epithelium from the reverse side of the flap



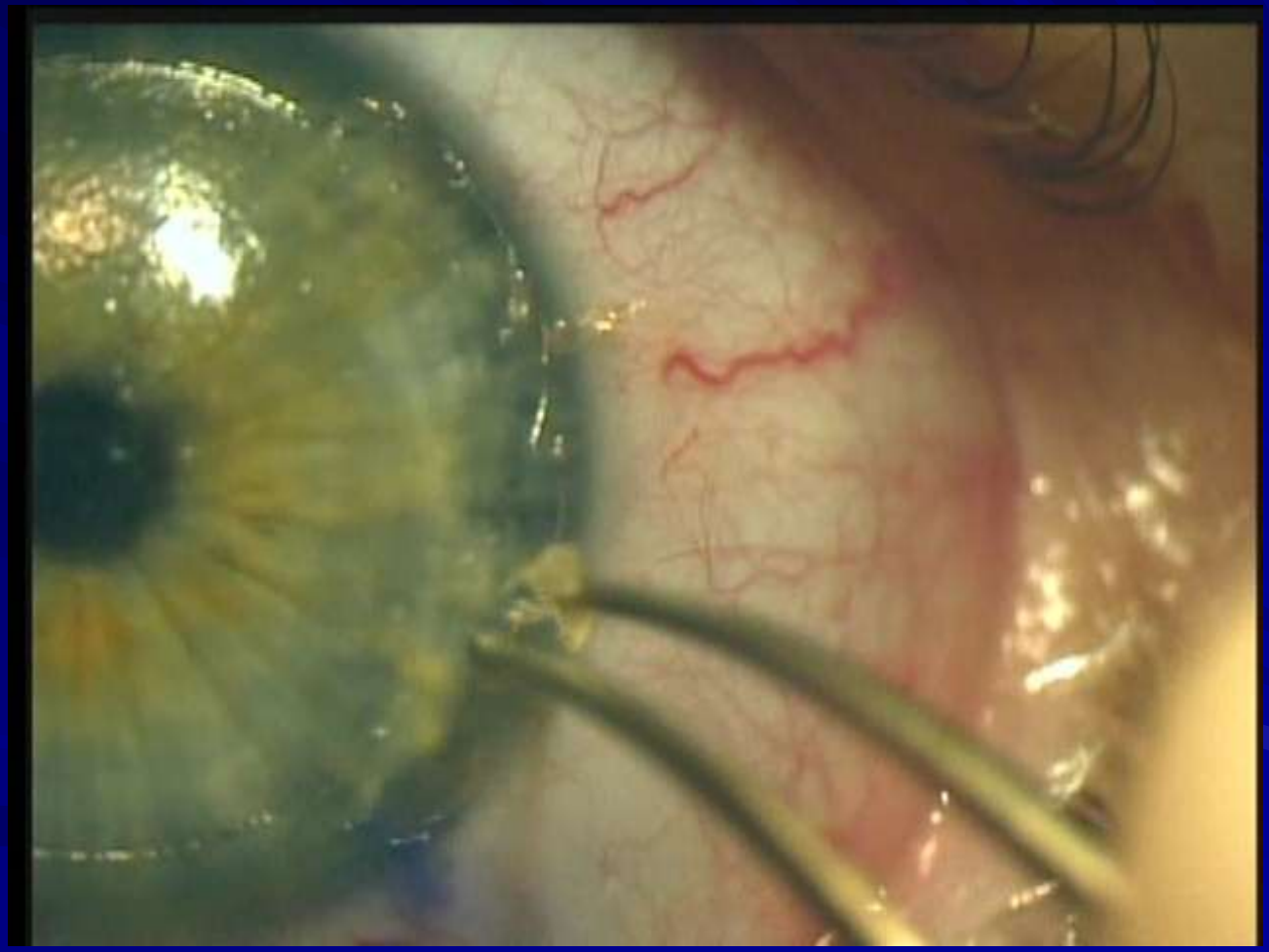
It is important to use numerous microsponges

Carefully remove all epithelium from the edge of the flap



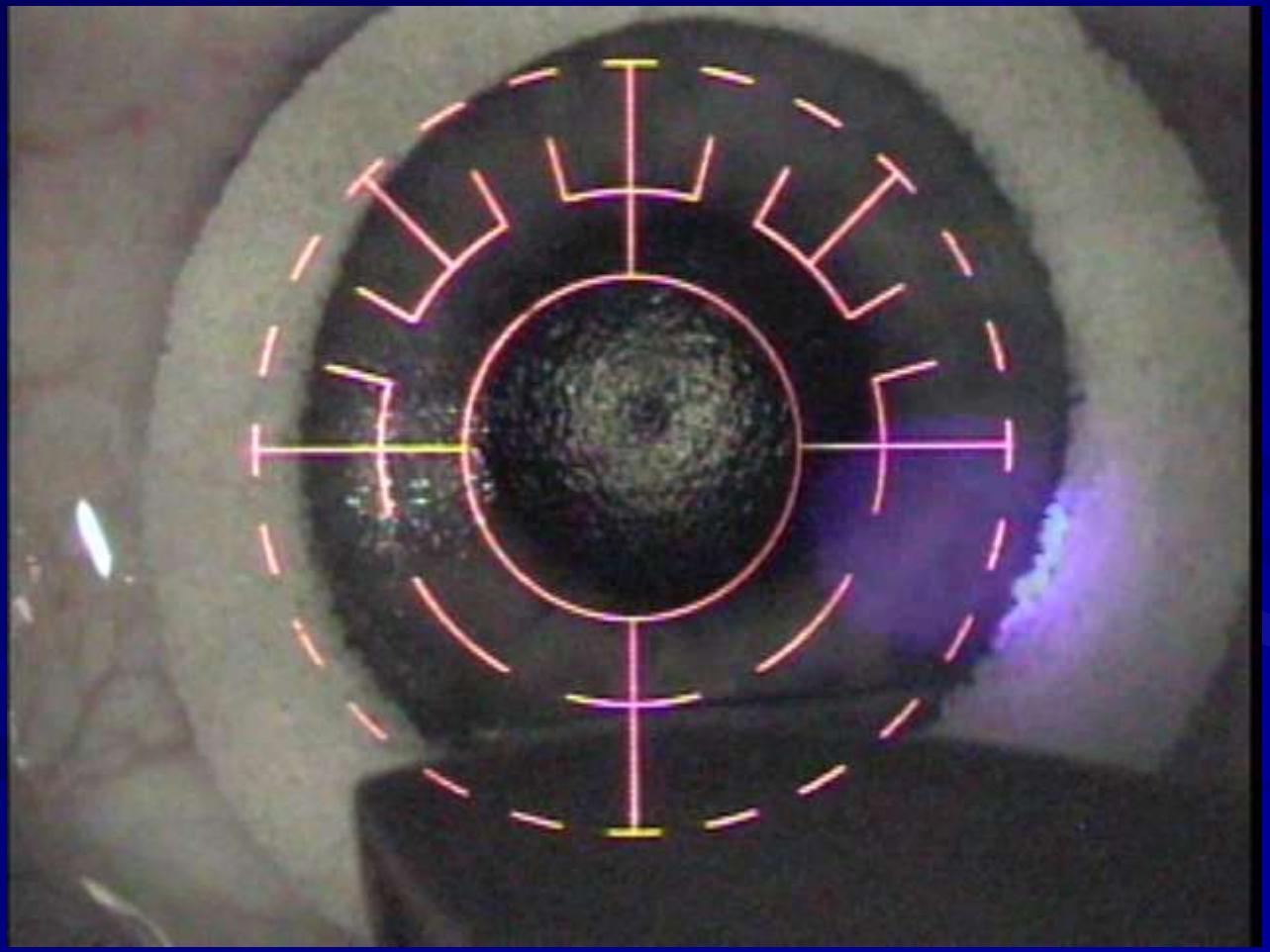
This is a slipped flap with irregular epithelium and other areas of early ingrowth

Recess the epithelium to the limbus in all areas affected



A bandage contact lens soaked in antibiotic drops is placed on the eye after surgery

Use a moist Chayet sponge to protect about 1 mm of the peripheral flap bed during the excimer treatment

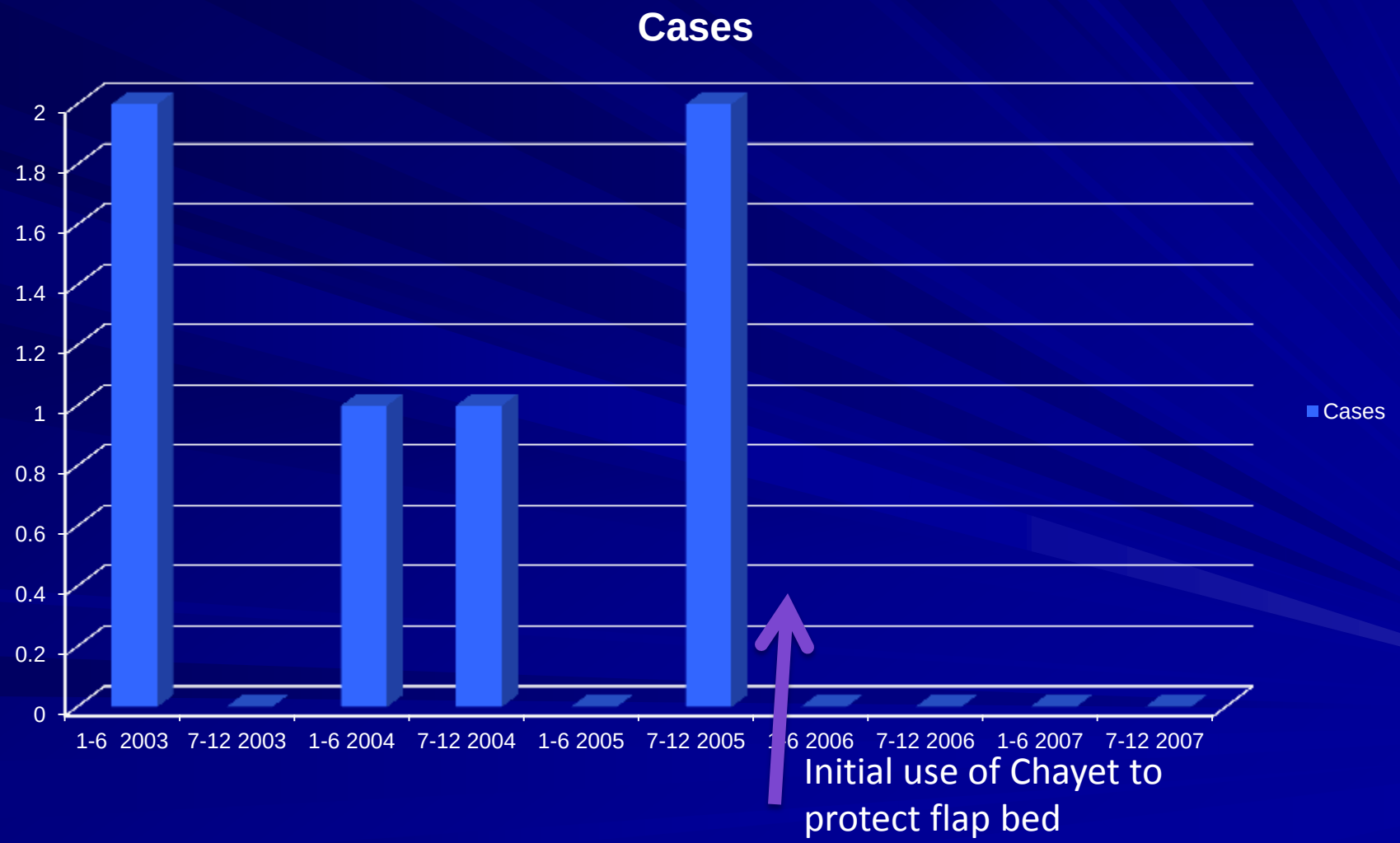


Note how much the tracker is needed in this patient

Results

- For each of the three years prior to the change in technique, two eyes each year required surgical intervention for epithelial in-growth following LASIK enhancement (1% of all enhancements).
  - Five of six eyes had hyperopic ablations which directly treated the peripheral LASIK bed.
- For the two years since the change in technique, no eyes have required surgical intervention for epithelial in-growth

Cases of Epithelial in-growth requiring surgical removal

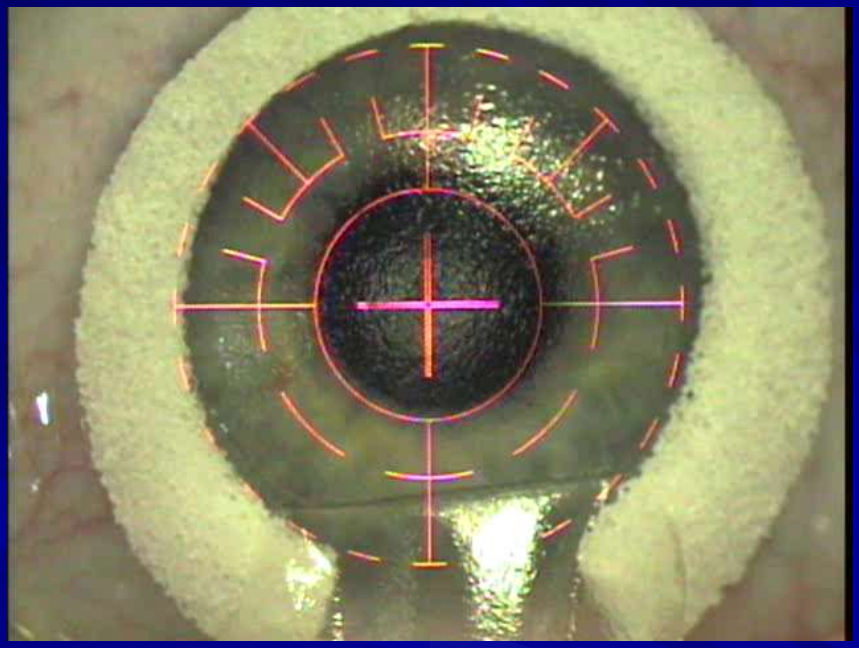


Prevention of epithelial in-growth

- Minimize epithelial manipulation and damage
  - Avoid hypertonic saline
  - Avoid excessive drying
  - Avoid using any topical non-steroidal drops
- If possible, avoid Wide Zone and Wavefront-Guided Ablations
- Protect the peripheral flap bed

Conclusion

- Protecting the peripheral LASIK bed from excimer laser ablation decreases the incidence of clinically significant epithelial in-growth.



Cases of Epithelial in-growth requiring surgical removal