Excellence Eye Research Centre
National High-Tech Centre
University "G. d'Annunzio" Chieti-Pescara
Head. Prof. Leonardo Mastropasqua

EVICR.net
EUROPEAN VISION CLINICAL RESEARCH

Femtolaser and ocular surgery

L Mastropasqua, L Toto

ARVO
The Association for Research in Vision and Ophthalmology

IT-ARVO Chapter Meeting

FARMACOLOGIA OCULARE
Life-changing research

Catania, 3 Febbario 2014

What patients want from eye surgery?

- Safety
- Quick visual recovery
- Excellent vision without glasses

Femtosecond laser

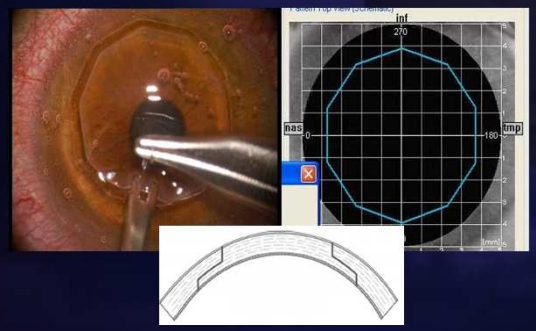
It is an ultrafast laser using a near infrared light to create cuts in ocular tissues

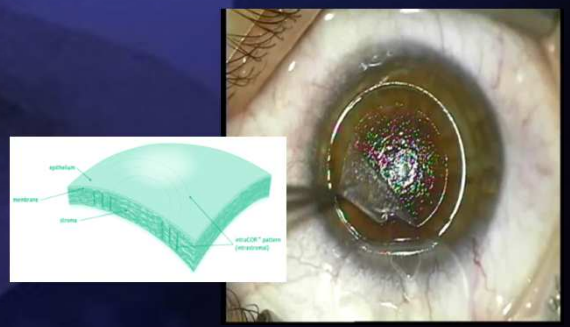
First used in corneal refractive surgery and corneal transplant

Still used today

Recently being used in cataract surgery

Femtosecond laser-assisted cataract surgery (FLCS)





Aim of refractive surgery

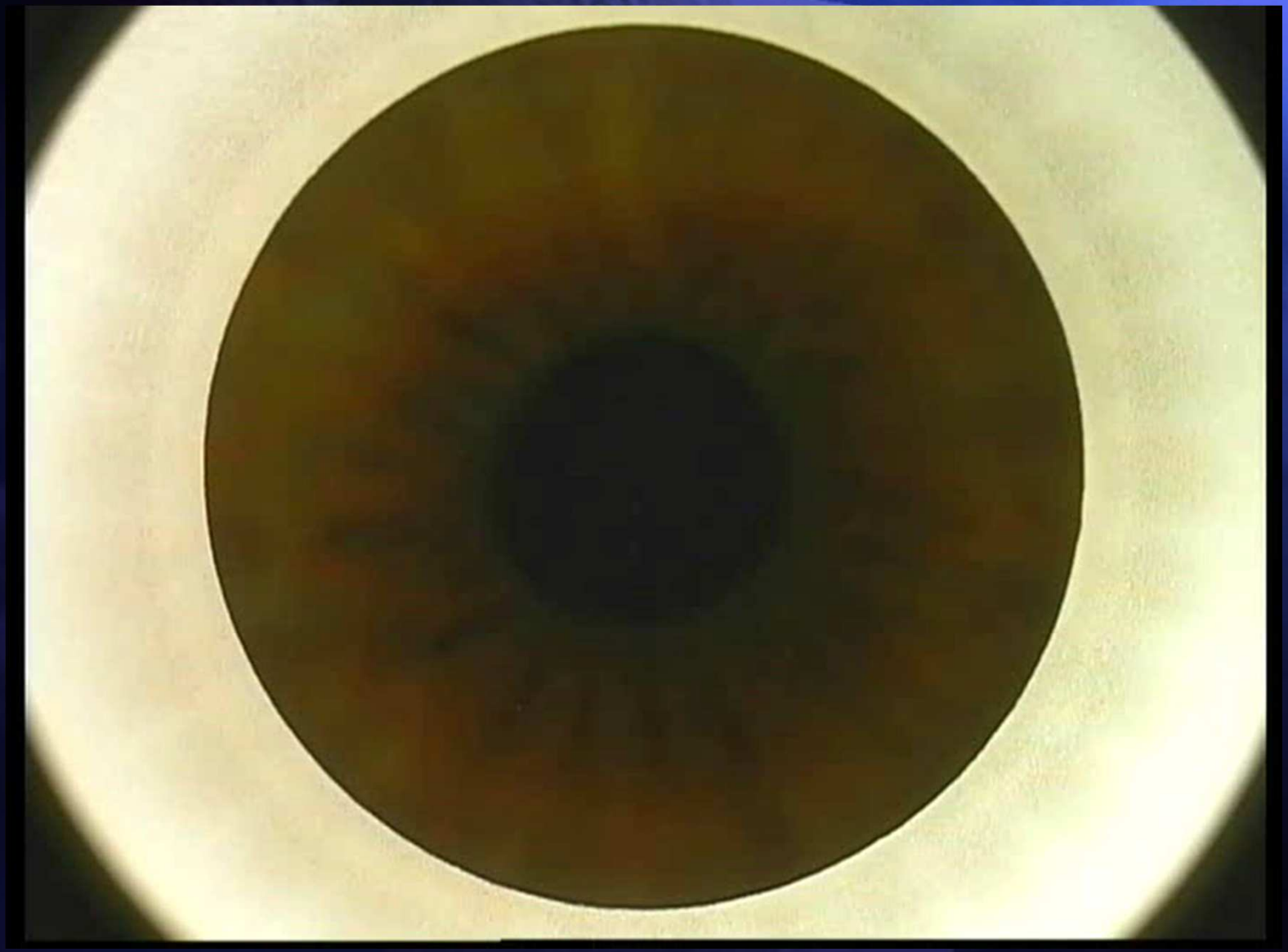
Minimally invasive RS maintaining high quality of vision particularly of high ametropias

Toward spectacle indipendence

Why Femtolaser ?

EXCELLENCE EYE RESEARCH CENTER
EXÈ

500 KhZ Visumax FSL flap creation in LASIK
110 microns thickness – 90° rim cut



Literature meta-analysis: Efficacy and predictability ↓ with ↑ of the refractive myopic error

Review

THE LANCET

Laser eye surgery for refractive errors

Tohru Sakimoto, Mark I Rosenblatt, Dimitri T Azar

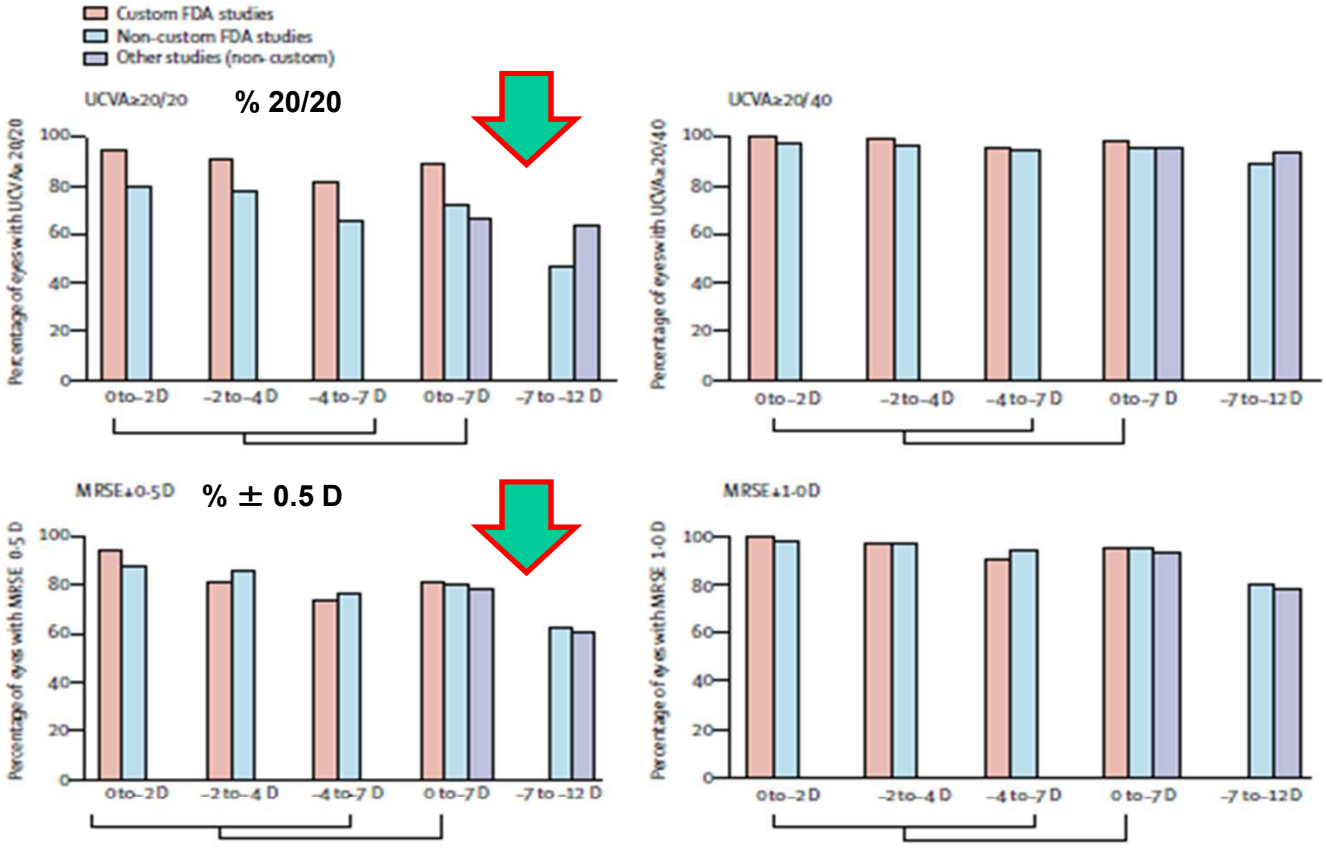


Figure 1: **Visual outcomes of LASIK for myopia at 3–6 months after surgery**
UCVA=uncorrected visual acuity. MRSE=manifest refraction spherical equivalents. For every assessment, results for low myopia with error 0 to −7 D (individual ranges and grouped) compared with high myopia with refractive error −7 D to −12 D.[37–40, 59–61]

High myopia (conventional laser ablation)
With the larger degree of refractive error and the concomitant need to remove more tissue in higher myopia, this group of patients is often analysed separately when measuring outcomes of refractive surgery. In the high myopia group, FDA data showed manifest refraction spherical equivalent within about 1·00 D of 80% and within about 0·50 D of 61%. Although 89% of patients were 20/40 or better, less than half (48%) achieved 20/20 or better. A loss of best

Comparison of low to moderate versus high myopia
In general, we might expect less accuracy and larger wound-healing effects with the deeper ablations. As the depth decreases, the cornea might also be destabilised, and this instability can further retard the ability to reach a target refraction. With the FDA data, a comparison of manifest refraction spherical equivalent between low-to-moderate and high myopia after LASIK shows a larger residual refractive error in high myopia. The difference between the low-to-moderate myopia of 96% within about 1·00 D and high myopia with 80% was even more indicative when accuracy to within manifest refraction spherical equivalent of about 0·50 D was analysed (81% for the lower myopic group and 61% for the higher myopic group).

Femtosecond LASIK flap

CLINICAL SCIENCES

Subbasal Nerve Density and Corneal Sensitivity After Laser In Situ Keratomileusis

Femtosecond Laser vs Mechanical Microkeratome

Sanjay V. Patel, MD; Jay W. McLaren, PhD; Katrina M. Kittleson, BS; William M. Bourne, MD

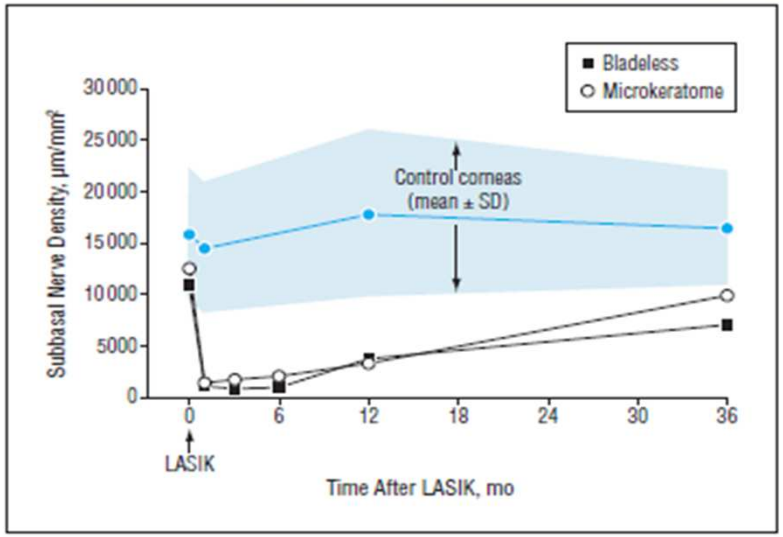


Figure 1. Corneal subbasal nerve density before and after laser in situ keratomileusis (LASIK). Subbasal nerve density did not differ between femtosecond laser (bladeless) and mechanical microkeratome treatments at any examination before or after LASIK. For both treatments, subbasal nerve density was decreased at 1 month after LASIK ($P < .001$) and remained decreased through 12 months ($P < .001$). At 36 months, subbasal nerve density did not differ from the preoperative density for either treatment; minimum detectable differences were 7081 µm/mm² and 7930 µm/mm² for femtosecond laser and mechanical microkeratome, respectively ($\alpha = .05/5$, $\beta = .20$, paired analyses).

Dry eye symptoms incidence is similar in FS

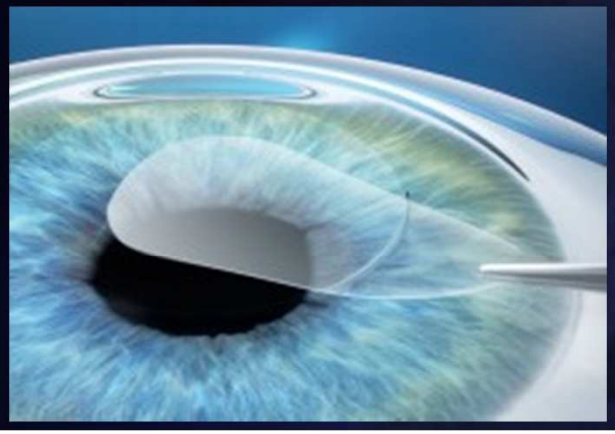
and Microkertome LASIK

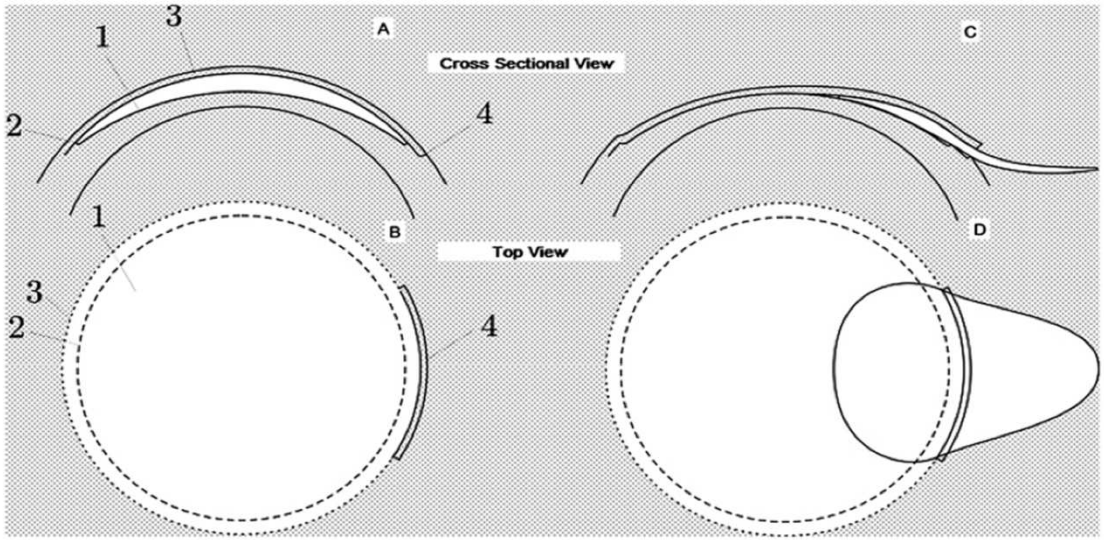
J Cataract Refract Surg. 2011
Golas L, Manche EE.
J Cataract Refract Surg. 2009
Salomão MQ, Ambrósio R Jr, Wilson SE.

The planar configuration of the femtosecond flap is not associated with faster reinnervation compared with microkeratome flaps

SMALL INCISION REFRACTIVE LENTICULE EXTRACTION (SMILE)

NO FLAP
ALL FEMTO
SINGLE STEP





Small incision FSL lenticule extraction: SMILE: 1 Incision 3.6 mm

Corneal surgery – SMILE

OD ● | ○ OS

Diagnostic data

Cornea vertex distance [mm]:	12.00
Manifest	
Sphere [D]:	-4.50
Cylinder [D]:	-1.50
Axis [°]:	160
Corneal radius [mm]:	7.80
Mean K-reading [D]:	43.28
Pachymetry [µm]:	546

Treatment data

Treatment pack size:	S
Suction time [hh:mm:ss]:	00:00:36

Cap data	
Diameter [mm]:	7.00
Thickness [µm]:	120
Side cut angle [°]:	90
Incision position [°]:	60
Incision angle [°]:	60
Incision width [mm]:	3.67

Nomogram info

Refraction, Version 3.0

Lenticule data

Optical zone [mm]:				6.00
Transition zone [mm]:				0.10
Thickness [µm]:	Min:	15	Max:	94
Side cut angle [°]:				90
Refractive correction				
Sphere [D]:				-4.50
Cylinder [D]:				-1.50
Axis [°]:				160

SMILE Refractive Correction: How much?

Myopia (Range of Correction)

- 1.0 D / 10.0 D

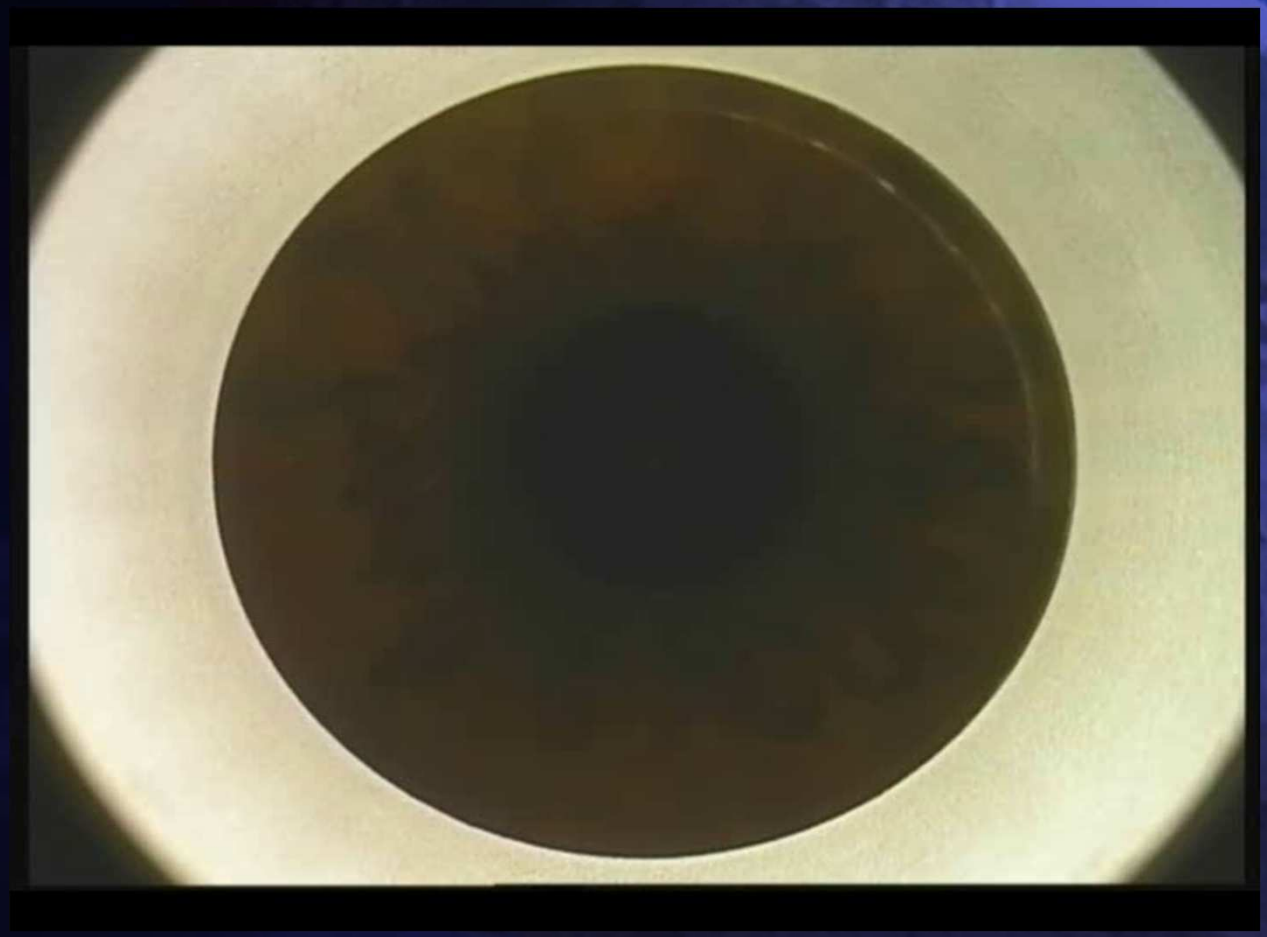
Astigmatism (Range of Correction)

- 1.0 D / 5.0 D

- Differences of tissue removal with respect to average excimer laser ablation (myopia: -6.00 / -10.0)

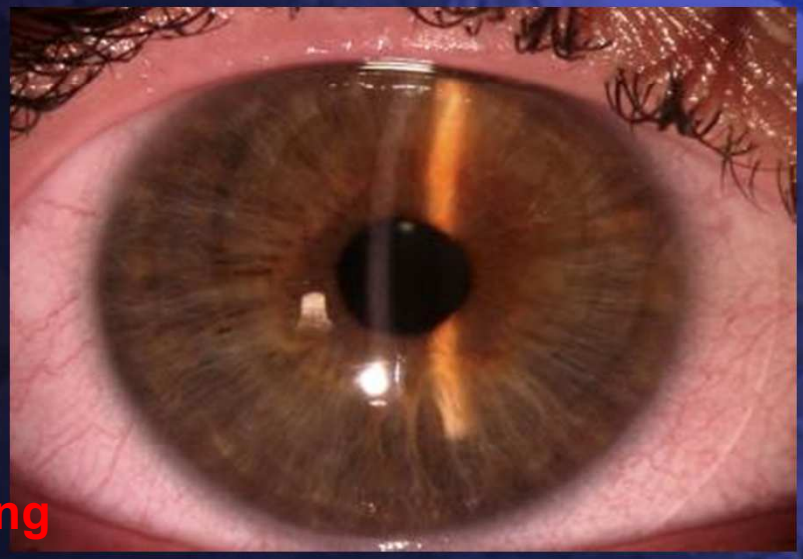
- 6.00 mm (- 8%)
- 6.10 mm (- 6%)
- 6.30 mm (- 4%)
- 6.50 mm (- 2%)

Small incision FSL lenticule extraction: SMILE: 1 Incision 3.4 mm

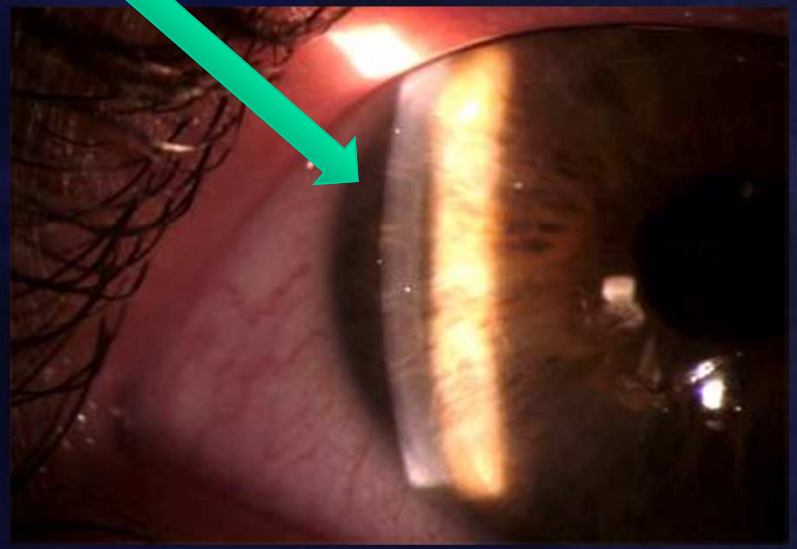


Mastropasqua's Small Incision Lenticule Extraction Kit

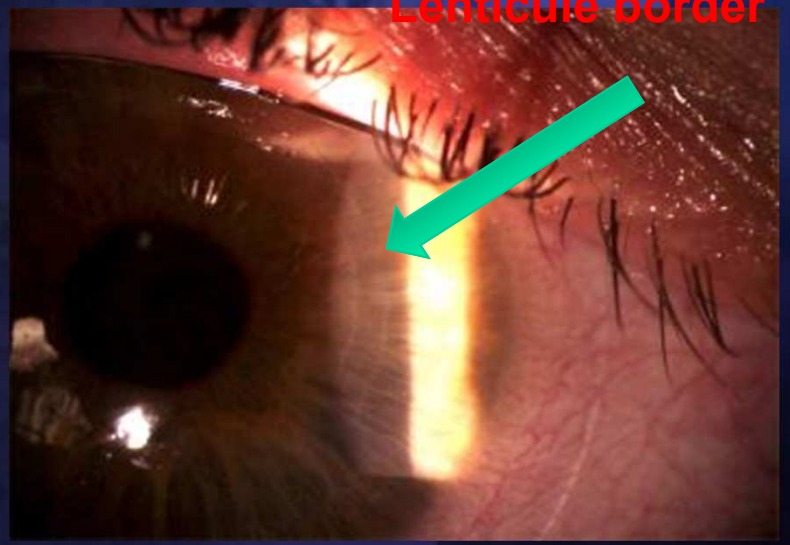
Small incision FSL lenticule extraction:
SMILE: Slit Lamp photographs 1 hour after surgery



Imprint of the suction ring



Lenticule border



Small-incision lenticule extraction for moderate to high myopia: Predictability, safety, and patient satisfaction

Anders Vestergaard, MD, Anders R. Ivarsen, MD, PhD, Sven Asp, MD, Dr Med Sci, Jesper Ø. Hjortdal, MD, Dr Med Sci, PhD

J Cataract Refract Surg 2012; 38:2003–2010 © 2012 ASCRS and ESCRS

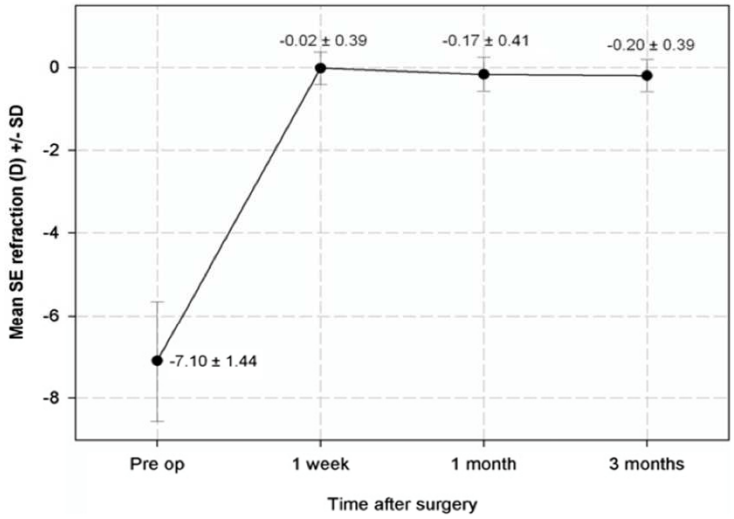


Figure 7. Stability: mean SE plotted as a function of time postoperatively in all eyes with emmetropia as target refraction that completed the 3-month follow-up (n = 124) (SE = spherical equivalent).

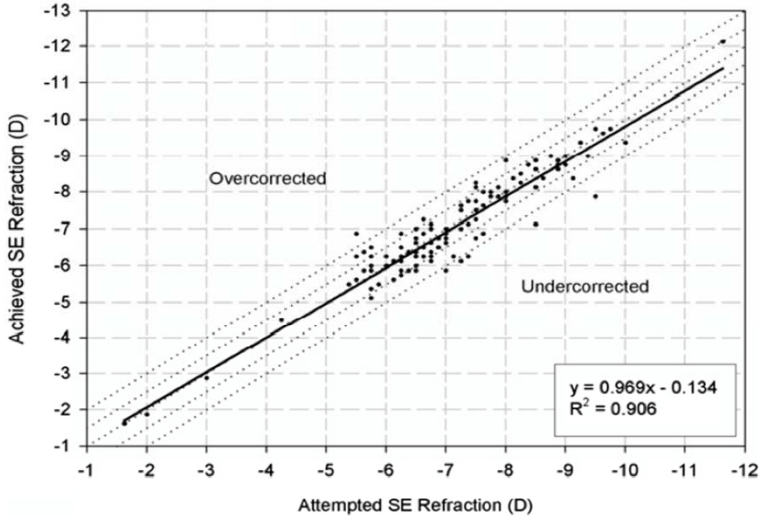
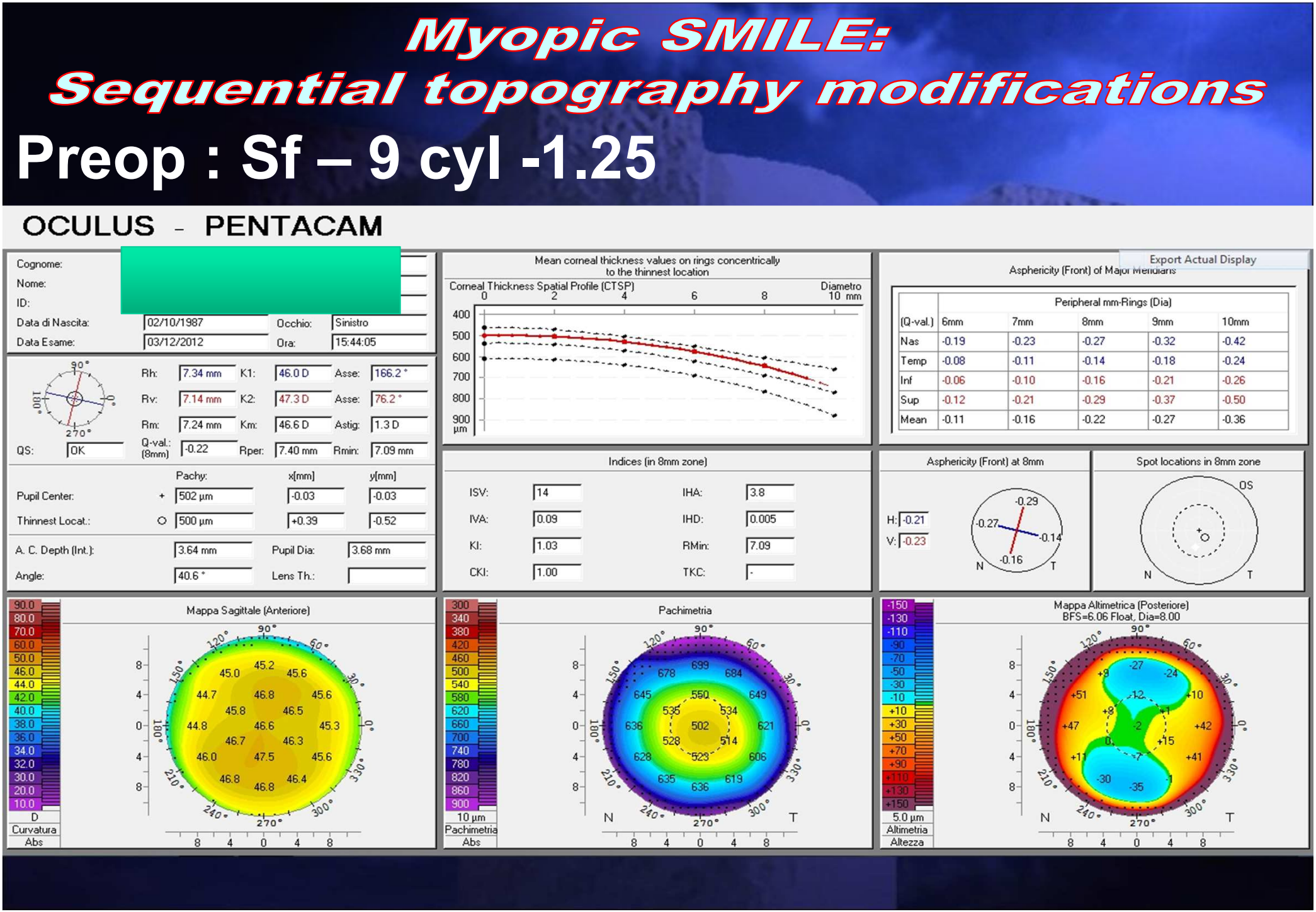
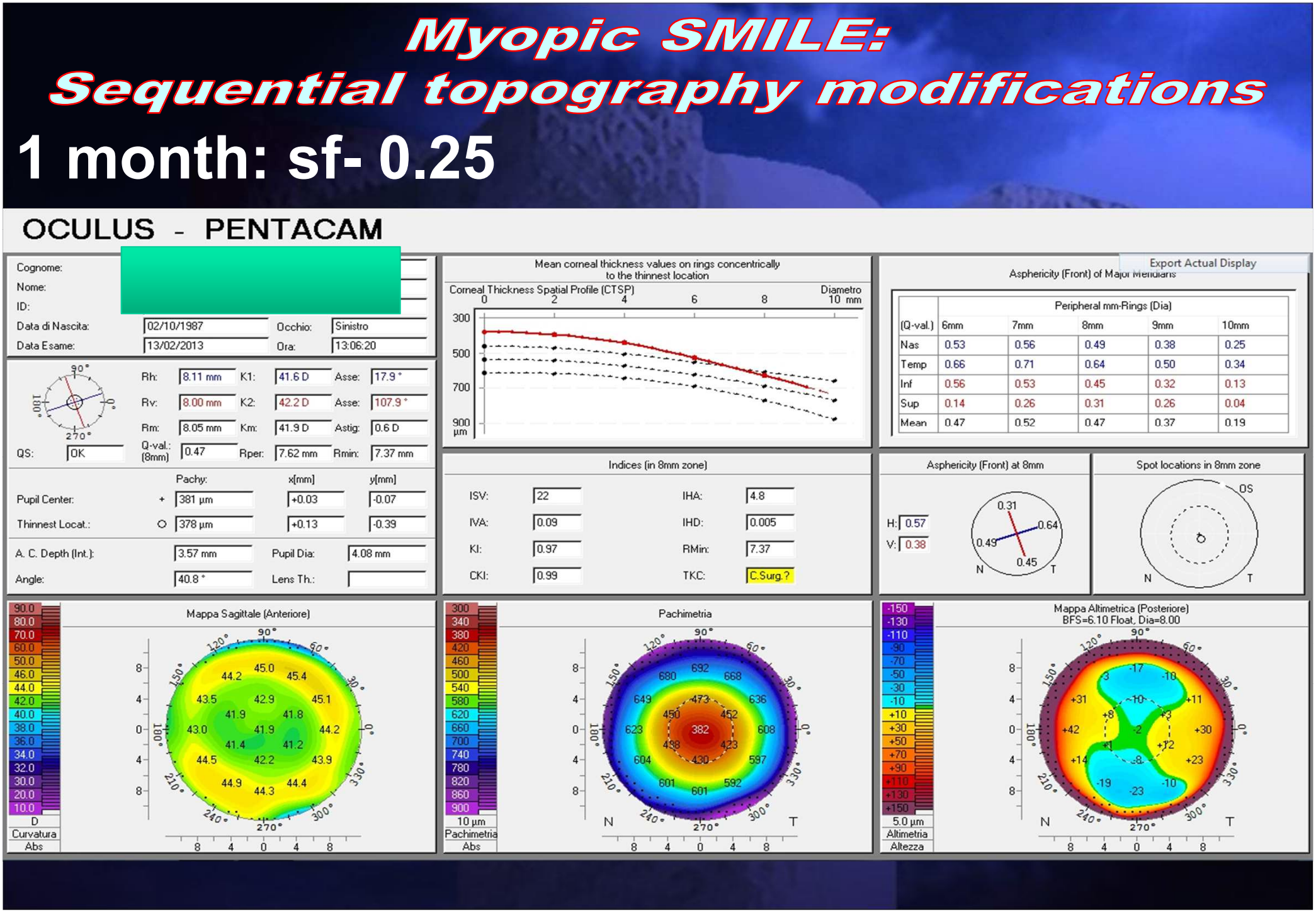


Figure 5. Predictability: attempted SE refractive change plotted against the achieved SE refractive change at 3 months (n = 127) (SE = spherical equivalent).

Myopic SMILE:
Sequential topography modifications
Preop : Sf – 9 cyl -1.25

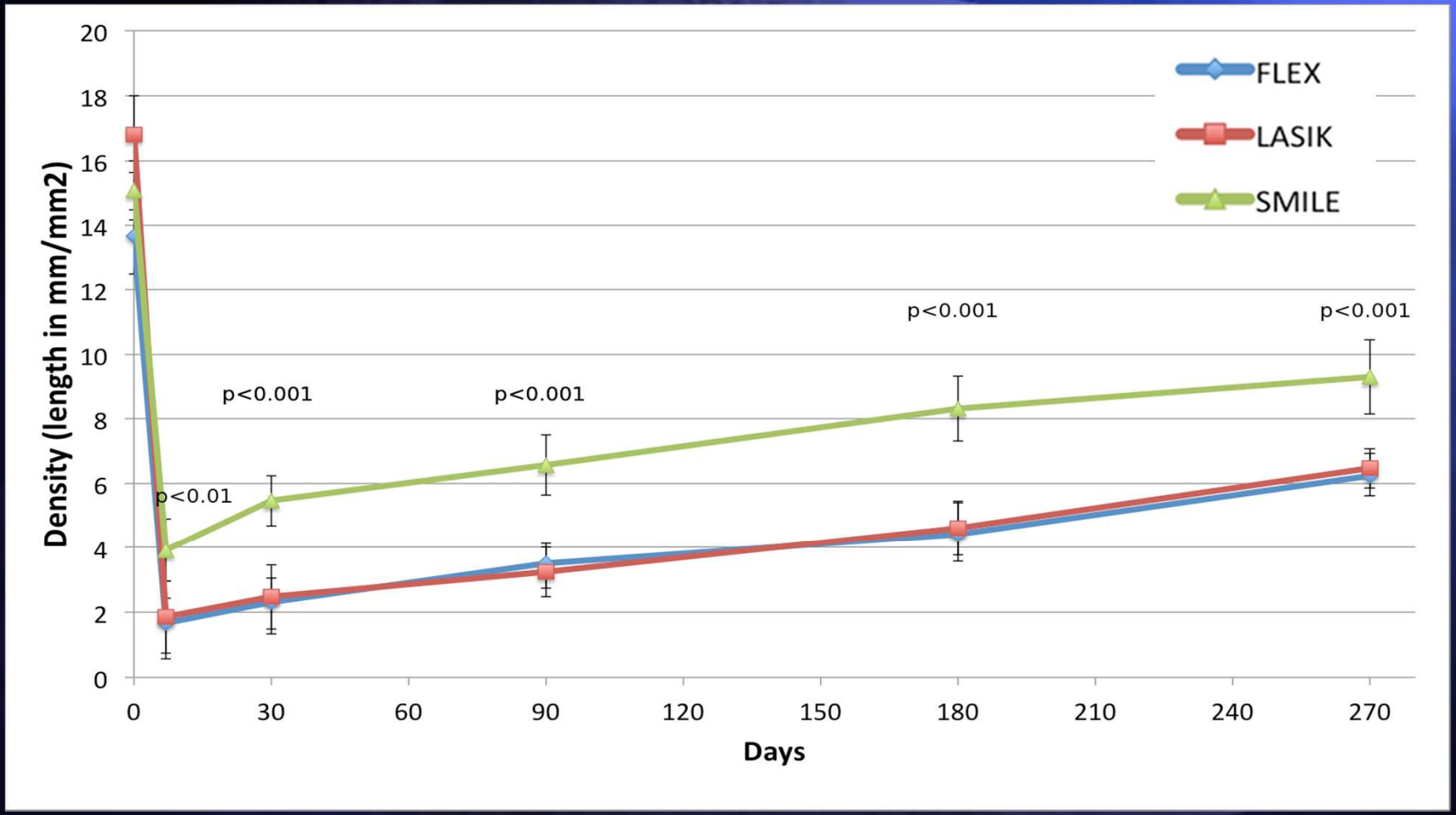


Myopic SMILE:
Sequential topography modifications
1 month: sf- 0.25



Central corneal sub-basal nerve density

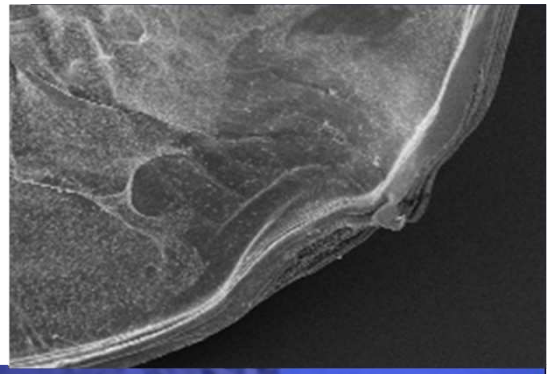
(*number of subbasal nerves: nerves/mm²*)

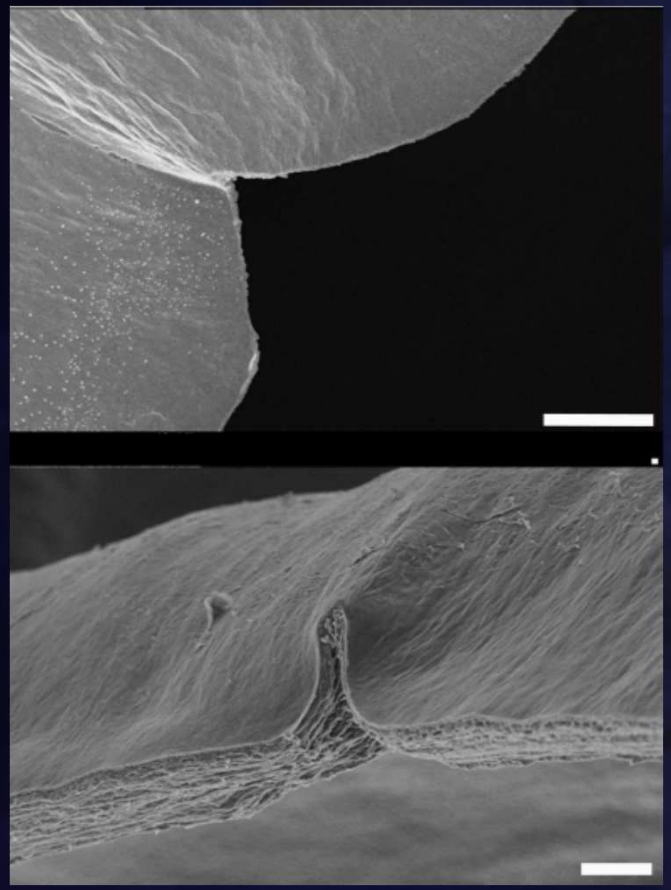


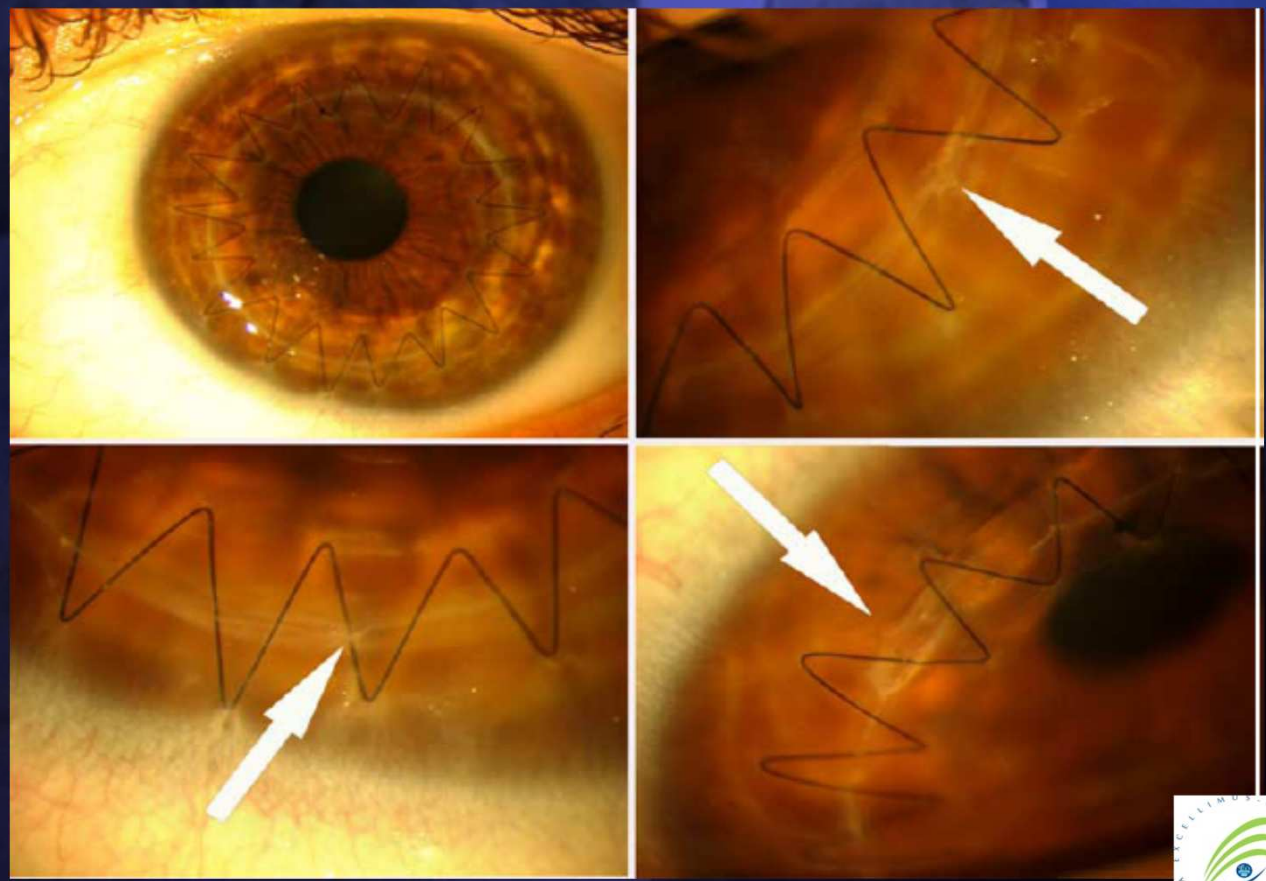
Subbasal nerve density (µm/mm²) – SMILE 9 months follow-up

Orientation Teeth in Nonmechanical Femtosecond Laser Corneal Trephination for Penetrating Keratoplasty

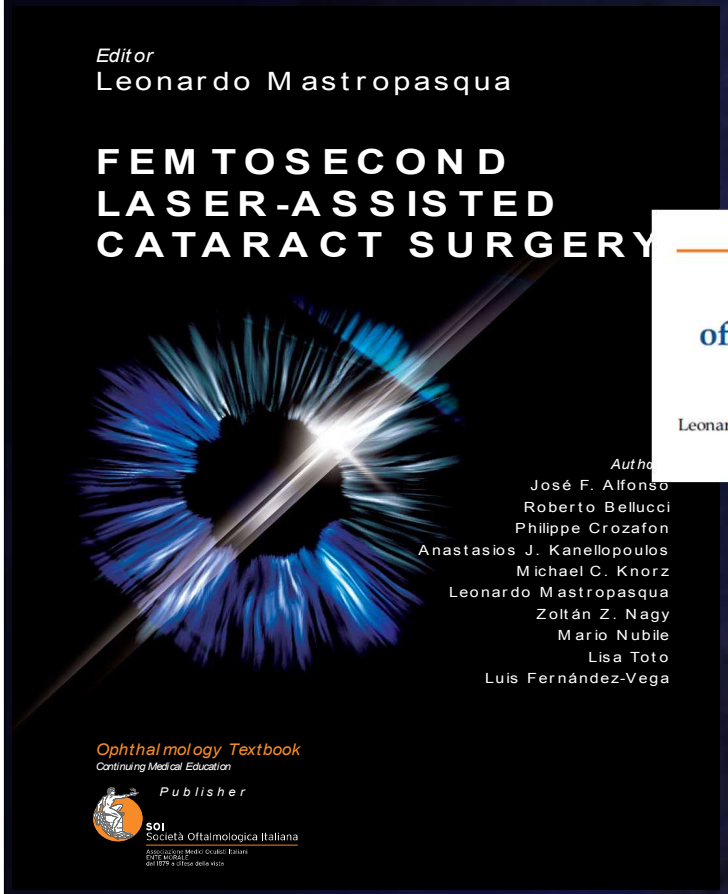
LEONARDO MASTROPASQUA, MARIO NUBILE, MANUELA LANZINI, ROBERTA CALIENNO, AND ORIANA TRUBIANI

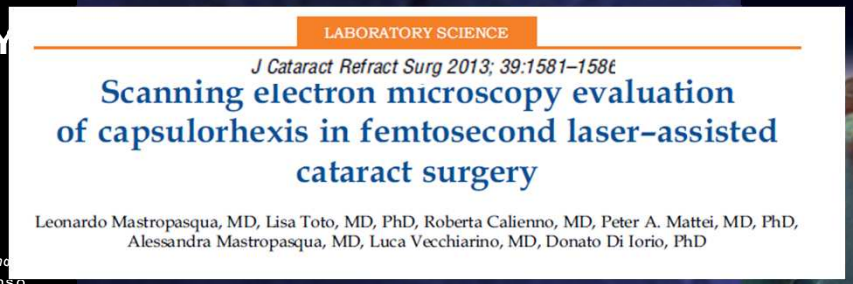


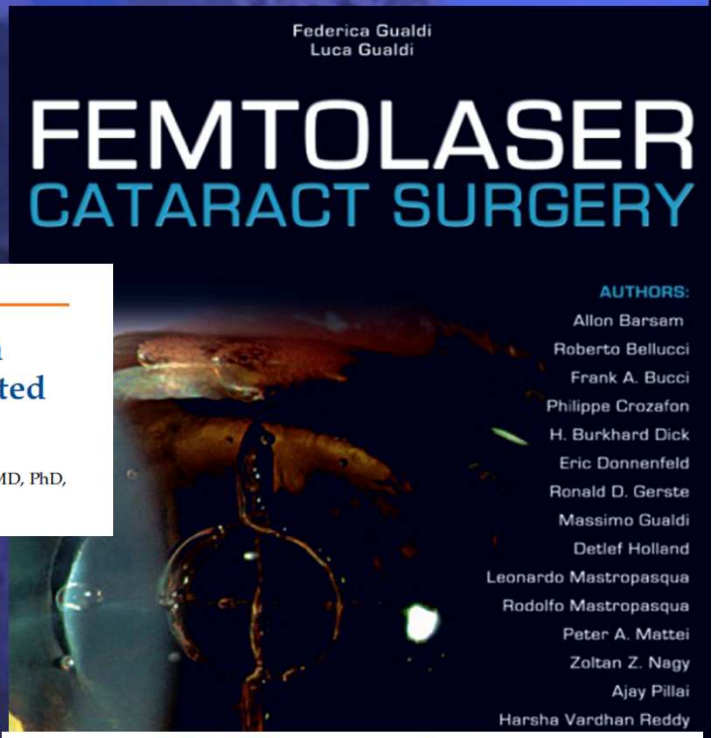




Why FLACS?







LensAR (Topcon):

Description of the Device, Procedure and Clinical Experience

L. Mastropasqua

Targets for cataract surgery

Residual spherical equivalent:

85-90% within 1 D
55% within 0.50 D

RCOphth 2004

Benchmark standards for refractive outcomes after NHS cataract surgery

Eye (2009) 23, 149–152

Biometry

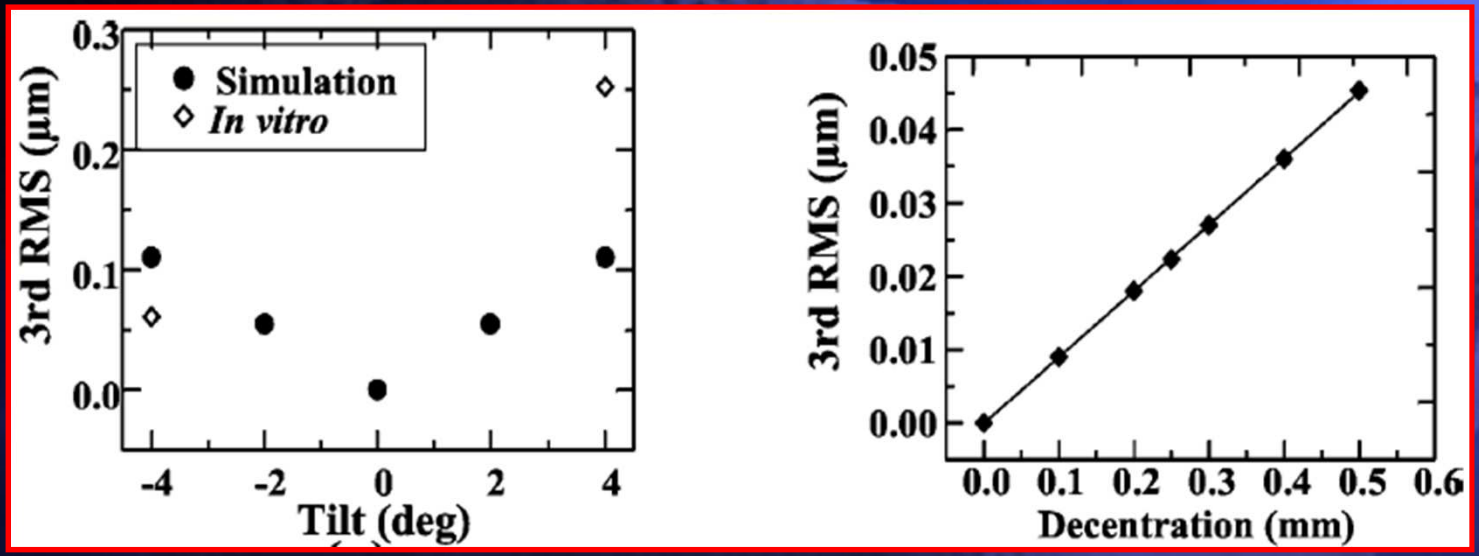
A constant

Effective lens Position (ELP):

Capsulorhexis construction

Targets for cataract surgery

High order aberrations:



Decentration >0.5 mm and Tilting > 7° induce coma and trefoil particularly with aspheric IOLs

Capsule shape and symmetry is fundamental

Barbero J Opt Soc Am A 2003, Taketani JCRS 2004, Dietse JRS 2005

Targets for cataract surgery

Surgical induced astigmatism (SIA):

- **site** and **size** of CCI
- **tunnel trauma** (phaco, Instruments)

Mackool RJ - SIA

2.75 Superior – 0.4D

3.0 Superior– 0.6D **KJO 2007**

3.2 Superior– 0.8D

Masket S – SIA

2.2mm temporal – 0.35D **JRS 2009**

3.0mm temporal – 0.67 D

Microcoaxial Torsional Cataract Surgery 1.8 mm Versus 2.2 mm: Functional and Morphological Assessment

Leonardo Mastropasqua, MD; Lisa Toto, MD; Luca Vecchiarino, MD; Marta Di Nicola, PhD; Rodolfo Mastropasqua, MD

OSLI 2011

Mean SIA 0.60±0.19 D in 1.8
0.64±0.55 D in 2.2 mm

Low amount of SIA

Predictable value with low variability

Targets for cataract surgery

Corneal astigmatism

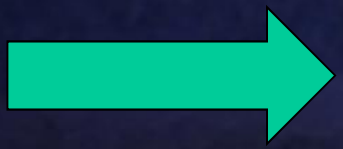
In cataract surgery candidates, preexisting corneal astigmatism between 0.25 D and 1.25 D is observed in 64.4% and in additional 22.2%, it is of 1.50D or higher.

Hoffman PC JCRS 2010. Ferrer-Blasco JCRS 2009

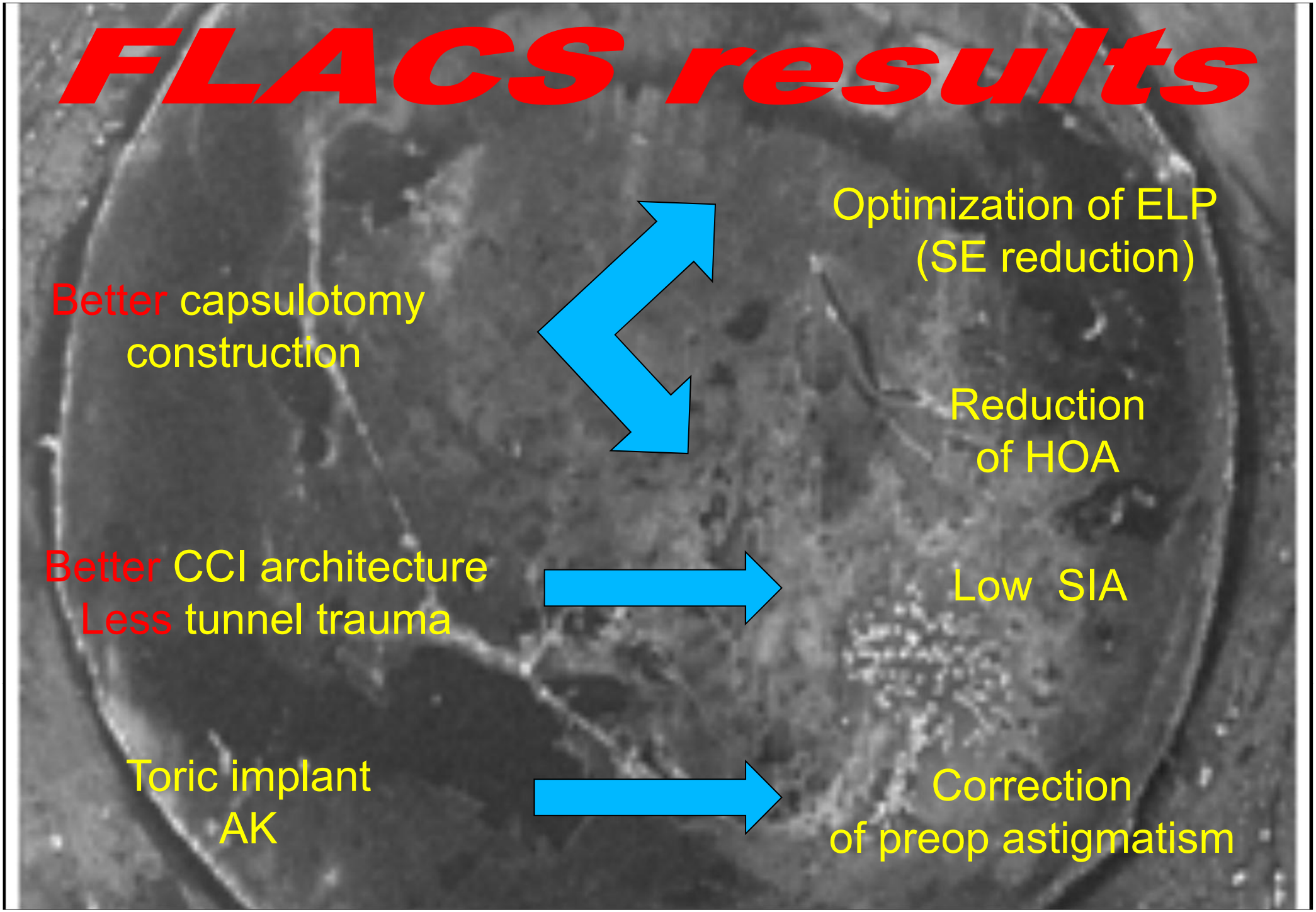
Astigmatism correction possibly at the same time of cataract surgery or as a separate procedure

Corneal

Intraocular

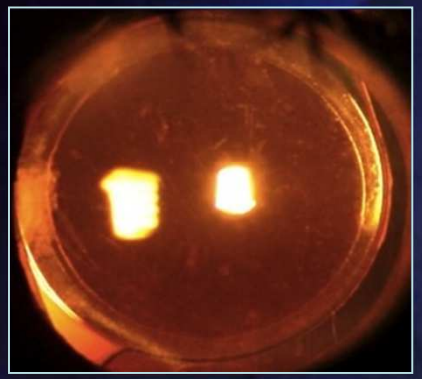


Precise and predictable Correction

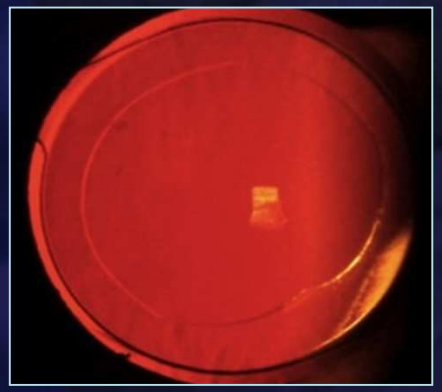

FLACS results
Optimization of ELP
(SE reduction)
Better capsulotomy
construction
Reduction
of HOA
Better CCI architecture
Less tunnel trauma
Low SIA
Toric implant
AK
Correction
of preop astigmatism

FLACS and rhexis

FLACS



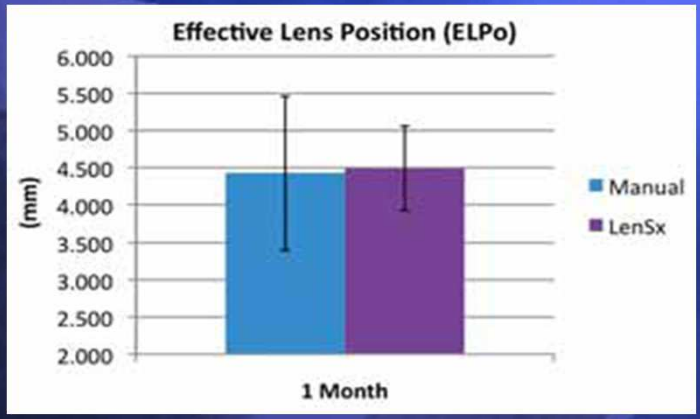
Manual



Better circularity of the FLCS rhexis
More symmetric and complete overlap of the rhexis edge over the IOL optic
Better IOL centration

Nagy JRS 2009, 2011

Better residual SE
due to better ELP (rhexis geometry)



Lower HOA : rhexis geometry

Ocular, Corneal, and Internal Aberrometry Parameters 6 Months After Surgery in Eyes That Underwent Continuous Curvilinear Capsulorrhexis or Femtosecond Laser Capsulotomy

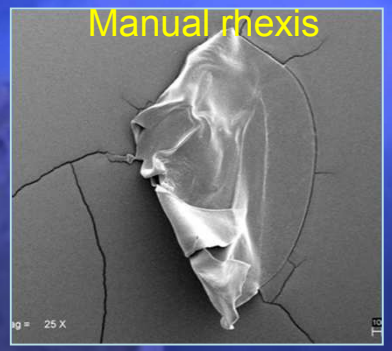
	Mean±Standard Deviation		
Parameter	CCC Group (n=51)	FS Group (n=48)	*P* Value*
Ocular			
Vertical tilt	0.09±0.44	−0.08±0.35	>.05
Horizontal tilt	0.10±0.49	0.16±0.39	>.05
Vertical coma	0.04±0.19	−0.02±0.16	>.05
Horizontal coma	−0.01±0.16	0.02±0.14	>.05
Corneal			
Vertical tilt	−0.11±0.49	−0.06±0.38	>.05
Horizontal tilt	−0.05±0.41	−0.04±0.32	>.05
Vertical coma	−0.04±0.17	−0.04±0.11	>.05
Horizontal coma	−0.03±0.11	−0.02±0.12	>.05
Internal			
Vertical tilt	0.27±0.57	−0.05±0.36	.006
Horizontal tilt	0.15±0.59	0.16±0.63	>.05
Vertical coma	0.10±0.15	0.003±0.11	.006
Horizontal coma	0.03±0.18	0.06±0.11	>.05

FLACS and rhexis

LABORATORY SCIENCE

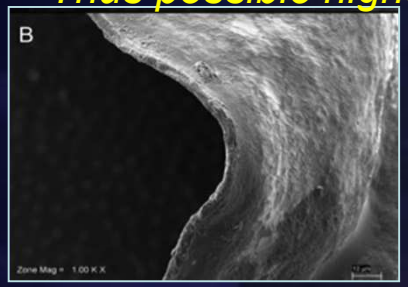
Scanning electron microscopy evaluation of capsulorhexis in femtosecond laser–assisted cataract surgery

Leonardo Mastropasqua, MD, Lisa Toto, MD, PhD, Roberta Calienno, MD, Peter A. Mattei, MD, PhD, Alessandra Mastropasqua, MD, Luca Vecchiarino, MD, Donato Di Iorio, PhD

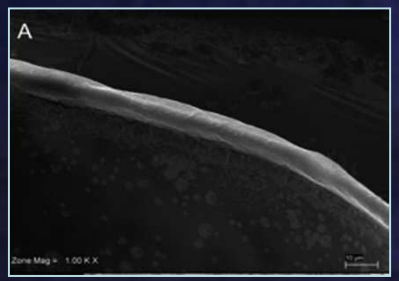


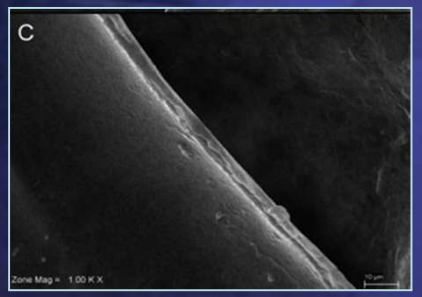
Better cut surface quality with lower energy
Thus possible higher capsule strength

7µJ FSL



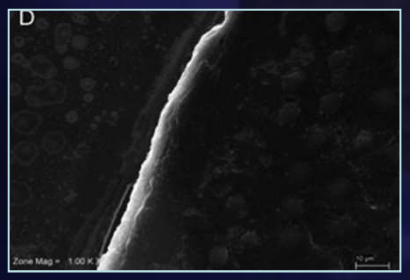
Manual

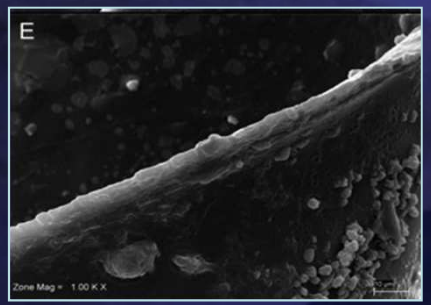




13.5 µJ FSL

14 µJ FSL

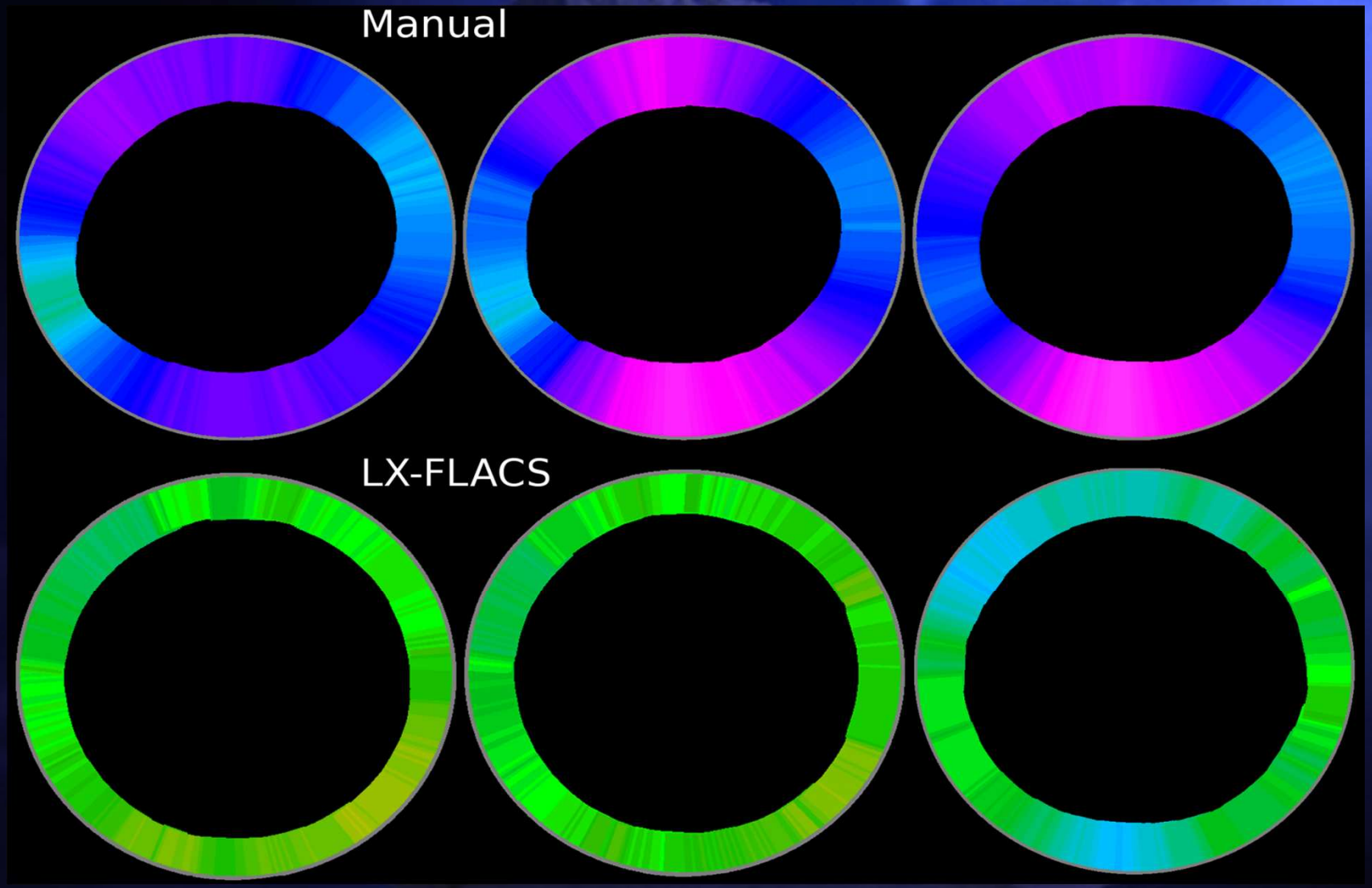




15 µJ FSL

Mastropasqua et al JCRS 2013

Overlap color map



Exè Chieti-Pescara software

Mastropasqua et al. JRS In press

FLACS and IOL positioning

Variables	7 days		30 days		180 days		*p-value*		
	LX-FLACS	MCCC	LX-FLACS	MCCC	LX-FLACS	MCCC	time[+]	group[#]	interaction[†]
IOL decentration (mm)	0.12±0.02	0.19±0.06	0.13±0.04	0.21±0.06	0.18±0.03	0.24±0.06	*<0.001*	*<0.001*	*0.910*

Minimal amount of decentration

Mastropasqua et al. JRS In press

Recent advancement with LensX

VERION™ Image Guided System - with LenSx® Laser

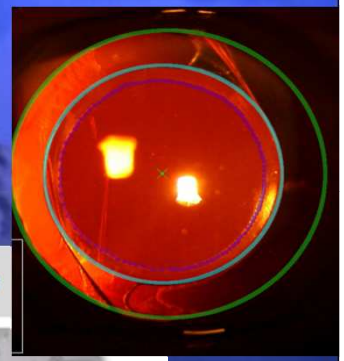
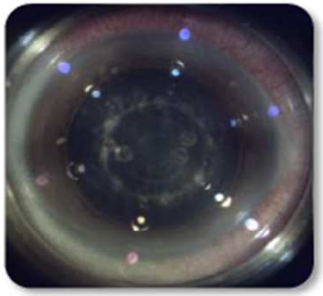
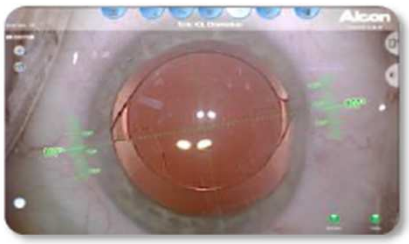
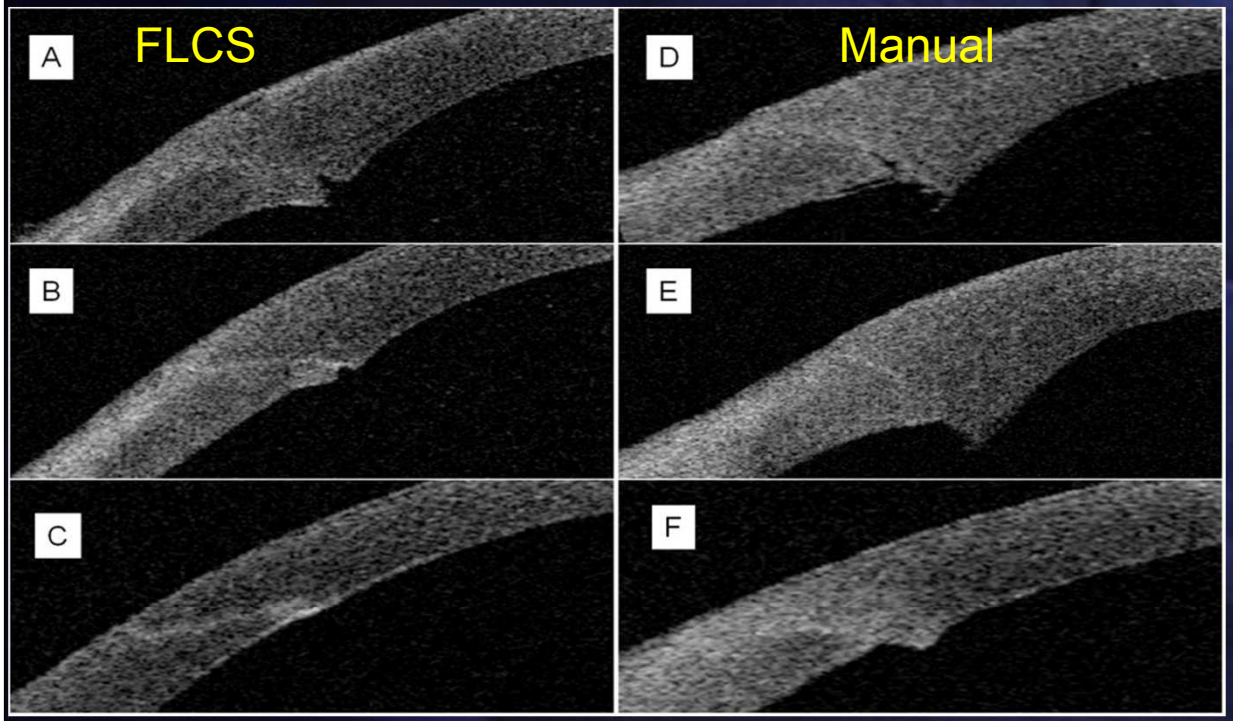


	Image	Plan	LenSx® Laser Treatment	Guide
System	 Verion™ Measurement Module	 Verion™ Vision Module	 Verion™ Digital Marker L	 Verion™ Digital Marker M
Workflow				
Function	Pre-op Measurement Keratometry Limbus, pupil & vessels detection	Planning IOL Calculation Surgery Planning (Incision, Implantation Axis)	LenSx® Laser Treatment Exact position of Incisions Centering of Capsulotomy and Lens fragmentation	Treatment Accurate centering of AcrySof® Multifocal IOL Precise alignment of AcrySof® Toric IOL

Femtosecond Laser Versus Manual Clear Corneal Incision in Cataract Surgery

Leonardo Mastropasqua, MD; Lisa Toto, MD, PhD; Alessandra Mastropasqua, MD;
Luca Vecchiarino, MD; Rodolfo Mastropasqua, MD; Emilio Pedrotti, MD; Marta Di Nicola, PhD

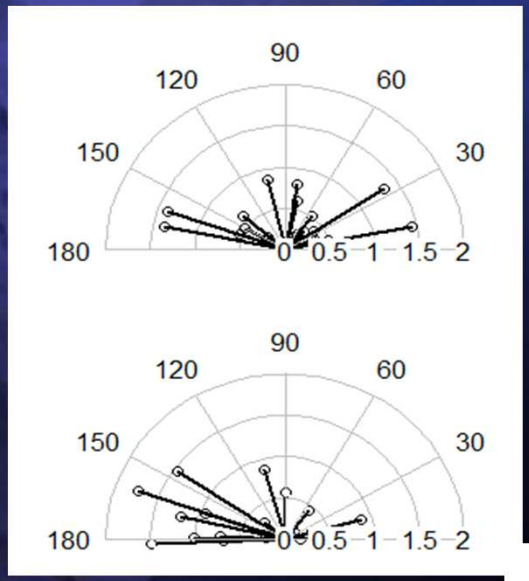
J Refract Surg. **In Press**



Perfect CCI architecture

Precise wound apposition and sealing

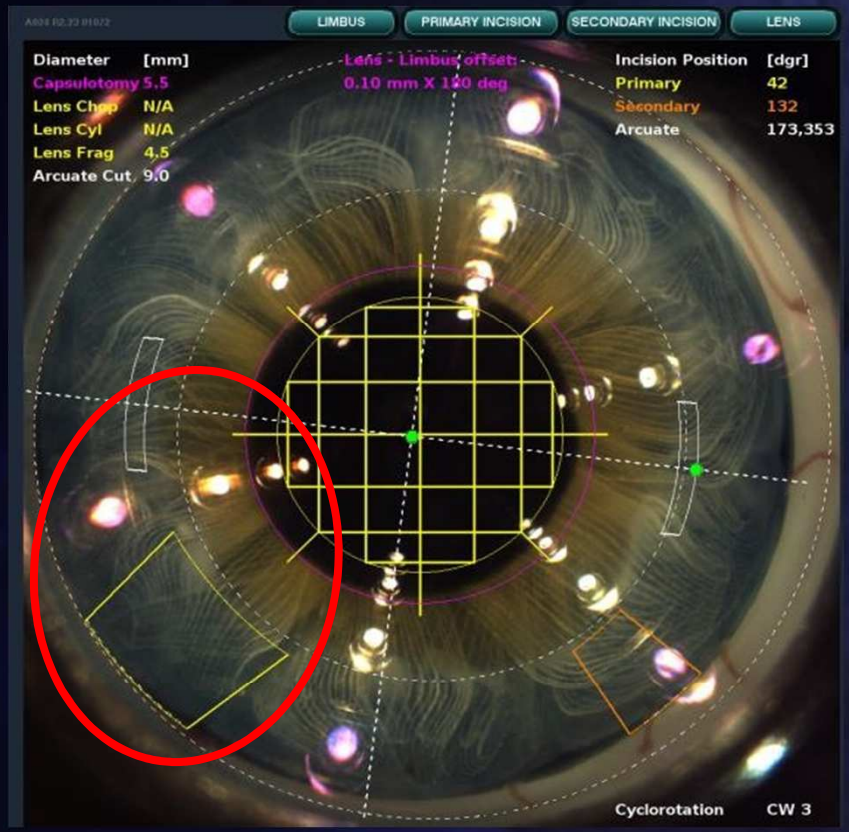
Perfect alignment



SIA= 0.64±0.25 D in FEMTO group
0.69±0.50 D in Manual group

Lower SIA variability in femto vs manual

Verion and CCI



SIA

site and **size** of CCI

Self-centering of the limbus helps to optimize corneal incision pre-positioning

FLACS and lens fragmentation

Toward Zero Effective Phacoemulsification Time Using Femtosecond Laser Pretreatment

Ophthalmology 2013;120:942–948

Robin G. Abell, MBBS,[1] Nathan M. Kerr, MBChB,[2] Brendan J. Vote, FRANZCO[1,2]

Mean reduction of EPT (83.6% with 30% of patients with 0 EPT)

Less corneal swelling and less endothelial cell loss in FCLS[7]

Lower CDE in Femto vs Manual

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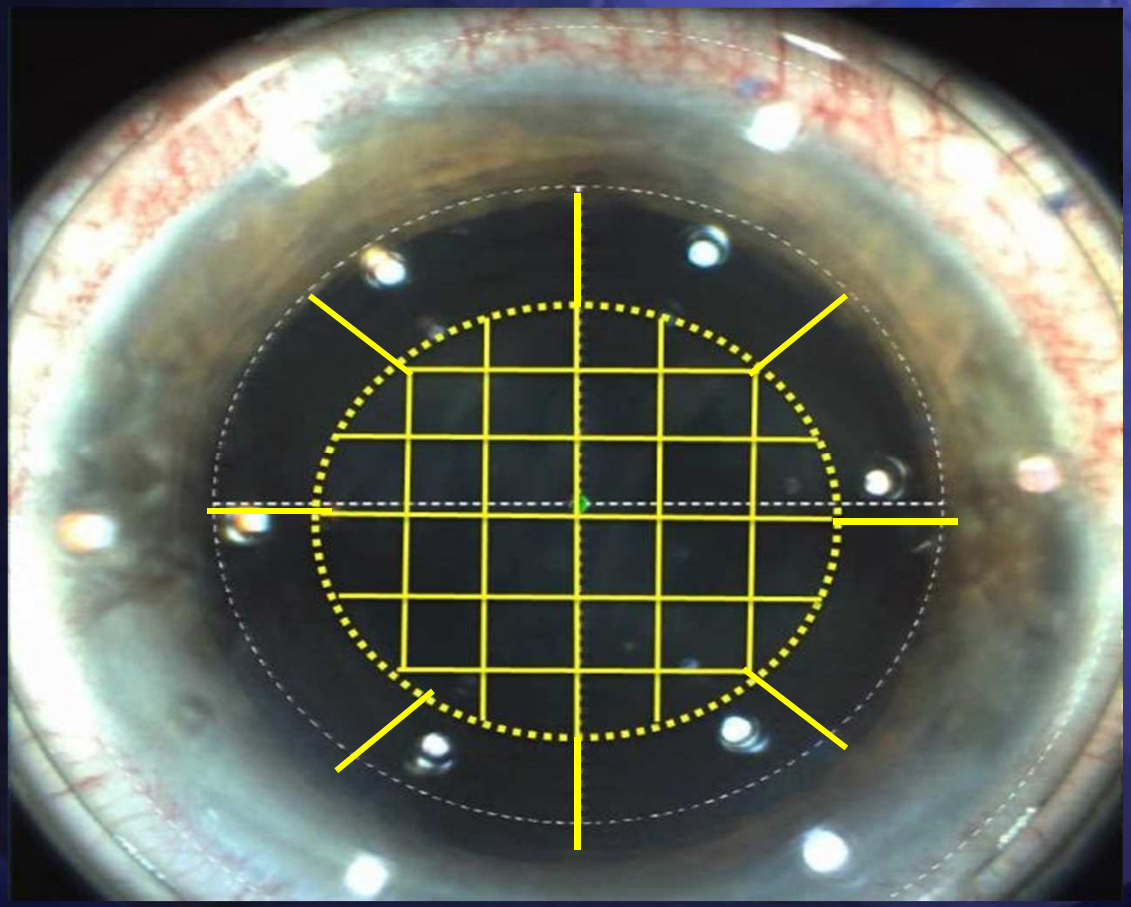
J Refract Surg. **In Press**

Variable	FEMTO	Manual	p-value†
Cumulative dissipated energy	9.9±2.7	13.1±6.7	***0.050***
Total time (sec)	55.1±20.	74.6±32.1	***0.028***
Phaco time (sec)	9.1±4.8	11.2±5.7	*0.215*
Torsional time (sec)	46.0±15.9	63.4±31.1	***0.032***

† t-test for unpaired data, FEMTO vs Manual;

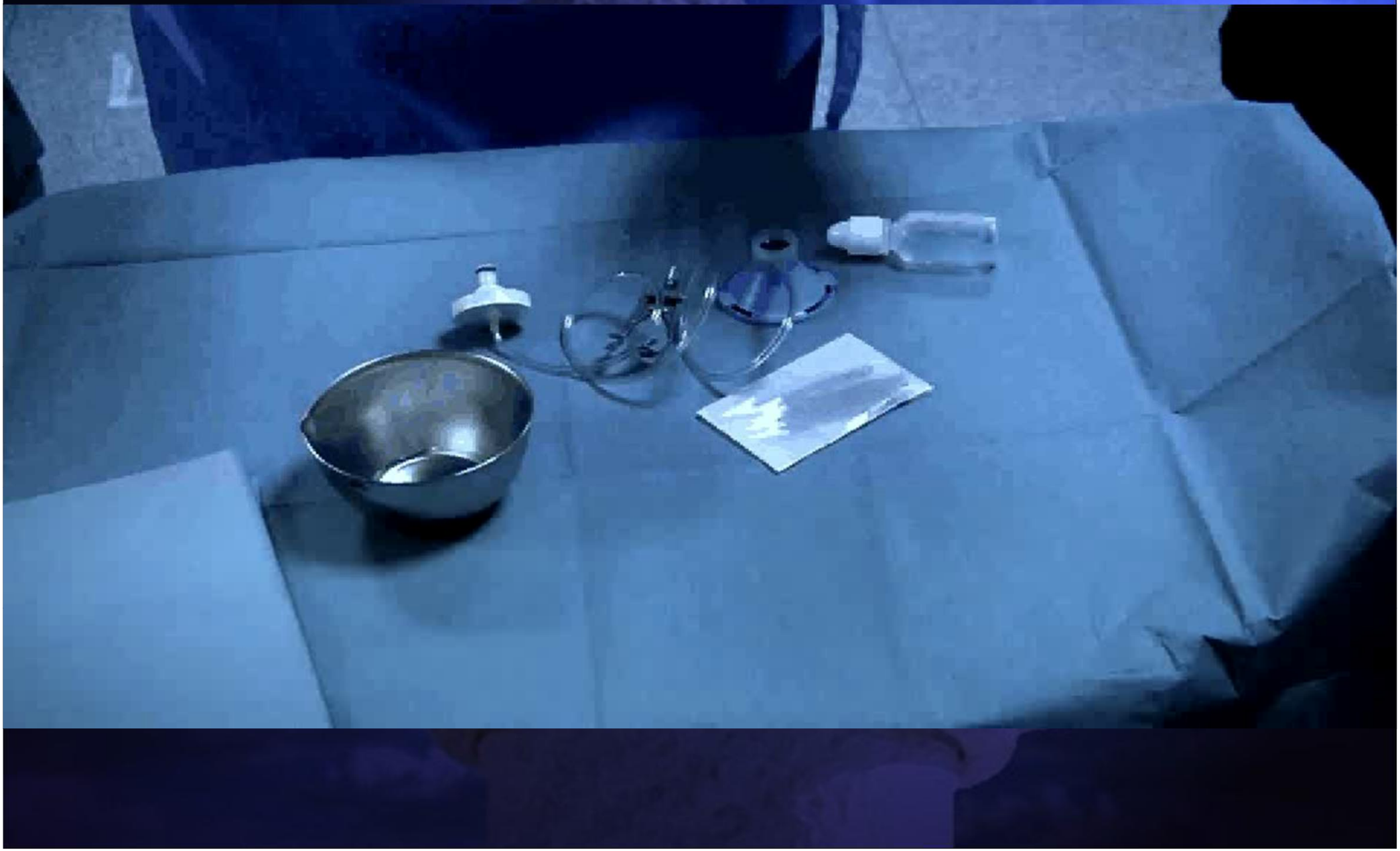
New frag patterns

Cubicon pattern

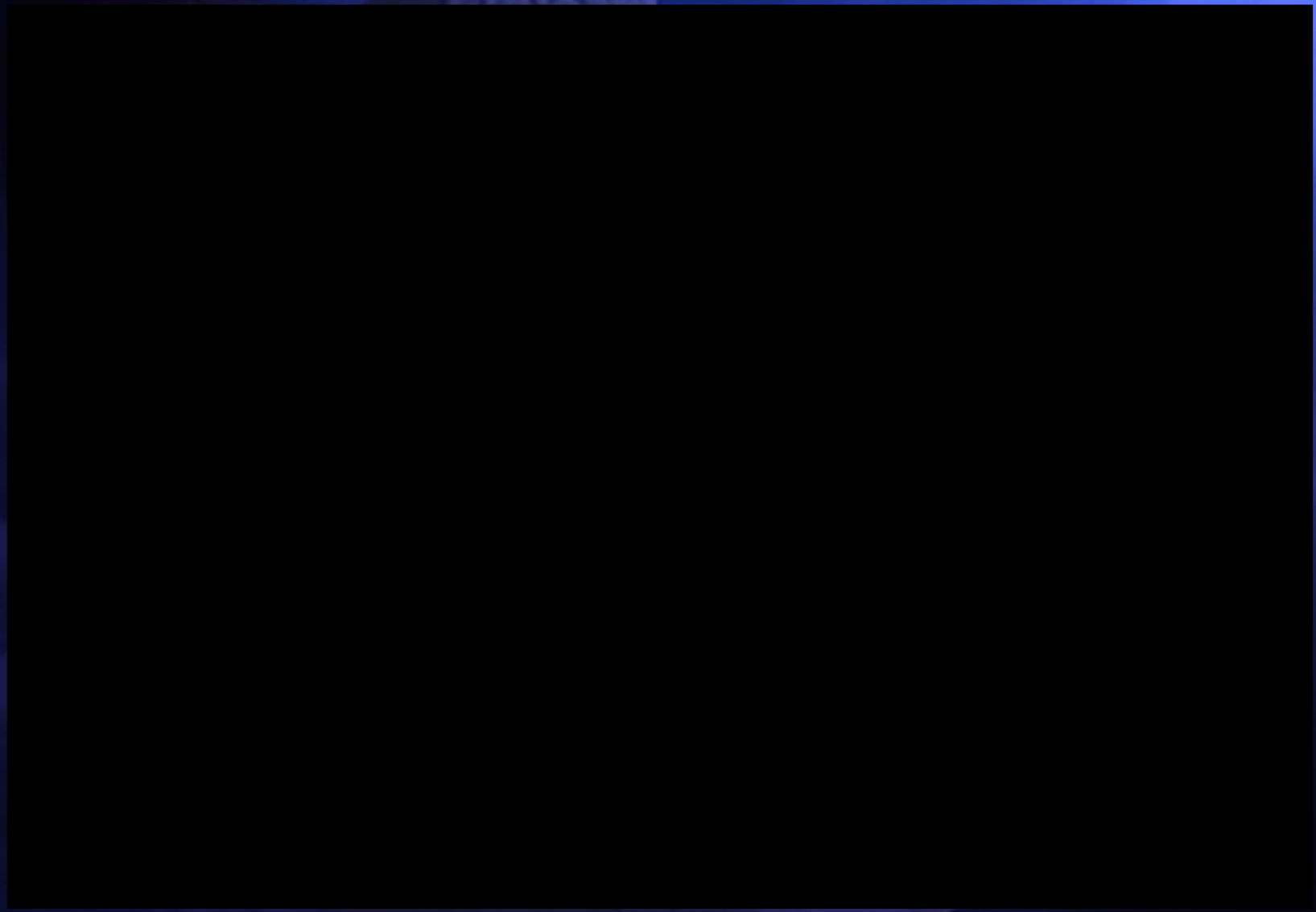


Toward zero phaco time

OCT-guided FSL cataract surgery



Schempflug-guided FSL cataract surgery

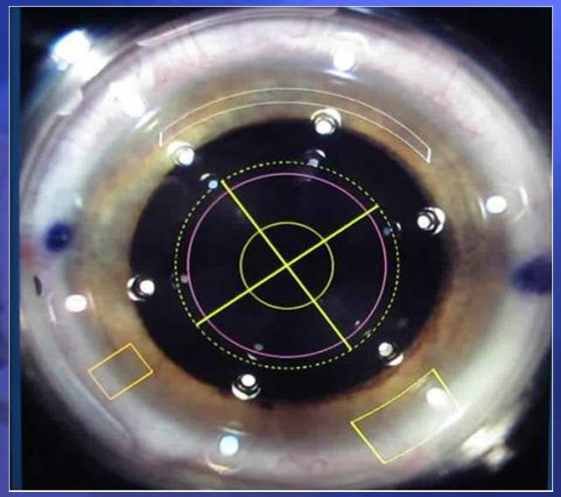


FLACS and AK during cataract surgery

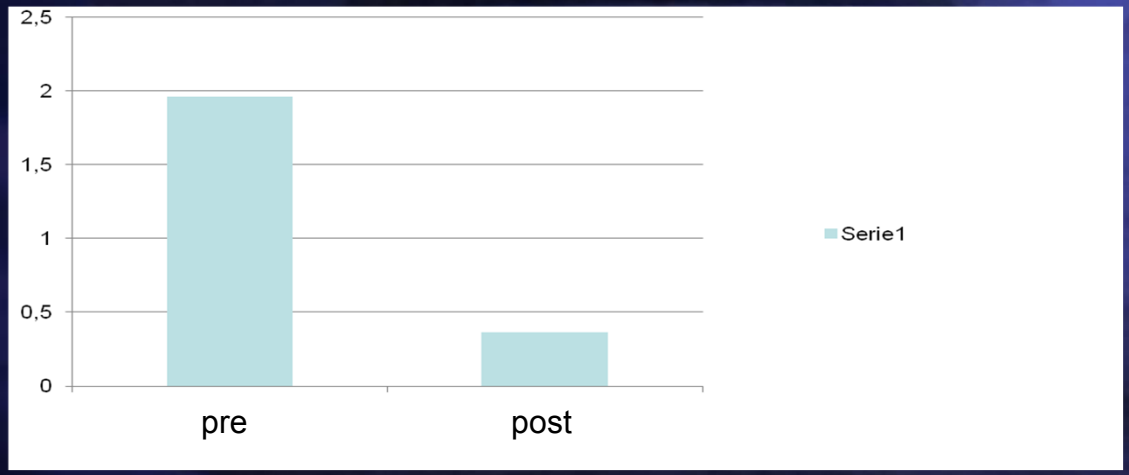
Femtosecond Laser Arcuate Keratotomy for the Correction of High Astigmatism after Keratoplasty

Ophthalmology 2009

Mario Nubile, MD, Paolo Carpineto, MD, Manuela Lanzini, MD, Roberta Calienno, MD, Luca Agnifili, MD, Marco Ciancaglini, MD, Leonardo Mastropasqua, MD



One-step procedure for cataract and astigmatism correction



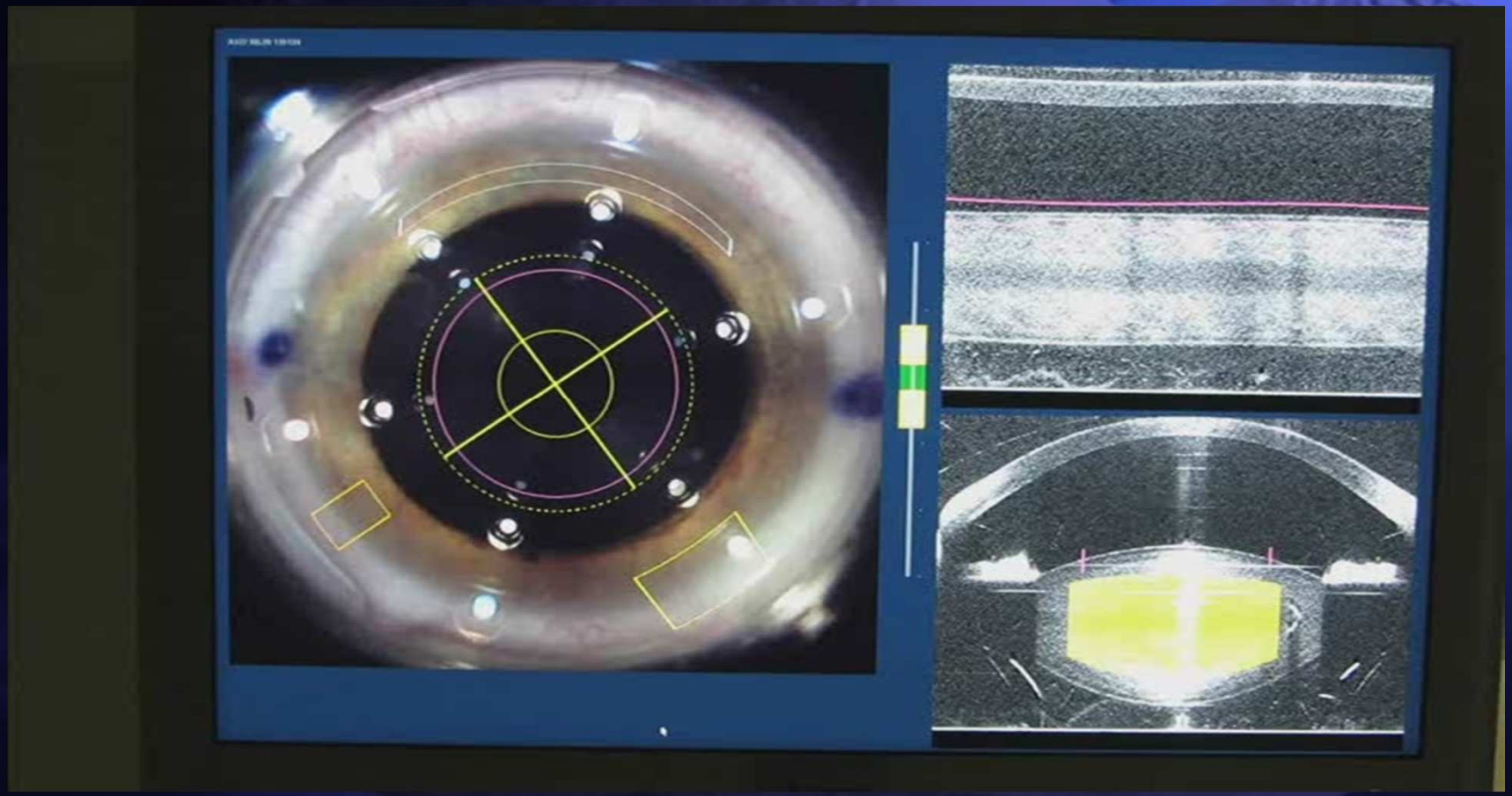
N of patients= 15
Follow-up: 6 months

* p<0.05

Mean astigmatism from 1.94 D to 0.32 D (preop range 0.75 D to 2.5 D)
83.5% decrease of topographic astigmatism

Mastropasqua et al, preliminary data

FLACS and AK



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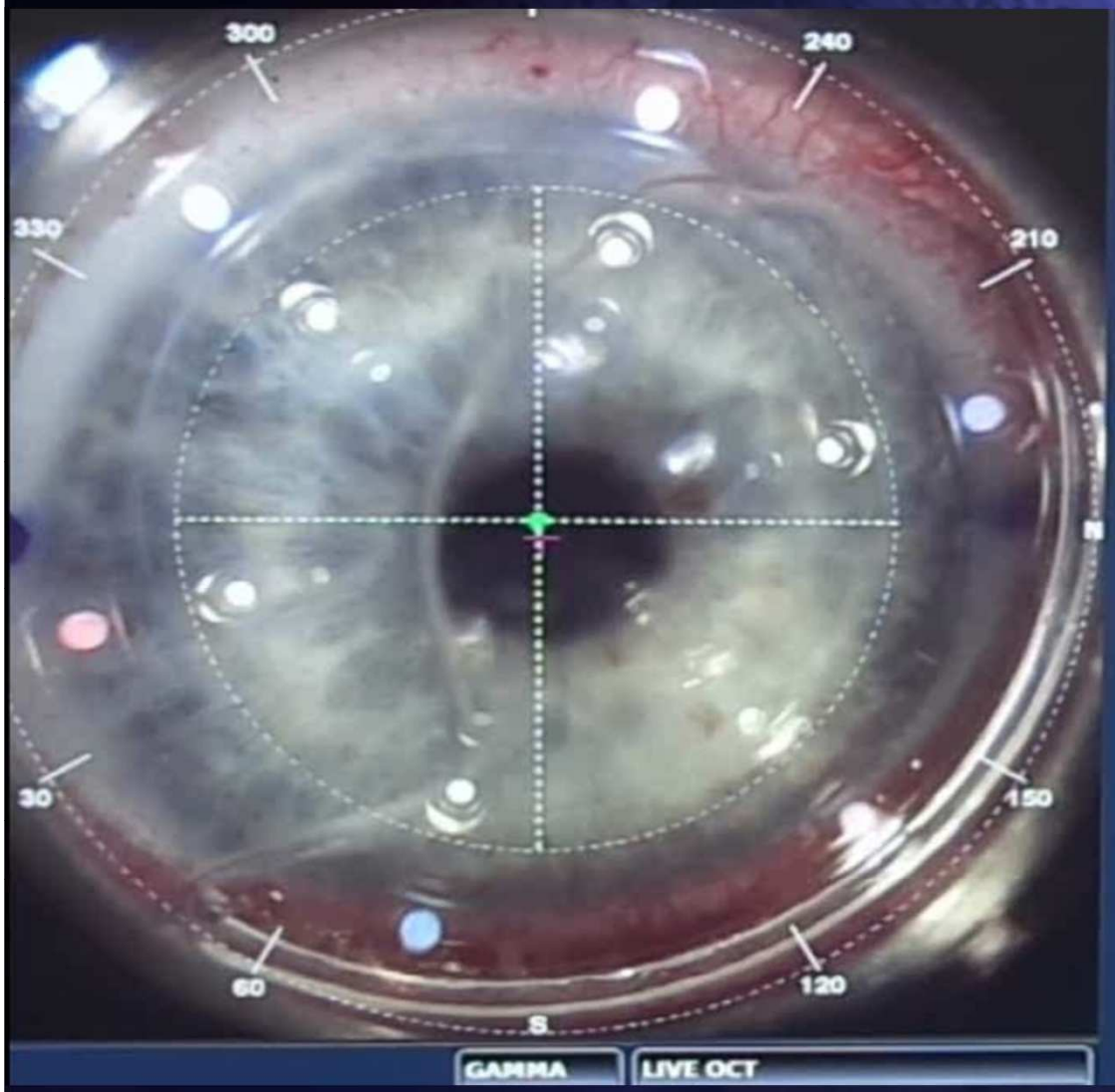
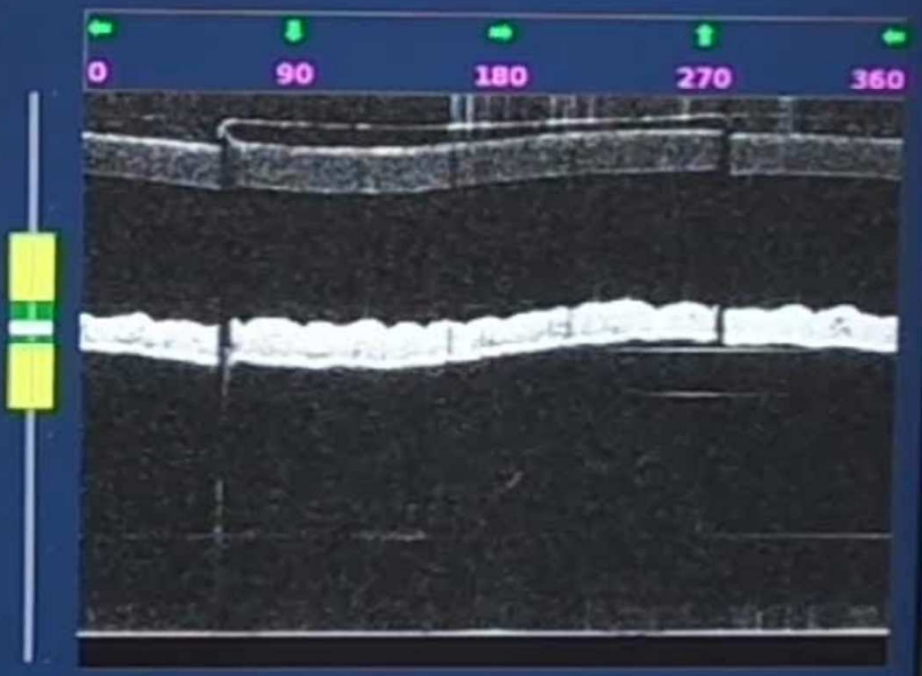
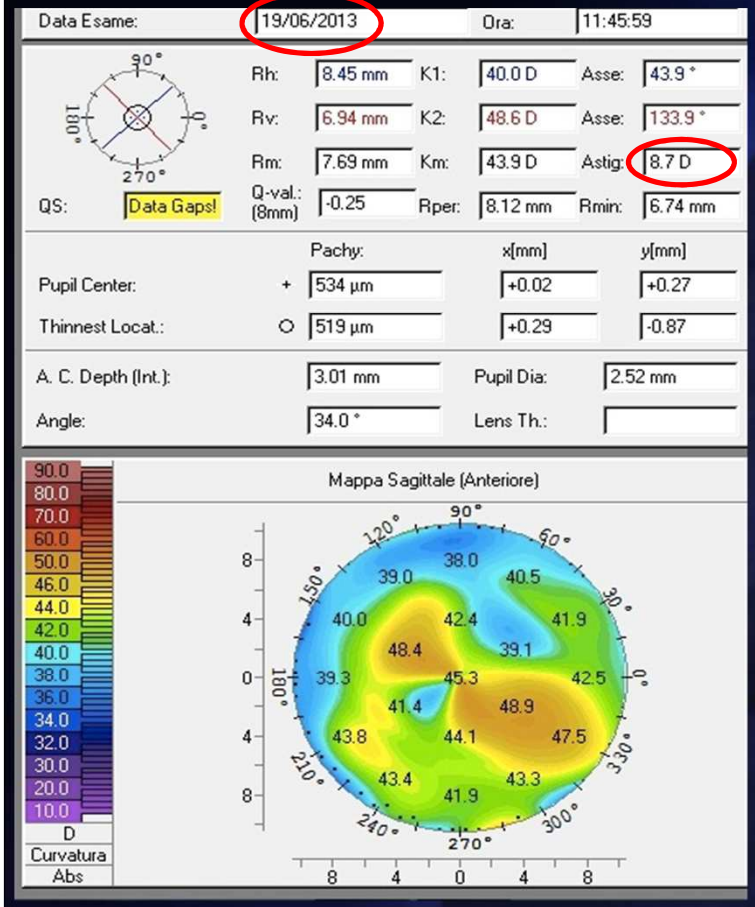
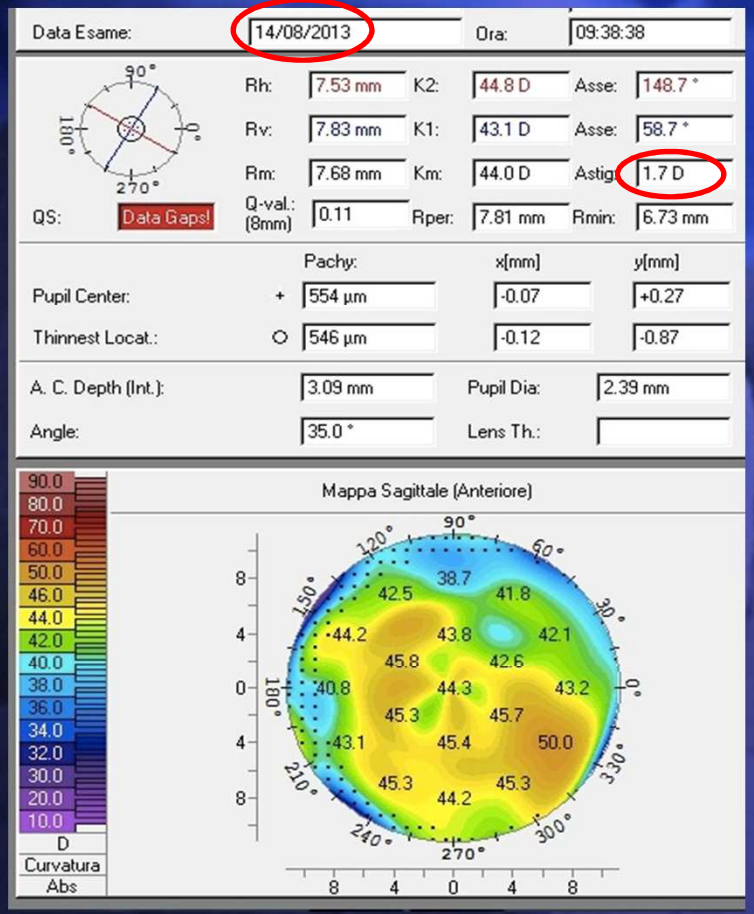
EXÈ

FLACS AK in post PK





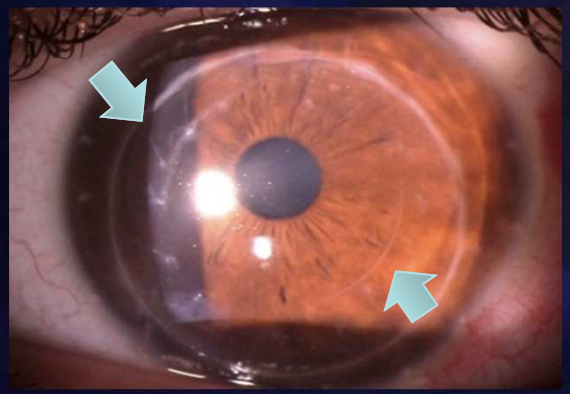


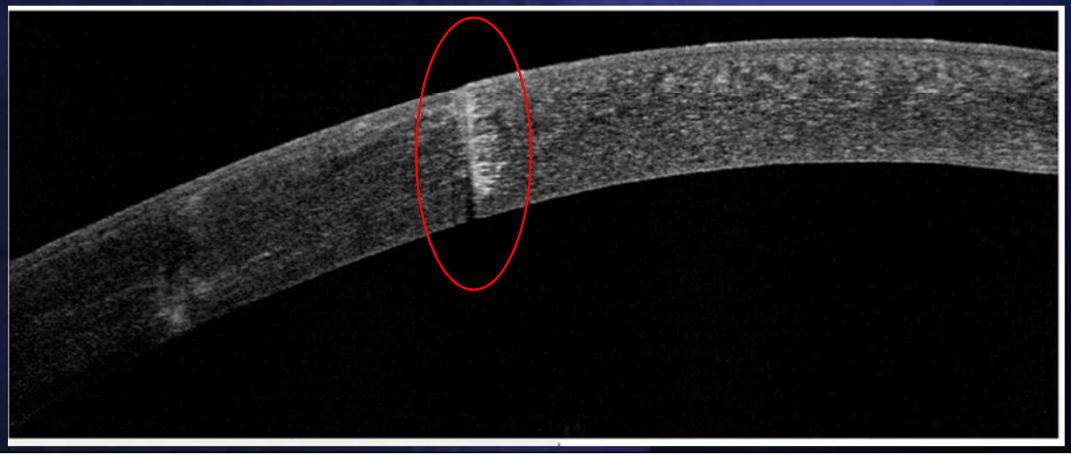


Topographic Astigmatism

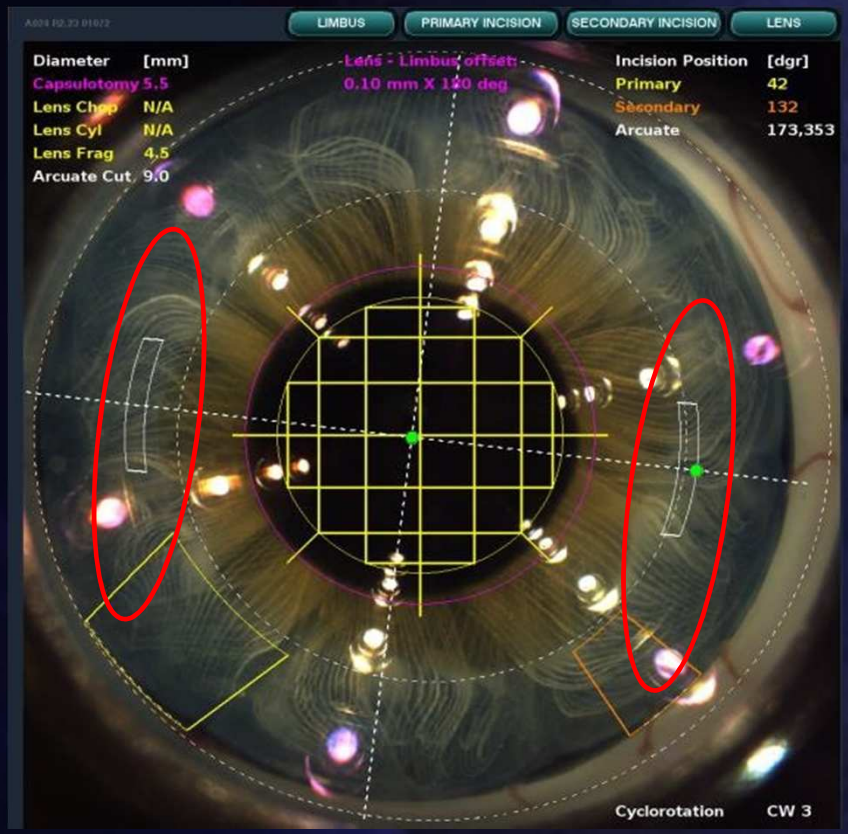
Pre: 8.7 D
BCVA: 0,15
UCVA: 0.7

Post: 1.7 D
BCVA: 0.0
UCVA:0.4





Verion and AK



Internal normogram for AK

Possibility to choose amount of astigmatism to be corrected with AK or toric IOL

SIA compensation

Non specular incision for irregular astigmatism

→Autocompensation of cyclotorsion

FLACS

First ERA

Improves visual and refractive outcomes of cataract surgery

Second ERA

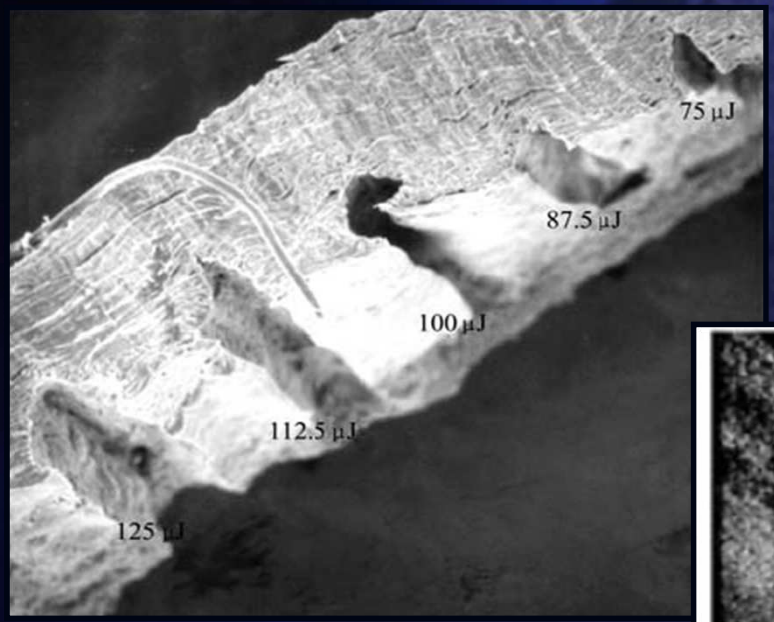
Perfect IOL aligment

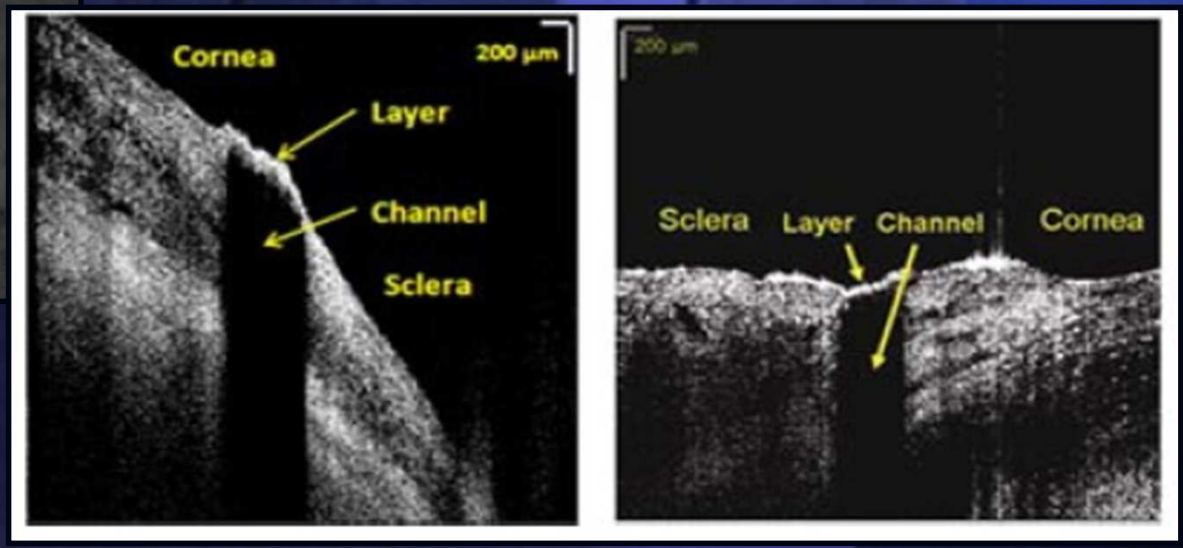
Reduction of SIA

Toward zero phaco

Scleral thinning with FSL

Next FUTURE





Front. Optoelectron. China 2008, 1(1–2): 162–167
DOI 10.1007/s12200-008-0022-4

An in vitro study of femtosecond laser photodisruption in rabbit sclera

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Scaffolding is essential to the construction of buildings[1]
[1] RALPH I. LLOYD MD, 1940