



Università di Verona  
Dipartimento di Neuroscienze, Biomedicina e Movimento  
Sezione di Oftalmologia  
Scuola di Specializzazione in Oftalmologia

Direttore: Prof. Giorgio Marchini

AOUI di Verona  
Dipart. Assist. Integr. di Neuroscienze  
UOC Oculistica



# Chirurgia del Glaucoma: perché tecniche differenti portano a risultati diversi sulla pressione intraoculare

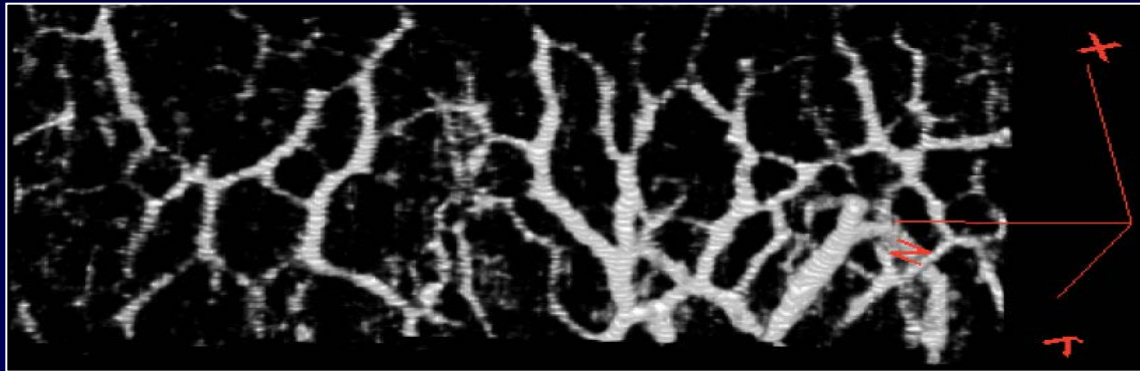
## Giorgio Marchini

Published in final edited form as:

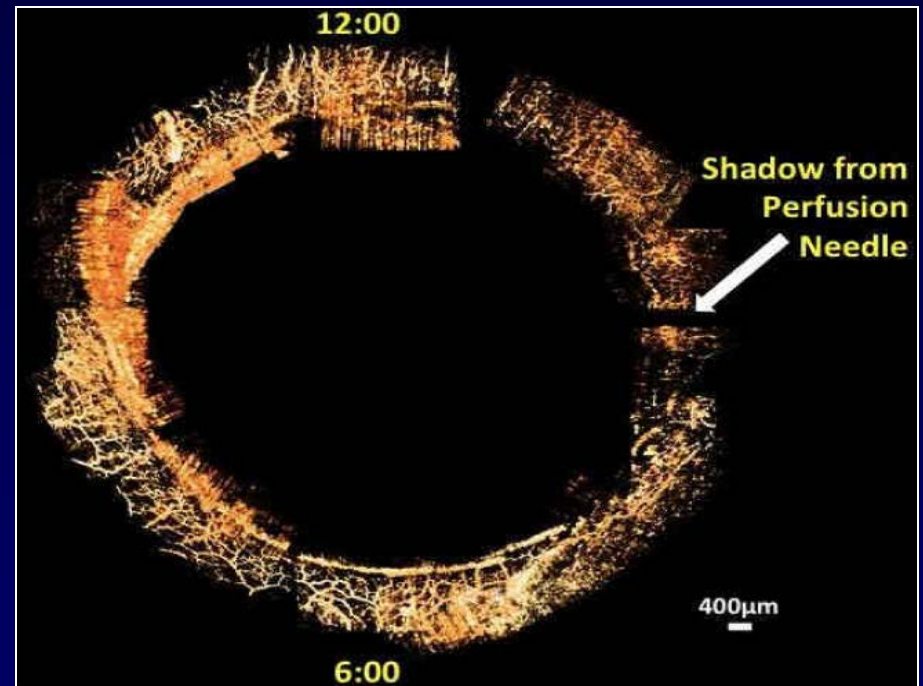
*Exp Eye Res.* 2011 September ; 93(3): 308–315. doi:10.1016/j.exer.2011.03.019.

## 3D Visualization of Aqueous Humor Outflow Structures In-Situ in Humans

Larry Kagemann<sup>1,2</sup>, Gadi Wollstein<sup>1</sup>, Hiroshi Ishikawa<sup>1,2</sup>, Ian A. Sigal<sup>1,2</sup>, Lindsey S Folio<sup>1</sup>, Juan Xu<sup>1</sup>, Haiyan Gong<sup>3</sup>, and Joel S Schuman<sup>1,2,4</sup>

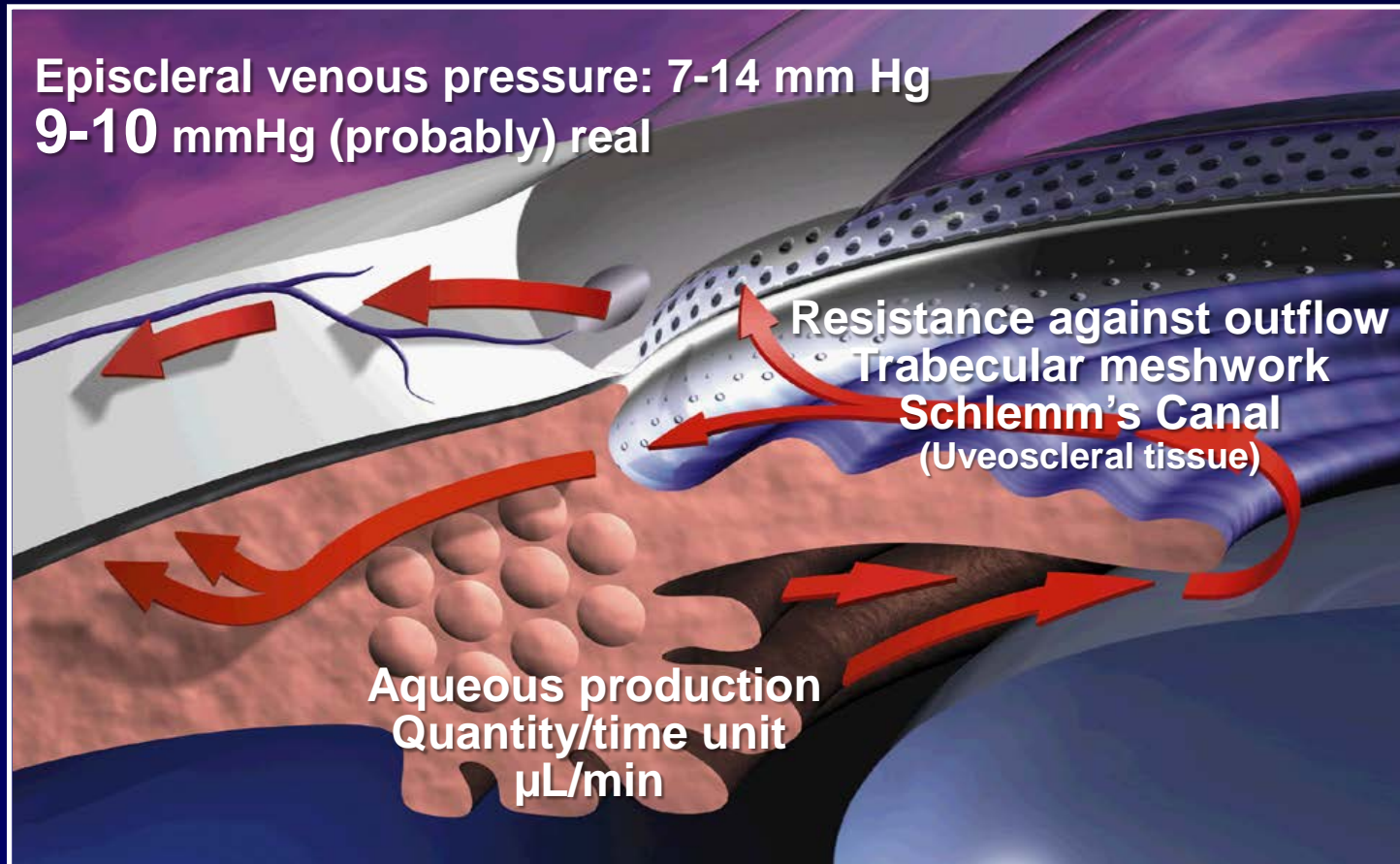


IntraScleral Venous Plexus (ISVP) image during active outflow rendered in 3D (*Bioptigen SD-OCT*).

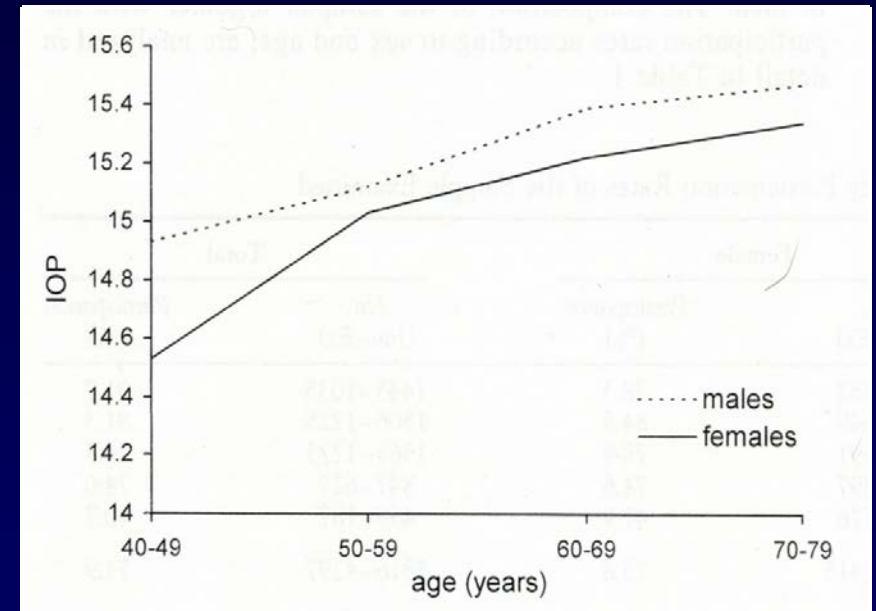
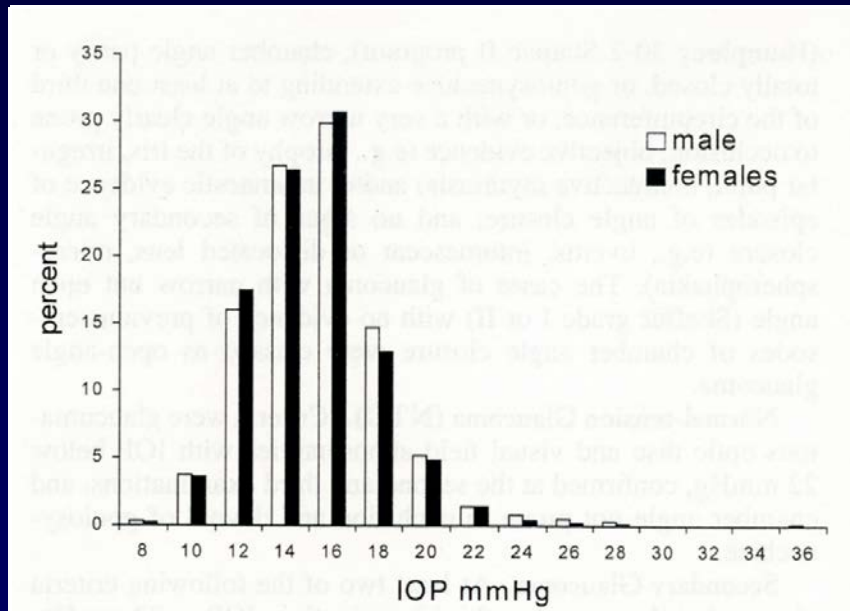


# Factors determining IOP level

*IOP level as a function of the balance/equilibrium among 3 factors*



# Normal value of IOP



Egna-Neumarkt Study (4297 subjects) - *Ophthalmology* 105:209; 1998.

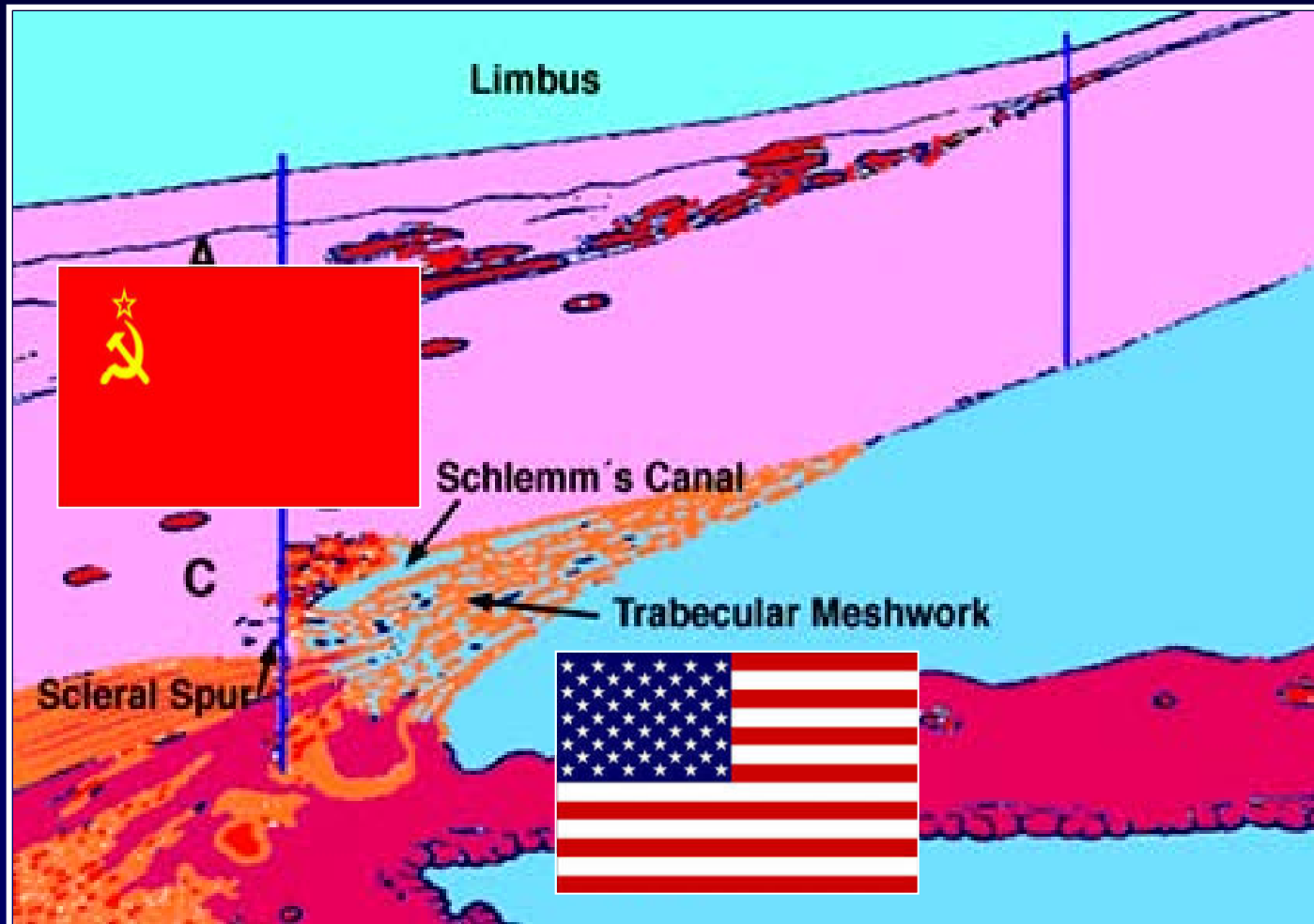
# Normal value of IOP

---

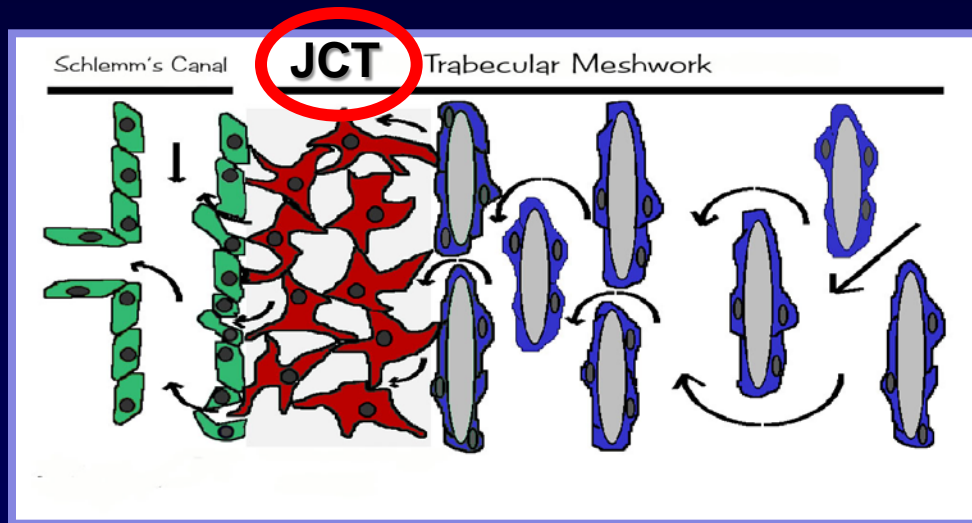
- $15.03 \pm 2.69$  mmHg (mean  $\pm$  SD)
- || 95.45 % of population within  $\pm 2$  SD  
(Gaussian parameter)

9.65    $\xleftarrow{-2\text{ DS}}$    15.03    $\xrightarrow{+2\text{ DS}}$    20.41

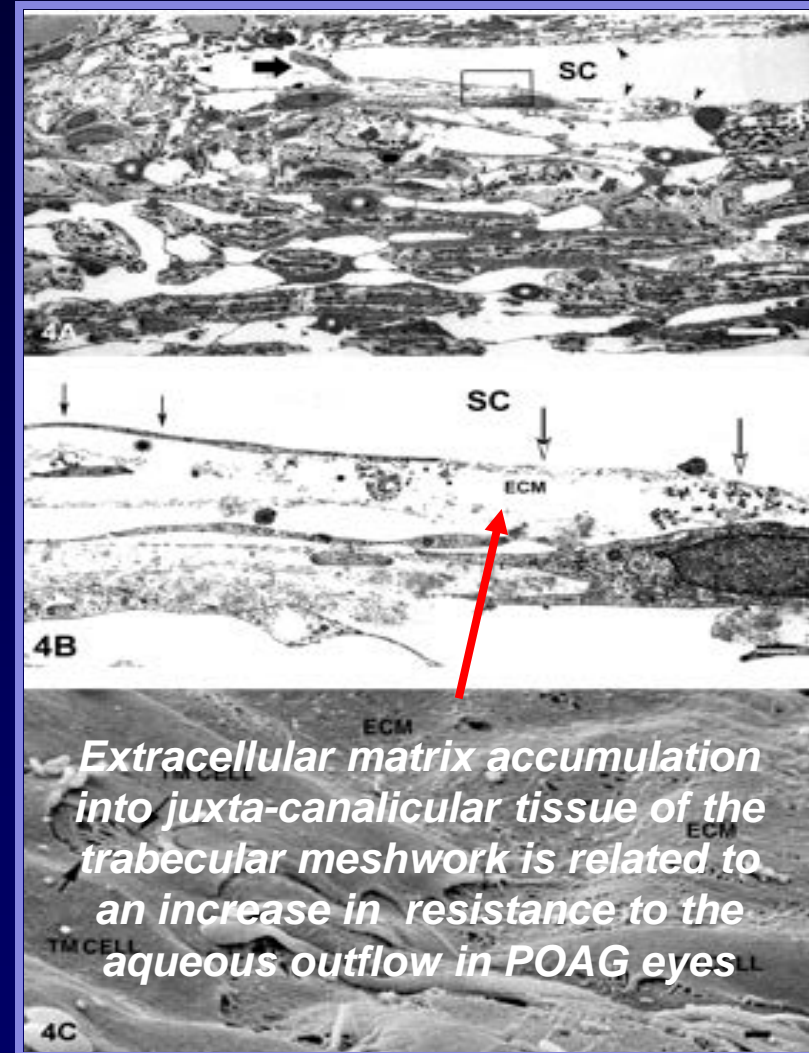
# Site of resistance



# Resistance to the aqueous outflow



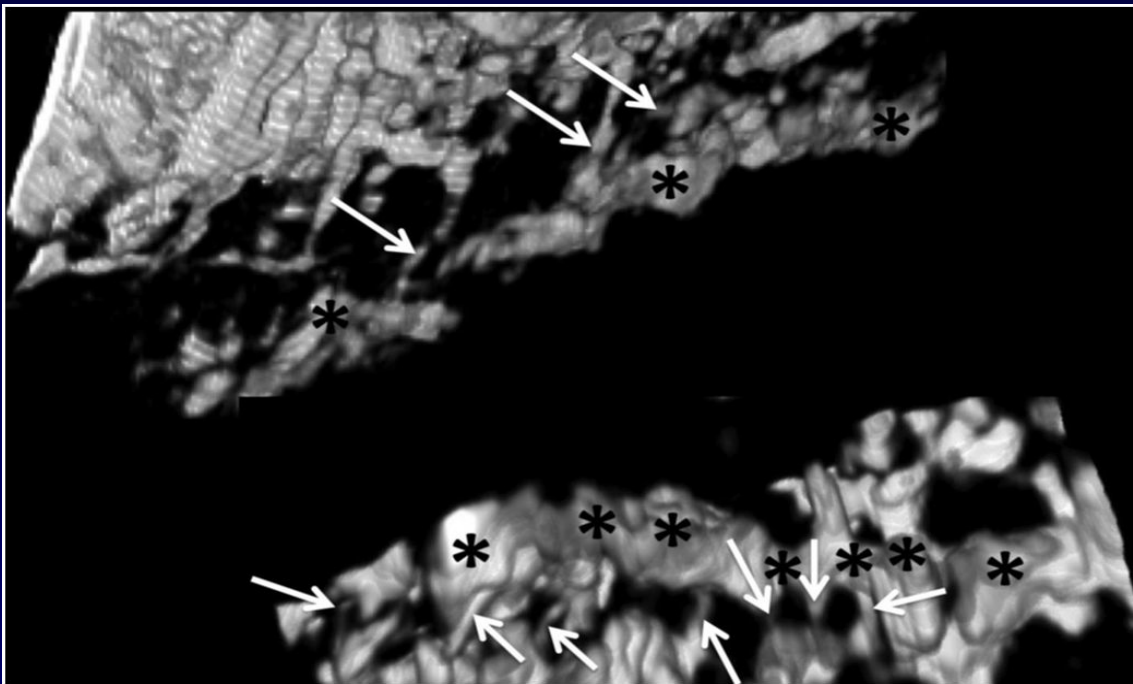
*The most resistance to the aqueous outflow is located into the juxtacanalicular trabeculum*



*Extracellular matrix accumulation into juxta-canalicular tissue of the trabecular meshwork is related to an increase in resistance to the aqueous outflow in POAG eyes*

## Visualization of the Conventional Outflow Pathway in the Living Human Eye

Larry Kagemann, MS<sup>1,2</sup>, Gadi Wollstein, MD<sup>1</sup>, Hiroshi Ishikawa, MD<sup>1,2</sup>, Zachary Nadler, BS<sup>1</sup>, Ian A. Sigal, PhD<sup>1,2,3</sup>, Lindsey S Folio, BS<sup>1</sup>, and Joel S Schuman, MD<sup>1,2,3</sup>



High IOP (very high increasing) may be the cause of

- collapse of Schlemm's canal
- closure of collector channels



# Different surgeries - Different IOP results

---

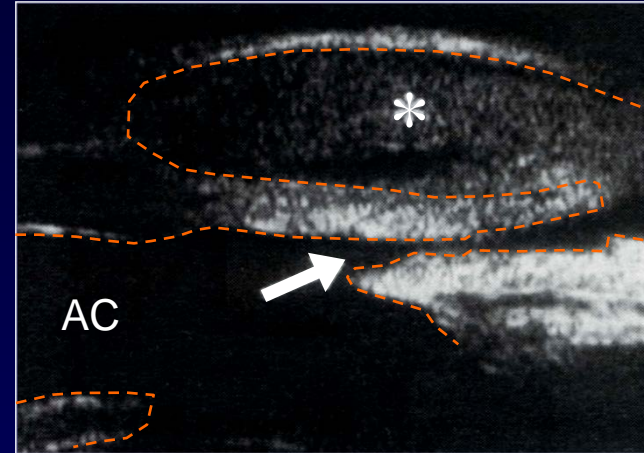
## *Scenario*

- External filtration: Trabeculectomy and Ex-press USF
- Controlled external filtration: Deep sclerectomy (+ goniopuncture)
- Opening of normal pathway
  - Ab externo: Visco canalostomy and Canaloplasty
  - Ab interno: Hydrus, i-Stent
- Opening of uveoscleral pathway
  - Ab externo: Goldshunt
  - Ab interno: Cy-pass

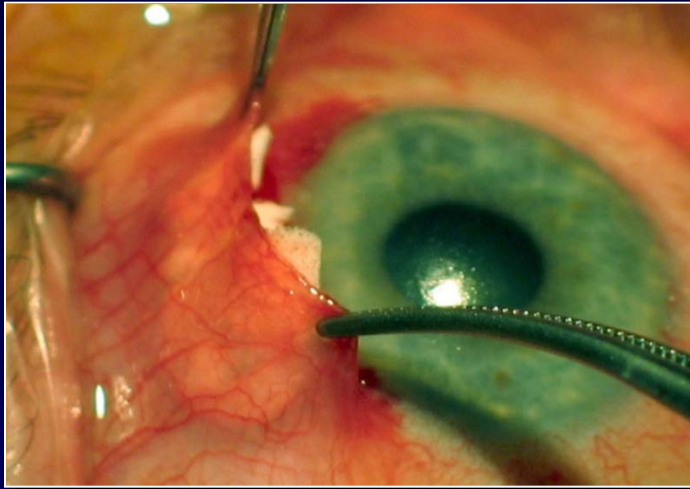
# 1 - External filtration - Trabeculectomy

Cairns, 1968 (Castelli, 1966)

- *Direct* communication between AC and subconjunctival space (\*).
- Conjunctival bleb.



# Trabeculectomy with MM-C



Intraoperative, before AC opening

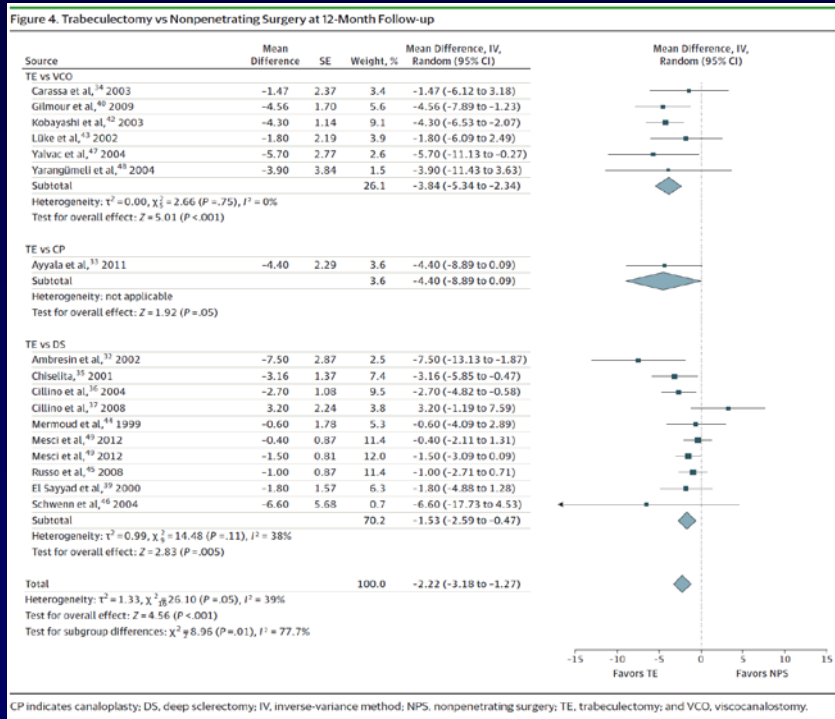
0.2-0.4 mg/ml

1-4 minutes

# Efficacy and Safety of Trabeculectomy vs Nonpenetrating Surgical Procedures A Systematic Review and Meta-analysis

Eliana Rulli, ScD; Elena Biagioli, ScD; Ivano Riva, MD; Giovanni Gambirasio, MD; Irene De Simone, ScD; Irene Floriani, PhD; Luciano Quaranta, MD

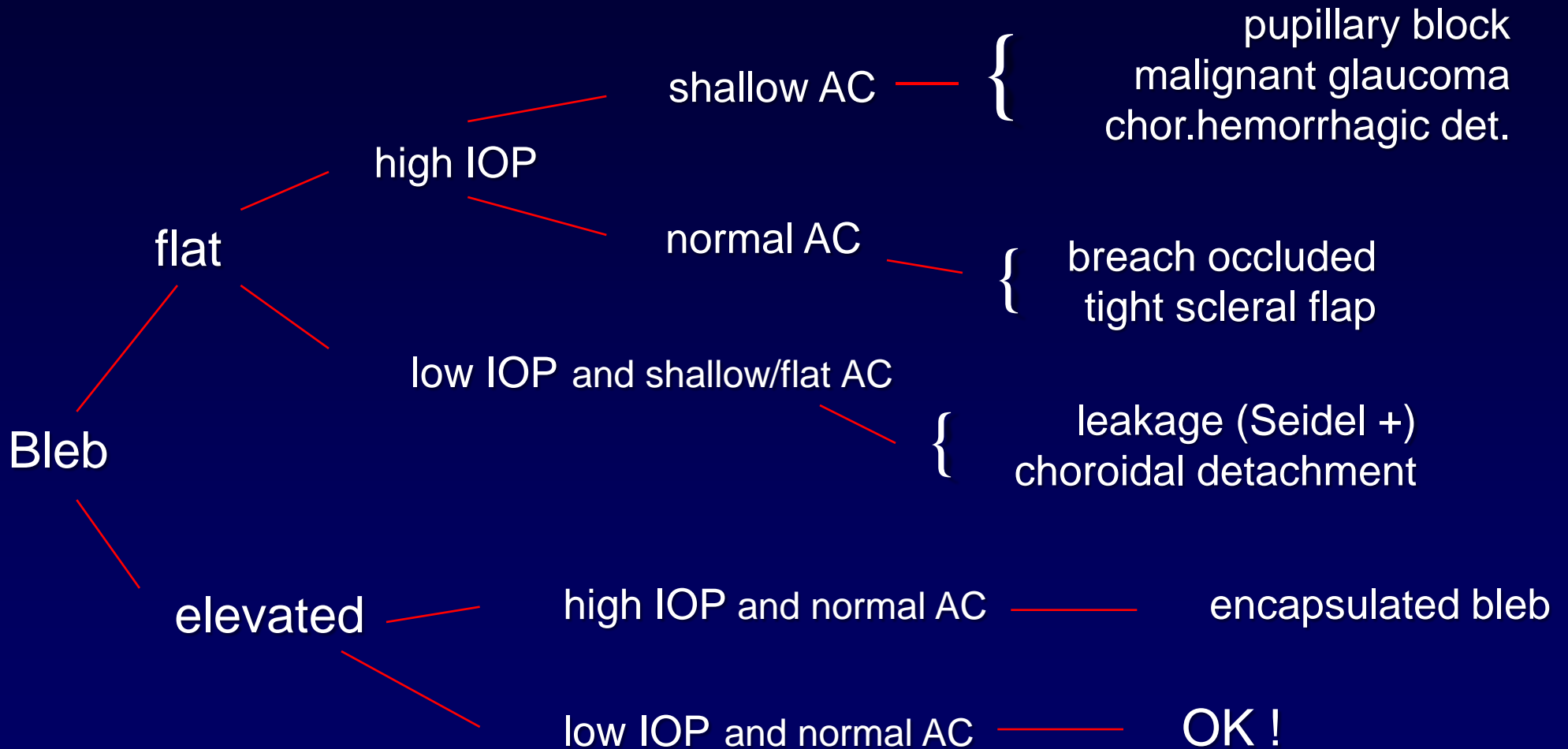
*JAMA Ophthalmol.* 2013;131(12):1573-1582.  
Published online October 24, 2013.



## IOP Results

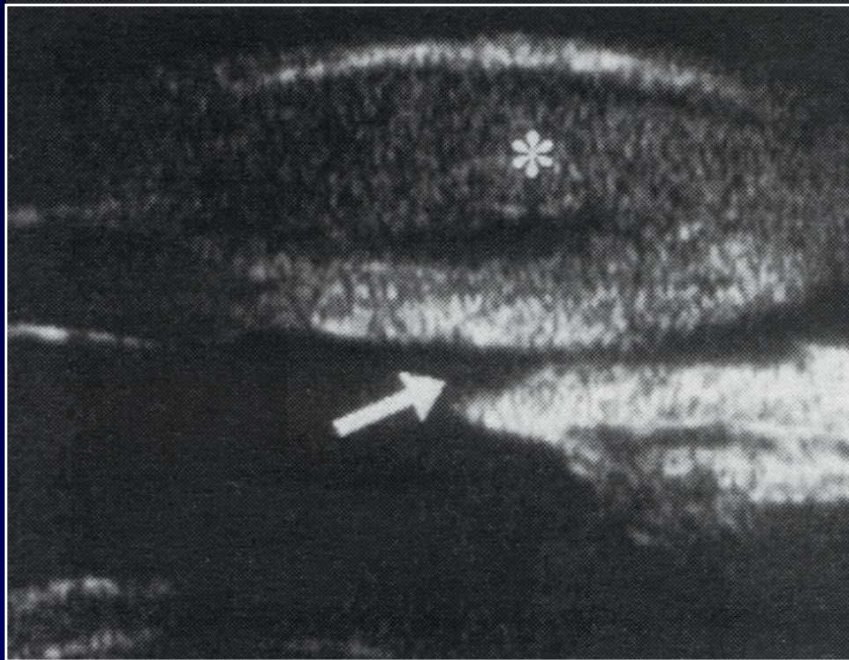
- Usually «low teen»
- Possibility of Hypotony  
(4-38% - 7 References)
- Tissue Scarring

# Postoperative bleb management

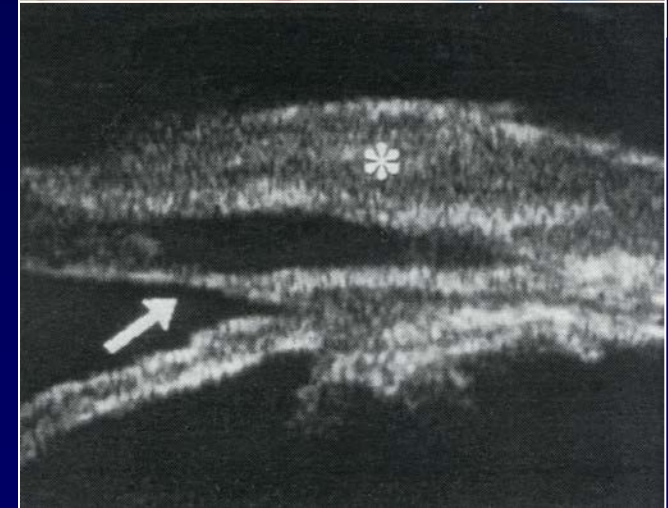
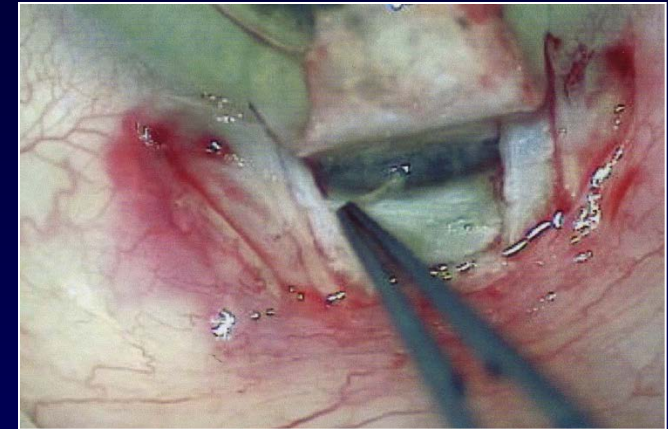


# 2 - Controlled external filtration

## Deep Sclerectomy - Rationale

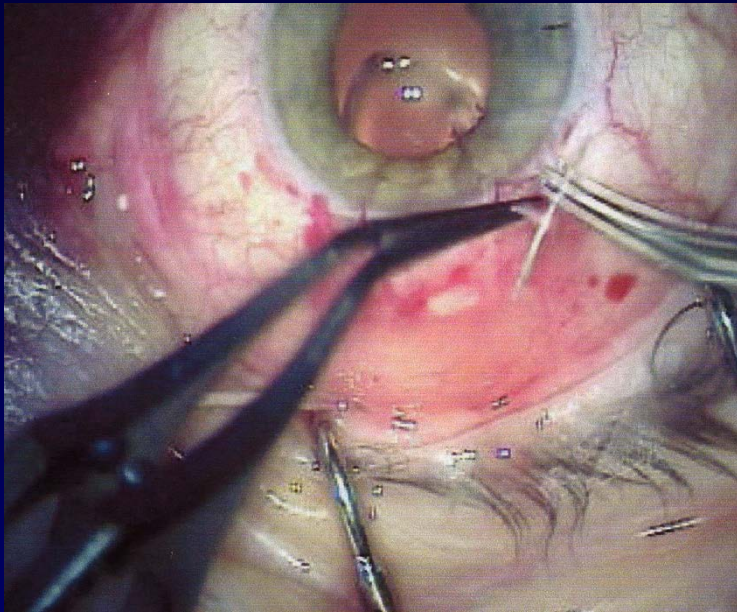


Trabeculectomy



Deep Sclerectomy

# Surgical technique of DS+implant (RHAI)



- Superficial scleral flap (5x5 mm)
  - Deep scleral flap (4 mm)
- Removal of external trabeculum
- Triangular implant (SK-GEL 3.5 mm)
  - Two nylon stitches

# IOP results of first surgery in POAG

n = 32      follow-up = 22 ± 5 m

---

Preop.    26.3 ± 4.5 mmHg

Postop.   16.0 ± 3.6 mmHg (- 39 %)

≤ 21 mmHg w/o drugs	19/32 (59 %)	14.4 ± 3.0 mmHg
≤ 21 mmHg w drugs	7/32 (22 %)	17.2 ± 1.8 mmHg*
> 21 mmHg w drugs	6/32 (19 %)	23.9 ± 2.4 mmHg*

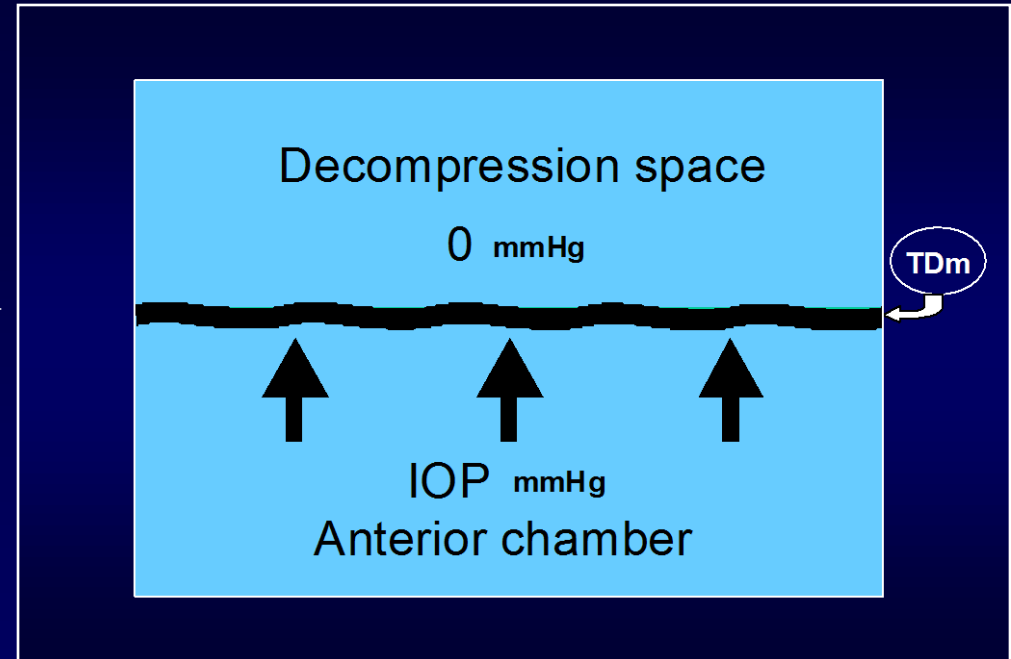
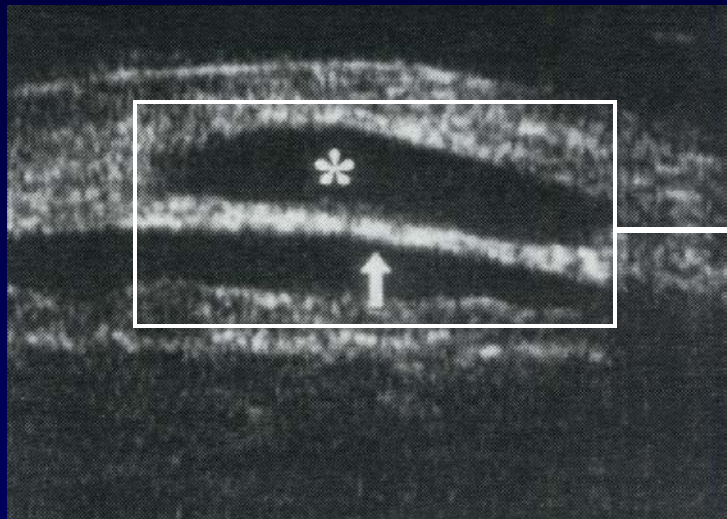
---

Qualified success = 81 %

without postoperative goniopuncture / 5-FU



# Decompression space (ds)

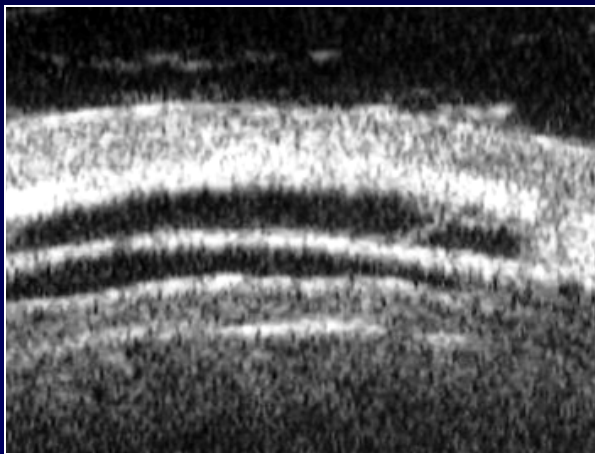


The aqueous flow depends on:

1. Resistance of the TDm
2. Gradient of pressure between AC and decompression space

# Decompression space (ds)

15 days postop.



3 months postop.  
12/15 scar tissue  
Without implant



1 year postop.  
15/15 detectable  
With implant  
(RHAI)

# Decompression space and IOP (n = 56)

	IOP $\leq$ 21 mmHg	IOP $>$ 21 mmHg	
Present/Partly detect.	39	7	46
Undetectable	1	9	10
	40	16	56

$\chi^2 = 18.994$      $p = 0.0001$

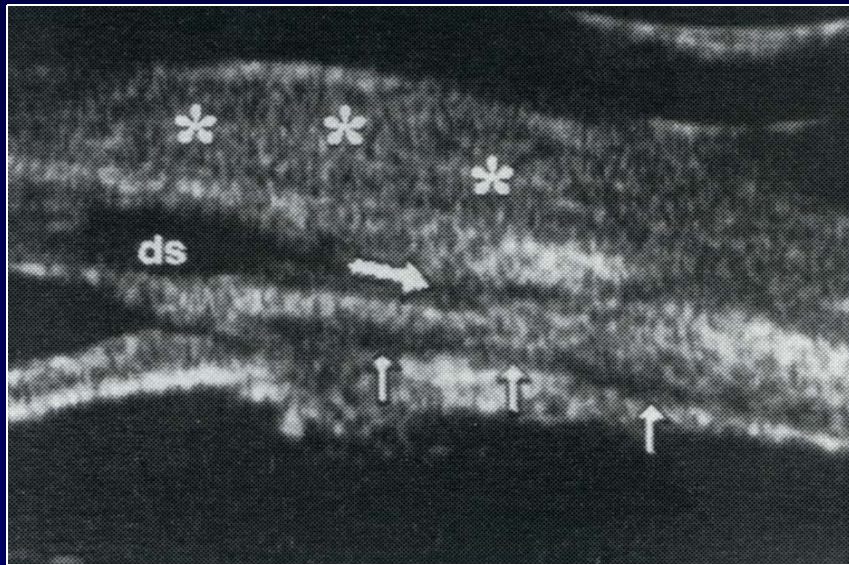
A visible decompression space  
doesn't mean successful surgery !

# IOP results of prospective comparative study after 1 year

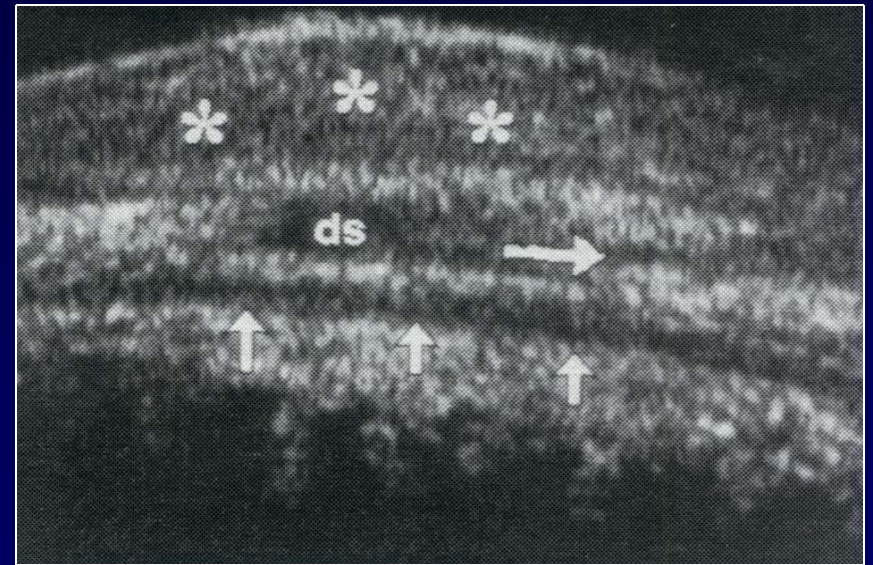
	Preop. IOP	Postop. IOP	
TRAB	25.9 $\pm$ 5.1	12.7 $\pm$ 4.8 *	- 51 %
DS+RHA1	23.4 $\pm$ 4.2	14.5 $\pm$ 2.9 *	- 38 %
DS	25.1 $\pm$ 3.8	18.4 $\pm$ 4.4 *	- 27 %

\* All differences between postop. IOP:  $p < 0.001$

# UBM characteristics associated with aqueous outflow



Longitudinal  
(anteroposterior)



Transverse  
(parallel to the limbus)

# UBM characteristics associated with aqueous outflow

---

Conjunctival filtering bleb	21/32 - 66 %
Supraciliary hypo-echoic area	19/32 - 59 %
Hyporeflectivity of scleral tissue	16/32 - 50 %
no UBM characteristics	3/32 - 9 %

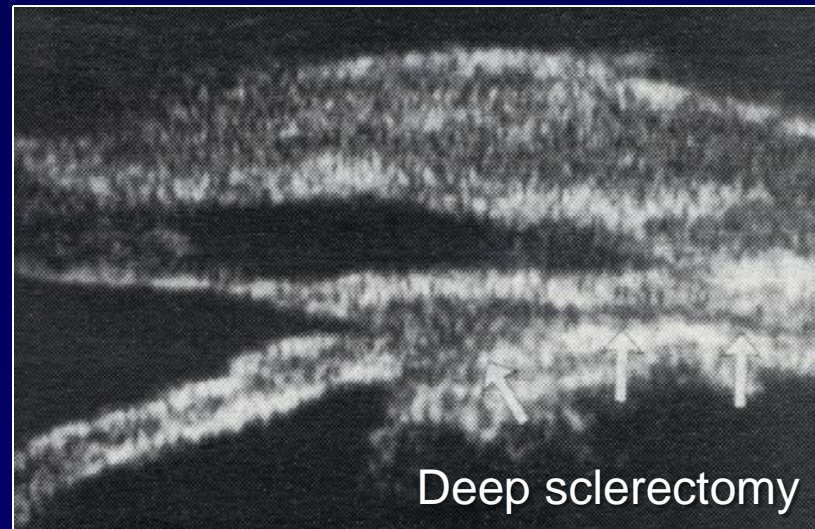
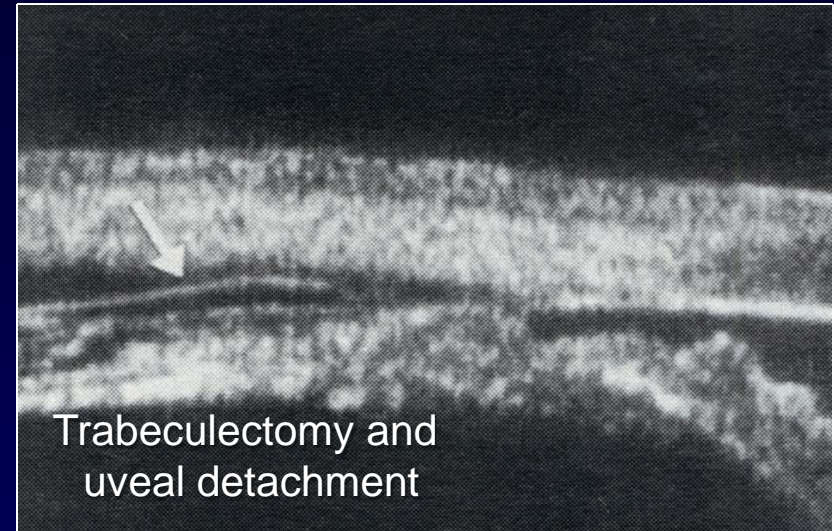
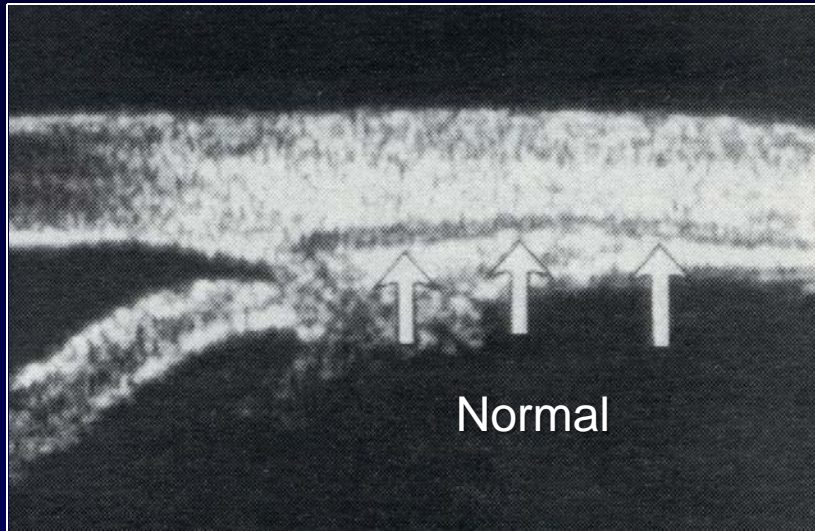
# UBM characteristics and IOP

## POAG - first surgery

	IOP $\leq$ 21 mmHg	IOP $>$ 21 mmHg	
0 UBM charact.	0	3	3
1 UBM charact.	9	1	10
2 UBM charact.	11	2	13
3 UBM charact.	6	0	6
	26	6	32

$\chi^2 = 14.984$   $p = 0.002$

# Supraciliary hypo-echoic area





# Supraciliary hypo-echoic area and postop. IOP after 1 year

SCHEA (n = 19)

15.4  $\pm$  3.1 mmHg

No SCHEA (n = 13)

16.9  $\pm$  3.9 mmHg

Clinical difference, not statistically significant (P = 0.251)

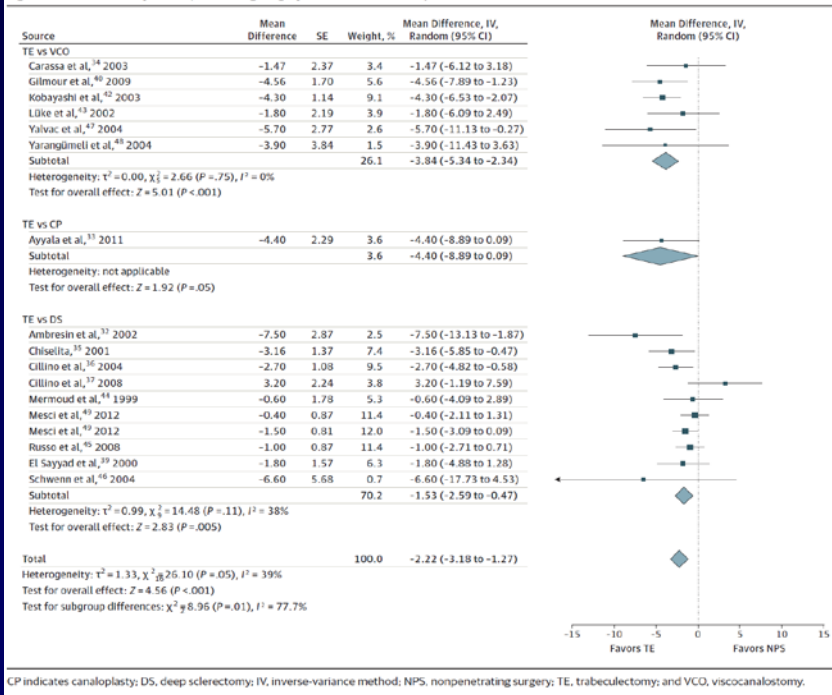
# Efficacy and Safety of Trabeculectomy vs Nonpenetrating Surgical Procedures

## A Systematic Review and Meta-analysis

Eliana Rulli, ScD; Elena Biagioli, ScD; Ivano Riva, MD; Giovanni Gambirasio, MD; Irene De Simone, ScD; Irene Floriani, PhD; Luciano Quaranta, MD

*JAMA Ophthalmol.* 2013;131(12):1573-1582.  
Published online October 24, 2013.

Figure 4. Trabeculectomy vs Nonpenetrating Surgery at 12-Month Follow-up



CP indicates canaloplasty; DS, deep sclerectomy; IV, inverse-variance method; NPS, nonpenetrating surgery; TE, trabeculectomy; and VCO, viscocanalostomy.

## IOP Results

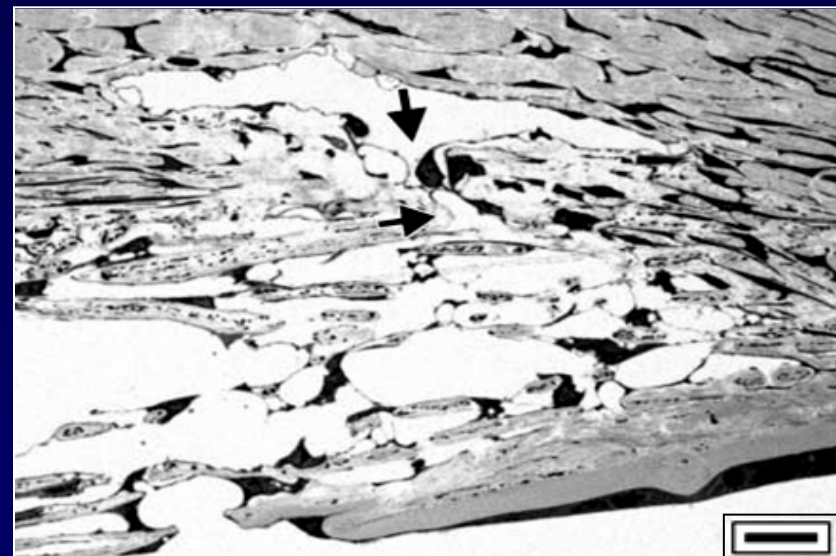
- Usually «mid (high) teen»
- Goniopuncture
- Different mechanism

# 3 - Opening of normal pathway Viscocanalostomy

## Viscocanalostomy in Rhesus Monkeys

*Ernst R. Tamm, MD; Roberto G. Carassa, MD; Daniel M. Albert, MD;  
B'Ann T. Gabelt, MS; Sarit Patel, MD; Carol A. Rasmussen, BA; Paul L. Kaufman, MD*

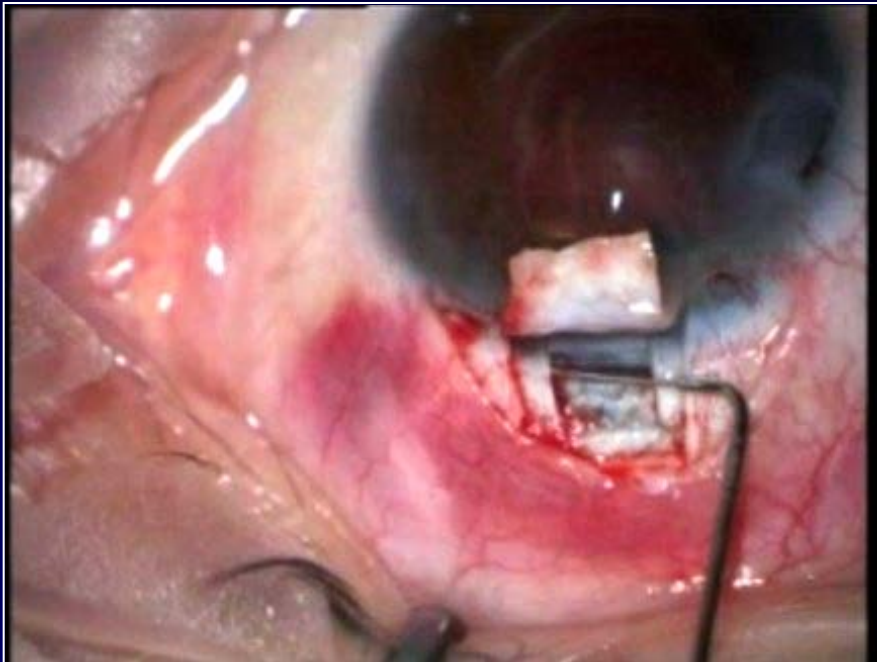
*Arch Ophthalmol. 2004;122:1826-1838*



2 months post-op

Reduced number of trabecular lamellae, large intertrabecular spaces  
Schlemm's canal forms protrusions toward the trabecular meshwork

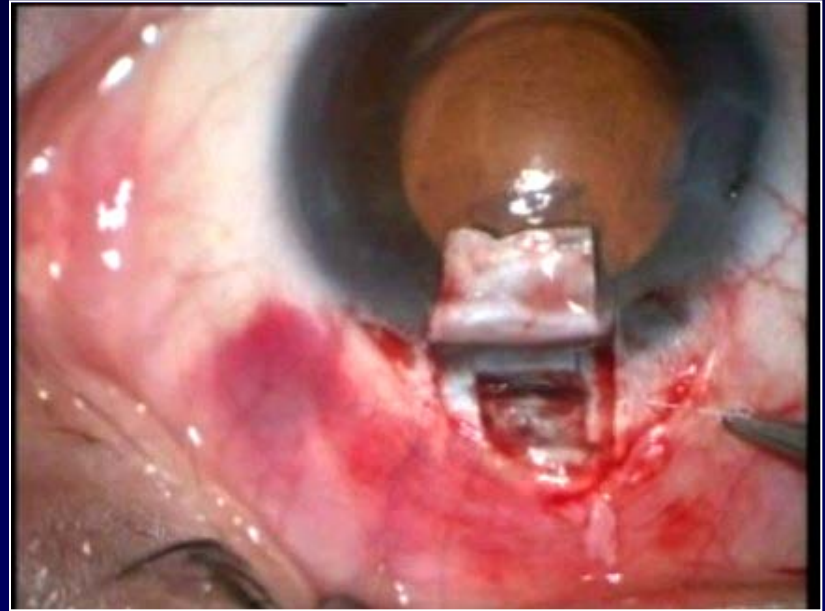
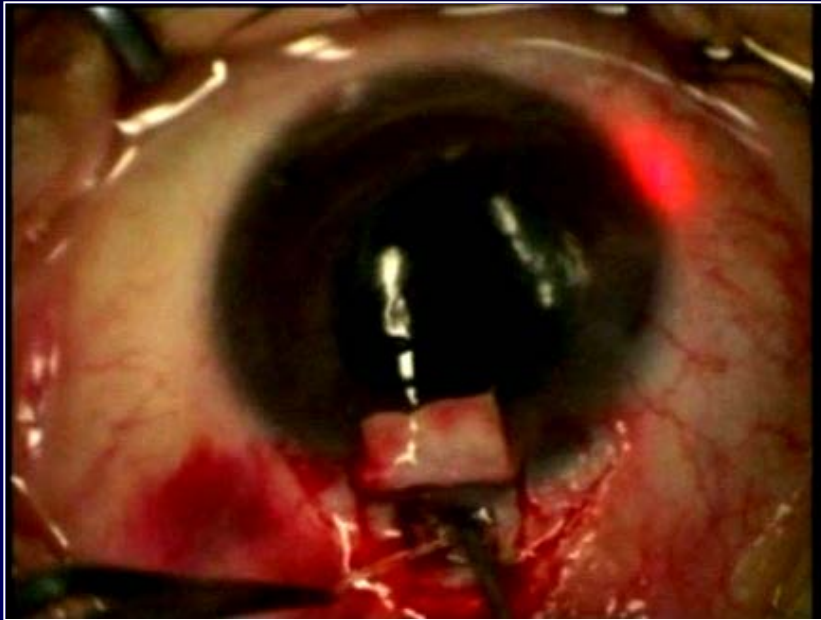
# Viscocanalostomy



## *IOP Results*

- Usually «mid teen»
- Opening of collectors channels and Schlemm's canal

# Canaloplasty - Surgery



# Canaloplasty: devices

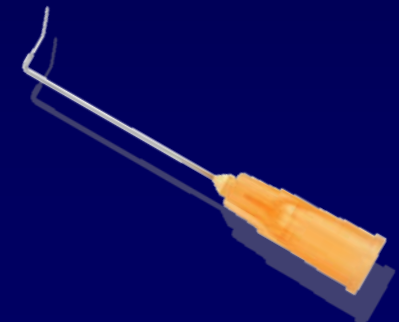
## GlaucoLight Fiber

*(D.O.R.C. International, Zuidland, The Netherlands)*



*atraumatic tip  
( $\Phi = 40G/0,15mm$ )*

*integrated  
battery-powered  
LED source*



*viscocanalostomy needle  
( $\Phi = 0,165mm$ )*

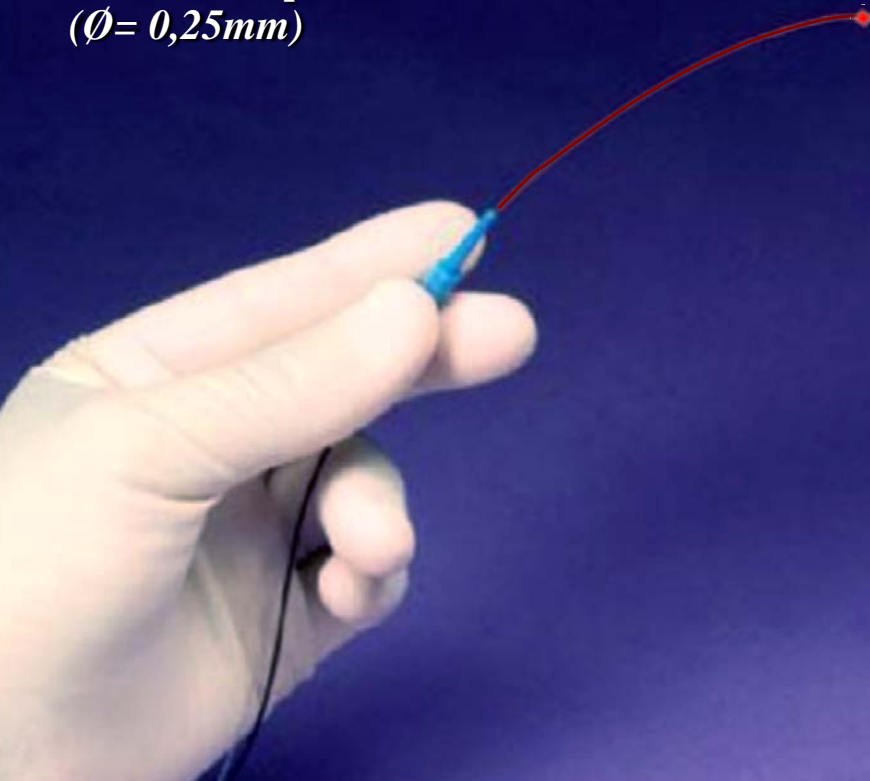
# Canaloplasty: devices

## iTrack™ 250A microcatheter

*(iScience Interventional, Menlo Park, CA, USA)*



*atraumatic tip  
( $\varnothing = 0,25\text{mm}$ )*



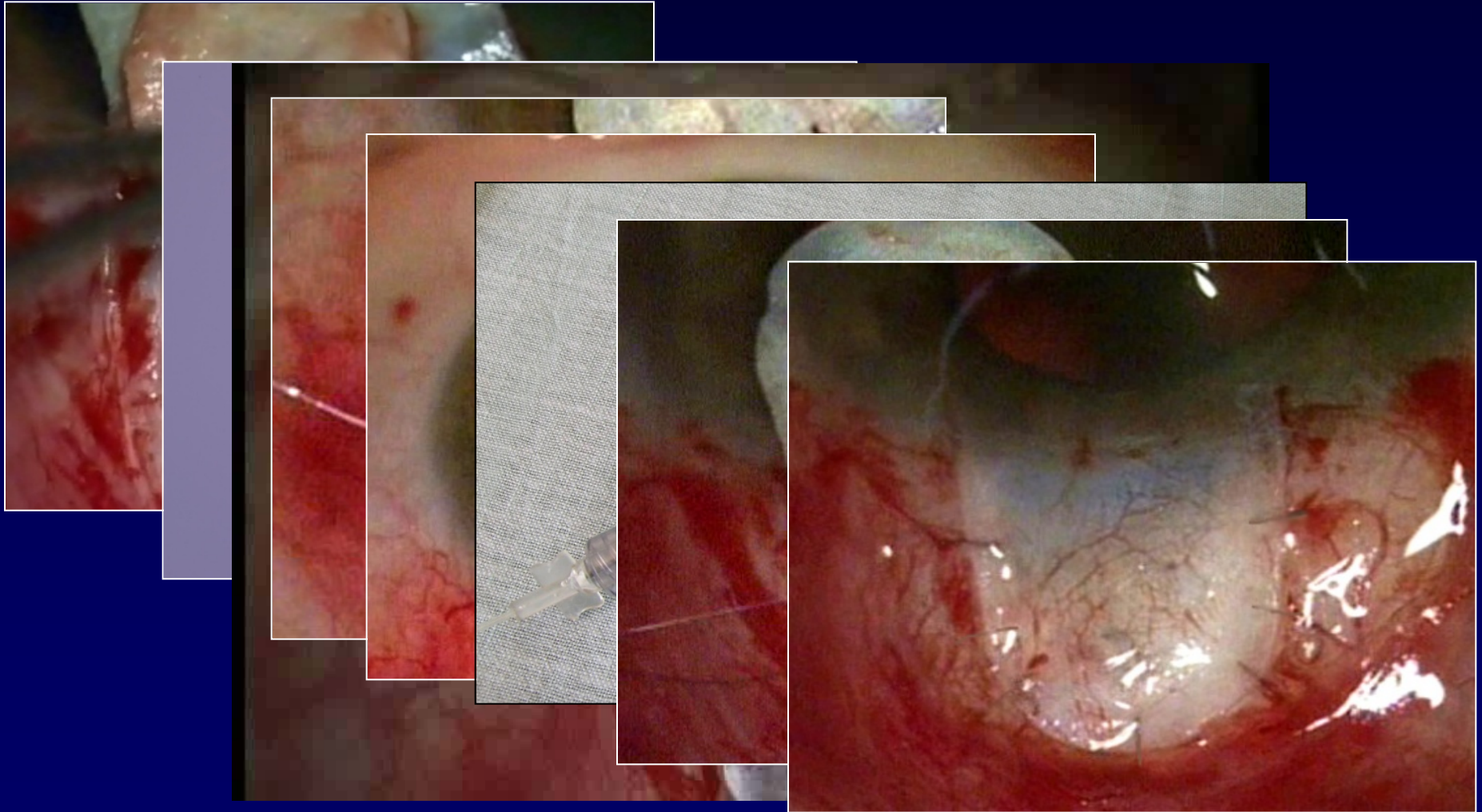
*Ophthalmic Viscosurgical  
Device (OVD)  
Micro-Injector*

*For precise injection of Healon GV  
while cannulating Schlemm's canal*

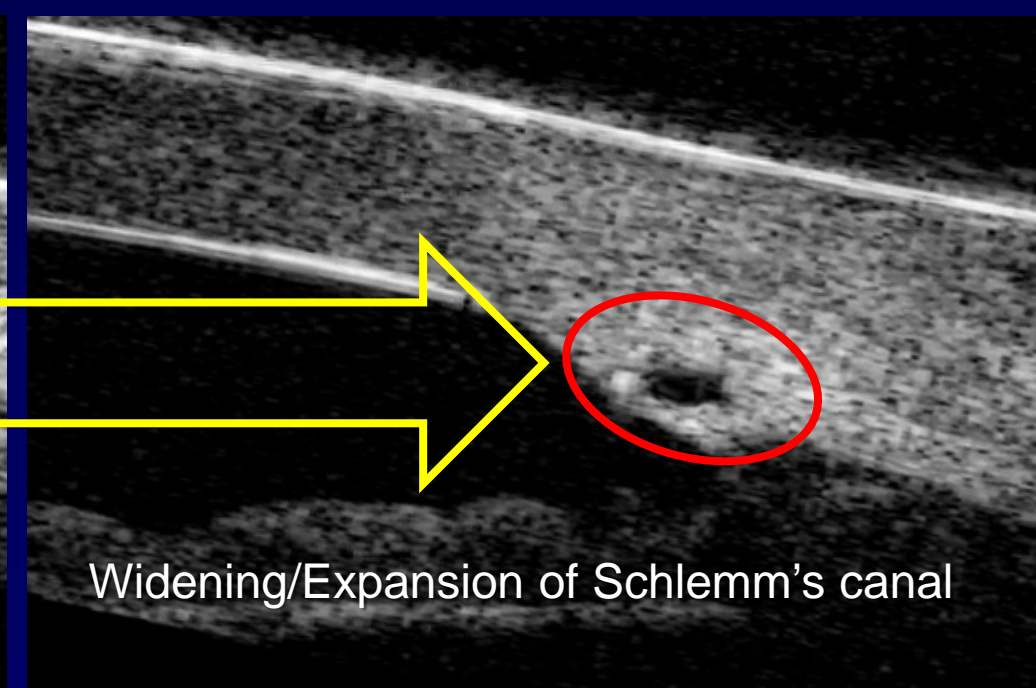
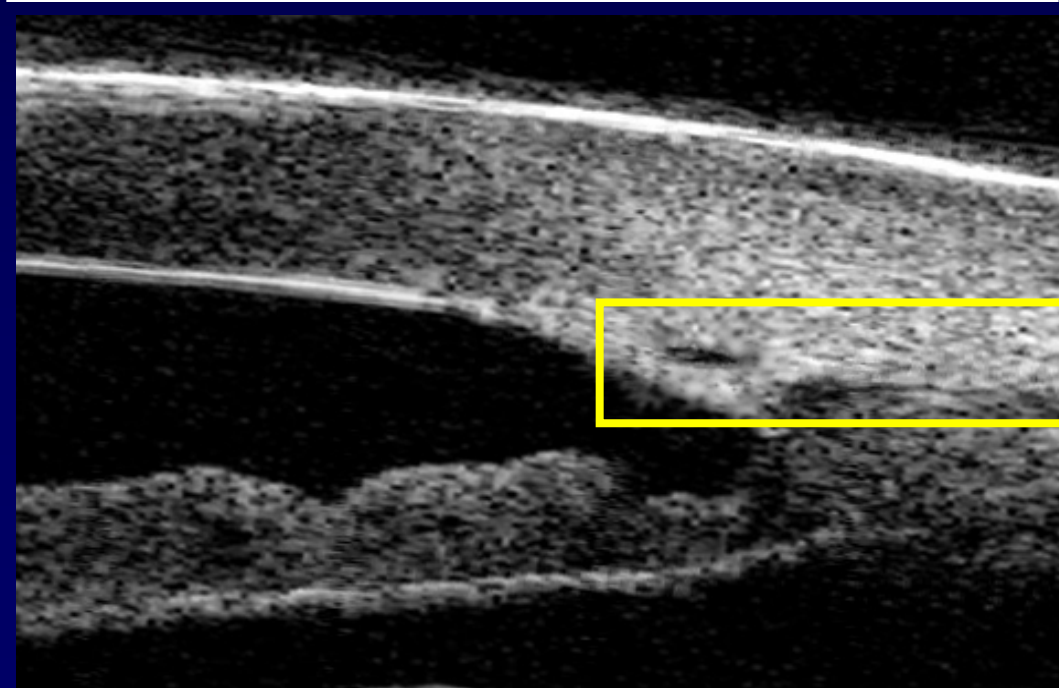
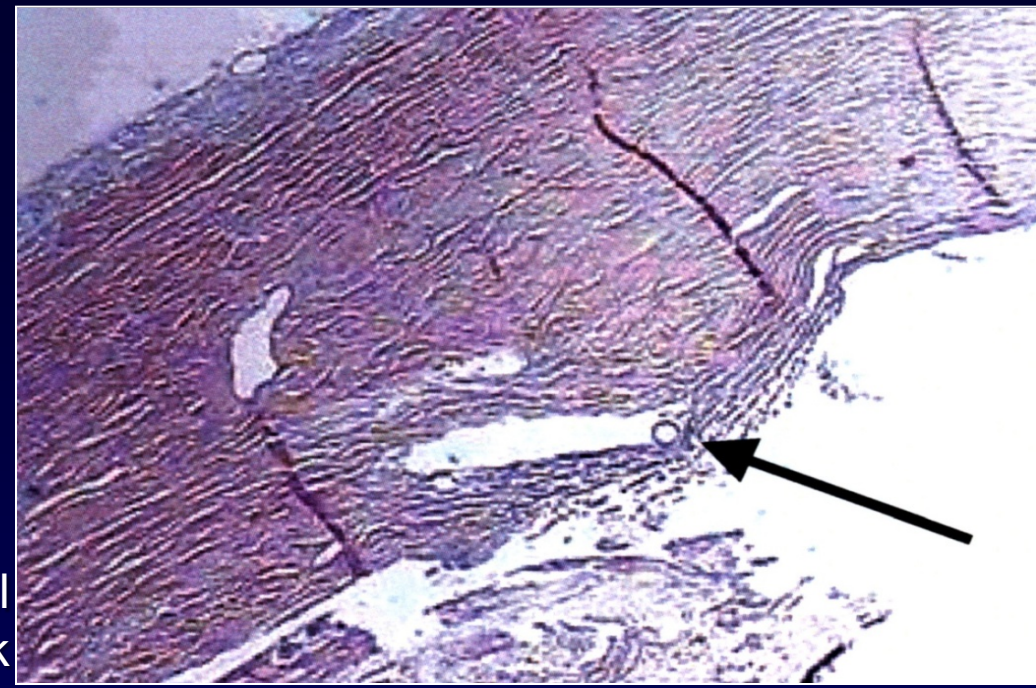
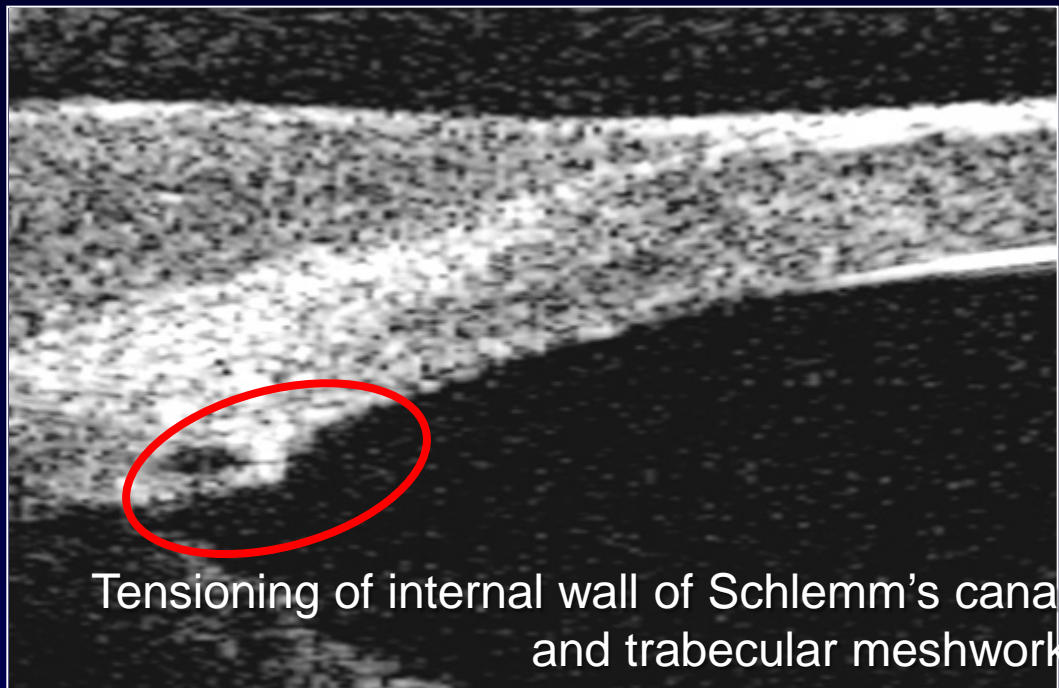
*iLumin™*

*Laser-diode based  
Microillumination System*

# Canaloplasty - Surgery







# Canaloplasty: Three-year results of circumferential viscodilation and tensioning of Schlemm canal using a microcatheter to treat open-angle glaucoma

Richard A. Lewis, MD, Kurt von Wolff, MD, Manfred Tetz, MD, Norbert Koerber, MD, John R. Kearney, MD, Bradford J. Shingleton, MD, Thomas W. Samuelson, MD

J Cataract Refract Surg 37; 682-690, 2011

**Table 2.** Outcomes.

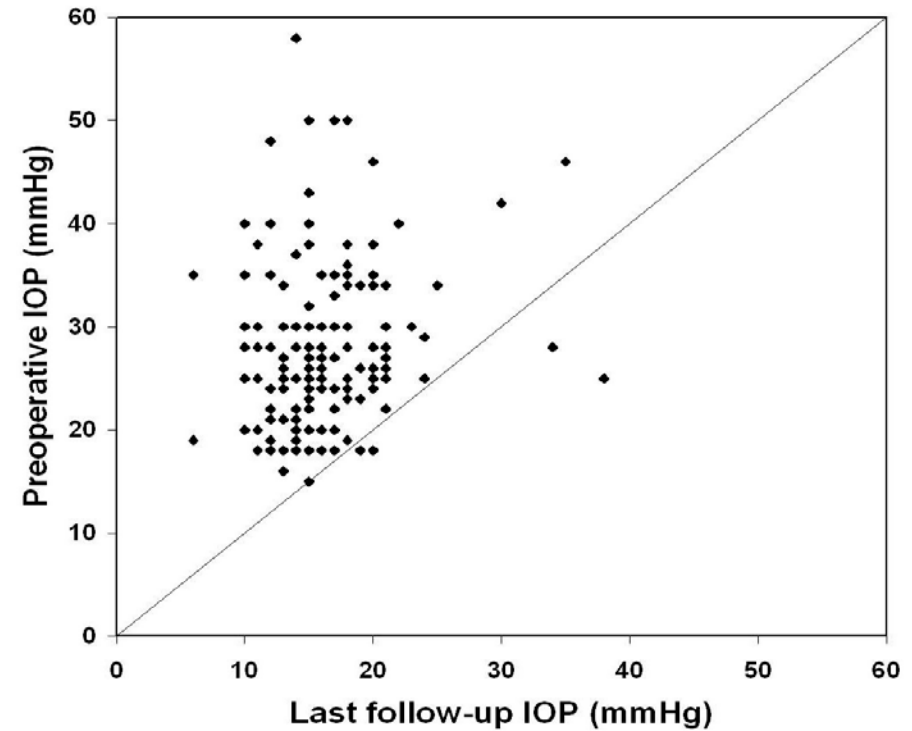
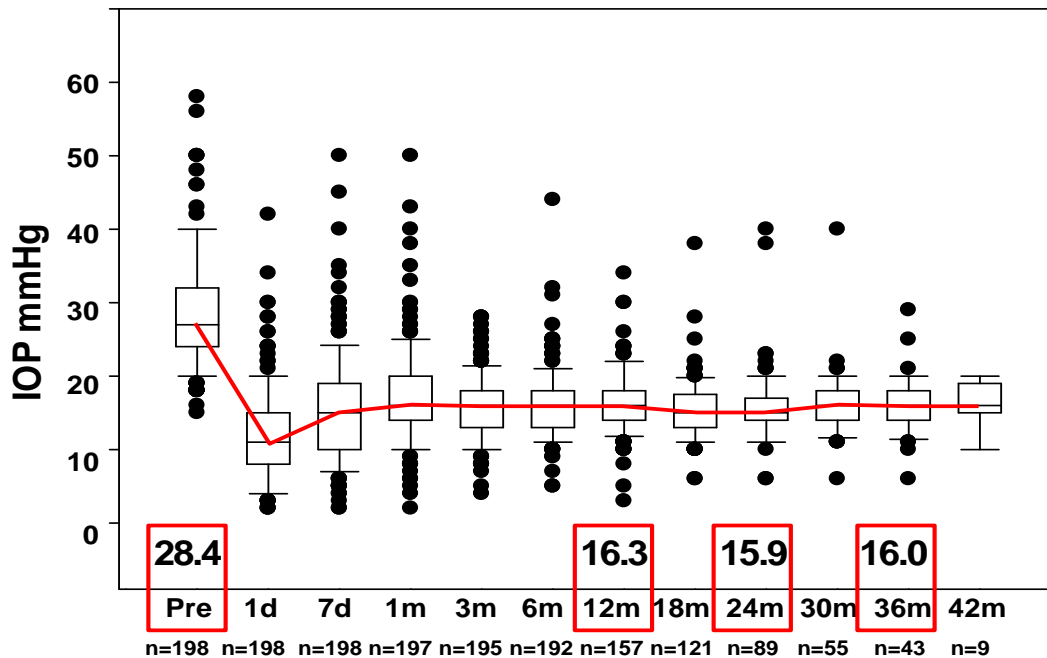
Exam	Group 1: All Eyes			Group 2: Canaloplasty Alone with Suture Placement			Group 3: Phacocanaloplasty with Suture Placement		
	n	Mean IOP (mm Hg) ± SD	Mean Meds (n) ± SD	n	Mean IOP (mm Hg) ± SD	Mean Meds (n) ± SD	n	Mean IOP (mm Hg) ± SD	Mean Meds (n) ± SD
Baseline	157	23.8 ± 5.0	1.8 ± 0.9	103	23.5 ± 4.5	1.9 ± 0.8	30	23.5 ± 5.2	1.5 ± 1.0
Postop(mo)									
3	136	15.7 ± 4.2	0.3 ± 0.6	91	15.9 ± 3.8	0.3 ± 0.7	25	14.0 ± 3.9	0.1 ± 0.3
6	132	15.4 ± 3.7	0.3 ± 0.6	86	16.1 ± 3.4	0.4 ± 0.7	25	12.8 ± 2.9	0.1 ± 0.3
12	136	15.6 ± 4.2	0.5 ± 0.8	91	16.1 ± 3.9	0.6 ± 0.8	27	13.6 ± 4.1	0.1 ± 0.4
18	128	15.9 ± 4.1	0.5 ± 0.8	87	16.2 ± 4.1	0.6 ± 0.8	20	14.5 ± 3.6	0.2 ± 0.4
24	132	15.8 ± 4.2	0.6 ± 0.8	89	16.1 ± 4.0	0.6 ± 0.8	25	13.4 ± 3.2	0.2 ± 0.4
30	122	15.6 ± 4.2	0.6 ± 0.8	82	16.3 ± 4.5	0.8 ± 0.8	25	13.8 ± 3.2	0.2 ± 0.5
36	134	15.2 ± 3.5	0.8 ± 0.9	89	15.5 ± 3.5	0.9 ± 0.9	27	13.6 ± 3.6	0.3 ± 0.5

IOP = intraocular pressure; Meds = medications; n = sample size

# Canaloplasty in open angle glaucoma. Mid-term results from a multicenter study

Brusini P, Caramello G, Benedetti S, Tosoni C

*J Glaucoma*

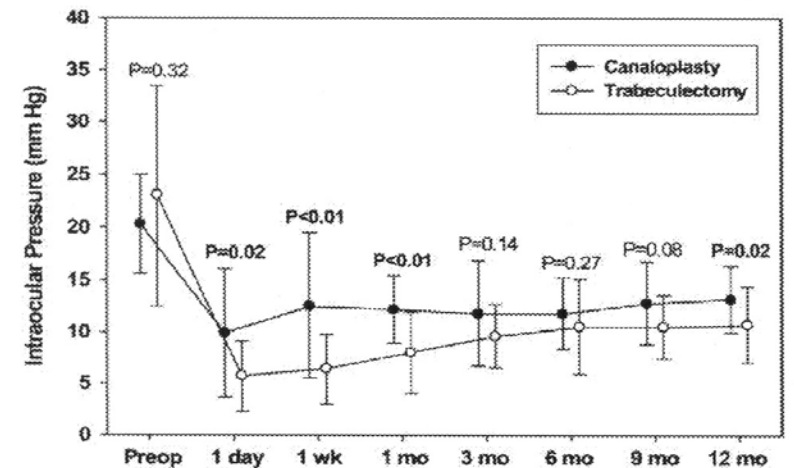


# Comparison of Surgical Outcomes Between Canaloplasty and Trabeculectomy at 12 Months' Follow-Up

Ramesh S. Ayyala, MD, FRCS,<sup>1</sup> Amina L. Chaudhry, MD,<sup>1</sup> Carola B. Okogbaa, MD,<sup>1</sup>  
David Zurakowski, PhD<sup>2</sup>

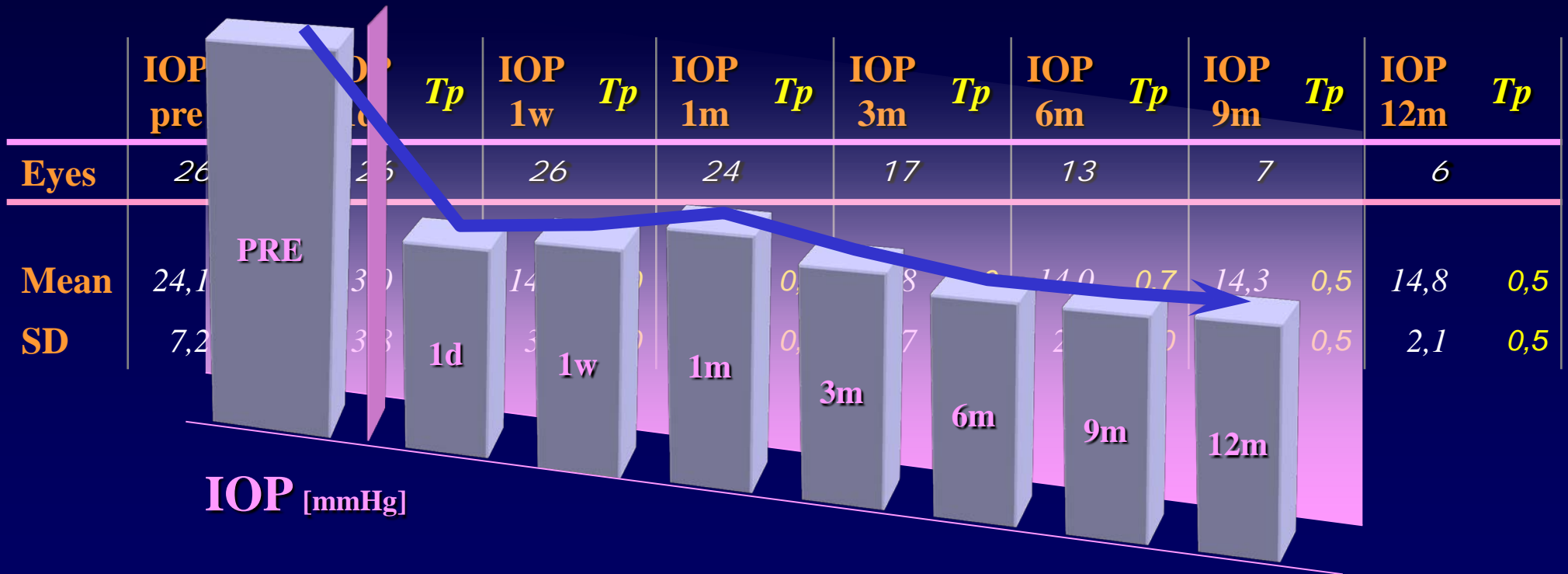
Ophthalmology 2011;118:2427-2433.

Time Point	Canaloplasty IOP (mmHg)	No. of Patients	Trabeculectomy IOP (mmHg)	No. Patients	P Value
Preoperatively	21.2±6.6	33	23.4±10.4	46	0.28
1 day	9.3±6.0	33	5.7±3.6	46	<0.01*
1 week	13.7±6.4	32	6.8±3.8	45	<0.001*
1 month	14.4±5.8	32	8.8±4.5	46	<0.001*
3 months	12.6±5.6	32	10.3±3.7	46	0.05*
6 months	12.1±4.0	32	11.2±4.5	43	0.40
9 months	12.9±5.1	33	11.6±3.4	39	0.18
12 months	13.8±4.9	33	11.6±4.0	46	0.03*



# Canaloplasty - Results

## IOP & Therapy



# Canaloplasty vs Trabeculectomy

---

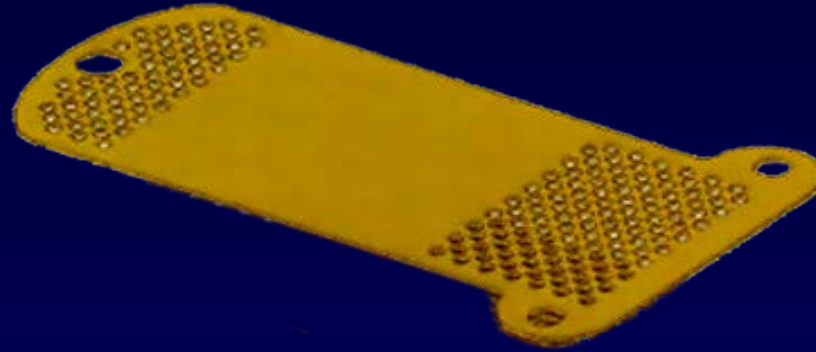
*1 year of follow-up*

IOP	14.7 ± 2.9	13.1 ± 3.0 (p<0.01)
Drugs	48 %	26 %
Compl.	n = 8 (1/3)	n = 22 (2/3)

# 4 - Opening of uveoscleral pathway

---

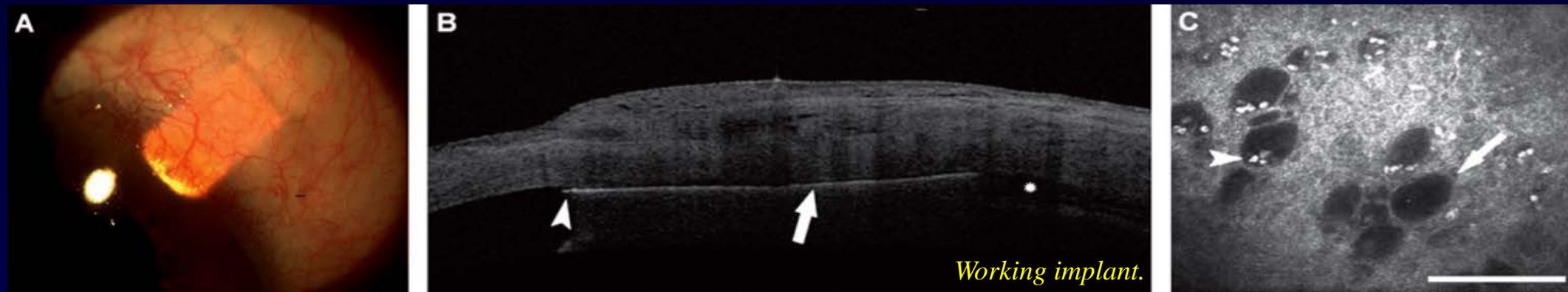
Ab externo: Goldshunt



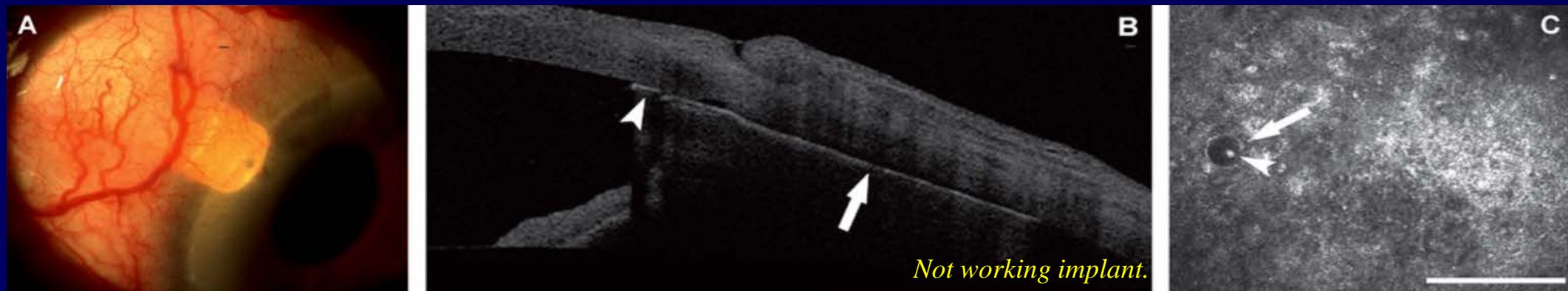
Ab interno: Cy-pass



# Gold shunt - Mechanism

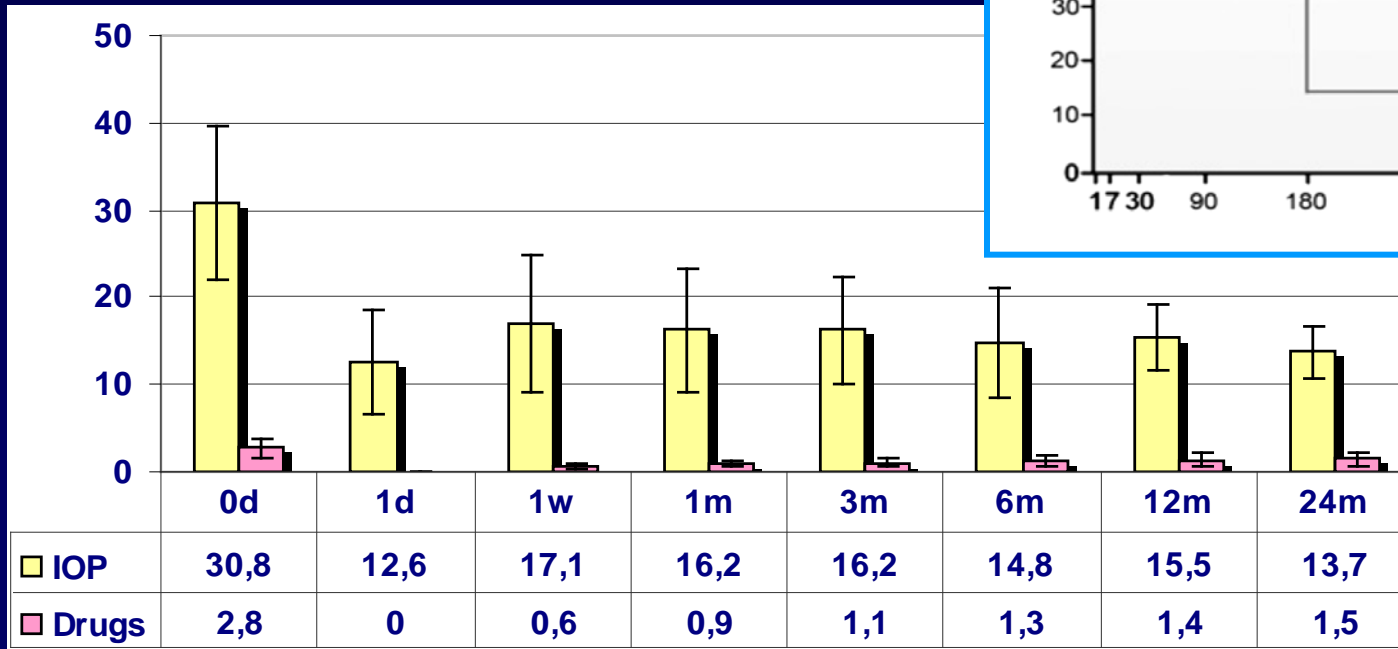
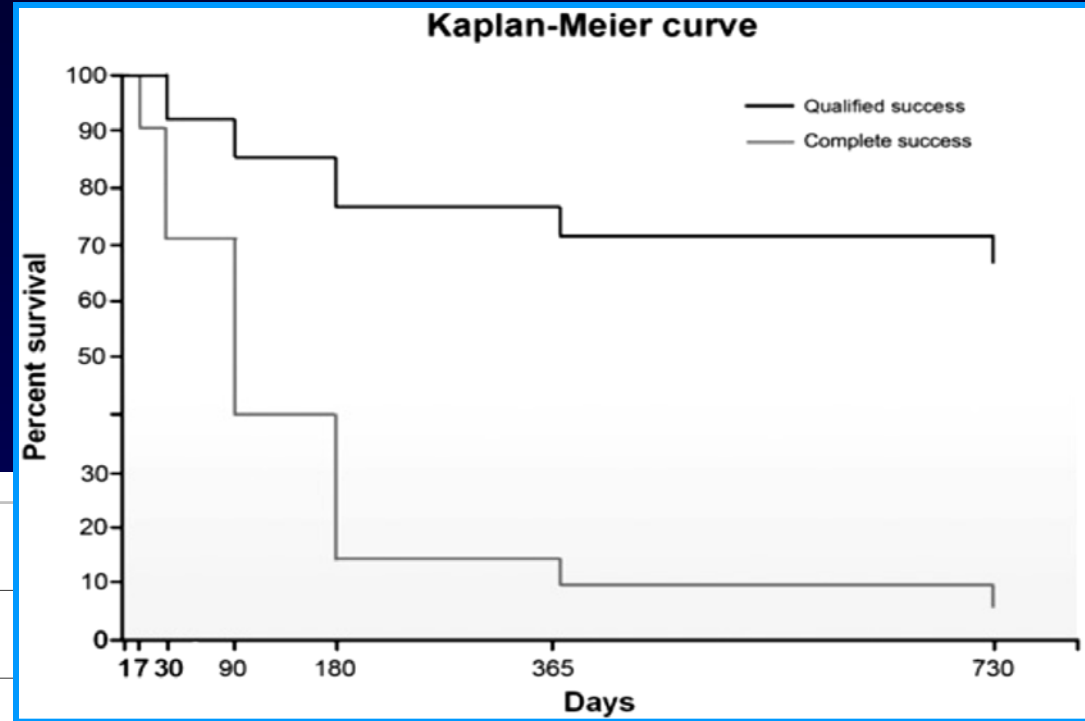


- Shunt between AC and suprachoroidal space
- Conjunctival intraepithelial microcysts at the site of implant

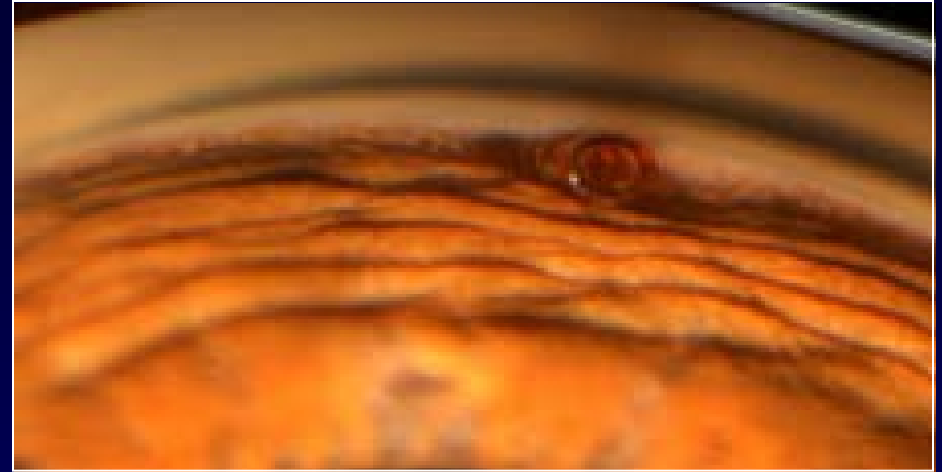




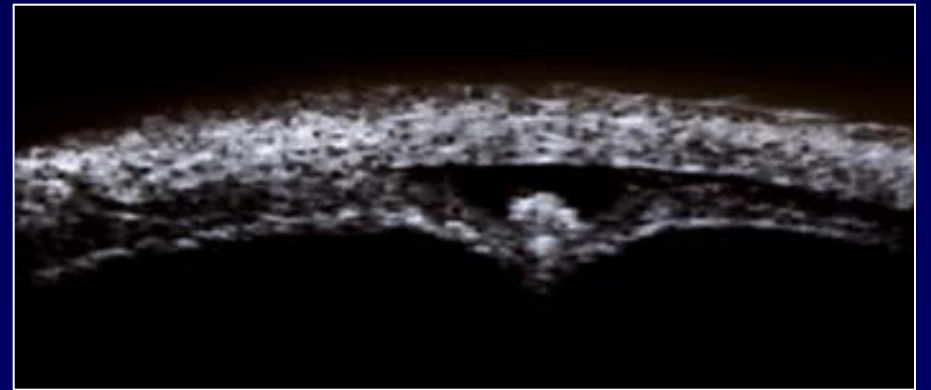
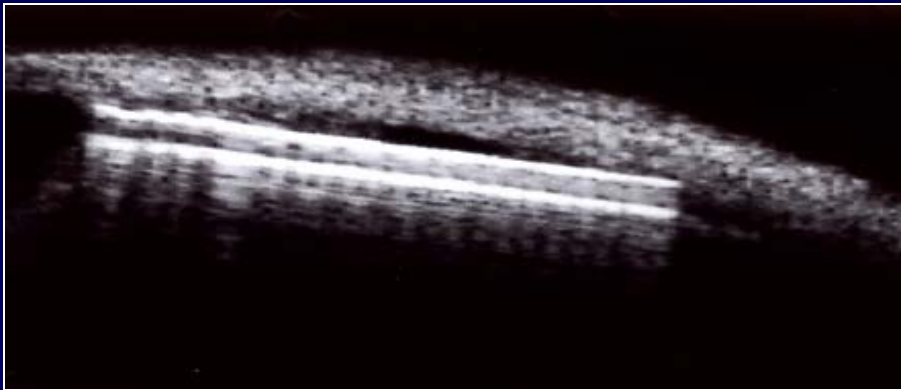
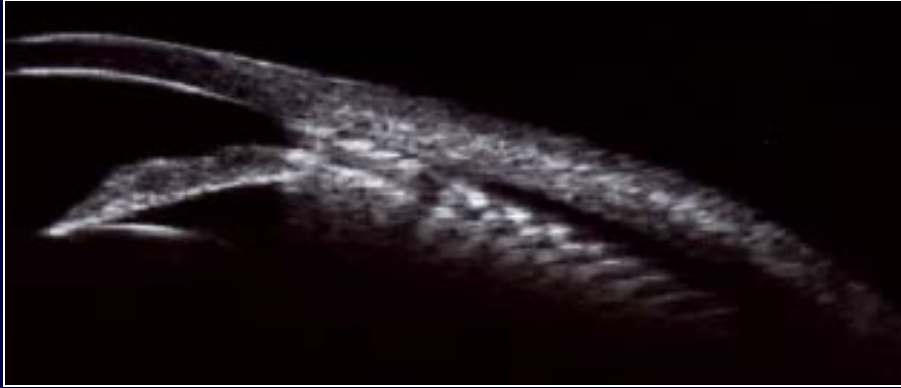
# Gold shunt - Results



# Cy-pass - Gonioscopy



# Cy-pass - UBM



# IOP decreasing effect

---

- No conclusion
- No “Convincing” references
- Short follow-up

# Indication for surgery

---

- Different surgeries
- Different post-operative IOP
- The choice has to be «customized»  
(patient and severity of glaucoma)

*Grazie*