Nd:YAG Capsulotomy for the New and Experienced

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FINANCIAL DISCLOSURE

- I do not have any relevant financial relationships to disclose.

Objectives

- Intro
- Overview of laser physics
- PCO
- Contraindications
- Nd:YAG capsulotomy procedure
- Videos
- Rarities
- Considerations
- Looking to the future

What makes a good surgeon?

"Intelligence, professionalism, conscientiousness, creativity, courage, and perseverance on behalf of your patients are the critical factors, and they outweigh the small differences in dexterity among most medical students."

-American College of Surgeons

What makes a good surgeon?

Specialist knowledge

Good communication skills

Bright eager mind, manual dexterity

Extensive experience of pre and post operative care

Ability to adapt and think on your feet

Leadership skills

Ability to inspire confidence in others

Emotional resilience

-Royal College of Surgeons of England

Why learn how to do laser procedures?

Capsulotomy

- Before laser capsulotomy there was manual capsulotomy with a cystotome
  - Manual capsulotomy may still be done from time to time

Nd:YAG Capsulotomy

- Photodisruptive tissue interaction
- Lasers allow non-invasive techniques
  - Enabling surgical intervention if a problem exists
    - Which may be many years after time of cataract surgery

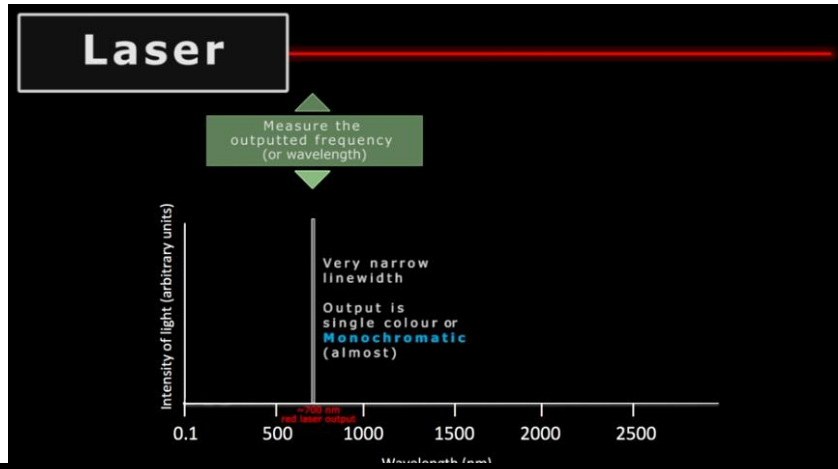
LASER

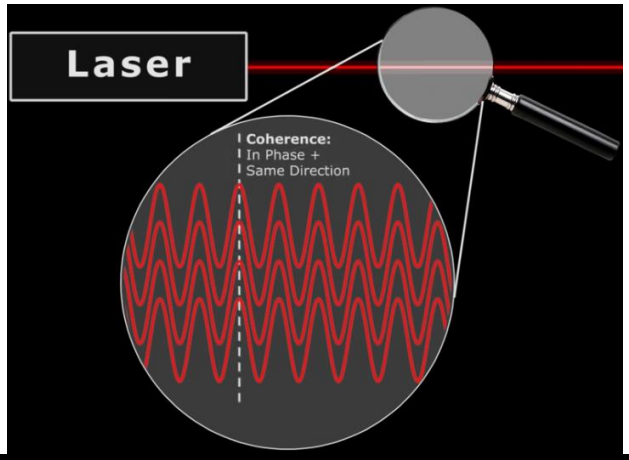
- Light Amplification by Stimulated Emission of Radiation

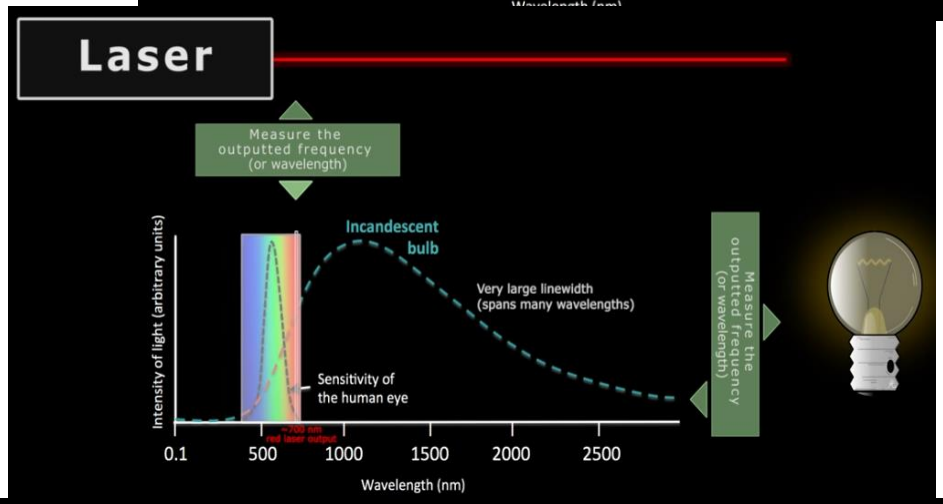
Some Basic Features

- Extremely narrow line width
- Monochromaticity
- Coherent and collimated light
- Energy output

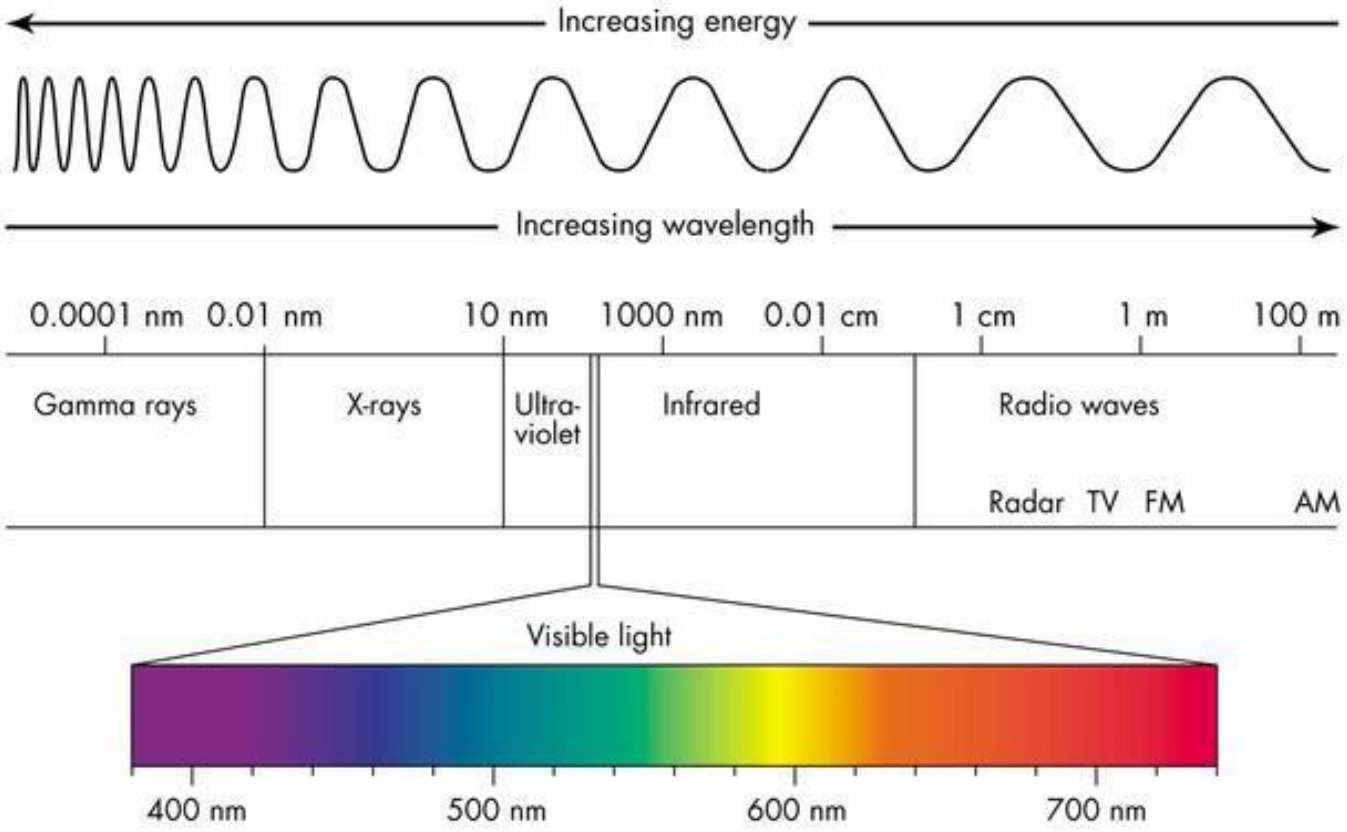
- Nd:YAG laser output for capsulotomy has wavelength of 1064nm







https://www.youtube.com/watch?v=_JOchLyNO_w&t=758s



https://sites.google.com/a/coe.edu/principles-of-structural-chemistry/relationship-between-light-and-matter/electromagnetic-spectrum

3 Key Components

- Stimulated absorption
  - Media is pumped with laser diode or flashlamp/tube = optically pumped
  - Neodymium doped yttrium aluminum garnet crystal
  - Excited state

- Spontaneous emission
  - Electrons fall from excited state to metastable state, then to other states/groundstate
  - Metastable state allows creation of population inversion

- Stimulated emission
  - Photon released during spontaneous emission during fall from metastable state interacts with another metastable state electron, causing emission of 2 photons in a packet
  - Packets of photons with same directionality, frequency, and coherence
  - Becomes the emitted light energy of laser

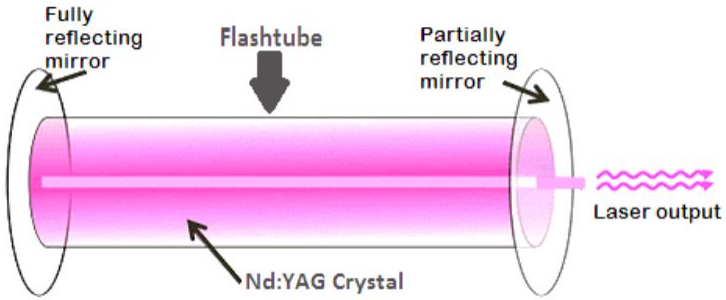
Output

- May be continuous or pulsed
- Pulsing may occur via several different mechanisms
  - Variable input from source
  - Q-switch
  - Mode-locking
- 1064nm – not visible
- Pulse duration 3-7ns
- Focused beam (16 degree cone angle)

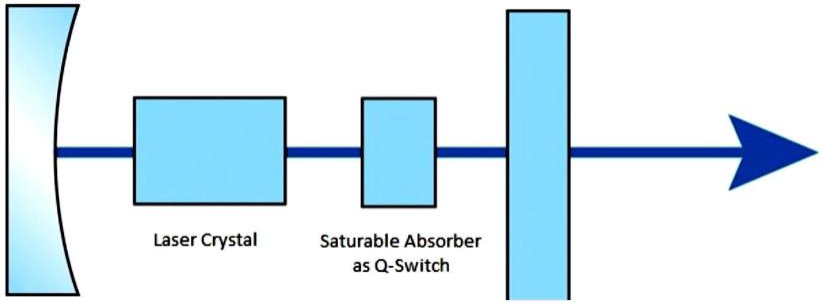
Q-Switch

- Multiple forms and complexities
- It is a special modulator the prevents the ability to lase
- Prevents the population inversion from decreasing (returning to ground state)
- Therefore increases population inversion until a maximum is achieved
- Q-switch opens and a large pulse of energy is released in short time frame
  - Allows for milli, nano, pico, femto second durations, applicable to different laser techniques

Rudimentary Schematics of Continuous Wave Nd:YAG vs Short Pulsed Q-Switched Nd:YAG



https://www.ucy.ac.cy/phy/documents/Documents/theses/undergraduate_theses/InN_nanowires-Loucas_Eracleous.pdf



General Laser/Tissue Interaction

- Transmission
- Reflection
- Scatter
- Absorption

- Capsulotomy is pigment independent
- IR light has deep penetration

Optical Focus and Plasma Formation

- HeNe aiming beam
- Laser lens (Abraham lens)
- Concave mirrors and other optics of the laser converge the 1064nm wavelength photons on an infinitely small focal point
  - Fixed spot size of ~8 microns
- Dielectric breakdown and plasma formation
- Acoustic shockwave and photodisruption

Critical Focus

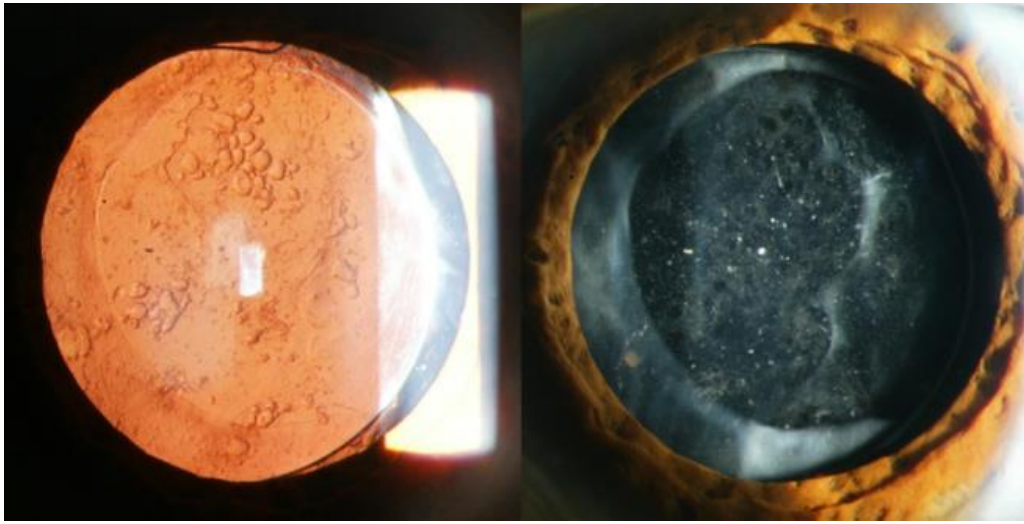
- Can have non-linear optical breakdown
- We want to work close to the plasma threshold at our focal point

https://www.amazon.com/Abraham-Capsulotomy-Yag-Laser-Lens/dp/B00NTNZ85W

- Suprathreshold, different interfaces/debris, and a smaller cone angle can influence unwanted plasma formation and a more anterior breakdown
- Larger cone angle localizes plasma near our focus
- Essentially the Abraham lens increases our cone angle and tightens up our focus
  - Leads to less optical breakdown of our laser beam while promoting plasma formation at our focus

Indication For Posterior Capsulotomy

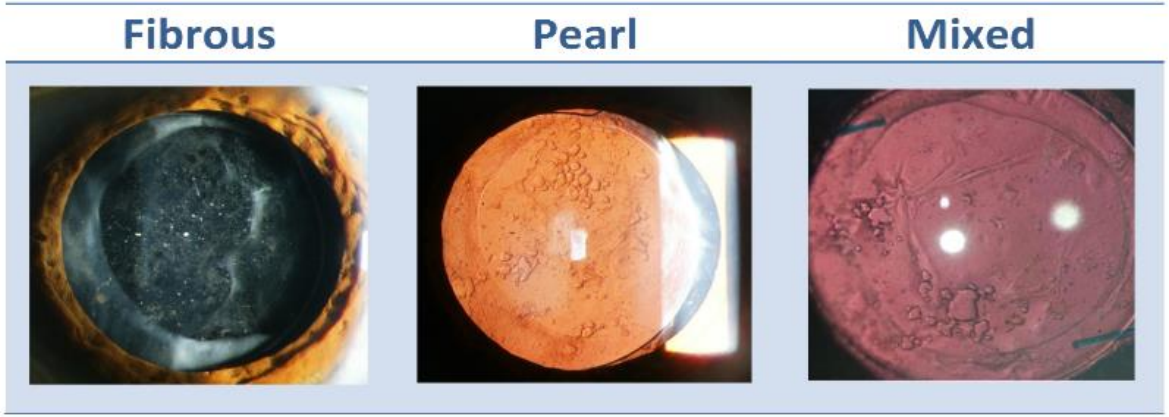
- Posterior capsular opacification (PCO)
  - Associated with decreased visual acuity, glare, photophobia
  - Impairment of visual function (interferes with patient's needs and quality of life)



https://www.oclvision.com/blog/what-is-a-yag-laser-treatment/

What is PCO?

- Lens epithelial cells (LECs) leftover in capsular bag following cataract surgery
- Proliferation, migration, epithelial to mesenchymal transition (EMT), collagen deposition, and lens fiber regeneration mechanisms
- 2 Types of PCO
  - Fibrous
    - LECs proliferate and migrate, undergo EMT and fibrous metaplasia
    - Causes wrinkles/folds in posterior capsule
  - Pearl
    - Equatorial LECs cause regeneration of crystallin expressing lenticular fibers, forms Elschnig pearls and Soemmering's ring
    - Most common form of PCO



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RESEARCH ARTICLE Open Access

Optical coherence tomography for an in-vivo study of posterior-capsule-opacification types and their influence on the total-pulse energy required for Nd:YAG capsulotomy: a case series

Gregor Hawlina[1*], Darko Perovšek[1], Brigita Drnovšek-Olup[1], Janez Možina[2] and Peter Gregorčič[2]

Abstract

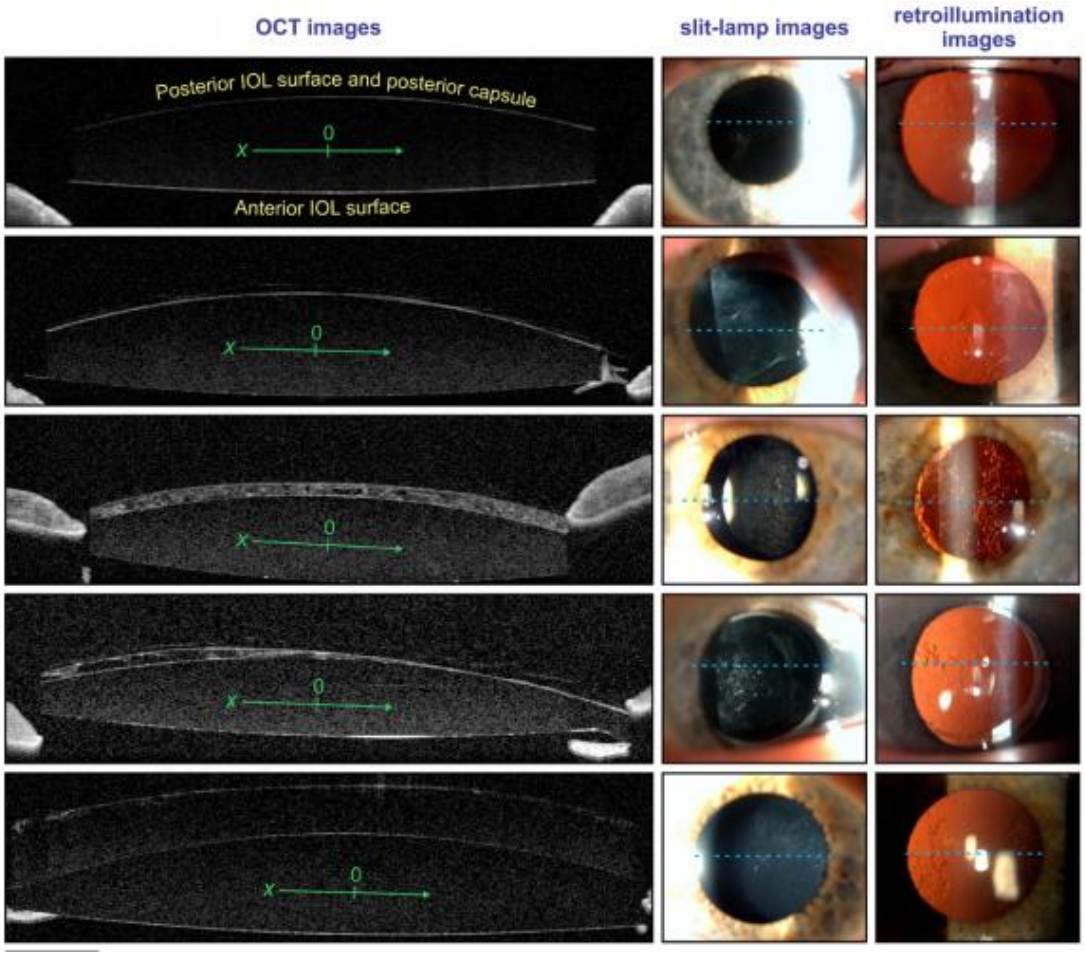
Background: Posterior capsule opacification (PCO) is the most common post-operative complication associated with cataract surgery and is mostly treated with Nd:YAG laser capsulotomy. Here, we demonstrate the use of high-resolution spectral-domain optical coherence tomography (OCT) as a technique for PCO analysis. Additionally, we evaluate the influence of PCO types and the distance between the intraocular lens (IOL) and the posterior capsule (PC), i.e., the IOL/PC distance, on the total-pulse energy required for the Nd:YAG laser posterior capsulotomy.

Methods: 47 eyes with PCO scheduled for the Nd:YAG procedure were examined and divided into four categories: fibrosis, pearl, mixed type and late-postoperative capsular bag distension syndrome. Using custom-made computer software for OCT image analysis, the IOL/PC distances in two dimensions were measured. The IOL/PC distances were compared with those of a control group of 15 eyes without PCO. The influence of the different PCO types and the IOL/PC distance on the total-pulse energy required for the Nd:YAG procedure was analyzed.

Results: The total-pulse energy required for a laser capsulotomy differs significantly between PCO types ($p = 0.005$, Kruskal-Wallis test). The highest energy was required for the fibrosis PCO type, followed by mixed, pearl and late-postoperative capsular bag distension syndrome. The IOL/PC distance also significantly influenced the total-pulse energy required for laser capsulotomy ($p = 0.028$, linear regression). Lower total-pulse energy was expected for a larger IOL/PC distance.

Conclusions: Our study indicates that the PCO types and the IOL/PC distance influence the total-pulse energy required for Nd:YAG capsulotomy. The presented OCT method has the potential to become an additional tool for PCO characterization. Our results are important for a better understanding of the photodisruptive mechanisms in Nd:YAG capsulotomy.

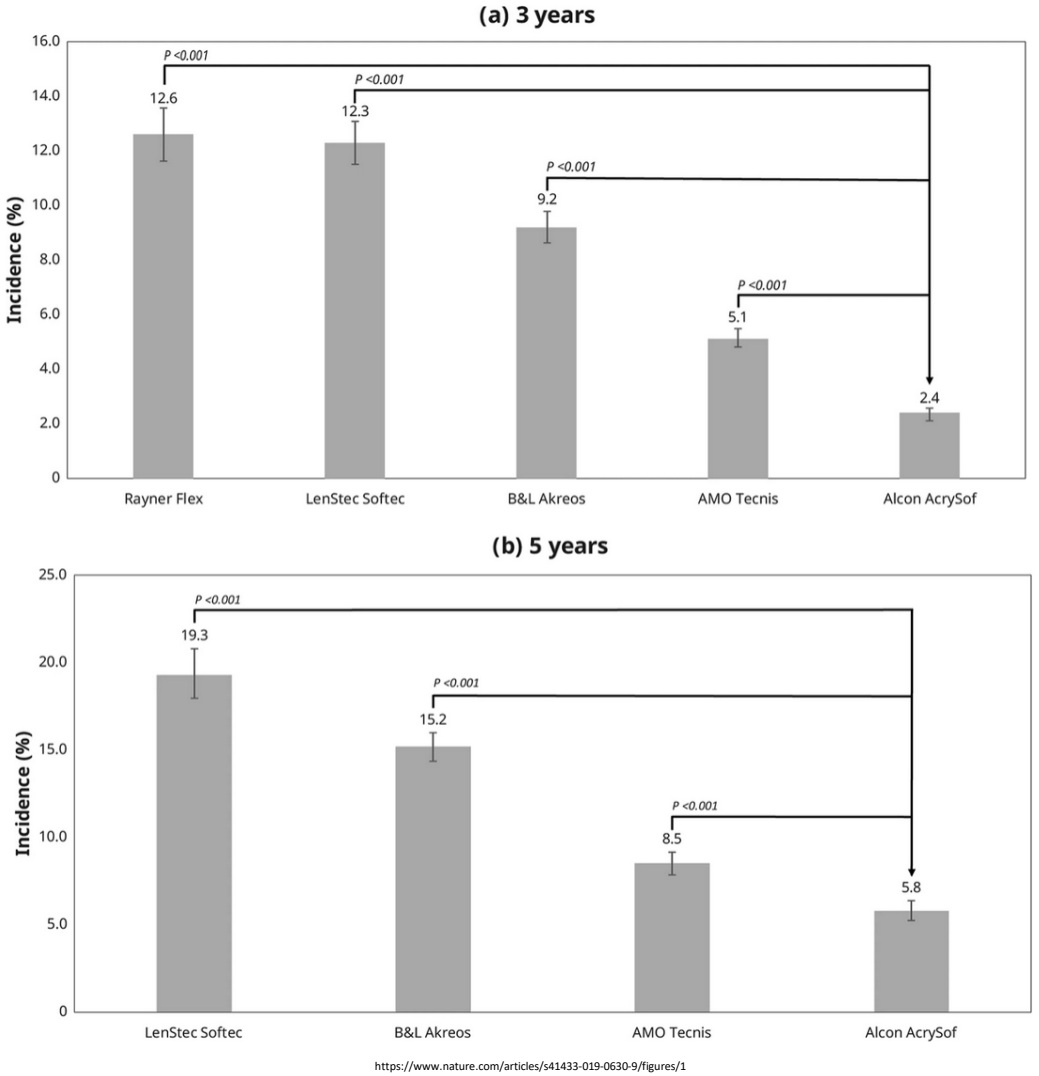
Keywords: Capsular bag distension syndrome, Capsulotomy, High-resolution spectral-domain optical coherence tomography, Nd:YAG, Posterior capsule opacification



Incidence?

- Dependent on implant type, surgical experience, level of surgical complication, materials used during surgery

- Silicone, hydrophilic acrylic, hydrophobic acrylic?



https://www.nature.com/articles/s41433-019-0630-9/figures/1

Contraindications

- Uncontrolled IOP
- Inadequate visualization of target
- Inadequate stability of the eye
- No potential for improvement in vision post procedure
- Uncooperative patient

Pre-operative

- History
  - When cataract surgery, IOL type, complications?
- Entrance testing
- Refract?
- Slit lamp
  - Look at pupil size prior to dilation and what PCO is present in the visual axis
- IOP
- DFE
  - Determine retinal stability, evaluate vitreous stability, look for vitreous strands/adhesions to IOL
- Macular OCT recommended
  - Fully assess macular profile looking for foveal irregularity, current or prior maculopathy

Pre-operative

- Informed consent*
  - Educate the patient on what the procedure is, why we are doing it, what outcome to expect, risks and benefits of doing/not doing the procedure, alternative procedures, and complications
- Dilate with 1% tropicamide and consider 2.5% phenylephrine if needed
- 1 drop of brimonidine in operative eye 15-30 minutes prior
- 1 drop of proparacaine in operative eye and fellow eye
- Use Genteal Gel, Celluvisc, Goniosol etc. as lubricant for Abraham lens
- Educate the patient on what do expect during the procedure

The Procedure

- Laser settings:
  - Energy settings vary depending on thickness and extent of opacity
    - Initial energy may range from 0.8-2.5mJ
    - We typically start at, and recommend staying within, 1.0-2.0mJ and adjusting from there based on laser/tissue interaction
  - Spot size is fixed, about 8microns
  - Pulse duration, 3-7ns
  - 1 pulse
  - Offset is 125-500 of posterior offset, most commonly 250um

The Procedure

- Focus HeNe beams on target of interest

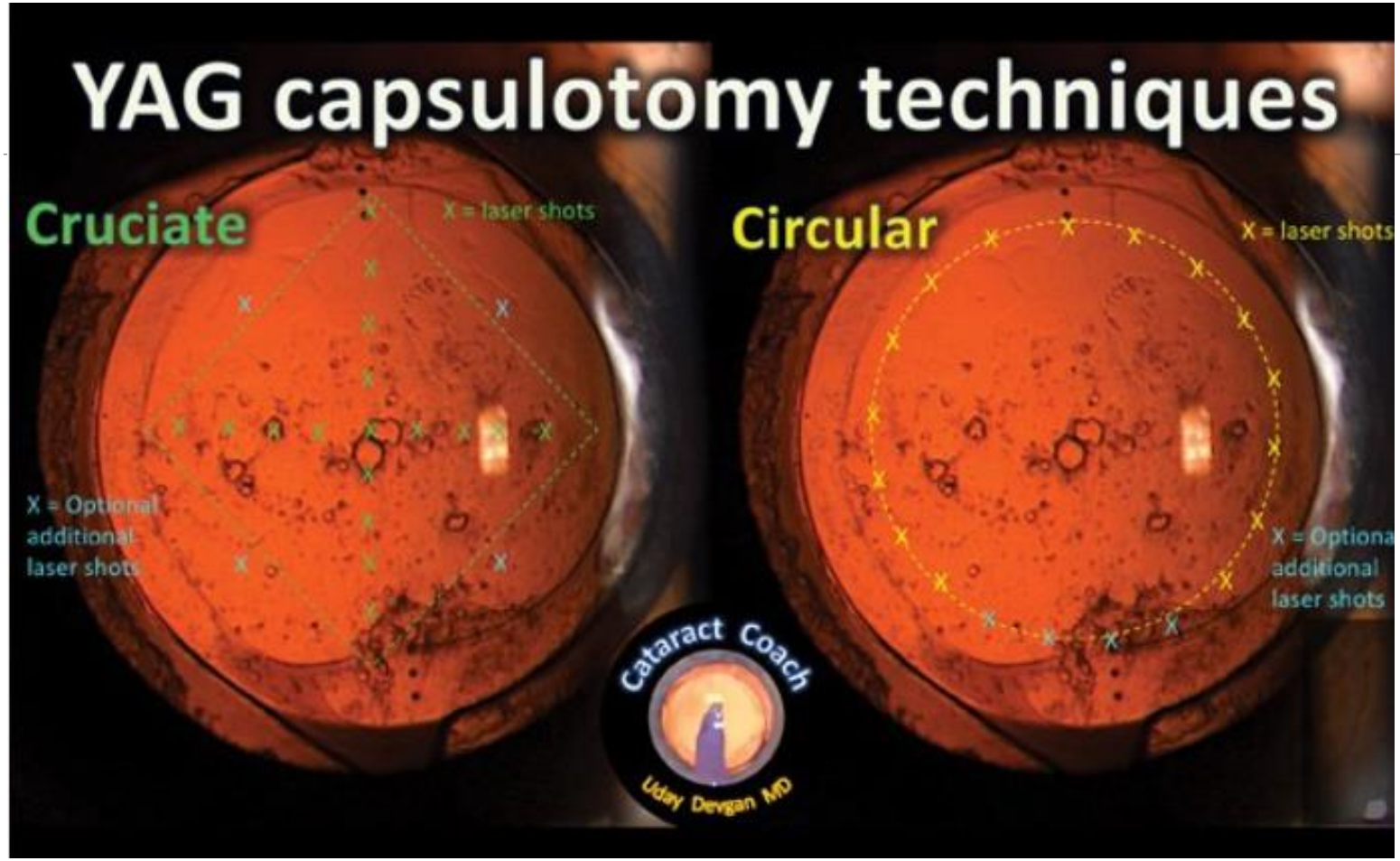
- Fire laser and observe tissue interaction
  - If interaction is adequate, continue procedure
  - If interaction is not adequate
    - Adjust focus and/or energy settings and continue

- We want size to be larger than pupil size in normal dim conditions (before pharmacologic dilation)
  - Approximately 4-5mm in diameter
    - Do not extend capsulotomy beyond diameter of IOL edges (IOLs are typically 6mm in diameter)
  - Keep at 4mm or less if Cyrstalens

- Perform cruciate or circinate pattern

- Ensure remaining corners/edges/vitreous adhesions are not obstructing visual axis and surrounding areas

- Procedure is completed, evaluate your work before leaving laser



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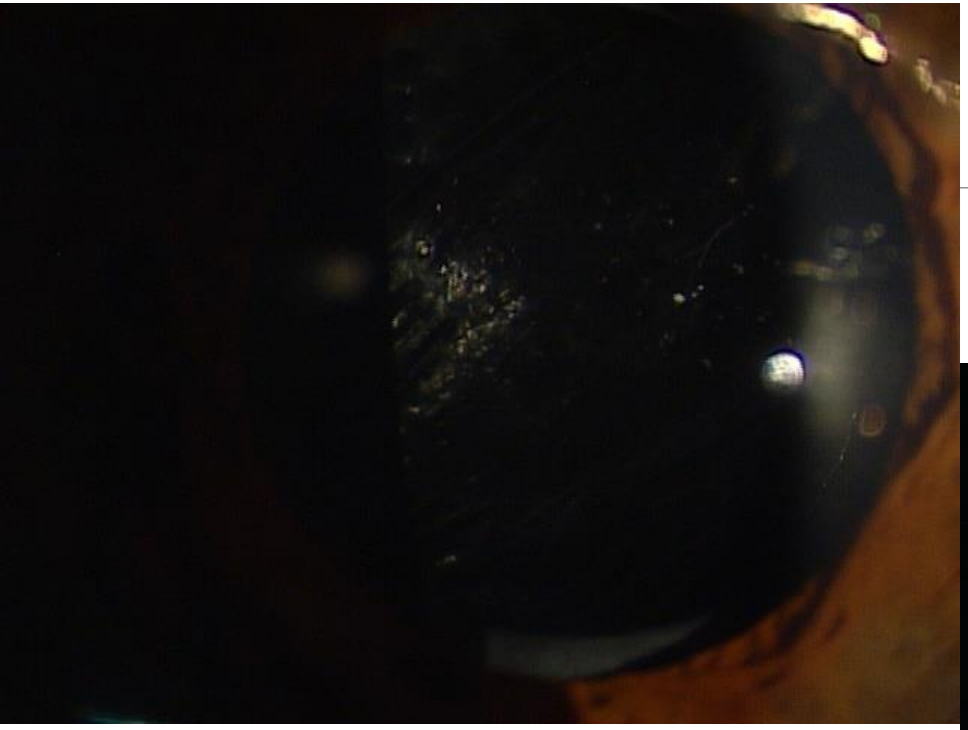
Tel:8629-82245172 8629-82210956 Email:ijopress@163.com

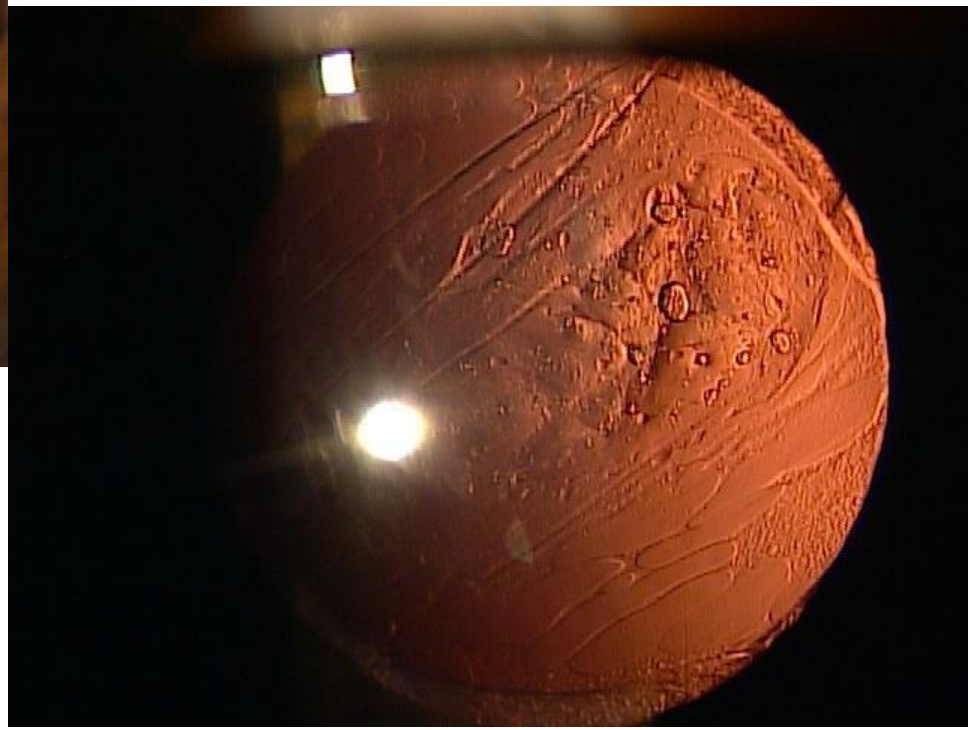
• Clinical Research •

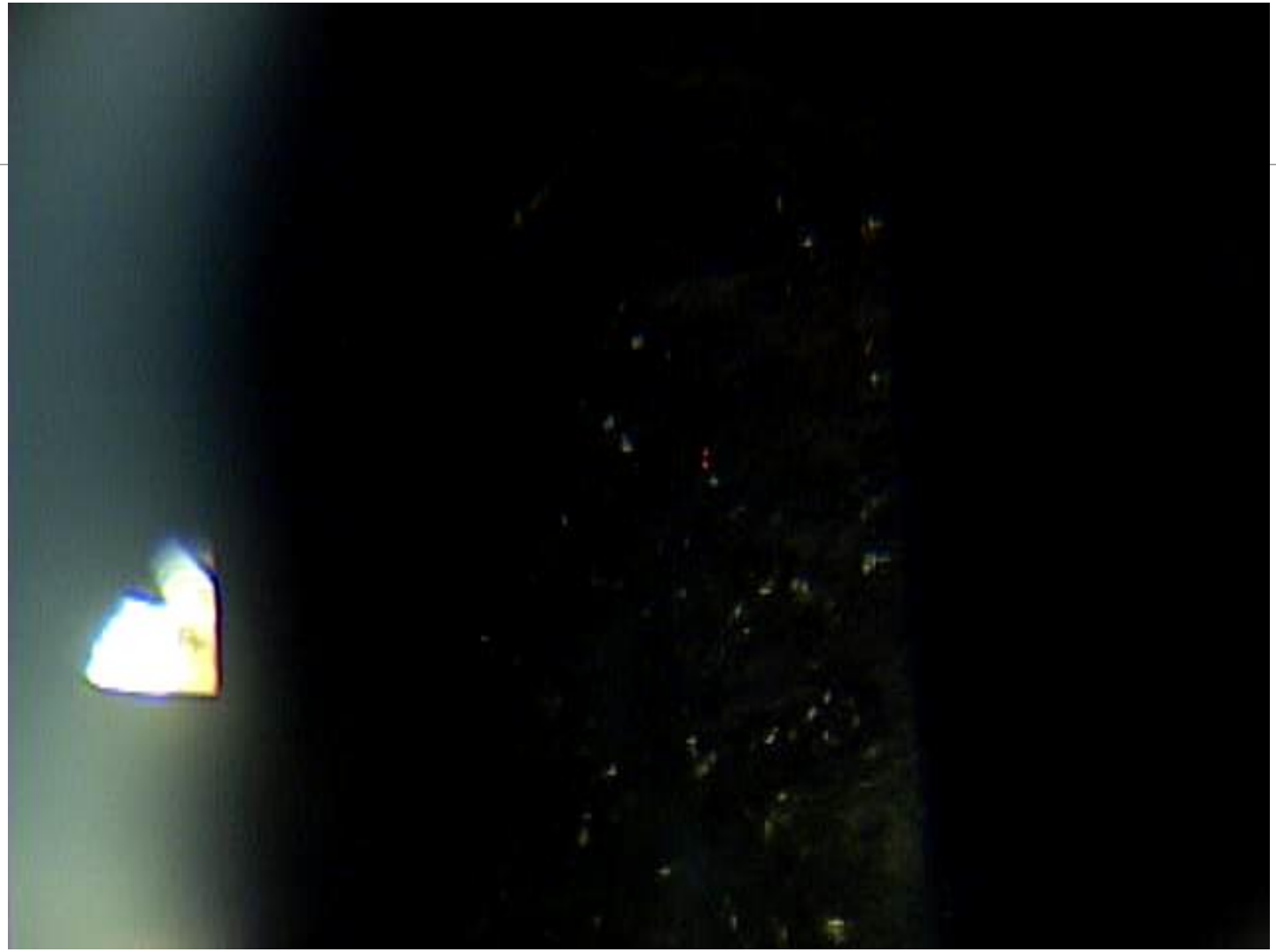
Comparison of two Nd:YAG laser posterior capsulotomy: cruciate pattern *vs* circular pattern with vitreous strand cutting

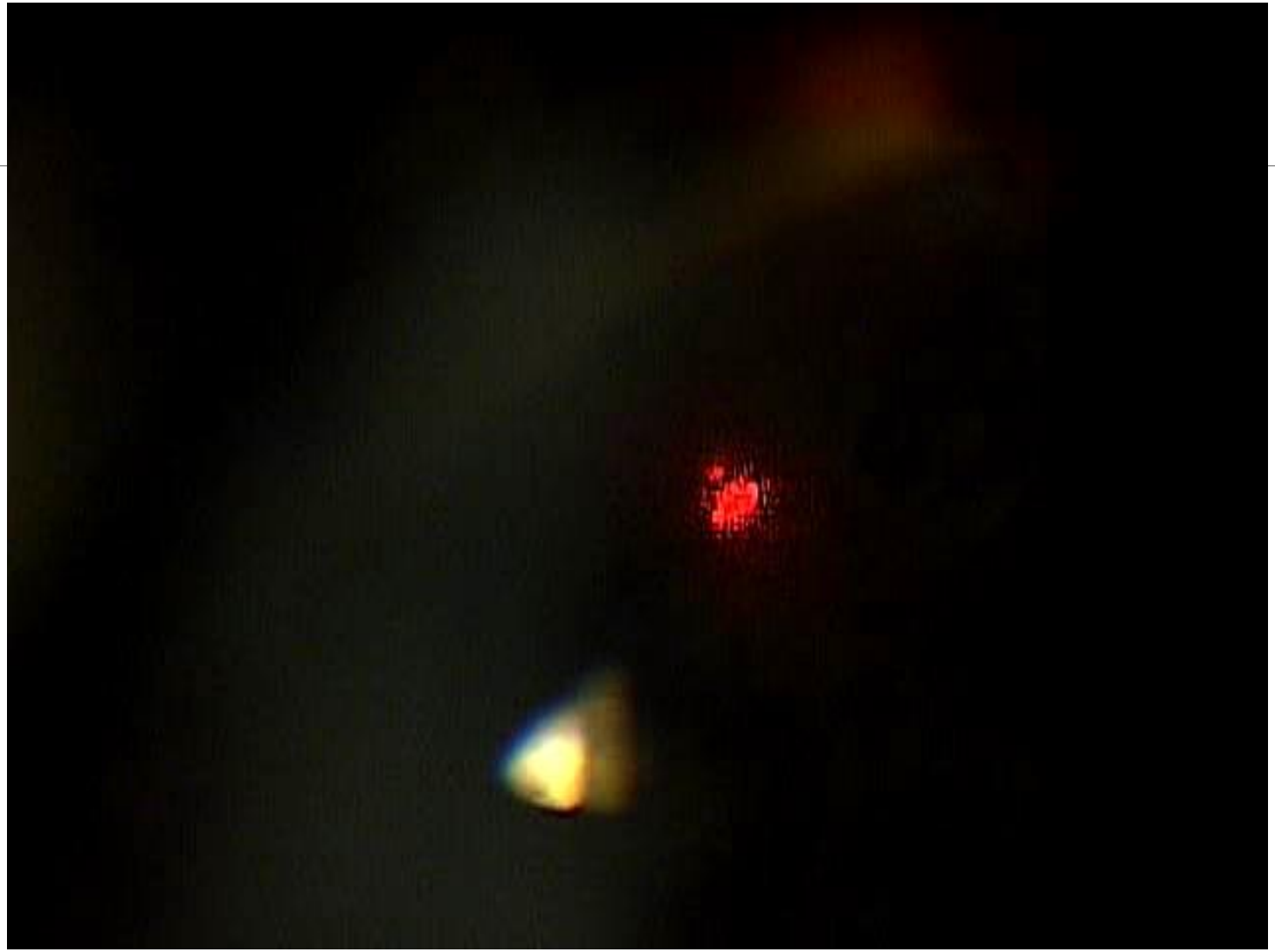
Jin-Soo Kim[1], *Jung Yeol Choi*[2], *Ji-Won Kwon*[3], *Won Ryang Wee*[1], *Young Keun Han*[1,2]

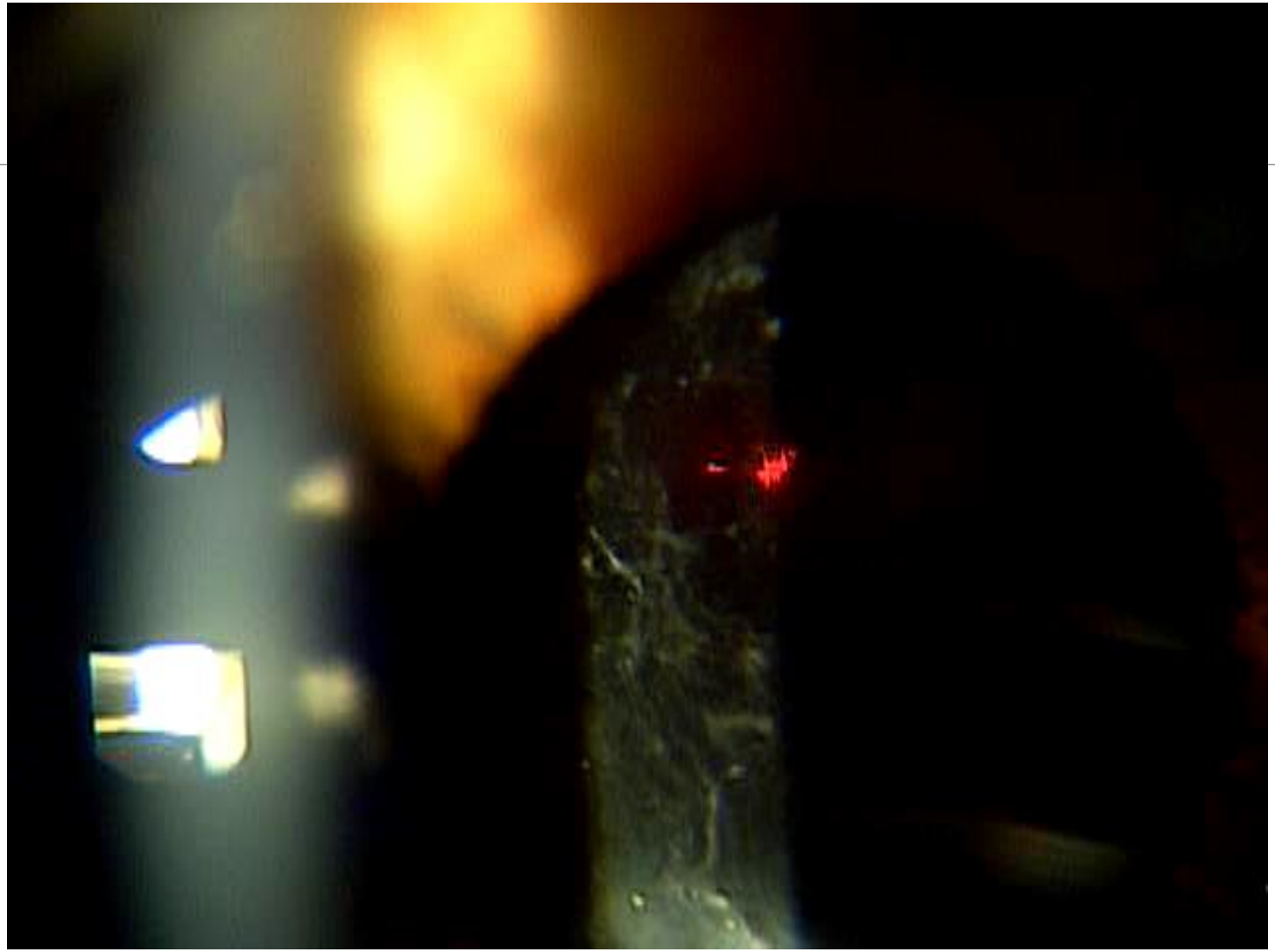
- Differences in total energy?
- Pits?
- Retraction?
- Hinge?
- Preference?

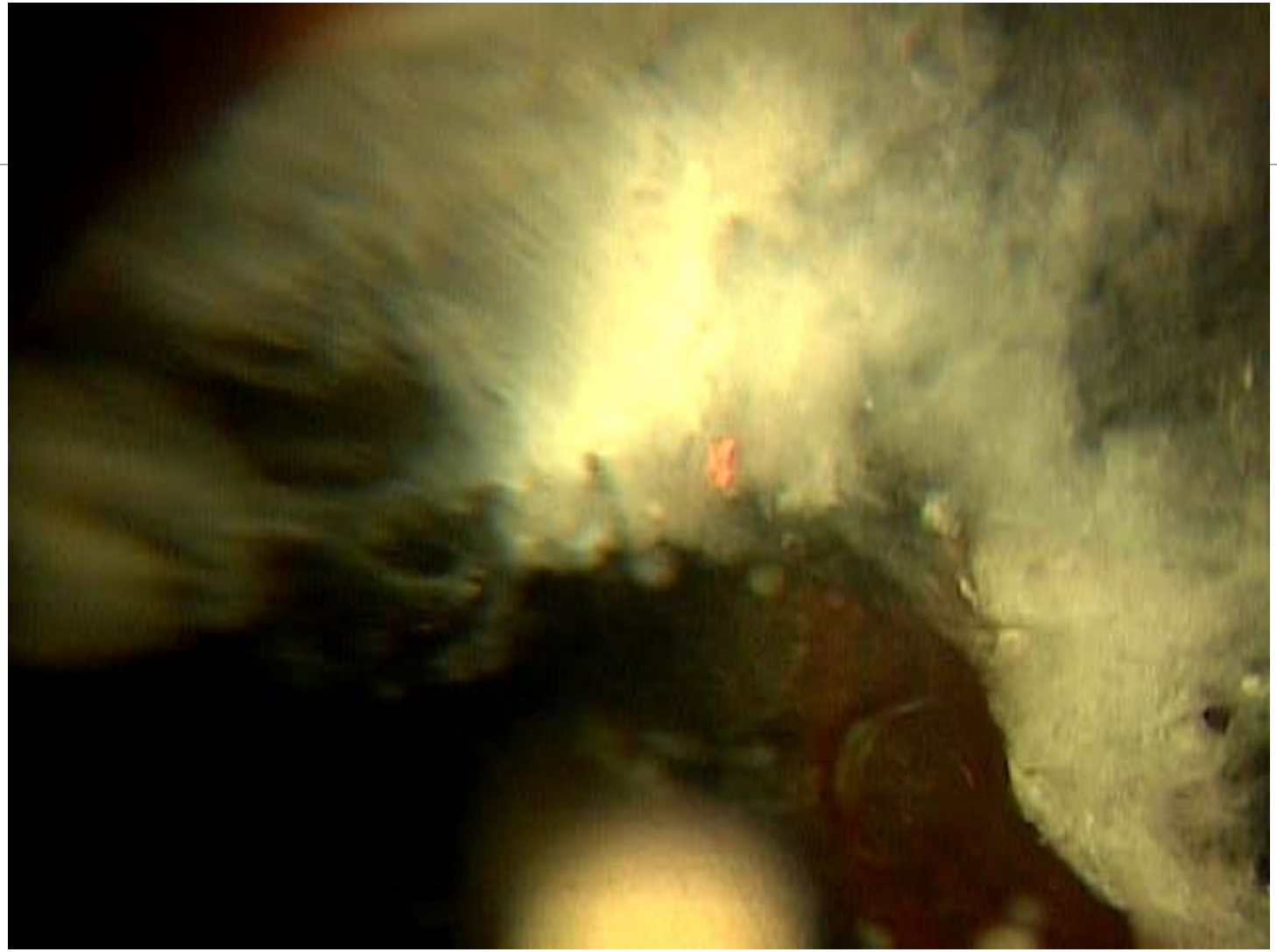




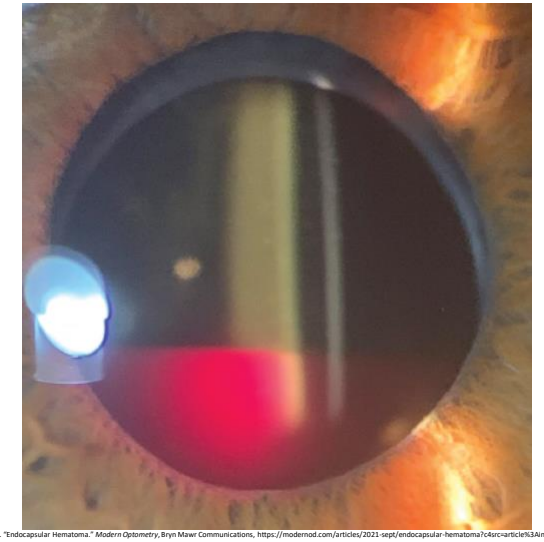








Endocapsular/Intracapsular Hematoma



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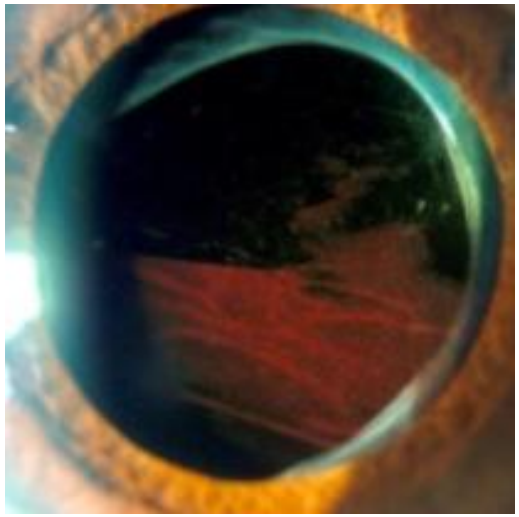

Muñoz, A. Ibáñez, et al. "Endocapsular Haematoma: An Unusual Complication of Phacoemulsification and Non-Penetrating Deep Sclerectomy." *Archivos De La Sociedad Española De Oftalmologia (English Edition)*, Elsevier Doyma, 28 Aug. 2020, https://www.sciencedirect.com/science/article/abs/pii/S2173579420301699?dgcid=rss_sd_all.

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Anterior Capsular Contraction

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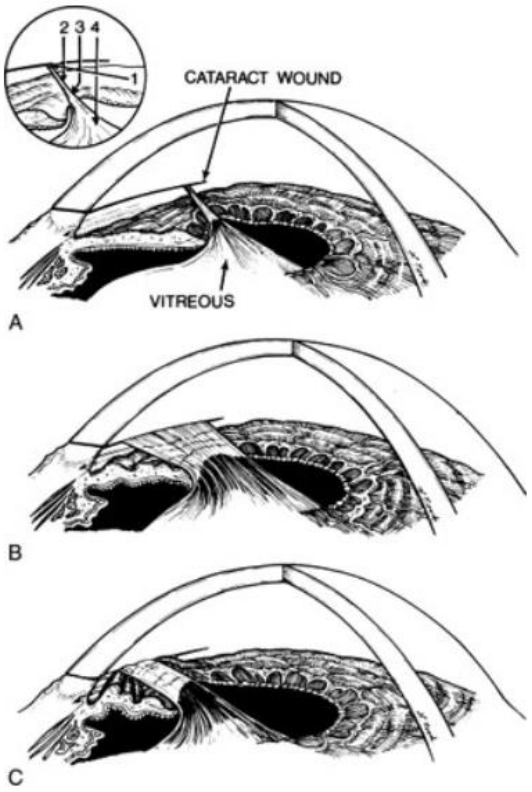
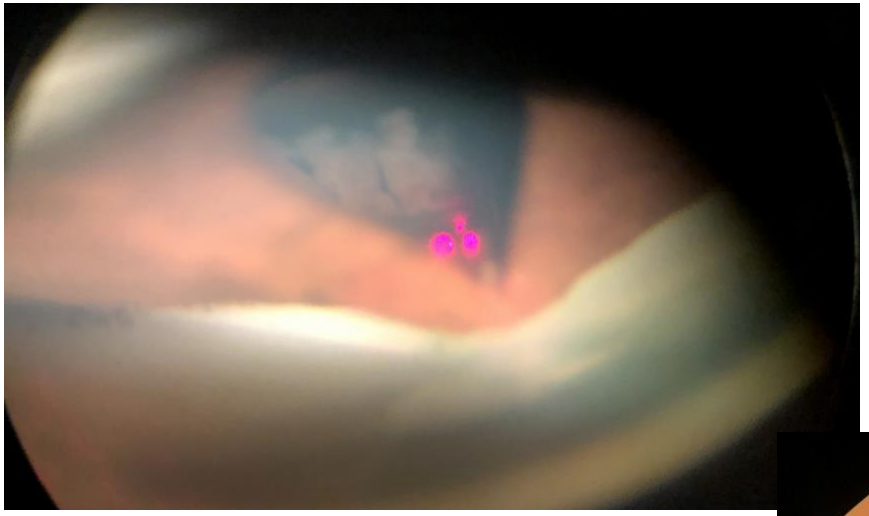
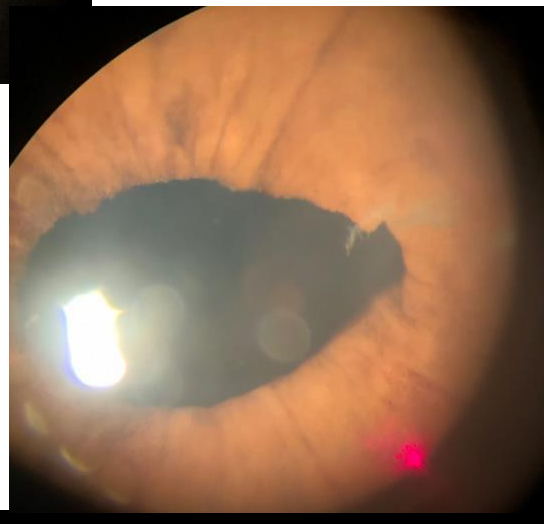
Vitreous Wick Syndrome







Figueiredo, Ricardo, and Tiago Morais-Sarmento. "Vitreous Wick Syndrome." *EyeWiki*, 24 Aug. 2021, https://eyewiki.aao.org/Vitreous_Wick_Syndrome.

Post Operative

- May need to rinse or clean eye
- 1 drop of brimonidine in post surgical eye
- Recheck visual acuity and IOP post procedure, 30min – 1hr
- Rx prednisolone acetate 1gtt QID in post surgical eye for 1 week
- Educate patient on signs and symptoms of complications
- Schedule patient for 1 week follow up and tell them to RTC sooner if they note decline in vision or comfort
- Record number of total pulses, total energy used, which eye procedure was done on, and how well the patient tolerated the procedure in your EHR chart

Check IOP?

JOCGP

10.5005/jp-journals-10028-1225

RESEARCH ARTICLE

Intraocular Pressure Spikes following Neodymium-doped Yttrium Aluminum Garnet Laser Capsulotomy: Current Prevalence and Management in Israel

Hindawi Publishing Corporation
Journal of Ophthalmology
Volume 2014, Article ID 846385, 5 pages
http://dx.doi.org/10.1155/2014/846385

Clinical Study

The Effect of ND:YAG Laser Posterior Capsulotomy Size on Refraction, Intraocular Pressure, and Macular Thickness

Eyyup Karahan,[1] Ibrahim Tuncer,[1] and Mehmet Ozgur Zengin[2]

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Clinical Ophthalmology

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ORIGINAL RESEARCH

Effect of Nd:YAG laser posterior capsulotomy on intraocular pressure, refraction, anterior depth, and macular thickness

Anil Parajuli[1]
Purushottam Joshi[2]
Prabha Subedi[3]
Chandni Pradhan[1]

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Clinical Ophthalmology

Size?

Energy?

Int J Ophthalmol, Vol. 11, No. 7, Jul.18, 2018 www.ijo.cn
Tel:8629-82245172 8629-82210956 Email:ijopress@163.com

• Clinical Research •

Induction of oxidative stress in human aqueous and vitreous humors by Nd:YAG laser posterior capsulotomy

Loredana Bergandi[1], Oleksii A Skorokhod[1,2], Federica Franzone[3], Rosalba La Grotta[1], Evelin Schwarzer[1], Raffaele Nuzzi[3]

• **CONCLUSION: These data, clearly suggest that any change that Q-switched Nd:YAG photo disruption may cause in the aqueous and vitreous compartments, resulting in a higher level of oxidative damage might be of considerable clinical significance particularly by accelerating the aging of the anterior and posterior segments of the eye and by worsening the intraocular pressure, the uveal, the retinal (especially macular) pathologies.**

Complications

- IOP spike – most common, ~12.6%
- Inflammation – second most common, ~ 9.9%
- IOL damage – Pits, ~7.8%
- Floaters – not assessed in study, probably most common benign problem
- CME – rare, ~2.9%
- Retinal detachment – rare, ~2.3%

Follow-up

- At 1 week follow up:
- Look closely for inflammation and retinal complications on your DFE
  - Refraction?
- If all is well, d/c prednisolone acetate, release back to referring doctor

Other Considerations?

- Looking to the future

  - Limiting incidence?
    - Silicone
    - Hydrophilic acryclic
    - Hydrophobic acryclic
    - Hydrophilic with hydrophobic surface

  - Pharmacologics
    - Intracameral?
    - Drug loaded IOLs?
      - How?

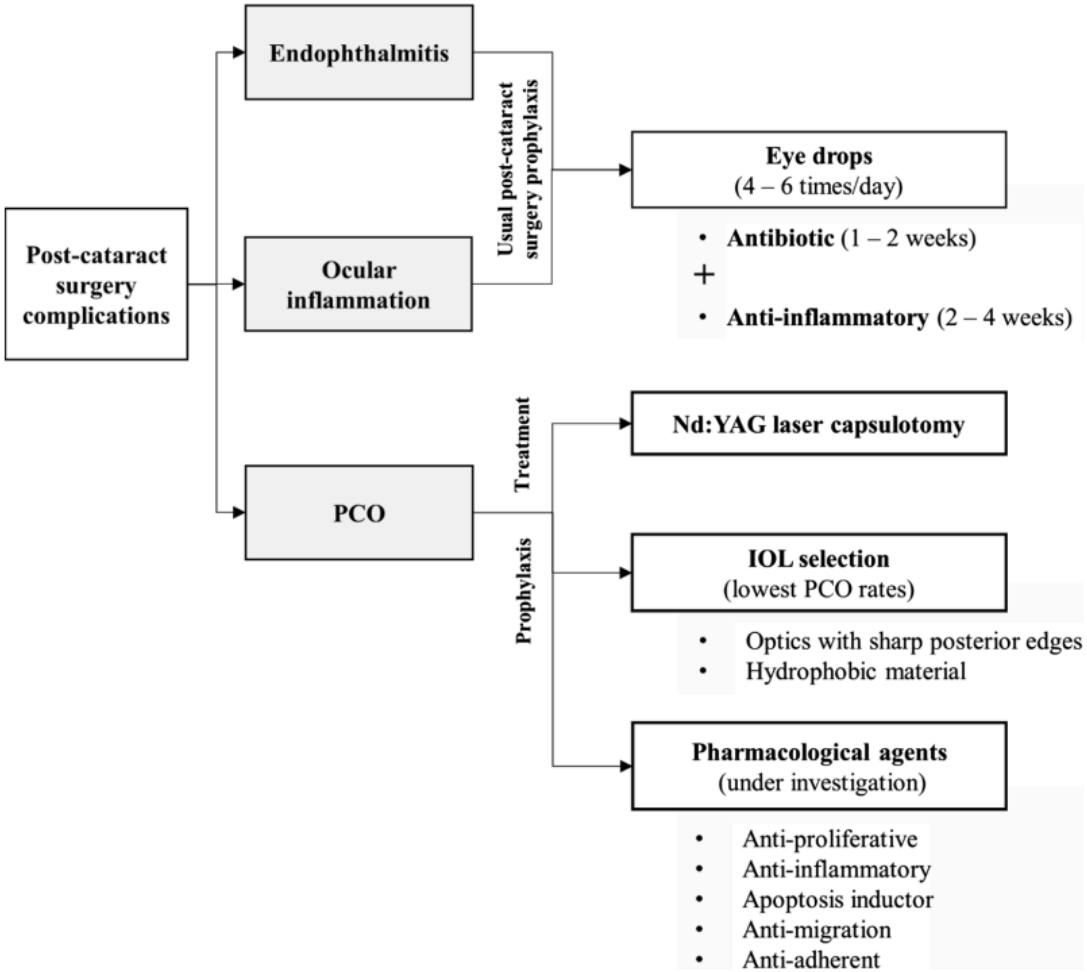

Fig. 1. Post-cataract surgery complications and the corresponding prophylaxis/treatment.

International Journal of Pharmaceutics 602 (2021) 120613

Contents lists available at ScienceDirect

International Journal of Pharmaceutics

journal homepage: www.elsevier.com/locate/ijpharm

Review

Intraocular lenses as drug delivery devices

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[b] CIIEM, Instituto Universitário Egas Moniz, Caparica, Portugal

ARTICLE INFO

Keywords:
Cataracts surgery
Endophthalmitis
Ocular inflammation
Posterior capsule opacification
Intraocular lenses
Drug delivery

ABSTRACT

Cataract surgery is one of the most common and safe surgical procedures nowadays. However, it is not free of risks as endophthalmitis, ocular inflammation and posterior capsule opacification (PCO) can appear as post-surgery complications. The usual eye drop therapy used as prophylaxis for the former two complications has limited bioavailability. In turn, the prevention of PCO involves an adequate surgical technique and a careful choice of intraocular lens (IOL) design and material. Also, different drugs have been tested to reduce incidence of PCO, but no prophylaxis demonstrated to be completely effective. In the past few years, IOLs have been proposed as drug delivery devices to replace or/assist the usual eye drop therapy in the post-operatory period. The great advantage of drug loaded IOLs would be to ensure a continuous drug delivery, independent of patient's compliance without requiring any further action besides IOL implantation. The biggest challenge of drug loaded IOLs production is to achieve a controlled and extended release that meet therapeutic needs without inducing toxicity to the surrounding ocular tissues or affecting the physical properties of the lens.

This review starts by addressing the possible complications after cataract surgery, as well as the most commonly adopted prophylaxis for each of them. The various types of IOLs are described and their main advantages/disadvantages are discussed. The different strategies pursued to incorporate drugs into the IOLs and control their release, which include soaking the IOL in the drugs solution, supercritical impregnation, surface modifications, and attachment of drug reservoirs to the IOL, among others, are reported. For each strategy, a summary of the publications is presented, which includes the target complication, the types and amounts of released drugs and the IOL materials. A brief description of each individual study is given afterwards. Optimization of drug loaded IOLs through mathematical modelling and possible issues raised by their sterilization are also tackled. At the end, the future commercialization of drug loaded IOLs is commented.

Global Period

90 Days

Physician Fee Schedule

CMS.gov

CPT 66821

- Non-Facility Price
  - Varies depending on change in RVUs, conversion factors, and geography
    - Averages about $390
- Facility Price
  - Same variable factors
    - Averages about $340

Questions?

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