A STUDY OF NEODYMIUM – YAG LASER IRIDOTOMY IN PRIMARY ANGLE CLOSURE GLAUCOMA

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CERTIFICATE

This is to certify that this dissertation entitled ***"A STUDY OF NEODYMIUM –YAG LASER IRIDOTOMY IN PRIMARY ANGLE CLOSURE GLAUCOMA"*** has been done by ***DR. A.M. SUMANTH KUMAR*** under my guidance in Department of OPHTHALMOLOGY, Madurai Medical College, Madurai.

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I, **Dr. A.M. SUMANTH KUMAR** solemnly declare that the dissertation titled ***"A STUDY OF NEODYMIUM –YAG LASER IRIDOTOMY IN PRIMARY ANGLE CLOSURE GLAUCOMA"*** has been prepared by me.

This is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of M.S.,(Ophthalmology) Branch - III degree Examination to be held in MARCH 2009.

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CONTENTS

INTRODUCTION

Acute angle closure glaucoma has always been a threatening and dangerous disease and one of the leading cause of blindness in Human society. Nearly all cases of blindness from glaucoma is preventable if disease is detected early and proper treatment is implemented.

In 1956 Gerd Meyer Schwickerath demonstrated the feasibility of creating an Iridectomy with Xenon light energy.

The LASER , a technologic improvement over Xenon light source has allowed iridectomies to be performed more safely than by standard methods because of many reasons as eye need not be opened, procedure requires only topical anaesthesia, procedure is less expensive and requires only shorter post operative recovery.

Nd-YAG laser iridotomy has become the currently preferred method for relieving the pupillary block. This study will attempt to look at the efficacy of Nd-YAG laser in creating iridotomy in cases of primary angle closure glaucoma.

AIM OF THE STUDY

This study is intended to evaluate the efficacy of Nd-YAG laser iridotomy in acute angle closure glaucoma with a follow up of 12 weeks.

REVIEW OF LITERATURE

The first attempt at creating an iridotomy with xenon light energy was done 50 years ago by Gerd Meyer Schwickerath,(1) a young Hamburg Ophthalmologist.

Perkins E.S in 1971 had suggested the use of laser iridotomy for secondary glaucoma(2). After about two years Perkins E.S and Brown N.A.P had reported the successful iridotomy with ruby laser(1973)(3).

In 1975 Abraham R.K and Miller G.L published the results of two years study of Argon laser iridotomy as an outpatient procedure, more safe and requiring only topical anaesthesia.(4)

Currently two types of laser are commonly used for iridotomies , the Nd-YAG and the Argon (5). Many clinical studies were published comparing Q- switched Neodymium- YAG with Argon for peripheral iridotomy (MC Alister J A , Schwartz L.W, Moster.M).

Pollack I.P in 1979 and Quigley H.A in 1981 had published the results of a long term study of YAG laser iridotomy and had suggested that Nd- YAG laser is preferable over Argon because it is easy to use ,more likely to penetrate the iris and less chance for these iridectomies to close over time.(6,7).

In 1984 Schrems.W et al indicated that the disturbance of the blood aqueous barrier with Nd-YAG laser is not essentially different from that of Argon laser, although tissue damage may be more pronounced.(7).

Klapper R.M in 1984 studied 20 patients who underwent Q switched Nd-YAG iridotomy for angle closure glaucoma . Of this 11 eyes were previous argon laser failures. Penetration was achieved in each case with several shots in one session. Complications were minor and transient.(8)

Robin A.L , Pollack I.P reported in their clinical study of 40 eyes of 20 patients that immediate post operative IOP was greater than 10 mm of Hg in 35% cases using Argon and 30% in YAG laser treated eyes. Other complications reported were haemorrhage, lens damage , focal corneal opacities and endothelial damage.(9)

In 1984 Buchner.M. Gloor and Robert.Y conducted a long term study comprising of 124 eyes and brought out the conclusions that Nd-YAG laser iridotomy should be the procedure of first choice in narrow angle conditions since fistulizing procedures involve risk of malignant glaucoma. It helps to alleviate the angle closure component, to diagnose its contribution to peak IOP and to facilitate an argon laser trabeculoplasty when needed.(10)

Yassur .Y, Melamed.S et al had recorded that Argon laser iridotomy is the procedure of choice for eyes with acute angle closure glaucoma and for preventive iridotomy in the fellow eye.(11)

Cashwell.L.F in his series of 112 eyes with 6 months follow up observed that when cornea is clear laser iridotomy is a better alternative to surgical iridectomy and can be used in out patients without the risk of intra ocular surgery. This alternative is especially beneficial to patients with combined mechanism glaucoma and to patients in whom surgery is contraindicated. (12)

In the same year Yamamoto.T, Shirato.S, Kitazava.Y performed Argon laser iridotomy in a total of 140 eyes of 140 patients with primary angle closure glaucoma. The IOP was controlled at below 20 mm of Hg in 29% without medication, 52% with reduced or the same medication as the pre operative treatment and in 13% with increased medication. In 6%IOP could not be controlled. (13)

Rivera A.H, Browns. R H and Anderson D.R in 1985 believed that increased use of an easy, low risk procedure represents improvemenrs in the quality of care.(14)

In 1986 Schrems. W et al conducted a prospective clinical trial comprising of 41 eyes with narrow angle glaucoma and a control group of

10 normotensive eyes.The patency of YAG laser iridotomy was checked after application of a rapidly acting parasympatholytic drug like tropicamide. Tropicamide mydriasis had no effect on IOP either in patients group or in the control group.(15)

Naveh. N , Zborowsky-M Gutman.L, Blumenthal.M conducted preliminary clinical study to evaluate the efficacy and immediate complications of Q switched Nd-YAG laser iridotomy in the treatment of acute and chronic angle closure. 90% cases required a single lasing session for patency and 10% required two sessions. Both these incidences are remarkably lower than that of argon laser iridotomy. Transitory closure of a prior patent iridotomy during the first hour after lasing was observed in 6.7% eyes. Patency was again noted up to three weeks and remained unchanged.

Immediate post operative complications included a marked in crease in IOP (42%), minimal transitory bleeding, transitory localized corneal odema at the lasing site .persistent iridocorneal adhesion at the lasing site was noted in three eyes, localized Lenticular opacities of non progressive type in one eye.(16)

Robin A.L Arkell.S. et al had done a field trial with a portable laser system. Prophylactic iridotomies were created with small portable,

battery operated, Q switched Nd-YAG laser with a slit lamp delivery system, in 44 Eskimos eyes with occludable angles.(17)

Mentges W.M, Heider.W and Ohrloff. C suggested that prophylactic Nd-YAG iridotomy is avaluable therapeutic procedure for the prevention of acute glaucoma in the fellow eye of one already found to be affected by glaucoma.(18)

In 1992 HO.T and Fan.R reported clinical study to evaluate the use of the Argon and Nd-YAG laser in sequential combination for iridotomy. Sequential argon YAG laser iridotomy combines most advantages of both laser types while avoiding some of their disadvantages.(19)

In the same year late histopathological findings of Nd-YAG laser iridotomies in humans by Tetsumo.K et al suggested that in human iris wound healing after Nd-YAG laser iridotomy occurs without induction of fibrous scar or proliferationof iris pigments in the epithelium. This indicates that there is no tendency towards late closure of the iridotomy sites.(20)

Observations by Li.J.z in 56 eyes of PACG(published in 1991) is that success rate of 100% with lowering of IOP pf 2.3 mm of Hg, along with diminished use of hypotensive drugs.(21)

Murphy P.H and Trope G.E reported 13 cases of monocular blurring or a bluish or coloured line after laser procedure.(22)

Fernandez and Rechemonde J.L reported iatrogenic lens complications like lens rupture , lens opacities and lens dislocation after a Nd-YAG laser attempt. They have also suggested that a proper patient selection, good techniques with cautious use of laser energy and meticulous attention to details should prevent this complication.(23)

Malignant glaucoma was reported by Robinson.A et al in 1990.(24)

Malignant glaucoma was again observed with acute angle closure in 6 eyes after Nd YAG laser iridotomyby Cashwell and Martin.(25)

Corneal endothelial loss was reported by Power. M.J and Collins.L.M and they have also observed that area of cell loss was reduced by approximately 50% when Abraham goniolens was used.(26)

Smith .T preferred using Argon laser pretreatment in the Nd YAG iridotomy as it was proved to significantly reduce the incidence of haemorrhage during Nd-YAG iridotomy.(27)

A study by Fleck B W in 4 cases of acute angle closure glaucoma has pointed out that an iridotomy should be atleast150-200 microns in diameter if acute angle closure glaucoma is to be reliably prevented.(28)

Nd: YAG laser iridotomy is effective in widening the drainage angle and reducing elevated IOP in east Asian people with primary angle closure. This suggests that pupil block is a significant mechanism causing closure of the angle in this population. Once glaucomatous optic neuropathy associated with synechial angle closure has occurred, iridotomy alone is less effective at controlling IOP.(42)

ANATOMY OF ANGLE OF ANTERIOR CHAMBER

Development :

Anterior chamber commences peripherally as a slit in the mesoderm between cornea and iris which gradually progresses centrally. The appearance of this cleft is probably due to disappearance of mesoderm between developing iris and cornea at about 30-40mm stage.

The anterior chamber is soon seperated from the lens by the pupillary membrane. It is always shallow and is still so at birth.

The region of the future angle is at first filled with loose mesodermal tissue which later disappears except for the portion at the extreme periphery.

Angle of the anterior chamber:

It is the peripheral recess bounded by the posteriorly by root of the iris and ciliary body and anteriorly by the corneosclera. The various pathways of aqueous from anterior chamber to the venous system include the trabecular meshwork, juxtacanalicular tissue, endothelium of the schlem's canal and the collector channels.

Trabecular meshwork:

In the meridional section the trabecular meshwork has a triangular shape with its apex at schwalbe's line and its base at sclera spur. The meshwork consists of a stack of flattened, interconnected, perforated sheets which run in meridional fashion from peripheral cornea and descemets membrane anteriorly to scleral spur posteriorly. Anteriorly these sheets are only 2-3 layers thick, but posteriorly 12-20 layers are detectable. The inner layer of trabecular meshwork border the anterior chamber and are referred to as uveal meshwork. The outer layers are separated from endothelial of schlemm's canal by a thin strip of connective tissue called juxta canalicular tissue. The ultra structure of trabecular meshwork consists of trabecular beams with a central core of collagen types I, III and elastin. The core is surrounded by a cortical zone that contains collagen types III, IV, V, laminin, fibronectin, heparin sulphate and proteoglycan. The beams are coveredby a continous layer of endothelial cells that are joined by gap junctions and tight junctions. The endothelial cells have micro filaments including actin.

Juxta canalicular tissue:

It is a thin layer of tissue 2 -20 microns thick that separates the outer layers of corneoscleral meshwork from the inner wall of schlemm's

canal. The tissue has a ground substance of glycosaminoglycans and glyproteins that contain type III collagen, curlycollagen, fibroblasts and star shaped cells(juxta canalicular cells).

Schlemm's canal:

It is an endothelial lined circular channel that runs circumferentially around the globe. It has a slit like lumen that is 190-370 microns in diameter. However in some eyes the lumen is irregular and even become a plexiform channel with multiple braches. The outer wall of schlemm's canal has a single layer of endothelium that lacks pores or vacuoles. The endothelium linning the inner wall of schlemm's canal consists of a mono layer of spindle cells.

Collector channels:

Schelmm's canal is drained by 20-30 collector channels that in turn drain into a complex system of intrascleral, episcleral and subconjunctival venous plexus. The collector channels arises from the outer wall of schlemm's canal at irregular intervals of 0.3 to 2.8mm. a few vessels may proceed directly from schlemm's canal to the episcleral and conjunctival veins.

Scleral spur:

The scleral spur is a fibrous ring that on meridional section appears as a wedge that projects from inner aspect of anterior sclera. The spur is attached anteriorly to the trabecular meshwork and posteriorly to the sclera and the longitudinal portion of ciliary muscle. When the ciliary muscle contracts it pulls the sclera spur posteriorly which increases the width of inner trabecular spaces and prevents schlemm's canal from collapsing. The spur consists of collagen types I and III and elastic tissue oriented in circular fashion.

Schwalbe's line:

Schwalbe's line is an irregular elevation, 50-150 microns width that runs circumferentially around the globe. This line or zone marks the transition from trabecular to endothelium, termination of descemet's membrane, and the insertion of trabecular meshwork into corneal stroma. Schwalbe's line is composed of collagen and elastic tissue.

Anatomy of iris:

The thin circular diaphragm with an average diameter of 12mm and thickness 0.5mm, except at collarette, where it is slightly thicker. Root of the iris at the middle of the anterior aspect of ciliary body and it is thinner peripherally.

Iris separates anterior chamber from posterior chamber and is bathed in the aqueous fluid on both aspects. The pupil permits flow between 2 parts of aqueous cavity of the eyeball. The pupil is a central aperture which serves as a path for light to enter the eye.

Surface of iris has radial ridges in the peripheral part and crypts of Fuch's in the region of circulus minor. At the floor of ridges and the crypts the superficial tissue layers of the iris are deficient, a point of importance for laser iridotomy. The iris contains pigment (melanin) in dark races and surface looks smooth and homogenous.

The collarette which is about 1.6mm from the pupillary margin divides iris surface in 2 parts, pupillary and ciliary zones.

The layers of iris from before backwards are:-

1. <u>The anterior limiting membrane:</u>

   A condensation of anterior part of stroma. The anterior limiting membrane is deficient at the crypts and much thinned at the contraction furrows. The color of iris depends on the anterior limiting membrane. In blue iris, anterior limiting membrane is thin.

2. Stroma:

consists of loosely arranged collagenous network in which are embedded following structures:

a) the sphincter pupillae muscle

b) blood vessels & nerves of iris

c) pigment cells and other cells

Sphincter pupillae:

1 mm broad, forming a rim all round the pupillary margin near the posterior surface of iris. Derived from ectoderm, when it contracts it constricts the pupil. Supplied by oculomotor nerve via short ciliary nerves. Each portion of sphincter adheres firmly to surrounding structures by vessels and by radial bundles of connective tissue. Hence after an iridotomy the portion of sphincter remaining does not contract up and the pupil can still react to light.

Blood vessels forming the bulk of iris run radially. In most part the sinuous course allows the free movement of the iris. They straighten out when the iris contracts and become wavy , when the iris dilates. There is anastomosis of the vessels at the root – circular anastomosis major and at the pupillary margin- circular anastomosis minor (arteriovenous anastomosis).

Nerves are derived from the long and short ciliary nerves.

Pigment cells : they are melanocytes.

Other cells : fibroblasts, macrophages and mastocytes.

3. Posterior membrane-

also known as anterior epithelium. Sometimes equated with dilator pupillae. It has non striated muscle cells, these dilator fibers merge with sphincter pupillae close to sphincter.

4. Posterior Epithelium-

This layer is derived from internal layer of optic cup. It has columnar epithelium with dark brown pigment cells- round or spindle shaped. After lining posterior surface it may curl round at papillary margin giving rise to black fringe. The posterior surface of iris is almost touching anterior surface of lens at the papillary area.

Types of Iris:

Dark iris-

The dark iris occurs most commonly in black and oriental patients. The stromal pigment is dense and the iris relatively thick, which gives it a firm, sometimes board like consistency. The dark iris is also referred to as hard iris. The frequency of surface crypts is variable, but even when they are present the underlying stroma may be difficult to penetrate.

Medium brown iris –

Light to medium brown in color and often Containing numerous crypts, this is generally the easiest to penetrate.

Fuzzy brown iris-

Light to moderate dark brown, this iris has a homogenous surface appearance with few or no crypts. The surface pigments of the fuzzy brown iris is very soft. Areas of darker, more granular pigment often overlie crypts and should be chosen as sites for penetration. If contraction burns are used in these irides, one should begin with low power in order to avoid bubble formation or pigment liberation. Beneath the pigmented surface layer of melanocytes and fibroblasts, the pigmentation of the stroma may be vary from totally lacking to dense and it is important to vary the approach and settings accordingly to the situation.

Blue iris-

Depending on the degree of stromal pigmentation, these irides range from hazel or bluish brown with numerous crypts(easy to penetrate with argon laser) to light grey with no crypts and superficial stroma that appears almost structureless (difficult to penetrate with argon). The Nd YAG laser is particularly useful in very light irides.

Soft iris:

In a soft iris moderate power coagulations create significant contraction of the surrounding stroma towards the site of impact. In such cases the iris stroma appears to flow into the site of iridotomy as one attempts to penetrate. These irides are usually light brown and often require preliminary contraction burns.

Physiology of aqueous outflow system

The trabecular meshwork and the outflow channels perform a number of important functions. They help in egressing of aqueous humor; trabecular endothelial cells phagocytose particulate matter and debris and provide structural support to prevent the collapse of schlemm's canal.

Routes of Aqueous outflow:

The two important routes of Aqueous outflow are:-

1) Trabeculo canalicular outflow
2) Uveoscleral outflow

1) Trabeculo-canalicular outflow (Conventional route)

This accounts for approximately 90% of aqueous outflow. The aqueous traverses uveal meshwork, corneoscleral meshwork, juxtacanalicular tissue and endothelial linning of canal. From the canal

fluid is transferred by 20-30 collector channels to an intrascleral venous plexus and anterior ciliary vein. Some of the aqueous is carried directly from schlemm's canal to episcleral plexus by the aqueous veins. Trabecular meshwork acts as a one-way valve and it is a crucial part of normal aqueous blood barrier. Another important function of trabecular meshwork is that the trabecular endothelial cells actively phagocytoses foreign material and debris where it acts as reticuloendothelial system of anterior segment of eye.

Trabecular meshwork directly regulates intraocular pressure or tissue distension and then provides feed back to modulate some process such as aqueous humor formation, ciliary muscle tone or glycosaminoglycan synthesis.

2) Uveoscleral outflow (also known as uveo vortex/ extracanalicular or un conventional route)

Accounts for 10% of drainage of aqueous . uveoscleral flow seems more primitive and resembles a leak more than a well designed fluid transport system. The aqueous humor enters the ciliary muscle until it reaches supraciliary and supra choroidal spaces. Uveoscleral flow increases when intra ocular pressure is raised from atmosphere pressure to the level of episcleral venous pressure. An increased IOP provide a greater driving force for Uveoscleral flow.

PRIMARY ANGLE CLOSURE GLAUCOMA (PACG)

INTRODUCTION:

PACG is a condition in which aqueous outflow is obstructed solely as a result of closure of the angle by the peripheral iris, occurs in anatomically predisposed eyes and is frequently bilateral. Affects 1 in 1000 over 40 years age. Male : Female ratio 1 : 4.

Predisposing factors:

They may be 1) Anatomical

2) Physiological

1) Anatomical:

They are a) relatively anterior location of iris lens diaphragm. b) shallow anterior chamber c) narrow entrance to the chamber angle. Three inter related factors are responsible for these characteristics namely axial growth of the lens, small corneal diameter and short axial length.

2) Physiological:

In predisposed eyes, PACG may occur when the dilator muscle contracts, excerting a posterior vector which increases the amount of apposition between the iris and anteriorly located lens, this in turn

enhances the degree of physiological pupillary block. The simultaneous dilation of the pupil renders the peripheral iris more flaccid. The relative pupil block causes the pressure in the posterior chamber to increase and peripheral iris bows anteriorly (iris bombe). Eventually the angle becomes obstructed by the peripheral iris and IOP raises.

Clinically they can be classified into the following five stages even though the condition does not necessarily progress from one to the next in an orderly sequence.

1) Latent 2) Intermittent (sub acute) 3) Acute (congestive & post Congestive) 4) Chronic 5) Absolute.

1) **Latent angle closure glaucoma:**

This stage is characterised by a shallow anterior chamber, a convex shaped iris diaphragm, close proximity of the iris to the cornea, normal IOP, narrow angle capable of closure (Shaffer grade 1-2). Without treatment an eye with latent PACG may remain normal, it may develop acute angle closure or to chronic angle closure without passing through other stages.

Treatment:

Depends on fellow eye. If it has acute or intermittent PACG, treatment is by laser iridotomy. Since without treatment the risk of an acute attack during next 5 years in 50%.

2) <u>Intermittent angle closure:</u>

This occurs when the angle is narrow in only one part. A rapid partial closure and reopening of angle occurs which may be precipitated by physiological mydriasis such as watching TV in dark room, physiological shallowing of anterior chamber when the patient assumes a prone or a semiprone position, or by emotional stress. Without treatment some eyes develop an acute attack where as others pass straight in to chronic angle closure phase. The patients usually presents with transient blurring of vision associated with haloes resulting from corneal epithelial oedema. There may be some eye ache or frontal headache. The attacks are recurrent and usually broken after 1-2 hrs by physiological miosis.

Treatment:

Is with intensive miotic therapy using pilocarpine-2% one drop every 5 min. the fellow eye should also be treated prophylactically with 1% G. pilocarpine four times daily and later with bilateral laser peripheral iridotomies.

3) **Acute congestive angle closure glaucoma:**

This stage is characterized by sudden and severe elevation of IOP as a result of total closure of the angle. This stage presents with rapidly progressive impairment of vision associated with periocular pain and congestion. Nausea and vomiting may occur in severe cases. On examination during acute stage shows a ciliary flush, elevated IOP, odematous cornea with epithelial vesicles. Anterior chamber is shallow with peripheral irido corneal contact which is best detected by directing a narrow slit beam on to the limbus at an angle of 90^0. The pupil is vertically oval, fixed in semi dilated position, unreactive to both light and accommodation. Subsequent examination after corneal oedema has cleared shows aqueous flare and cells, dilated and congested blood vessels on iris, odematous hyperemic optic disc.

Initial treatment:

This stage is initially treated with systemic medication like acetazolamide orally or I.V, hyperosmotic agents like mannitol. Topical medication with beta blocker twice daily may be helpful in reducing IOP. Once the IOP is controlled 2% G pilocarpine is instilled twice (15 min apart) and then 1% G pilocarpine drops four times daily and then a prophylactic laser iridotomy.

Subsequent treatment:

It is aimed at re establishing the communication between the posterior and anterior chamber by making an opening in the iris peripheral iridotomy is usually done in cases with less than 50% angle closure by peripheral anterior synechae. If more than 50% is closed filtration procedure is usually required. In practice, however most eyes are treated first by laser iridotomy and filtration surgery is reserved for those that fail to respond.

4) Chronic angle closure glaucoma:

The clinical features of chronic PACG are those of POAG except that gonioscopy shows a variable amount of angle closure. If routine gonioscopy is not performed in all cases the diagnosis will be missed. The management depends on the mechanism of angle closure is as follows.

a) Group 1:

This is characterized by creeping synechial angle closure which starts superiorly and spreads inferiorly. Initially treatment is by laser iridotomy to eliminate any pupil block, prevent the development of new peripheral anterior synechiae and to make medical control easier. If the iridotomy and medical therapy are ineffective, filtration surgery will be required.

b) Group 2:

Occurs as a result of intermittent attacks. These cases will already have had a laser iridotomy so that medical therapy should be added as and when necessary.

c) Group3:

Is caused by the combination of POAG with narrow angles , usually associated with the long term use of miotics. These cases should be treated by laser iridotomy to make medical therapy more effective.

5) Absolute stage :

It is the final phase to which a chronic phase glaucoma may pass on to with or without the phase of intermittent subacute attacks. In this stage the eye is completely blind, anterior ciliary vessels are dilated and a reddish blue zone surrounds the cornea, cornea is clear, but insensitive with or with out vesicles(bullous keratopathy). The anterior chamber is very shallow, the iris atrophic and may have a broad zone of pigment around the pupil. The optic disc is deeply cupped with a very high intraocular tensions. The eye is generally painful with temporary exacerbations and eventually suffers degenerative changes like ciliary or equatorial staphyloma.

Treatment : A painful blind eye due to absolute glaucoma can be treated with cyclotherapy .

LASER IRIDOTOMY IN PACG

Instrumentation:

LASER - Light Amplication of Stimulated Emission of Radiation.

Basic Principles:

It was Albert Einstein who speculated that if an atom with an excited electron was struck by a photon and the photon has a energy level equal to the difference between the electrons higher and lower levels, then the incoming photon could trigger the atom to return to its ground state by releasing a photon. This process is called stimulated emission and the photon released would have the same wavelength, direction and phase as incoming photon. Thus a single photons can produce two identical photons and stimulated emission has the potential for producing a chain reaction.

Thus if a system described above is enclosed between two mirrors , the photons will bounce back and forth creating multiple stimulated emission of light otherwise termed light amplification. The mirrors are set to form a cavity which in addition to amplifying the light creates a parallel beam and acts as a resonator to limit the number of wavelengths.

Elements of a laser:

All ophthalmic laser require three basic elements to operate-

1) There must be an active medium that emits coherent radiation. The medium may be gas- argon, krypton

   solid- ruby, Nd- Yag.

2) Suitable energy source that can pump the atom molecules or ions.

3) Some form of optical feed back or gain.

Types of laser:

Laser are classified into the following types, solid, Gas, Dye and Excimer.

The laser beam can be delivered as a continous wave or pulsed mode. In the latter situation which is more common, the energy is concentrated and delivered in a very short period or time which can be accomplished in one of the two ways.

A) Q – Switching :- where light is not allowed to travel back and forth in the cavity until maximum population inversion is reached. This is achieved by an electric shutter or misalignment of the mirrors. When the shutter is opened or the mirrors are aligned stimulated emission and

light amplication occur suddenly and energy is released in a pulse of a few to tens of nano seconds.

B) In Mode Locking:- the energy released after achieving maximum population inversion and different modes of light are synchronized creating peaks of energy which are emitted in tens of nano seconds as a chain of pulses each of which lasts for a few tenths of pico seconds.

C) Nd-YAG Laser- This is the most common solid state laser. The active element is a triple ionized Neodymium(N+3) that is incorporated in to a host material called synthetic Yttrium- Aluminium - Garnet crystal (Y3 A15 O2). Nd YAG laser rods are available in diameters of 1 to 10 mm and lengths 50 to 150 mm. the Nd YAG is optically pumped by a flash lamp which is focused on it by an elliptically reflecting cavity, the laser rod and lamp being at foci. Approximately 1% of the Yttrium ions are replaced by the Nd +3 ions during crystal growth and only 2% of the electrical power brought in to the flash light is converted in to laser energy with the remaining 98% wasted as heat. The Nd YAG emits radiation at 1064nm and can be operated in a continous wave or in various pulsed modes.

PROPERTIES OF LASER ENERGY:

a) Coherence:- The photons are in phase with each other in line and space.

b) Collimation: Light amplification occurs only for photons that are aligned with the mirrors. A nearly parallel beam is produced so as to provide a small focal spot when the light is delivered through an optical system.

c) Monochromacy: narrow range of wavelength of the length of the laser beam as the photons are emitted due to release of energy between two defined levels of atoms.

d) High intensity: the light amplification of a laser can produce a beam with significantly more intensity than that of the sun.

Laser delivery system:

Most laser units utilizes a slit lamp biomicroscope in which a system of fiber optics and / or mirrors in an articulated arm direct the laser beams from the laser tube through the slit lamp into the patient's eye. Various types of contact lenses are used in laser surgery. Some contain mirrors to direct the laser beam in to anterior chamber angle, while others incorporate convex lenses to concentrate the light energy on

the iris. An aiming beam of attenuated laser energy like low power He-Ne with a red beam at 632.8 nm coaxial with Nd-YAG pathway allows the surgeon to position and focus the laser beam on the target tissue.

INDICATIONS:

Laser iridotomy can be used as an alternative to surgical iridectomy in almost any situation in which the iridectomy is a necessary and these indications are as follows.

a) Imperforate surgical iridectomy.

b) Nanophthalmos

c) In cases where surgical iridectomy is not safe.

d) Cases where surgical iridectomy is refused.

e) Fellow eye after a complicated surgical iridectomy.

f) Fellow eye in malignant glaucoma.

g) Chronic angle closure glaucoma.

h) Combined mechanism glaucoma.

i) Pupillary block after cataract operation.

j) Suspected malignant glaucoma.

Energy Setting:

Although energy levels vary widely from machine to machine and sometimes within the same machine, majority of iridotomies are made with settings between 3 and 30 mJ/ shot. Minimum settings for an iridotomy in blue iris using Abraham's lens are approximately 3 to 4 mJ/ shot and with 1 to 3 shots / burst. Energy levels from 50% to 100% higher are necessary when performing iridotomy on thick brown iris. Energy delivery can be increased by using more power/ shot or more shots/ burst.

Proper focus is absolutely essential. The aiming beam is focused so that it is exactly on the anterior surface of the iris. The Nd- YAG laser beam is not retro focused so that it will strike in exactly the same position as the aiming beam. Power beam and aiming beam should be exactly coincidental and it should be checked periodically.

SITE OF IRIDOTOMY:

Any quadrant can be used for laser iridotomy although the superior nasal quadrant is the most preferred site. It has the advantages of

1) Iridotomy is beneath the upper lid.

2) Laser beams are directed towards nasal periphery of the retina.

Iridotomy is usually made in between the middle and outer 1/3 of the iris. However if this is not feasible due to peripheral corneal haze or proximity of peripheral iris and cornea, a more central location may be used as long as it is peripheral to the sphincter muscle. Depending on the pigmentation of iris, the iridotomy technique can be suitably tailored for medium brown iris, dark brown iris and blue iris.

The iridotomy should be placed as close to limbus as possible without causing endothelial cell burns due to the proximity of the iris to the endothelial surface. This is usually three quarters of the way from pupil to limbus with an argon laser. The 12'O clock position is usually avoided because bubbles created during iridotomy can migrate to this area and block visualization.

To prevent later mono ocular diplopia, the iridotomy should be performed within 2 mm of the base of the iris and an area along the 9 'O clock and 3'O clock involving the palpebral fissure should be avoided.

Technique:

An area of thin iris or a large crypt is usually easier to penetrate. In lightly pigmented eyes a local area of increased pigmentation such as a freckle may improve the absorption of laser energy. In the blue iris the radially arranged white collagen strands in the stroma are very difficult

to penetrate with argon laser and it is helpful to select a treatment site where two strands are more widely separated. (Hoslun's HD Miggliazzo CV, laser iridotomy technique for blue irises. Ophthalmolo Surgery 15:488, 1984)

When compared to either continous wave or pulsed argon lasers the Q switched Nd-YAG laser has the advantage of producing a quicker , more efficient iridotomy with equal or fewer complications including less frequent closure of the iridotomy.

The extremely high energy levels and short exposure times of pulsed Nd-YAG lasers electro mechanically disrupt the tissues, independent of pigment absorption and the thermal effect. The technique involves perforation of the iris with energy levels in the range of 5 to 15mJ. Pulsed duration and spot size are fixed and Abraham's lens can be used to focus the beam more precisely.

Focusing through the Abraham lens on the iris surface the red Helium Neon double beam may focus to a single spot and then advancing further 0.1mm posterior through the anterior surface into depth of iris stroma the single spot again becomes two spots. This indicates focus at a slightly deeper iris stroma than the anterior surface.

Caution should be used to avoid firing the laser through an already open iridotomy as it is possible to damage the anterior lens capsule. Iridotomy should be of adequate size to remain patent life long.

The indicators of complete patency is seeing the posterior pigment epithelium disrupted, watching for a through and through opening, an immediate flow of posterior chamber aqueous humor through patent iridotomy carrying pigments with it into anterior chamber, visualization of anterior lens capsule and transillumination through the iridotomy accompanied by an immediate deepening of peripheral part of anterior chamber.

If iridotomy is not complete with one application of laser beam, it is better to see another crypt. It is not usually wise to enlarge an iridotomy immediately as the edges are shredded and further applications may tend to sieve formation rather than an discrete iridotomy. It can be enlarged just to the side of previous iridotomy and even tiny Nd-YAG iridotomy remains patent.

Complication of Nd-YAG laser iridotomy:

1) Iritis
2) Pigment dispersion
3) Haemorrhage
4) Transient rise in IOP
5) Lens opacities
6) Rupture of anterior lens capsule
7) Localized corneal odema or scar
8) Failure to obtain patent iridotomy
9) Late closure of iridotomy
10) Transient pain and blurred vision.

MATERIALS AND METHOD

This study includes two sets of patents. First group consists of 42 eyes of 42 patients diagnosed as primary angle closure glaucoma, second one 40 eyes of 40 patients in which the other eye had history of PACG. Both group were treated with Neodymium-YAG laser iridotomies at the Department of Ophthalmology, Govt. Rajaji Hospital, Madurai between the period from April 2007 to August 2008.

Selection criteria

1) The patients who presented with acute angle closure glaucoma in one eye.
2) The patients who had acute angle closure glaucoma in one eye and were subjected to laser iridotomy as a preventive measure for the fellow eye.

Methods of examination:

All cases with any other ocular pathology were excluded from this study as well as secondary angle closure glaucoma cases were not taken up for this study. All the patients were evaluated with complete history, ocular examination with torch light , slit lamp biomicroscopy, visual acuity with Snellen's E chart, intraocular pressure measurement with schiotz indentation tonometer. Anterior chamber depth examination with torch light, van Herick's slit lamp technique and goldmann 3 mirror

gonioscopy (Shaffer's grading) and fundus examination were done in all cases.

The provocative tests were not done. The patients with acute attack was treated with antiglaucoma medications and Nd YAG laser iridotomy was only done when intra ocular pressure was under control and cornea had absolutely cleared.

Patients were prepared for Nd YAG laser iridotomy with 2% pilocarpine and 4% xylocaine eye drops. Abraham contact lens was used in all cases. Iridotomy was done with coherent VISUALS YAG –II laser made by m/s ZEISS, WEST GERMANY. Iridotomy was made either at 11' or 1'0 clock position in the peripheral iris. Either a crypt or thin area on the iris was selected. The amount of energy to make an opening on the iris was 4-6mJ.

The iridotomy was considered patent when the posterior pigment epithelium was seen to be disrupted and a through and through opening was seen on the iris, An immediate flow of a posterior chamber aqueous humor gush through the patent iridotomy carrying pigments with it into the anterior chamber. Visualization of deepening of peripheral part of anterior chamber and transillumination were conclusive evidences of the patency of the iridotomy. When the patency of iridotomy was doubtful

repeat Nd- YAG iridotomy was done either at the same spot or at a different site within a week.

A follow up was conducted on these patients for a minimum period of 3 months. It included IOP measurement with Schiotz tonometer and goniscopy on the day of iridotomy, after 1 hour, Second day, one week, one month and then three months after. Visual acuity recorded was checked in all cases post operatively and during follow up.

All the patients were closely watched for intraoperative and post operative complications. Gonioscopy was done to assess angle depth and to confirm the patency of iridotomy in all patients. Post operatively all patients were put on cipro- dexamethasone 0.1% drop 4^{th} hourly for a week.

Following Nd YAG laser iridotomy the patients with transient elevation in IOP of less than 10mm of Hg were treated with timolol maleate 0.5% twice daily and those with more than 10mm of Hg rise were given timolol maleate 0.5% twice daily along with tab. Acetazolamide 250mg thrice daily.

The patients in whom peripheral anterior synechiae were involving more than 50% angle were not taken up for Nd YAG laser iridotomy. In such cases a filtering surgery was done.

OBSERVATIONS & RESULTS

1: AGE INCIDENCE:

Total number of primary acute angle closure glaucoma patients who were treated with Nd YAG laser iridotomy was 42. These patients were grouped according to their age from below 40 years to 70 years with interval of 10 years. Maximum number of patients(50%) were between ages 51-60 years and minimum (4.76%) patients were above 71 years.

Table 1

Age group	No of patients	Percentage
40 - 50 years	5	11.90%
51-60	21	50.00%
61-70	14	33.30%
71 and more	2	4.76%

2. Sex incidence

A higher incidence was seen among females (66%) than in males (33.33%) in this study.

Table 2

Total no of patients	Males	Females	Percentage	
			males	females
42	14	28	33%	66%

3: Sex/age incidence

Table 3

age	Sex		Percentage
	Males	Females	
< 40 years	Nil	Nil	nil
41-50	Nil	5	12.00%
51-60	7	14	50.00%
61-70	6	8	33.33%
71 and above	1	1	04.76%
Total	14	28	

4. Distribution of patients according to age sex and diagnosis:

Table 4

Age group	**30-40**		**41-50**		**51-60**		**61-70**		**>70 yrs**	
Sex	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Acute PACG in one eye	nil	nil	nil	5	7	14	6	8	1	1
Treatment given as prophylaxis	nil	nil	nil	5	7	14	6	8	Nil	Nil

5. Energy requirements:

Table 5

Minimum total energy needed to obtain patent iridotomy was	46.42mJ
Maximum total energy needed to obtain patent iridotomy was	117.50mJ
Mean energy in males	52.80mJ
Mean energy in females	60.79mJ
Mean energy in light brown irides	95.90mJ
Mean energy in brown irides	48.15mJ

6: Case wise distribution of bursts used & no of sitting done:

Depending on the penetrability of the iris tissue, various bursts mode were used from one to five, maximum no. of cases were treated using three bursts (62% of cases). When the patency of the iridotomy was not attained with one sitting another attempt was made to perform to iridotomy within one week. 37 patients could be treated successfully in one sitting (88% of cases). Only 5 needed a repeat sitting within a period of one week (12% cases).

Table 6

No of bursts used	1 burst	Nil
	2	8
	3	32
No of sittings used	1^{st}	37
	2^{nd}	5

7. Table showing total energy, sittings required in both sex

Table 7

Total energy(mJ)		**Males**			**Females**		
		<50	**50-100**	**>100**	**<50**	**50-100**	**>100**
Burst	1	—	—	1	—	—	3
	2	2	5	—	—	8	3
	3	2	4	—	—	12	2
	4	—	—	—	—	—	—
Sittings	1	13	—	—	—	24	—
	2	1	—	—	—	4	—

8. Color of iris

Table 8

Brown color	42 cases

RESULTS

- Primary angle closure glaucoma formed 0.74%. new cases in this hospital.
- Female to male preponderance ratio is 2:1.
- Peak presenting age of PACG was between 51-60 years , which formed 50%.
- 42 eyes of 42 patients presenting with primary angle closure glaucoma were treated with Nd YAG laser iridotomy. In the same population 40 eyes of 40 patients with in the 42 patients were subjected to Nd YAG laser iridotomies on a prophylactic basis.
- All eyes with acute stages of PACG had patent iridotomies at the 3^{rd} month of follow up.
- 34 eyes which were treated with Nd YAG laser iridotomy for PACG had angle closure attack for the first time and 8 eyes gave history suggestive of past attacks and synechiae less than 90^0.
- No eyes with or without synechiae had shown closure of angle in the post YAG iridotomy period.

- In brown irides the minimal energy required to obtain patent iridotomy was 46.4mJ and maximum 100.5mJ.

- In light brown irides the minimal energy required to obtain patent iridotomy was 90.6mJ and maximal was 120.8mJ.

- The various complications recorded in this series of clinical study were the following. Pigment dispersion observed in 66.66% cases. Haemorrhage in the form of micro bleeding in 11% of cases and hyphema occurred in no cases. 66.66% eyes had recorded transient elevation of IOP and 12% had corneal oedema, of which 1 cases(25%) developed multiple macular grade opacities in the follow up period. No other complications were recorded in the entire follow up of the series.

- All the patients were given topical steroids in the post YAG period to control inflammation.

- 25 patients who had post YAG increase in IOP of less than 10 mm of Hg were treated with timolol maleate eye drops and 3 patients who had a raise of more than 10 mm of Hg were treated with timolol and oral acetazolamide.

- All the cases included in the study showed permanent reduction in IOP, although 28 cases(66.66%) had shown a transient elevation of

IOP following the YAG iridotomy. Maximum elevation was at the end of 1 hour procedure. These cases were responding very well to topical timolol and acetazolamide and IOP started lowering on second day.

Table 1

Success rate of Nd YAG iridotomy in this study

indication	No of eyes treated	%	Patency after 3 months	closure	Success rate
Acute stage of PACG	42	100%	42	nil	100%
Prophylactically in the other eye	40	100%	40	nil	100%

Table 2

Nd YAG iridotomy complications

Complications		No of eyes	Percentage
Pigment dispersion		28	66.66%
Bleeding	Micro haemorrhage	05	12%
	Hyphema	Nil	0.00%
Transient elevation of IOP	<10mm of Hg	25	60%
	>10mm of Hg	3	7.00%
Corneal oedema		4	12.00%
Focal lens opacities		Nil	0.00%
Others		Nil	0.00%

DISCUSSION

In this study the effect of Neodymium YAG laser iridotomy was evaluated on 42 patients with acute angle closure glaucoma on a therapeutic and prophylactic basis. All the patients were followed up for a period of 12wks during which the visual acuity, IOP and angle of anterior chamber were monitored.

Of the 82 eyes studied there was a high correlation with the findings of Lowe R.F (30) and Hillman J S in 1979 (31).

This study showed a female predilection of the disease which too is in good concurrence with the previous studies of Drance S.M (1973)32, Olurin O (1977) 33, Fontana S.T and Brubacker R.F (1980)34.

The management of angle closure glaucoma has benefited considerably in the past decade by introduction of Argon laser iridotomy. In general laser iridotomy when compared to surgical iridectomy offers the advantage of less complications. Penetration of iris in blue and very dark brown irides present some difficulties with argon. Schwartz using pulsed argon laser reports 20% failure to penetrate brown iris and 35% failure to do so in blue iris. Post laser closure is another complication known to argon. Quigley reports that in 148 cases 50 cases had (33%) required retreatment. Pollack reports that in a series of 77 consecutive

cases which were followed up for 4 years 26 cases (34%) required retreatment.

In contrast to argon laser where action is thermal and causing effect by burning and shrinkage of iris tissue, the Nd YAG laser for practical purposes is a cold laser, the tissue disruption being caused by optical breakdown and resulting shock waves. Transparent as well as pigmented tissue can therefore be cut with ease. Color of the iris becomes irrelevant . Nd YAG iridotomy appear to have minimal tendency to close in eyes uncomplicated by inflammation or neovascularization.

Comparisons with the literature

a. Efficacy and total energy required to obtain patent iridotomy.

	Klapper R M et al	**Naveh n et al**	**Present study**
Single session	100%	90%	90.4%
Two session	Not available	10%	9.5%
Total energy	32-96 mJ	20.8- 97 mJ	46.42 -117.5mJ

b. Closure of Nd YAG laser iridotomy

Pollack I P et al	**Klapper R M et al**	**Naveh N et al**	**Present study**
Nil	Nil	10%	Nil

c. Post Nd YAG iridotomy IOP rise:

It is now recognized as a common although usually transient complication. In present study 25 eyes showed an increase of less than 10mm of Hg in IOP over the baseline. The greatest rise observed was at 1 hour after YAG laser iridotomy. The maximum elevation in IOP was however 12.0mm of Hg.

d. Bleeding from iridotomy site:

Moster M R Schwatrz spaeth G L et al	Klapper R et al	Naveh N et al	Pollack I P et al	Present study
34.2%	15%	20%	45%	12%

e) Corneal odema:

Pollack I P Robin A L	Present study
35%	12%

In this present study we were able to control the IOP below 23mm of Hg without any medication in 100% patients.

Yamamoto J Shivato S Kitazawa Y		Present study
Without medication	29%	Without medication 100%
With same or reduced medication	52%	
Increased medication	13%	
No control even with medication	6%	

The various complications reported by other authors like lens opacities, lens subluxation, monocular blurring, lens rupture and aqueous mis direction syndrome (malignant glaucoma) were not met in this study.

CONCLUSIONS

From the study we can conclude that primary angle closure glaucoma, is an uncommon disease of the sixth decade,. It must be diagnosed and managed quickly and effectively to prevent visual loss.

Once an acute attack has been controlled with anti glaucoma medication, a Nd YAG laser iridotomy is indicated and it can be safely and successfully done to prevent the attack from recurring. It has also been found to be of much safety and efficacy in the fellow eyes of patients in whom one eye suffered an attack or gives a past history suggestive of it.

Nd YAG laser iridotomy is indicated in the prodromal stage, stage of constant instability and acute congestive stage.

A laser setting of multiple bursts with low total energy has been found to be more effective than burst with high total energy.

Transient elevation in IOP, micro haemorrhage, pigment dispersion, corneal odema and delayed opacification were seen as the most frequent complications. The transient elevation in IOP was seen for a period of 1-3 hours, the peak of which was seen in 1 hour and it could be controlled with topical B- blocker agent alone or in combination with acetazolamide. The bleeding was from the iris vessels and was in the

form of micro haemorrhage. No case of hyphema was seen. Corneal oedema which occurred in very few cases in the immediate post laser period was self limiting and fully resolved in all cases within a period of 1 week.

The other complication of Nd YAG laser iridotomy reported by previous studies like lens opacification, subluxation, aqueous misdirection syndrome were not reported in this study.

All the patients treated showed considerable reduction in IOP increase in the angle of the anterior chamber and significant improvement in visual acuity.

Anti-glaucoma medications could be stopped as soon as the IOP started lowering following a functioning laser iridotomy and all the patients were well stabilized at the end of the follow up.

Prophylactic iridotomy in the other eyes efficiently prevented an attack of angle closure glaucoma.

It follows that Nd YAG laser iridotomy is particularly beneficial to reduce the IOP in primary angle closure glaucoma and is a very efficient measure in preventing an attack of angle glaucoma in predisposed eyes.

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PROFORMA

A. Name of the patient: Hospital No.

Age: sex:

B. History of present illness: pain/colored haloes/ blurred vision headache/ redness

Treatment history:
Optical history:

Family history:

C. Examination findings RE LE

congestion conjunctival

ciliary

cornea clear/ hazy

epithelium

stroma

endothelium

anterior chamber general depth

shallow/ normal

peripheral depth grade 4/3/2/1

(using slit lamp technique of van herick)

A C content: clear/ flare/ flare & cells/pigments.

iris bombe : yes/ no

iris color: dark brown/medium brown/ blue

pattern: normal/ distorted

atrophy: yes/ no

pupil : size: normal / dilated

shape: round / vertically oval/ irregular

reaction: brisk/ sluggish/ non reacting

synechiae: yes / No

lens : clear/ pigments over anterior capsule

visual acuity: snellen's test types.

fundus: direct ophthalmoscope:

disc:

vessels:

macular

back ground:

I.O.P: schiotz tonometry:

goniscopy: goldmann's triple mirror lens : grade 4/3/2/1/0.

(shaffer's system of grading angle)

D. Laser iridotomy indications: prodromal/ constant instability / acute congestive / fellow eye with ACG.

E. Pre Nd-YAG(if any):

pilocarpine/ timolol maleate/ acetazolamide/ mannitol.

Duration

F. Status after pre Nd-YAG treatment: I.O.P

G. Details of Nd -YAG iridotomy:

topical anaesthesia : yes / no

iridotomy site : upper temporal / upper nasal

energy setting : ……..mJ.

No.of shots :

No. of setting required to attain patency : one / two/more than two.

H. Follow up: : post YAG I.O.P vision AC depth gonioscopy

a) after 1 hour

b) after 2 hour

c) after 1 day

d) after 1st week

e) after 1 month

f) after 3 months

I. Post Nd YAG iridotomy treatment (if any) corticosteroids/ pilocarpine/ timolol maleate/ acetazolamide duration

J. Complications following Nd YAG laser iridotomy.

a) Transient pain & blurred vision

b) Corneal burns / endothelial loss

c) Iris pigment release / bleeding from iridotomy site/ micro haemmorrhage/ hyphaema.

d) Uveitis

e) Lens : perforation of lens capsule Localized non progressive lens opacity.

f) Retina : retinal burns/ CME/ retinal detachment.

g) IOP rise: transient / prolonged.

h) Visual loss:

i) Choroidal detachment

j) Failure to obtain patent iridotomy

k) Late closure of iridotomy.

Appendix-I

Abbreviations used:

AACG	-	acute angle closure glaucoma.
AG	-	absolute glaucoma
ACD	-	anterior chamber depth
AZ	-	acetazolamide
BV	-	blurring of vision
Ch	-	colored halos
CF	-	counting fingers
CCC	-	circum corneal congestion
CE	-	corneal odema
CO	-	corneal opacity
CG	-	chronic glaucoma
Gn	-	gonioscopy
HE	-	micro haemorrhage
Gr	-	grade
HA	-	headache
IOP	-	intra ocular pressure
LE	-	left eye
µM	-	microns

mJ	-	milli Joules
mm	-	millimeter
Pa	-	pain
PAS	-	peripheral anterior synechae
PACG	-	primary angle closure glaucoma
PL	-	perception of light
PD	-	pigment dispersion
PG	-	prodromal stage
PI	-	peripheral Iridotomy
PY-I	-	prophylactic iridotomy
RE	-	right eye
R	-	redness
S	-	steroid
Sy	-	symptoms
Sn	-	Signs.
T	-	timolol maleate
VA	-	Visual acuity
Tr.ill	-	trans illumination
+ve	-	patent iridotomy
-ve	-	closed iridotomy.

Appendix II

Master chart—1

Details of clinical presentation of PACG

Sl No	Name	Hospital No	Age Sex	Eye Rx	Clinical features	Signs & ACD	Gn gr	IOP mm of Hg	V .A
1	Muthukarupan	78216	73M	RE	Pa, Bv	CE+III	0	44.5	6/24
2	Govindarajan	78538	52M	LE	Bv,PA+	CE+II	0	54.2	6/12
3	Chinnamma	75004	71 F	RE	Bv+Pa+	CE+ I	0	64.0	6/24
4	Ponthayee	75095	43 F	RE	Bv+ Pa+	II	0	59.1	6/12
5	Manikandan	75118	56M	LE	Pa+	I	0	18.9	6/24
6	Muniyammal	75293	48 F	RE	Bv+	CE+	0	42.14	6/36
7	Thangamani	75707	63M	RE	Pa+ Bv+	CCC ,I	0	49.8	6/9
8	Palanimmal	76097	60F	LE	Bv+	I	0	53.6	6/60
9	Periyadakki	78353	45F	LE	Pa+,Ch+	II CCC+	0	43.4	6/18
10	Pushpam	80818	57F	LE	Ch+	I	0	40.2	6/12
11	Periyadakkan	81864	69M	LE	Pa+	I	0	81.7	PL
12	Mariappan	84225	59M	RE	Bv+	CE+ I	0	49.8	6/12
13	Karupaiah	85005	52M	LE	Bv+	CE+ II	0	57.6	6/24
14	Janaki	85234	62 F	LE	Pa+ Bv+	II	0	49.9	6/18
15	Subbammal	89543	59 F	LE	Bv+	CCC+ II	0	40.2	6/18
16	Gopalakrishna	91003	48M	LE	Pa+ Ch HA	CE+ I	0	53.6	6/36
17	Tamilselvam	92340	58M	LE	Ch+	CE+ I	0	50.6	6/36
18	Thayammal	960831	53 F	LE	Ch+ Bv+	CE+I CCC+	0	34.5	6/18
19	Vasantha	96566	65 F	RE	Bv+Ch+HA +	CE+ I	0	41.5	6/12
20	Pandiammal	97456	61 F	RE	Pa+	CCC+ CE+	0	38.8	6/12

Sl No	Name	Hospital No	Age Sex	Eye Rx	Clinical features	Signs & ACD	Gn gr	IOP mm of Hg	V .A
21	Vellaiammal	98269	52 F	RE	Pa+ Bv+	CCC=	0	64.0	6/24
22	Seethammal	98510	52 F	RE	Bv+	CE+II	0	66.2	6/24
23	Adakki	98892	54 F	RE	Bv+	CE+ I	0	35.8	6/36
24	Pandi	99102	63 M	RE	Bv+ Ch+	CCC+ I	0	54.2	6/24
25	Muniyandi	99456	70 M	LE	Bv+Ch+	CCC+	0	41.5	6/367
26	Kadeeja begaum	99503	58 F	LE	Ch+ HA+	CCC+ II	0	37.8	6/60
27	Ponnamma	100558	60 F	LE	Bv+	CCC+ CE+	0	45.8	6/60
28	Lakshmi	102459	61 F	LE	Bv+	CE+ II	0	46.9	6/36
29	Periyalagan	103700	68 M	LE	Bv+	CE+ II	0	37.8	6/24
30	Chinakarupaiah	103457	58 M	RE	*Ch+	CE+I	0	59.8	5/60
31	Jeyasheela	105780	63 F	RE	Pa+	CE+	0	54.2	CF3m
32	Shanmugam	104560	52 M	LE	Pa+ Bv+	CE+ I	0	46.9	6/60
33	Muthupandian	110980	54 M	LE	Ch+ HA+	CE+ I	0	64.0	6/36
34	Haneefa begaum	113806	56 F	RE	Ch+ Bv+	CE+II	0	34.5	6/24
35	Eshwari	116890	55 F	LE	Bv+	CCC+II	0	57.6	6/60
36	Mariammal	118456	62 F	RE	Bv+ Pa+	CE+ I	0	49.9	6/36
37	Ramuthayee	119034	63 F	LE	Ch+	CE+ I	0	43.4	6/24
38	Alagammal	123209	63 F	RE	Pa+Ch+HA +	CE+II	0	53.6	6/60
39	Chinnadaki	126703	60 F	LE	Pa+	CE+ I	0	42.1	6/36
40	Saithanbeevi	129043	53 F	RE	Bv+	CE+II	0	59.1	6/36
41	Meenammal	157803	64 F	LE	Bv+	CE+CCC+	0	54.7	6/60
42	Palaniammal	160234	54 F	LE	Bv+	CE+ I	0	50.6	4/60

Master chart -2

Treatment data

Sl no	IOP pre YAG	Total energy	Post YAG Rx features	Post YAG VA	Poat YAG Gn, Trans illumination
1	26.6	84.4	S	6/24	III Tr+
2	24.4	96.0	S+T	6/12 F	III Tr+
3	29.0	78.5	S+ T	6/24	III Tr+
4	22.4	87.6	S+ T	6/18P	III Tr+
5	20.6	89.0	S	6/24	III Tr+
6	23.8	74.0	S	6/36	II Tr+
7	23.1	96.0	S+T	6/18	III Tr+
8	22.4	108.0	S+T+Az	6/60	III Tr+
9	26.6	92.0	S+T	6/18	II Tr+
10	23.1	96.0	S+T	6/12	III Tr+
11	33.0	72.0	S	6/18	III Tr+
12	25.1	98	S	6/12	III Tr+
13	24.4	46.8	S	6/18	III Tr+
14	20,6	70	S+ T	6/9	III Tr+
15	23.8	92.5	S+T	6/18	III Tr+
16	25.8	94.5	S+	6/24	II Tr+
17	20.6	48.4	S	6/36	III Tr+
18	23.8	51.9	S+T	6/18	II Tr+
19	24.4	60.4	S+T	6/12	III Tr+
20	20.6	90.6	S+T	6/24	III Tr+
21	25.8	72	S+T	6/24	II Tr+
22	29.0	42.6	S	6/24	III Tr+

Sl no	IOP pre YAG	Total energy	Post YAG Rx features	Post YAG VA	Poat YAG Gn, Trans illumination
23	23.8	54.8	S	6/36	II Tr+
24	30.4	24.1	S+T+Az	6/60	II Tr+
25	24.4	69.8	S+T	6/24	III Tr+
26	22.4	77.0	S+T	6/60	III Tr+
27	29.0	98.0	S+T	6/60	III Tr+
28	22.4	76.4	S+T	6/36	III Tr+
29	23.0	68.4	S+T	6/24	III Tr+
30	23.1	102	S+T+Az	6/36	II Tr+
31	26.6	99	S+T	6/24	III Tr+
32	23.8	100.5	S+T	6/60	III Tr+
33	21.3	99	S+T	6/36	III Tr+
34	29.0	120.8	S+T	6/24	II Tr+
35	26.6	90.6	S+T	6/24	II Tr+
36	23.1	56.4	S	6/18	III Tr+
37	25.8	36.4	S	6/24	III Tr+
38	23.8	75.0	S+T	6/18	III Tr+
39	22.4	71.8	S+T	6/24	III Tr+
40	20.6	79.5	S+T	6/36	II Tr+
41	18.5	46.6	S	6/12	III Tr+
42	28.0	102.5	S+T	6/60	II Tr+

Master chart 3

Follow up data IOP, Gn,VA

Sl No	1st hour	2nd day	1st week	1st month	3rd month	Complications
1	24.4,III,6/18	23.8III 6/18	23.8 III 6/12	21.3 III 6/12	19.6 6/12	PD,
2	31.6 III 6/12	28.3III 6/12	23.8III 6/12	20.6 III 6/9	20.6/9	MHE
3	20.6III 6/24	19.6III 6/12	21.3 III 6/24	18.9III 6/24	18.9 6/24	PD
4	34.5III 6/24	33.0III,6/24	23.8 III6/24	20.6III 6/24	20.6 6/24	NIL
5	19.6 III 6/12	19.6III 6/12	18.9 III6/12	18.9 III 6/12	18.9.6/9	PD
6	22.4 III 6/36	21.9III 6/36	19.3III6/18	18.9 III 6/12	18.9 6/12	NIL
7	28.0 III 6/9	26.6 III 6/9	23.1 III 6/9	21.9 III 6/9	20.6 6/6P	NIL
8	34.4 III 4/60	31.8II 4/60	30.4III 6/24	23.8III 6/18	21.6 6/18	PD CE
9	31.8II 6/18	23.1 II 6/18	23.1 II6/12	20.6 II 6/12	18.9 6/9P	NIL
10	17.3II 6/12	17.0 II 6/12	17.3 II 6/12	17.3 II 6/12	17.3 6/12	NIL
11	17.3 II 6/24	15.8II 6/18	14.6II 6/18	14.6 II 6/12	15.96/12	NIL
12	29.4II 6/24	35.8 III6/24	31.8III6/12	23.1III 6/12	20.6,6/12	PD MHE
13	23.8 II 6/24	21.3II6/24	21.3 II 6/24	21.3 III 6/24	20.6 6/24	MHE
14	29.0III6/12	21.9III6/12	18.9 III 6/9	17.3III 6/9	17.3 6/9	NIL
15	23.8II 6/18	20.6II6/18	20.9 II 6/18	18.9II6/9	17.3 6/12	NIL
16	31.8II 5/60	27.2II6/60	21.9II 6/24	19.8 III6/18	18.9 6/18	MHE .CO
17	33.9II 6/36	27.2II6/36	21.9II6/18	20.6III6/18	20.6 6/18	NIL
18	28.0III6/18	21.3III6/18	20.6III 6/18	18.9III 6/18	18.9 6/12P	NIL
19	29.4III6/18	23.8III6/18	21.8III6/12	21.9III 6/12	19.8 6/12	NIL
20	29.3III 6/24	3.8III6/24	20.6III6/18	18.9II 6/18	20.6 6/18	NIL
21	28.6 III 6/24	20.6III6/24	20.6 III6/12	18.9III 6/12	18.9 6/9	NIL
22	20.1III6/24	18.9II6/24	17.3III6/12	17.3III6/12	17.3 6/9P	NIL

Sl No	1st hour	2nd day	1st week	1st month	3rd month	Complications
23	31.6II6/36	24.4II 6/36	21.3	II 6/18	20.6 II 6/12	MHE
24	28 II 6/18	20.6II6/18	19.8II 6/12	18.9II6/12	17.3 6/12	NIL
25	27.2III6/36	22.4III6/36	22.4III6/12	20.6III6/12	20.66/12	NIL
26	26.6III6/60	18.9III6/60	18.9III6/24	17.3III6/18	18.9 6/12	NIL
27	18.5III6/60	18.5III6/60	17.3III6/24	17.3III6/12	17.3 6/9	NIL
28	26.6III 6/36	21.9III6/36	20.6III6/24	20.6III6/12	20.6 6/12	PD
29	27.2III6/24	23.1III6/24	21.3III 6/12	21.3III6/12	20.6 6/12	NIL
30	29.0III6/24	21.3III6/60	21.3III 6/60	21.3III6/18	20.6 6/12	NIL
31	30.4IIICF	25.8 III CF	21.3III6/36	21.3 III 6/18	20.6 6/18	MHE
32	21.3III6/60	18.9III6/60	15.9III6/24	15.9III6/24	17.3 6/12	NIL
33	26.6II6/24	18.9II6/24	18.9II6/18	18.9 II 6/12	18.9 6/9P	NIL
34	33 II 6/60	28II 6/60	23.8II 6/24	23.8II6/12	20.6 6/9	CE CO
35	29.4II 6/24	23.8II6/24	21.3II6/24	21.3II6/9	20.6 6/9	MHE
36	21.3III6/60	18.9III6/60	18.9III6/18	18.9III6/9	18.9 6/9	NIL
37	29.0III6/18	22.4III6/18	22.4III6/18	22.4III6/12	20.6 6/12	PD
38	26.6 III 6/24	23.8 III6/24	20.6 III6/9	20.6III6/9	20.6 6/9	NIL
39	28.0II6/60	21.8II6/60	20.6II6/12	20.6II6/12	20.6 6/12	CE
40	24.4II 6/12	20.6II6/12	20.6II6/12	20.6 II 6/12	20.6 6/6P	NIL
41	17.3 III6/12	15.9III6/12	15.9III6/12	15.9III6/6P	15.9 6/6P	NIL
42	31.8II6/60	24.4II6/60	24.4II 6/24	120.6II 6/24	20.6 6/12	NIL

Master chart 4

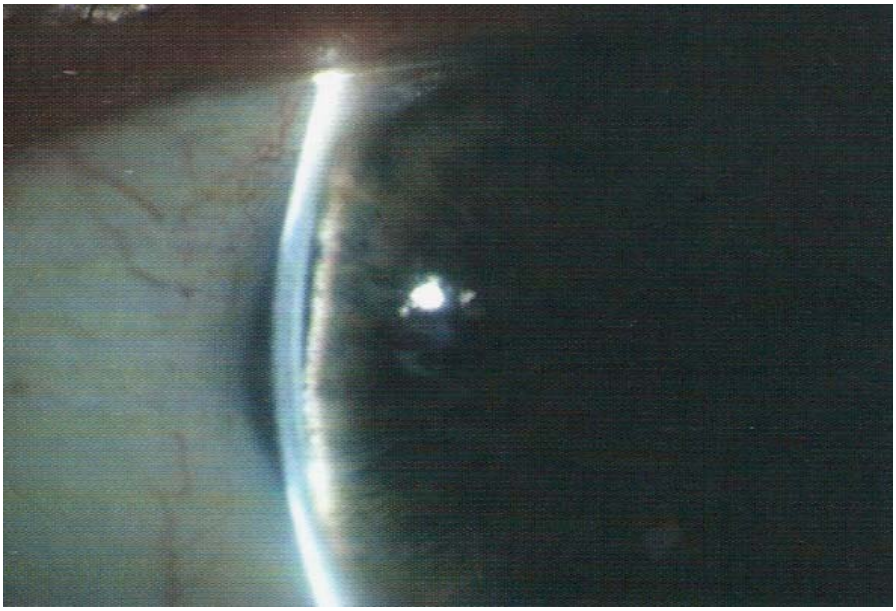
Details of cases in which fellow eye was treated prophylactically.

Sl no	Name	Hosp. no	age	Eye treated	IOPmm of Hg	Gn	VA	Post YAG IOP mm of Hg	Post YAG VA
1	Govindarajan	78538	52M	RE	21	I	6/9	19.6	6/9
2	Ponthayee	75095	43 F	LE	18.4	II	6/18	15.9	6/12
3	Manikandan	75118	56M	RE	17.3	II	6/12	17.3	6/9P
4	Muniyammal	75293	48 F	LE	17.3	I	6/24	17.3	6/18
5	Thangamani	75707	63M	LE	17.3	II	6/12P	17.3	6/12
6	Palanimmal	76097	60F	RE	18.9	I	6/12	17.3	6/9
7	Periyadakki	78353	45F	RE	21	I	6/24	17.3	6/18
8	Pushpam	80818	57F	RE	20.6	II	6/6	18.4	6/6
9	Periyadakkan	81864	69M	RE	17.3	II	6/6P	17.3	6/6
10	Mariappan	84225	59M	LE	18.9	I	6/12	15.9	6/12
11	Karupaiah	85005	52M	LE	18.9	I	6/9	15.9	6/9
12	Janaki	85234	62 F	RE	17.3	I	6/9	14.6	6/6
13	Subbammal	89543	59 F	RE	19.6	I	6/24	17.3	6/24
14	Gopalakrishna	91003	48M	RE	15.9	II	6/6	14.6	6/6
15	Tamilselvam	92340	58M	RE	16.2	II	6/9	15.9	6/9
16	Thayammal	960831	53 F	RE	18.6	II	6/6	17.3	6/6
17	Vasantha	96566	65 F	LE	17.3	II	6/24	17.3	6/12
18	Pandiammal	97456	61 F	LE	20.6	II	6/24	18.9	6/24
19	Vellaiammal	98269	52 F	LE	18.9	II	6/36	18.9	6/36
20	Seethammal	98510	52 F	LE	17.3	II	6/18	17.3	6/18
21	Adakki	98892	54 F	LE	14.6	II	6/24	14.6	6/24

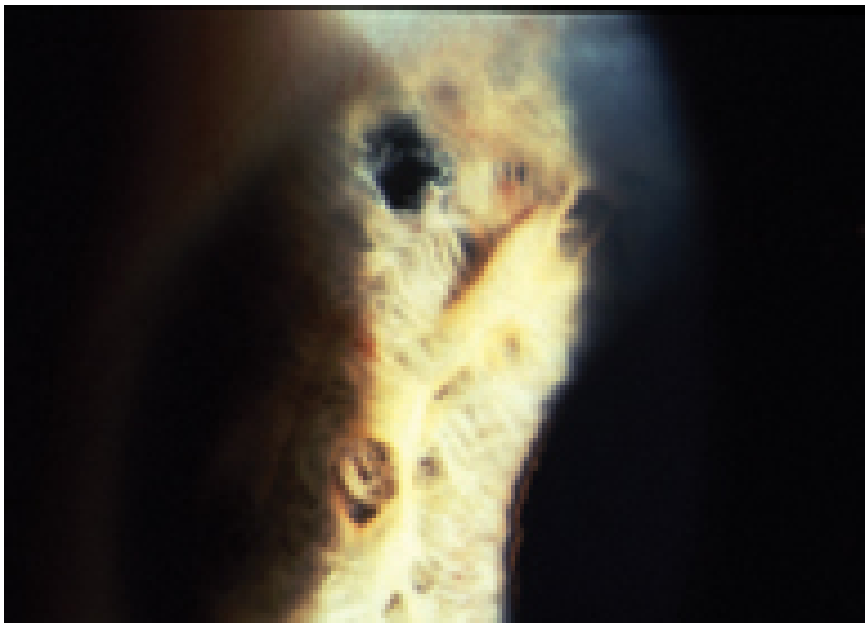
S.No.	Name	Hospital No	Age Sex	Eye Rx	IOPmm of Hg	Gn	VA	Post YAG IOP mm of Hg	Post YAG VA
22	Pandi	99102	63 M	LE	17.3	I	6/24	17.3	6/24
23	Muniyandi	99456	70 M	RE	18.9	I	6/36	18.9	6/36
24	Kadeeja begaum	99503	58 F	RE	14.6	II	6/60	14.6	6/60
25	Ponnamma	100558	60 F	RE	17.3	II	6/60	17.3	6/60
26	Lakshmi	102459	61 F	RE	18.9	II	6/24	18.9	6/24
27	Periyalagan	103700	68 M	RE	18.9	II	6/24	18.9	6/24
28	Chinakarupaiah	103457	58 M	LE	17.3	II	6/36	17.3	6/36
29	Jeyasheela	105780	63 F	LE	18.9	II	6/60	18.9	6/60
30	Shanmugam	104560	52 M	RE	17.3	II	6/36	17.3	6/36
31	Muthupandian	110980	54 M	RE	14.6	II	6/24	14.6	6/24
32	Haneefa begaum	113806	56 F	LE	17.3	II	6/24	17.3	6/24
33	Eshwari	116890	55 F	RE	15.9	II	6/24	15.9	6/24
34	Mariammal	118456	62 F	LE	18.9	II	6/18	18.9	6/18
35	Ramuthayee	119034	63 F	RE	20.6	II	6/24	20.6	6/24
36	Alagammal	123209	63 F	LE	18.9	I	6/36	18.9	6/36
37	Chinnadaki	126703	60 F	RE	15.7	II	6/36	15.7	6/36
38	Saithanbeevi	129043	53 F	LE	17.3	II	6/36	17.3	6/36
39	Meenammal	157803	64 F	RE	17.3	II	6/36	17.3	6/36
40	Palaniammal	160234	54 F	RE	18.9	II	6/60	18.9	6/60

THE VISUALS ND YAG II LASER SYSTEM

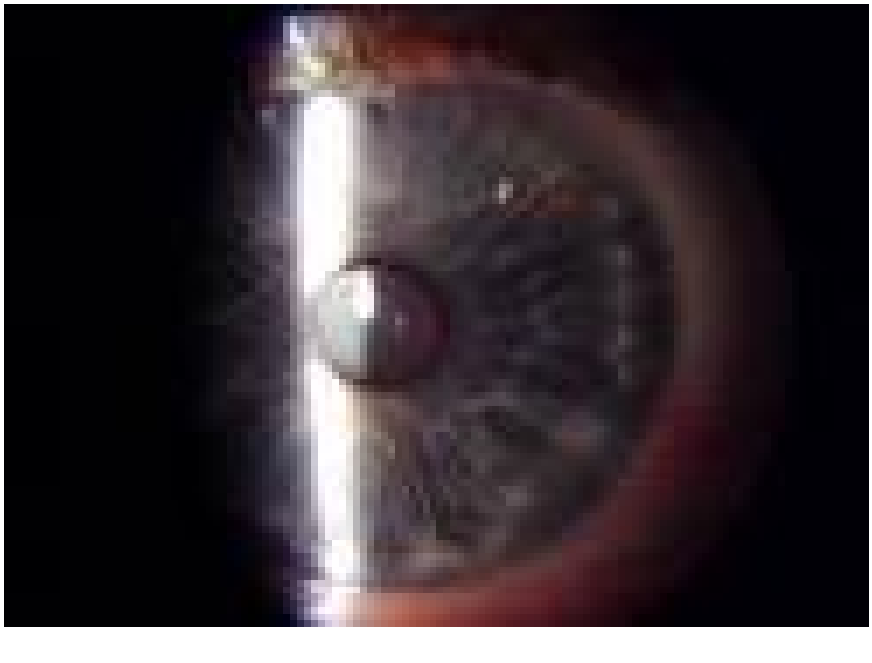
VAN HERICK'S TECHNIQUE – REVEALING A SHALLOW ANTERIOR CHAMBER



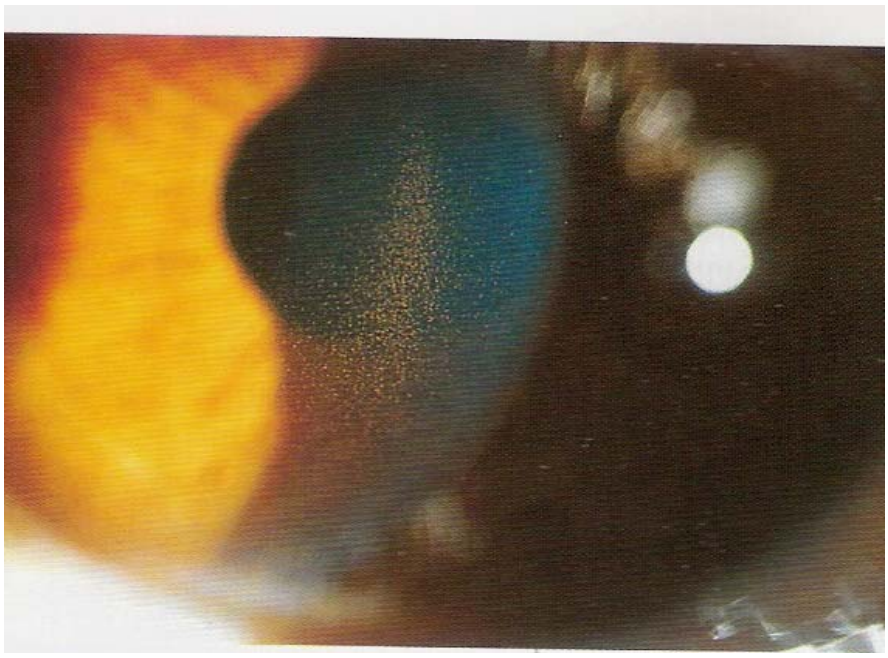
A PATENT LASER IRIDOTOMY



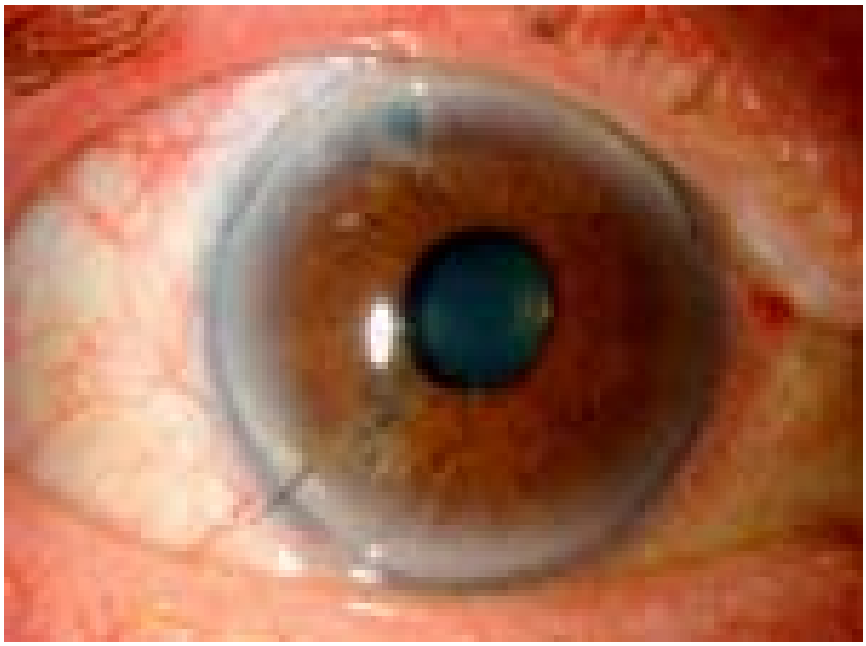
TRANSILLUMINATION TEST SHOWS PATENT IRIDOTOMY



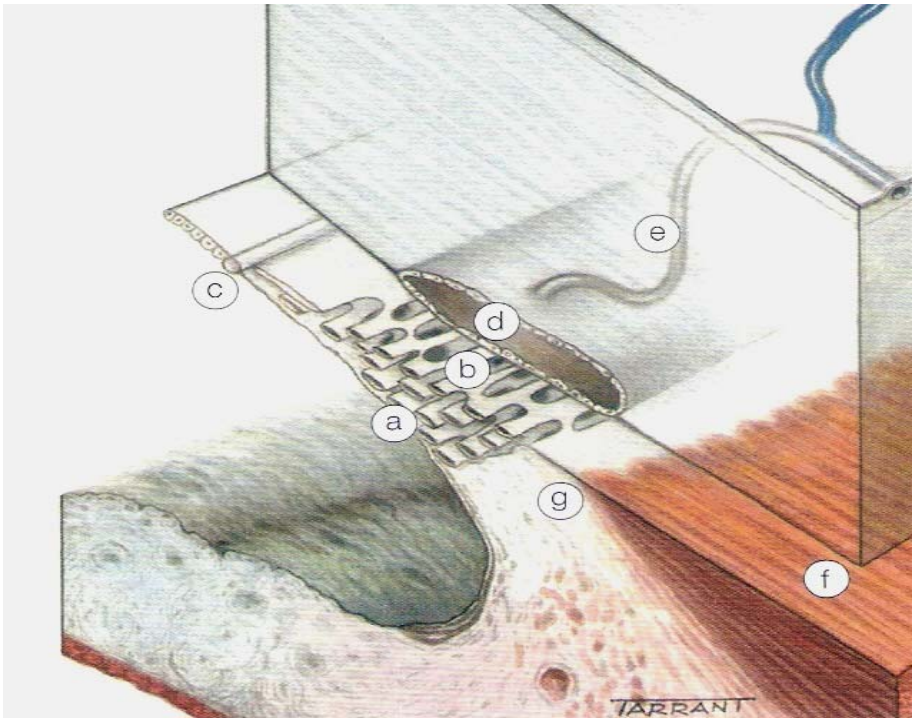
PIGMENT DISPERSION OF THE IRIS



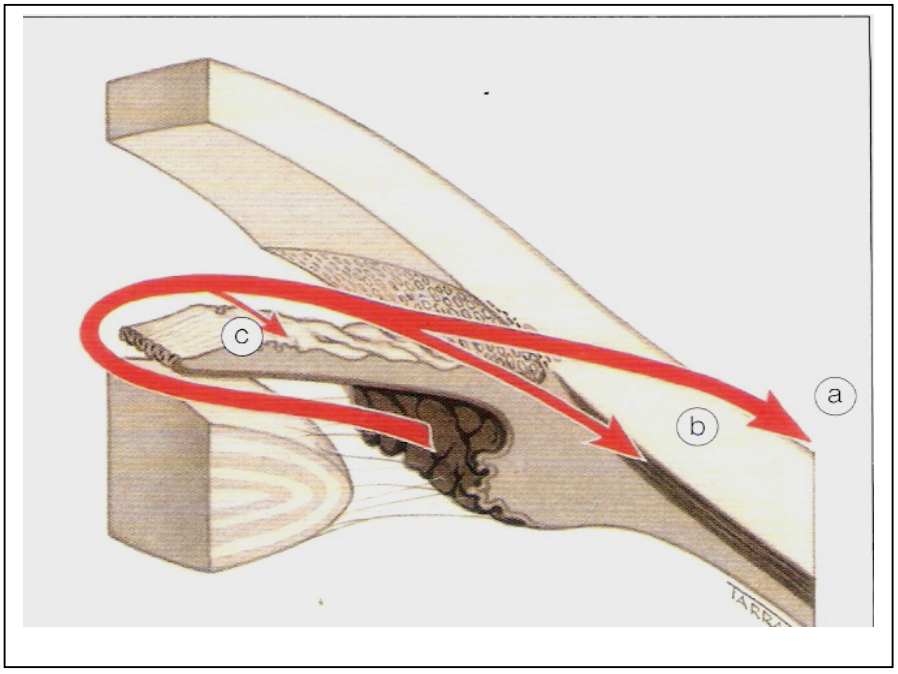
CORNEAL OPACITIES



ANATOMY OF OUT FLOW CHANNELS

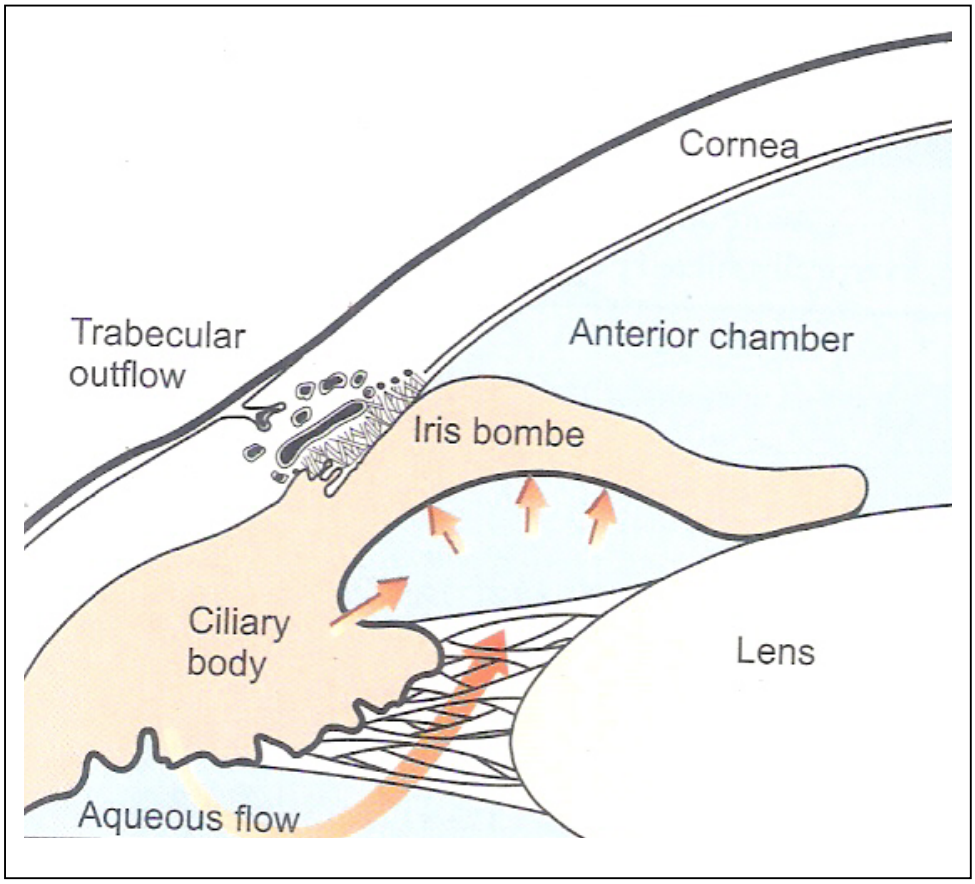


ROUTES OF AQUEOUS OUT FLOW



HISTOLOGY OF IRIS

PUPILLARY BLOCK CAUSING ANGLE CLOSURE



PERIPHERAL LASER IRIDOTOMY RELIEVING

PUPILLARY BLOCK