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Effect of Nd: YAG Laser Capsulotomy on Intraocular Pressure in Sample of Iraqi Pseudophakic Patients

A Dissertation Submitted to the Institute of Laser for Postgraduate Studies, University of Baghdad in Partial Fulfillment of the Requirements for the Degree of Higher Diploma in Laser in Medicine - Ophthalmology

BY

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Dedication

To my father soul, who learn me how to be merciful with patients

To my mother, who spend her life for me

To my wife and family

Ahmed

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Abstract

Introduction

Posterior capsule opacification is one of the most common post cataract surgery complication which mean thickening of posterior lens capsule leading to decrease in visual acuity and contrast sensitivity.

Nd: YAG laser posterior capsulotomy performed in order to clear the visual axis and improve visual acuity.

Objective

This study is conducted with view to determine the significance of intraocular pressure elevation and visual improvement after laser capsulotomy in pseudophakic eye patients

Patients and method

Nd: YAG laser (1064 nm) was used to perform capsulotomy to a twenty eyes of seventeen patients, eleven males and six females with age range from 39 to 73 years old and post cataract surgery period ranged from 6 months to 4 years. Intraocular pressure (IOP) were checked with air puff tonometer and visual acuity (VA)by Snellen's chart. Pre capsulotomy checking of IOP and VA was done then rechecking IOP after 30 min, 1 hour, 2 hours and 3 hours then after one-week reevaluation of IOP and VA done.

Results

Elevation of IOP was documented after 30 min post procedure and increasing for the next 3 hours but didn't became clinically significant and didn't exceed 25 mmHg. Most of patient (65%) get 2 line, or better, correction of VA.

Conclusion

Elevation of IOP is common after laser capsulotomy and is mostly related to total laser energy. No need for ocular hypotensive drugs when the treated patient had normal IOP prior to procedure.

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Abbreviation

Nd	*Neodymium*
YAG	*Yttrium—Aluminum-Garnet*
PCO	*Posterior capsule opacification*
Phaco	*Phacoemulsification*
ECCE	*Extracapsular cataract extraction*
SSI	*Scleral small incision*
IOL	*Intraocular lens*
PMMA	*Polymethylmethacrylate*
ms	*millisecond*
ns	*nanosecond*
ps	*picosecond*
IOP	*Intraocular pressure*
VA	*Visual acuity*
BCVA	*Best corrected visual acuity*
CW	*Continuous Wave*
CVA	*Cerebrovascular accident*
RD	*Retinal detachment*
D	*Diopter*
CME	*cystoids macular edema*
mmHg	*millimeter mercury*

CHAPTER ONE

INTRODUCTION AND BASIC CONCEPTS

1. Introduction

Posterior capsule opacification is one of the most post cataract surgery complication which mean thickening of posterior lens capsule due to remnant of lens epithelial cells that proliferate after a period and leading to decrease in visual acuity, contrast sensitivity and difficulty in reading and driving.

Nd:YAG laser posterior capsulotomy is a non interventional procedure by which a rupture in the posterior capsule is performed in order to clear the visual axis and improvement of visual acuity achieved. Previously this was done surgically by a needle.

This study will discuss the effect of Nd: YAG laser capsulotomy on intraocular pressure and on visual acuity improvement.

1-1 Review of ocular anatomy

The eye is a complex organ with precise dynamic optical system that focusing light on a layer of receptors which convert light energy to nerve impulse. These impulse conducted to the visual cortex of the brain through a system of nerves to set up a conscious visual image. [1]

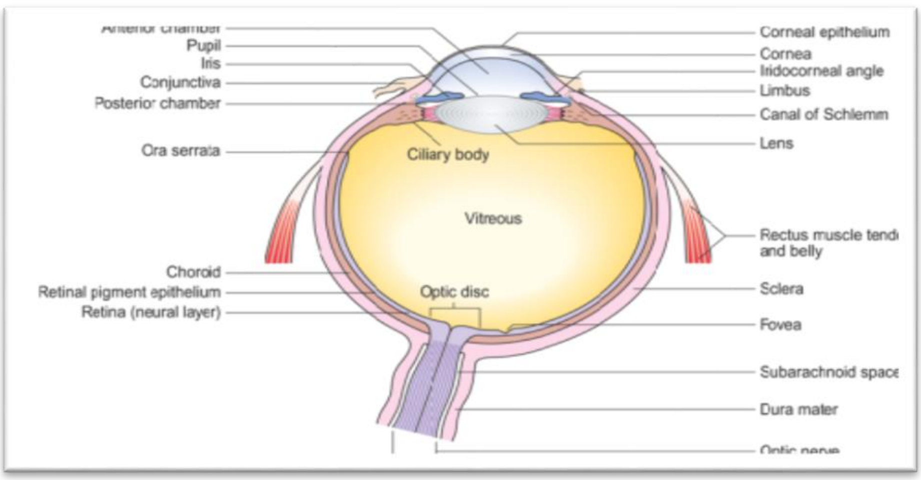

Fig.1-1 Anatomical layers of the eye

The eye (fig.1-1) composed mainly from the following

Conjunctiva: is a transparent mucous membrane lining the inner surface of the eyelids and the surface of the globe as far as the limbus. It is richly vascular structure.

Cornea: It is the most anterior and transparent part of the eye. Composed of 5 layers with average total thickness of 540 micrometers. It is a-vascular and the most densely innervated tissue in the body. It is responsible for about three-quarters of the optical power of the eye.

Sclera: It is strong, a vascular structure composed mainly from collagen fibers. The sclera covers the posterior four fifths of the surface of the globe, with an anterior opening for the cornea and a posterior opening for the optic nerve. The tendons of the rectus muscles insert into the superficial scleral collagen.

Uveal tissue: It is the pigmented vascular layer of the eye and comprises the iris, ciliary body and choroid.

Crystalline lens: It is a biconvex structure located directly behind the posterior chamber and pupil. The lens contributes 20 D of the 60 D of focusing power of the average adult eye. The anteroposterior width of the lens is about3-6mm. The lens has certain unusual features. It lacks innervation and is avascular.

Lens capsule: It is the basal lamina and product of the lens epithelium. It is rich in type IV collagen and other matrix proteins. Synthesis of the anterior lens capsule proceeds throughout life, so that its thickness increases, whereas that of the posterior capsule remains relatively constant. Its thickness is 15.5 micrometer for the anterior capsule and 2.8 micrometer for the posterior capsule [1].

Retina is the light sensitive structure in the eye, it contains the photoreceptors (rods and cons) which are responsible for action potential generation that transmitted to the visual cortex via the optic nerve.

1-2 Ocular refraction system

In the eye, light is actually refracted at the anterior surface of the cornea and at the anterior and posterior surfaces of the lens (fig.1-2). It should be noted that the retinal image is inverted. The connections of the retinal receptors are such that from birth any inverted image on the retina is viewed right side up and projected to the visual field on the side opposite to the retinal area stimulated. [2]

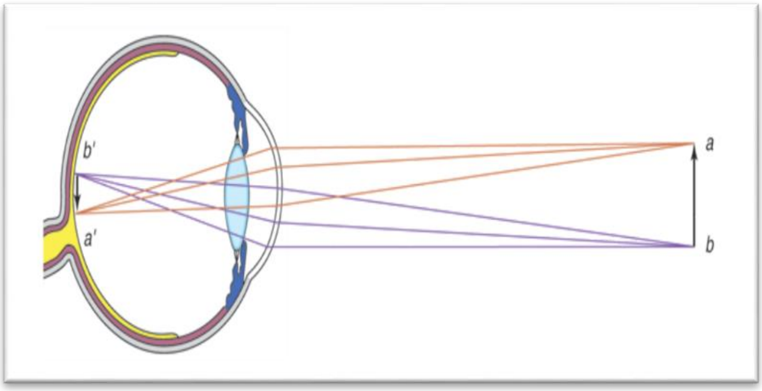

Fig.1-2 Refractive system of the eye

1-3 Intraocular pressure (IOP)

Aqueous humor is produced from the ciliary body and drained through the trabecular meshwork in the anterior chamber angle. The rate of production and the rate of drainage determine the fluid pressure inside the eye (intraocular pressure). The reason for this is because the vitreous humor in the posterior segment has a relatively fixed volume and thus does not affect intraocular pressure regulation (fig.1-3). Tonometry is the method used to determine this. IOP is an important aspect in the evaluation of patients at risk from glaucoma. Most tonometers are calibrated to measure pressure in millimeters of mercury (mmHg).

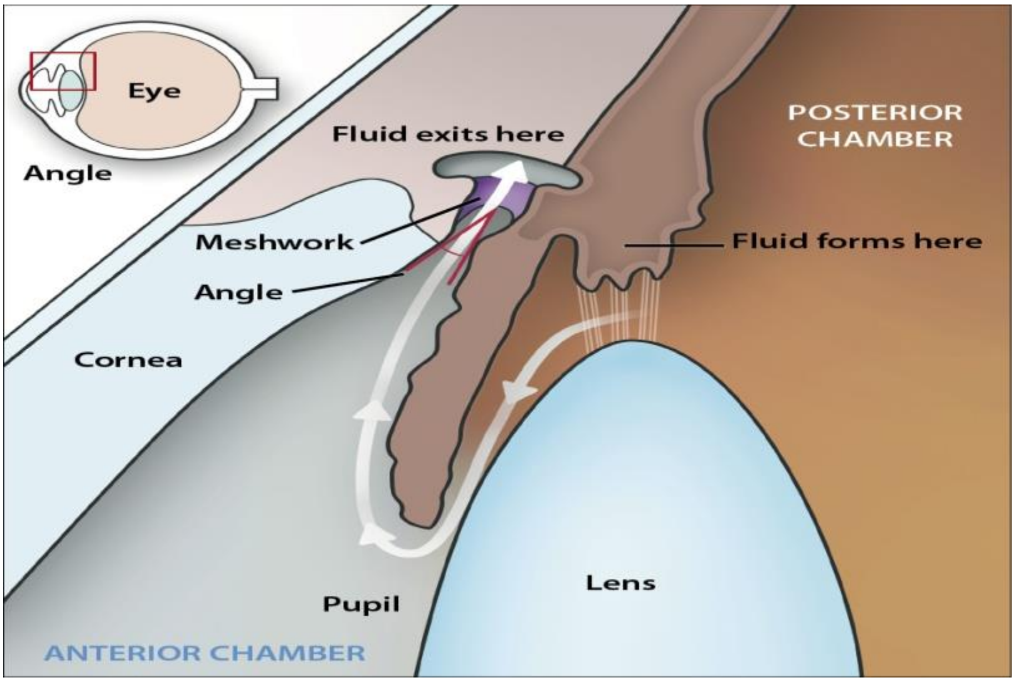

Fig.1-3 intraocular pressure physiology

1-4 Cataract

A cataract is a clouding of the crystalline lens of the eye (fig.1-4) which leads to a decrease in vision.[1] It often develop slowly and can affect one or both eyes.[1] Symptoms may include faded colors, blurry vision, halos around light, trouble with bright lights, and trouble seeing at night.[2] This may result in trouble driving, reading, or recognizing faces.[3] .Cataract are the cause of half of blindness and 33% of visual impairment worldwide [3] [4]. The most common causes of cataract are age, trauma, congenital and drugs such as steroids. Most common risk factors include diabetes, smoking and drinking alcohol [4]. Treatment of cataract is surgical and many methods are described such as extracapsular cataract extraction (ECCE), scleral small incision (SSI) and phacoemulsification [5].

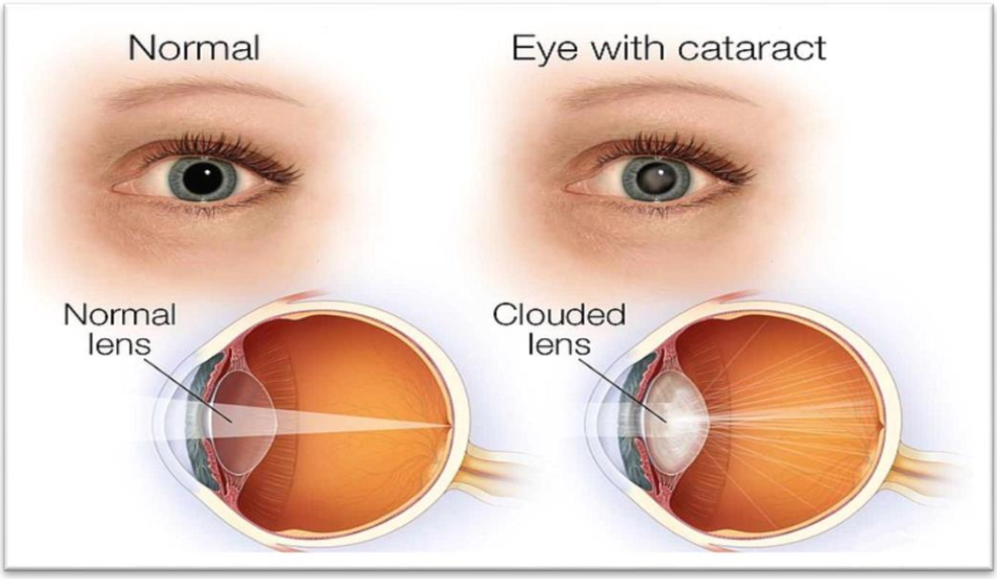

Fig.1-4 Appearance of cataract

1-5 Posterior capsular opacification and management

Posterior capsular opacification (PCO) is one of the most common long term complication of cataract surgery (fig.1-5) with incidence rate of about 28% in 5 years following procedure [6]. PCO developing mechanism take the interest of researchers and many studies were published belongs to this [7] [12]. PCO occur due to remnant of lens epithelial cells in capsular bag after cataract surgery that proliferate after a period and leading to thickening of the capsule and decrease in visual acuity. Understanding of the pathogenesis has led to the improvements of cataract surgery techniques by using proper intraocular lens (IOL) materials such as polymethylmethacrylate (PMMA)or silicon [13]and design a special optics and haptics of IOL with sharp- edged [14] [17]. Such improvements decreased the incidence rate of PCO or delayed its onset [19] [22].

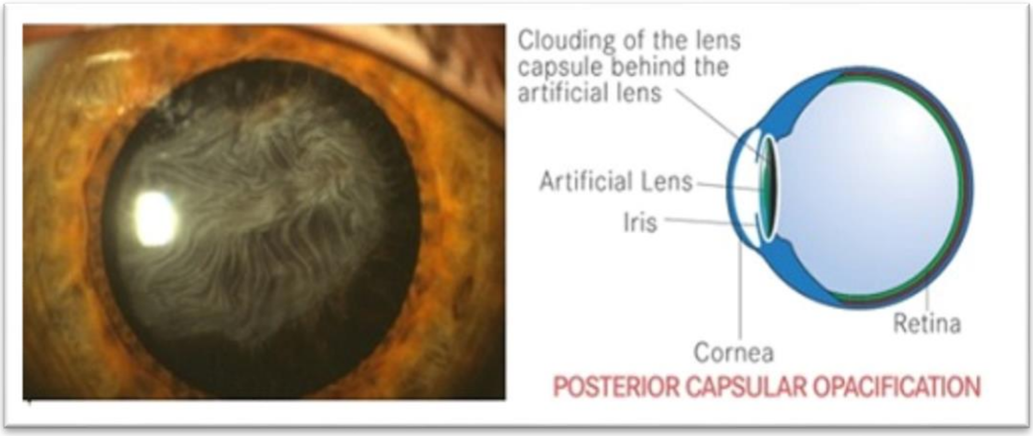

Fig.1-5 posterior capsular opacification

Two patterns of laser shots are commonly used, cross pattern and can opener method [23].

Cross pattern method (fig.1-6) is easy to learn and requires relatively less procedural time [24] [25]. However, pit marks and cracks of along the visual axis of the IOL optic may happen since the procedure is performed in axial region, and it may cause forward light scatter from capsule remnants and subsequent glare symptoms [23]

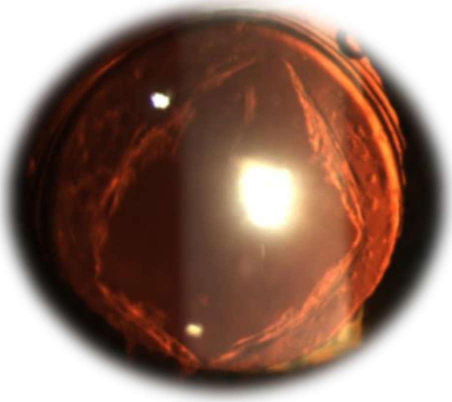

Fig.1-6 Cross pattern laser capsulotomy

In 'can opener method' (fig.1-7) laser capsulotomy is conducted along the circumference of the optic. This procedure can prevent the damage to IOL axial region, but involves a drawback that visual axis can be hidden by large free-floating remnant [26].

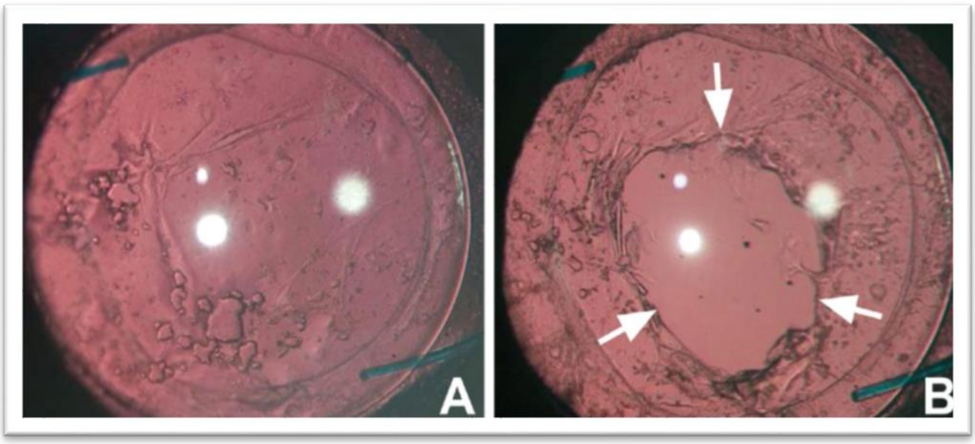

Fig.1-7 Can-opener laser capsulotomy

1-6 Physical principles of Nd: YAG laser

Nd: YAG (Neodymium: Yttrium—Aluminum-Garnet) laser is the most widely used and commonest variety of solid state laser. Trivalent rare earth ion Neodymium (Nd^{3+}) is the laser active element hosted either in a glass or crystal. Neodymium laser is most efficiently incorporated in the Yttrium Aluminum-Garnet crystal ($Y_3Al_5O_{12}$) and commonly termed as YAG. Yttrium-Aluminum-Garnet is a hard, synthetic crystal of remarkable optical quality. It is also mechanically very stable to withstand enormous laser energy. The active element like Neodymium (Nd) is called “dopant”. Incorporation of this active material (dopant) to the YAG crystal is termed “doping”. Neodymium (atom) is added to Yttrium (atom) in the proportion of 1: 100. The doped material is now laser active with an electron cloud surrounding the neodymium (Nd) and emits at a wavelength of 1064 nm. The shape of the laser rod is a cylinder with flat optical surfaces at either end. The optical pumping system is kept very close to the laser rod for efficient optical pumping. Nd: YAG laser operation depends on the optical pumping source.

Continuous Wave operation(CW) here Nd: YAG laser is optically pumped by continuous arc lamp.

Pulsed operation—Nd: YAG laser is optically pumped by flash lamp.

Types of pulse mode Pulse length

A. Long pulsed 0.1 to 1.0 ms (10^{-3} seconds)

B. Short pulsed

- Q-switched 5 to 20 ns (10^{-9} seconds).
- Mode-locked 30 to 100 ps (10^{-12} seconds).

A flash lamp or a continuous arc lamp is used to optically pump the Nd: YAG laser for pulsed operation or continuous wave (CW) operation respectively. These lamps emit radiation over a much larger range of which neodymium (Nd) ions absorb. These bands then act as stimulants for ions to absorb energy and to be in the uppermost level of the four level system shown in Figure (1-8). These ions will decay non radioactively to the upper laser level. This level is the metastable level from which transition takes place to the lower level and then on to the ground state. The lower laser level does not have a high population at initial stage which makes Nd: YAG easy to lase and easy to obtain continuous wave (CW) operation

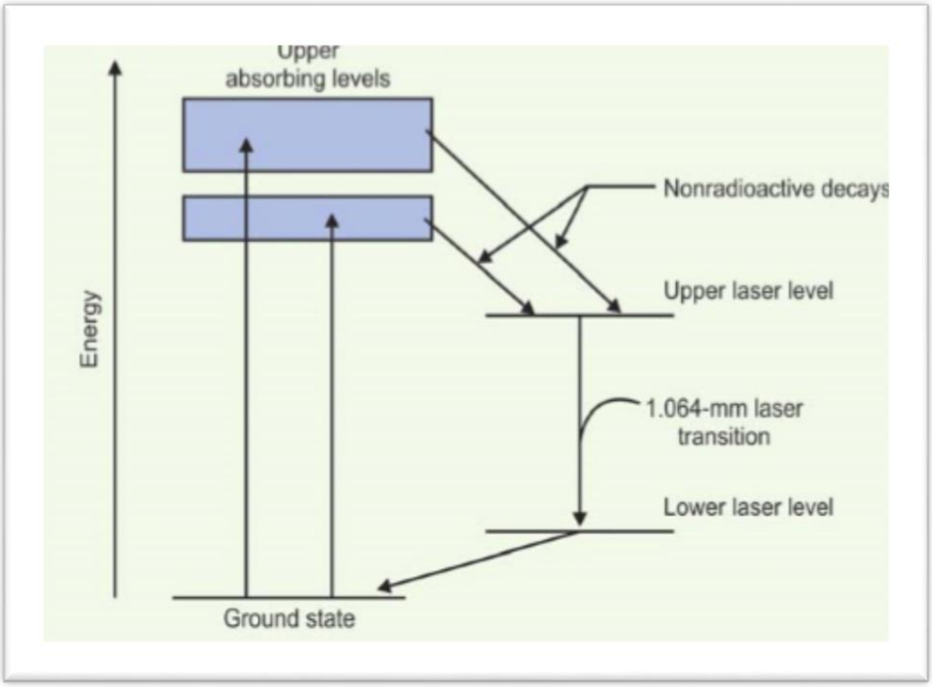

Fig.1-8 Energy levels of the Nd: YAG Laser

1-7 Laser tissue interaction (fig.1-9)

The effect of Laser on biological tissue can be divided in to two categories;

Wavelength dependent and wavelength independent

1-7-1 Wavelength dependent

The interaction here depends largely on the laser wavelength that has impacted the tissue since it is a very important parameter that determines the index of refraction as well as the absorption and scattering coefficients. [27]

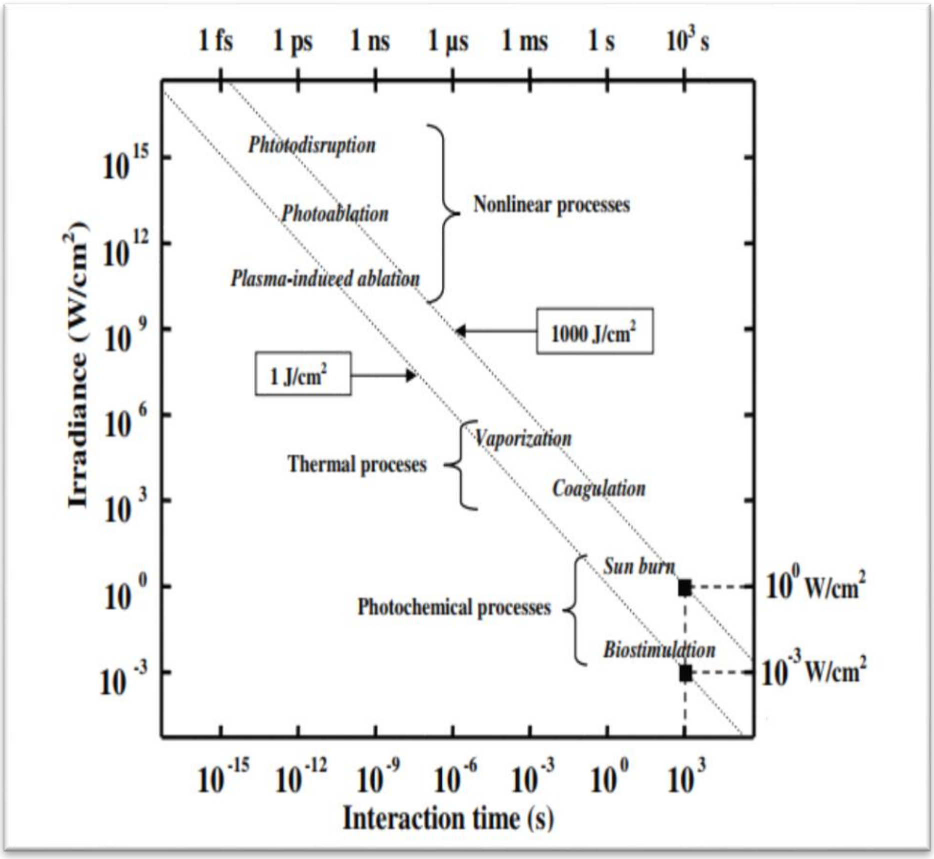

Fig. 1-9 laser tissue interaction [30]

Photochemical Interactions

Photochemical interactions take place at very low power densities (typically 1W/cm^2) and long exposure times ranging from seconds to continuous wave.

Photo thermal interaction

In biological tissue, photon energy changed to heat when 2 condition exist;

1. Absorption of photon by biological molecule to produce an excited molecule.
2. Collisions with other molecules lead to gradual deactivation of the exited one and increase in kinetic energy (increased tissue temperature).

Photo ablation

Under effect of direct Laser radiation of certain wavelength and intensity, each monomer unit undergo excitation from an attractive to repulsive state. This promotion is associated with volume change and tissue dissociation leading to tissue ablation with minimal thermal effect.

1-7-2 Wavelength independent

These interaction mechanisms rely on plasma generation, at high power density 10^{11} -10^{16}W/cm^2 associated with lasers operating in short pulse duration (nanosecond, picoseconds). At high intensities, the electric field strength of radiation is also very large, which is sufficient to cause dielectric breakdown in the tissue. The generation of plasma with laser pulses in the nanosecond range is thermionic emission and in the picoseconds or femtoseconds range is multi-photon ionization. [27]

Plasma induced ablation

Optical break down can be induced when obtaining power densities exceeding 10^{11}W/cm^2 in solids and liquids in picoseconds time. Ablation is obtained by ionizing plasma formation with an end result of very clean ablation associated with an audible report and bluish plasma sparking. [27]

Photo disruption

In this type of interaction, in addition to plasma formation, shock wave is generated leading to cavitation and jet formation. This ends up with fragmentation and cutting of tissue by these mechanical forces. Pulse durations in nanosecond usually induce photo disruption. Power densities may reach up to 10^{16} W/cm^2. [27]

1-8 Optical Breakdown and Plasma Formation

Optical breakdown and plasma formation are the two critical events central to photo disruption. Optical breakdown is a sudden event with a drastic change to the target. When irradiated with laser the electrons gain enough power to completely dissociate from their atoms and the total area becomes ionized. Light energy can create this ionized state when high irradiation is achieved. Physicists call this ionized state a “Plasma”. Plasma is considered as fourth state of matter apart from solid, liquid and gas. The ionized tissue along with its sheared off electrons is termed as “Plasma”. In the plasma state the electrons carrying a negative charge is dissociated from the atom. The nucleus of the atom contains only positively charged protons and neutrons (neutral) and behaves like a positive ion. Due to this character plasma is a good conductor of electricity. However, in most other properties plasma state resembles gaseous state. When plasma is created the optical breakdown threshold is attained. Light energy can create plasma commonly between 10^{10} and

10^{12} W/cm^2. Irradiation [28]. The process of optical breakdown is initiated when the electrical field strength is in excess of 10^7 volts/cm. In the plasma state neutrons and protons of atoms and their free negatively charged electrons are moving at high speed and are subjected to collision with one another. The electrons recombine with their parent atoms in a lower energy level which causes release of light. This release of light is the source of spark produced by Nd: YAG laser. It occurs in nature in the form of lightning.

1-9 Laser safety Precaution

The risk of injury to retina by Nd: YAG laser is minimized due to electron rich plasm that blocks (Fig.1-10) further passage of light beyond the plasma by absorption and/or scattering of incident light (plasma shielding).

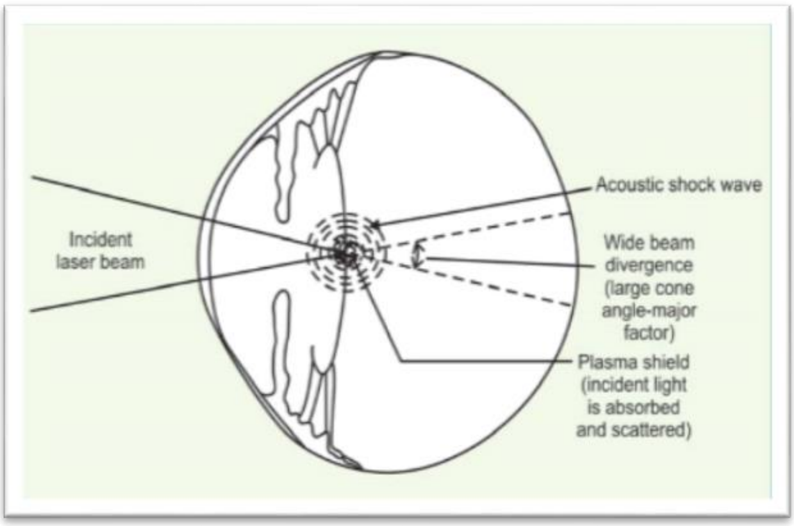

Fig. 1-10 Retinal protection, Laser at papillary plain

1-10 Aiming laser system

YAG laser optical delivery system consists of a binocular stereoscopic slit lamp microscope with Helium-Neon (He-Ne) laser coaxial aiming beam(s). A pulsed Nd: YAG laser requires separate focusing beam due to the following reasons.

- There is no emission of laser between pulses.
- The Nd: YAG laser emission rays are invisible (1064 nm-at infrared end of light spectrum).
- The He-Ne laser emits a visible red beam of 632.8 nm wavelength.
- The Helium-Neon (He-Ne) laser emits continuous wave lower power irradiance at a subthreshold level for retinal injury.

He-Ne laser is the most common visible wave length laser developed by Javen and coworkers in 1961. Single or multiple helium-neon (He-Ne) beams are employed for aiming of Nd: YAG laser by various commercially available Nd: YAG laser equipment manufacturers. However, the dual beam system is most widely incorporated in Nd: YAG lasers. The aiming He-Ne beam may be of the following types:

1. Single solid beam: Here the point of focus is brightest, sharp and of smallest spot size.

2. Annulus or circle pattern: Here the point of focus is also of similar criteria as of single solid beam.

3. Dual (Two beam) pattern: The aiming beam is best focused by this system. Here a single point of focus changes into a dumb bell shape and then into two separate points. The point of focus is identified by the laser surgeon by the super imposition of two He-Ne beams to form a single sharp beam. When the laser surgeon accurately aims this single sharp crossing point of the two He-Ne beams on the target tissue, the Nd: YAG

laser beam is also accurately aimed and focused on the target tissue, i.e. He-Ne aiming beam is coaxial with the Nd: YAG laser beam.

Helium-Neon laser (He-Ne-632.8 nm) beam focus and invisible Nd: YAG laser (1064 nm) beam do not necessarily coincide in all equipments. In some lasers the Nd: YAG laser focus is preset 0.3 mm behind the He-Ne laser beam focus. This 0.3 mm difference in focus between the two laser beams (aiming and treatment) is referred to as “Offset”. Idea behind “offset” is to minimize damage to the intraocular lens during Nd: YAG posterior capsulotomy by automatically posterior defocusing. In posterior defocusing optical breakdown occurs in anterior vitreous. The shock wave propagates forward and ruptures selectively posterior capsule.

1-11 Literature review

Niharika K Shetty and Sriya Sridhar in 2016 state that " all pseudophakic patients may not require anti-glaucoma medication pre, or post Nd YAG laser capsulotomy. Only patients who required more than 40 shots during the procedure would need a close observation and if persistent rise is documented, ocular hypotensives may be advised " also they document the significant correlation of IOP spike with the number of Nd- YAG Laser shots delivered when shots are more than 40, provided the energy was restricted to 20 mJ and below.[29]

Karahan *et al* in 2014 state that " Patients who underwent a larger capsulotomy have a higher hyperopic shift and IOP elevation ", they correlate the size of capsulotomy to IOP elevation value in 68 pseudophakic eyes.[30]

In 2012, Ari *et al* state " Increased IOP and macular thickness are inevitable after Nd:YAG laser capsulotomy, but the severity and duration are less when a total energy level less than 80 mJ is used". [31]

Waseem and Khain 2010 state " Higher YAG laser energy has significantly higher chances of raising IOP ". [32]

Long term effect on IOP was studied by Ge J. *et al* in 2000 and state that after Nd:YAG capsulotomy, long-term IOP is often elevated above precapsulotomy baselines, especially in glaucoma patients or patients who experience a significant IOP increase within hours after the capsulotomy. [33]

1-12 Aim of the work

This work is conducted with view to determine the significance of intraocular pressure elevation and visual improvement after Nd: YAG (1064nm) laser capsulotomy in pseudophakic eye patients.

CHAPTER TWO

MATERIALS AND METHOD

The study conducted in Ibn Al Haitham Ophthalmic Teaching Hospital in Baghdad, a sample size of twenty eyes was studied in six months' duration.

In this chapter, the laser system (Nidek YC1400) used in this work with air puff tonometer (Nidek NT4000 auto non-contact tonometer) will be illustrated. Patient's selection and preparation, procedure of Nd: YAG capsulotomy and post laser treatment medication will have discussed.

2-1 The Laser system

Nidek YC 1400 Nd: YAG laser system with diode laser aiming beam are used in this study mounted on slit lamp microscope (fig.2-1 and 2-2) with specification listed in table 2-1 and 2-2. [34]

Fig 2-1 Nidek YC1400 Nd: YAG laser system

Fig 2-2 Nidek YAG Laser system specification

Table 2-1 Specification of treatment laser

Type of laser	Nd:YAG laser
Wavelength	1064nm
Pulsing method	Q-switching
Pulse duration	7nsec.
Pulse interval	50 micro second
Pulse repetition rate	3Hz
Energy output(per pulse)	0.3 – 25 mJ max
Spot size	8 micrometer
Cone angle	16^{o}
Focus shift	0 -250 micrometer for both anterior and posterior
Cooling method	Ambient air

Table 2-2 Specification of aiming beam

Type of laser	Laser diode
Wavelength	630-680 nm
Energy output	5mW
Aiming method	Dual beam method

2-2 Air puff tonometer

The 'tonometer' is the name given to an instrument designed to measure the IOP of the eye in units of millimeters of mercury (mmHg). Non-contact tonometers (NCTs) produce a pulse of air to flatten a small region at the apex of the cornea (approximately 3mm). A piston, which is contained within a cylinder and rapidly moved by a solenoid, produces a puff of air that increases linearly with time and is released through a nozzle until there is sufficient force to momentarily aplanate the cornea. The area applanated is detected by an optical system. The instrument then calculates the time required for the air to applanate the eye. This time is related to the IOP of the eye [35]. The NT- 4000 is an NCT used to measure the IOP of patients' eyes(fig.2-3). It consists of a combined main unit and measuring unit, installed on a base. The main unit houses the monitor, control panel and joystick. The measuring unit houses the air nozzle and photo sensor. The base houses the chin rest and printer. [36]

Fig 2-3 Air puff tonometer, Nidek NT 4000

2-3 Patient's selection

Pseudophakic patients for more than 6 months of surgery with posterior capsule opacification and IOP within normal range (11-21 mmHg). No ocular surface disease, no uveitis, no retinal detachment and no history of CVA.

During the period of the work (6 months) a twenty eyes of seventeen patients were evaluated. Eleven male and six females, fourteen unilateral and three bilateral. Fifteen eye had phaco surgery and only five had ECCE surgery (table 2-1and figure 2-4).

Table 2-1 The sex, eye distribution and surgery type

	No. of patients	Unilateral eye patient	Bilateral eye patient	Eyes total no.	Phaco	ECCE
Male	11	9	2	13	11	2
Female	6	5	1	7	4	3
Total	17	14	3	20	15	5

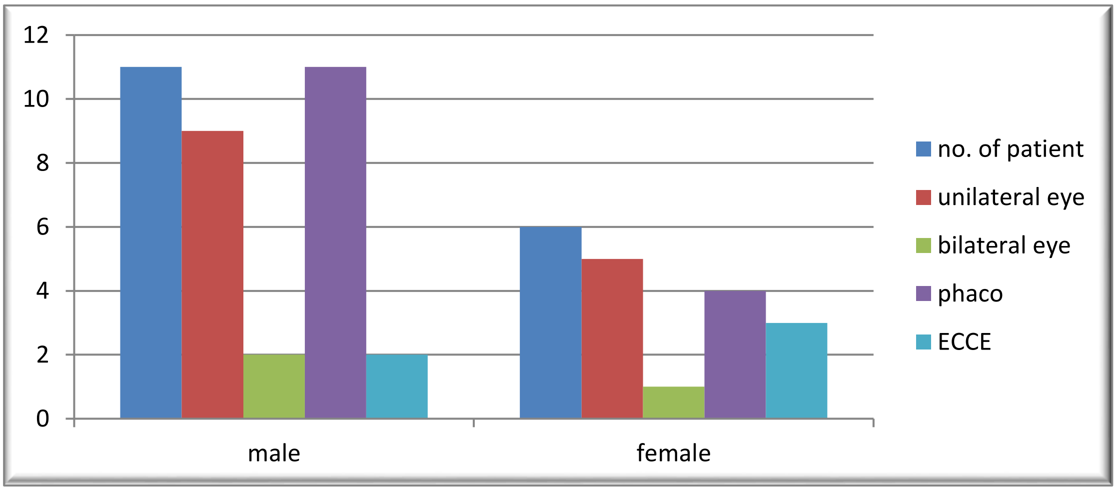

Fig.2-4 The sex, eye distribution and surgery type

Average age of the patients is 60.1 years (table 2-2 and figure 2-5) with average period post surgery is 1.2 year (table 2-3 and figure 2-6). All patients had can opener type of Nd: YAG laser capsulotomy.

Table 2-2 the age distribution according to sex

	31-40	41-50	51-60	61-70	71-80	Total
Male		1	4	6	2	13
Female	1		4	2		7
Total	1	1	8	8	2	20

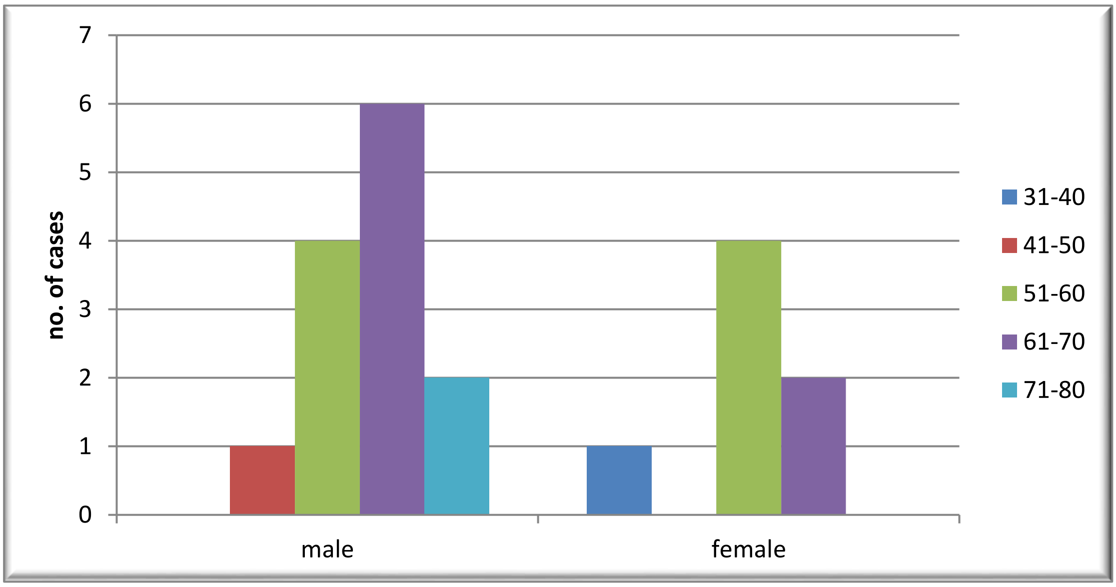

Fig.2-5 The age distribution according to sex

Table 2-3 Post-operative period till capsulotomy.

	6m-12m(1y)	13m-24m(2y)	25m-36m(3)	37m-48m(4)	Total
No.of eyes	4	9	5	2	20
percentage	20%	45%	25%	10%	100 %

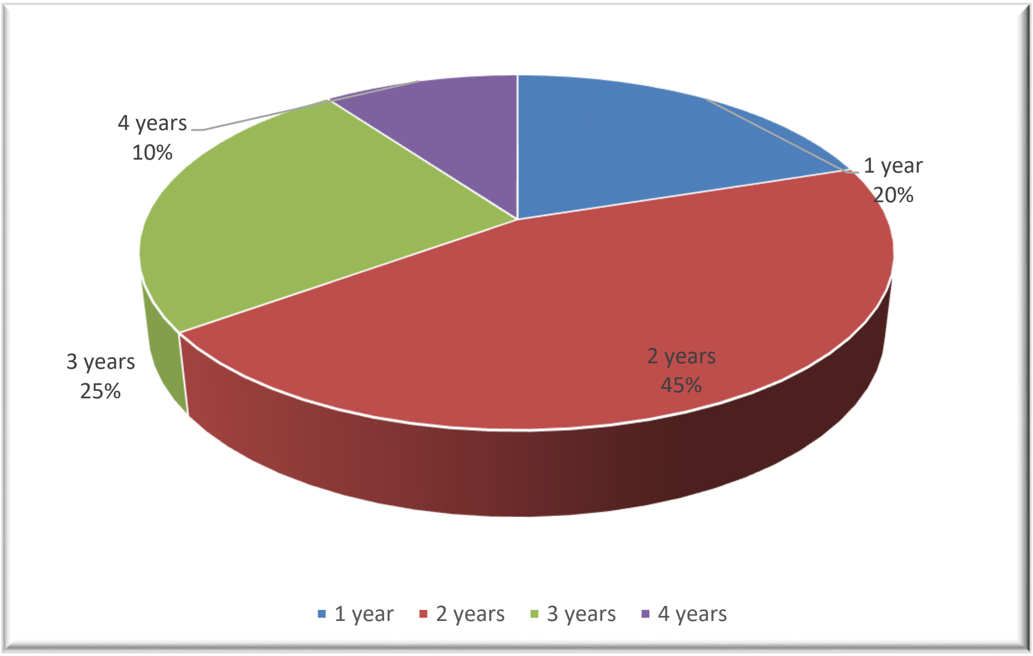

Fig. 2-6 Post-operative period till capsulotomy

2-4 Preparation for laser capsulotomy

Seventeen patient were selected, explanation of the procedure in detail was done. The patients reminded that laser capsulotomy is a painless procedure that require a fixed eye and steady head lasting about 2 minute. Informed consent was obtained from all patients.

Pretreatment full ocular examination including

Visual acuity (VA) and best corrected VA (BCVA).

IOP measurement by Nidek NT 4000 tonometer.

Slit lamp biomicroscopy for ocular surface diseases, and fundoscopy using Volk aspheric +90D non-contact lens.

2-5 procedure technique

- Pupil dilation with topical tropicamide 1% eye drop 30 minute prior to procedure.
- Topical anesthesia with tetracaine hydrochloride 0.5% eye drop to reduce blinking rate.
- Comfortable sitting of the patient with steady fixation.
- Posterior defocusing of the target by 50-100 micrometer to prevent IOL pitting.
- Starting with 1mJ then increasing the energy according to the result.
- Shots are placed across tension line to get maximum effect with minimum shots.
- Can opener technique have performed.
- Post laser capsulotomy IOP checking 30, 60, 120 and 180 minutes.

- Post capsulotomy topical steroid, dexamethasone 0.1% is prescribed.
- One week follow up for IOP and BCVA checking.

2-6 Complication

Nd: YAG capsulotomy is not without complication. Expected complication are transient elevation of IOP, cystoids macular edema(CME), IOL pitting, acute glaucoma, anterior hyaloid face rupture, rhegmatogenous retinal detachment, iritis, hyphema, IOL dislocation and endophthalmitis.

Fortunately, no serious complication occurs in this study except IOL pitting in 3 eyes (15%) which was visually non-significant and anterior hyaloids face rupture in 1 patient (5%).

2-7 Laser safety in work

The laser system is placed in a semi dark, dust proof room where no direct sunlight exposure and well controlled room temperature and humidity achieved. Labels with warning logotype and information about laser type, class and wavelength are attached to the room door (fig 14). All personnel inside laser room were discharged out. Black painting of room walls prevent back reflection and scattering of laser beam.

Finally, the delivery unit has a protective filter that prevent reflection of radiation back to physician's eyes.

Fig2-7 Warning label attached to laser room

CHAPTER THREE

RESULTS AND DISCUSSION

3-1 Introduction

This chapter deal with work results, related figures and tables, discussion, conclusion and recommendations for colleagues when treating PCO with Nd: YAG laser.

3-2 Effect of Nd: YAG laser capsulotomy on IOP

IOP is evaluated pre capsulotomy then 30 min, 1hr, 2hr and 3 hrs. as shown in table 3-1. Average of IOP show significant increase of IOP in 1st 3 hours post procedure with rapid rise in 30 min. then steady rise in the next hours. This increase in IOP attributed to clogging of trabecular meshwork with capsular debris and to the inflammatory mediators that released due to the acoustic shock wave which alter the meshwork and aqueous dynamics as shown in figure 3-1[37].

Table 3-1 IOP elevation, in mmHg, post laser capsulotomy in 1st 3 hours
(*, + and - are bilateral case)

	IOP Pre YAG (mmHg)	IOP 30min Post YAG	IOP 1hr post YAG	IOP 2hr post YAG	IOP 3hr post YAG	IOP 1week post YAG
Case1	14	14	15	15	16	14
Case2	13	15	15	16	16	13
Case3	19	22	23	24	24	17
Case4	11	11	12	13	15	13
Case5	19	21	22	22	23	16
Case6	15	16	16	17	17	15
Case7	13	16	18	19	19	15

Case8	20	24	25	26	26	17
Case9	14	16	14	14	15	14
Case10	17	17	17	18	18	15
Case11	14	14	15	15	16	14
Case12	11	16	15	17	17	16
Case13	13	15	15	16	17	15
Case14	16	15	15	16	16	14
Case15*	14	14	17	18	15	13
Case16*	14	14	14	15	16	15
Case17$^+$	18	19	19	22	24	17
Case18$^+$	16	18	19	20	23	16
Case19$^-$	17	19	21	21	23	16
Case20$^-$	15	17	17	18	22	15

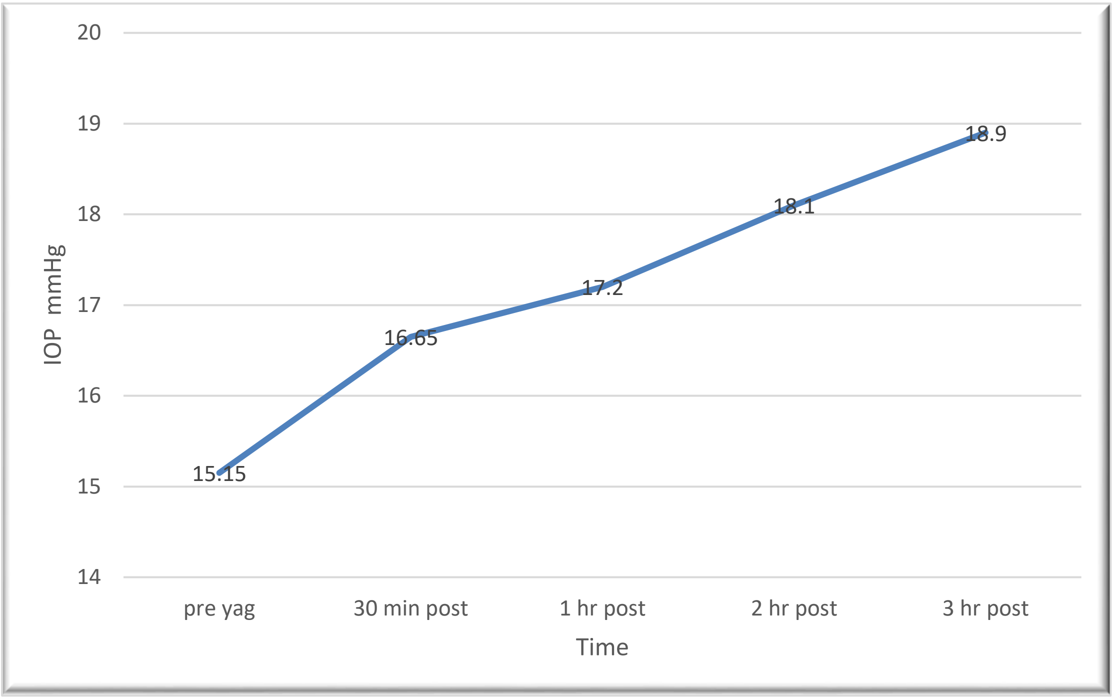

Fig 3-1 Average of IOP increase after laser capsulotomy

Comparison between pre and 1-week post procedure show return of IOP to its original value for 7 patients (35%), decreased for 8 patients (40%), increased for 5 patients (25%) as shown in table 3-2. Slight difference from original pressure (< 5 mmHg) was noticed for those who show fluctuation in IOP (fig3-2). All patients didn't take any IOP lowering medication post procedure, only topical steroid in form of dexamethasone eye drops 4 times daily (fig3-2). This result is slightly different from that stated by Levy's et al study who states a significant decreased IOP post capsulotomy [23] while fourmen et al study showed significant late onset increase of IOP post capsulotomy [37].

Table 3-2 IOP after 1week compared to pre YAG capsulotomy

	No. of patients	% of patient
No difference	7	35%
Decreased IOP	8	40%
Increased IOP	5	25%
Total	20	100%

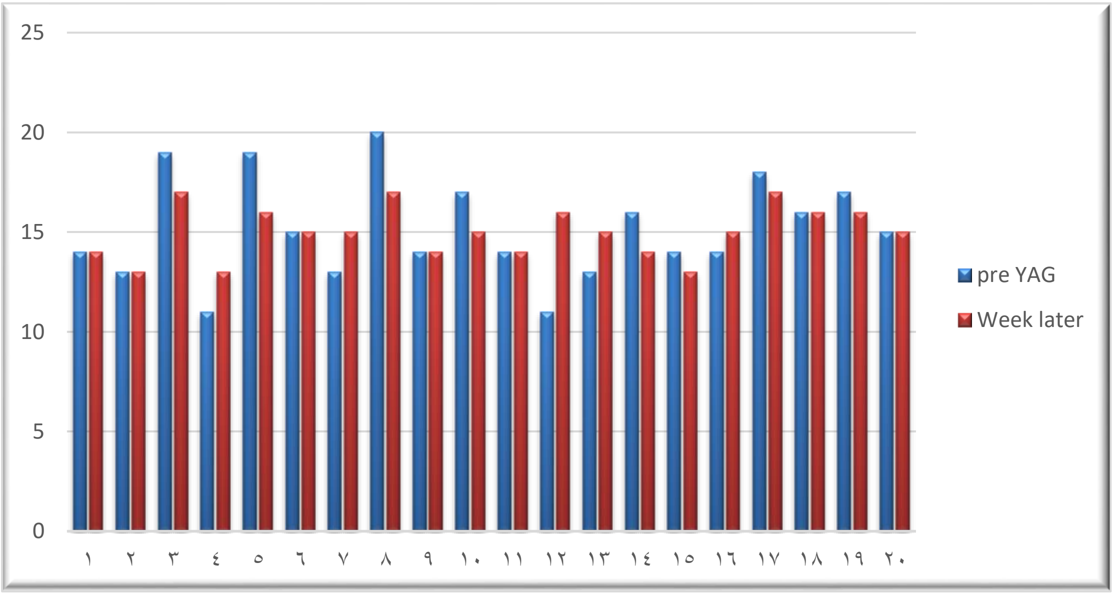

Fig 3-2 IOP 1-week post capsulotomy

3-3 Effect of Nd: YAG energy on IOP

Different value of laser energy was used according to PCO thickness. Total energy recorded by multiplying number of shots with pulse energy (table 3-3). Significant IOP elevation were noticed with increased total energy used (figure 3-3). This result is similar to results of many studies done in different centers on different times and all of them recommend the use of minimal energy in laser capsulotomy to minimize IOP spike [38] [39] [40].

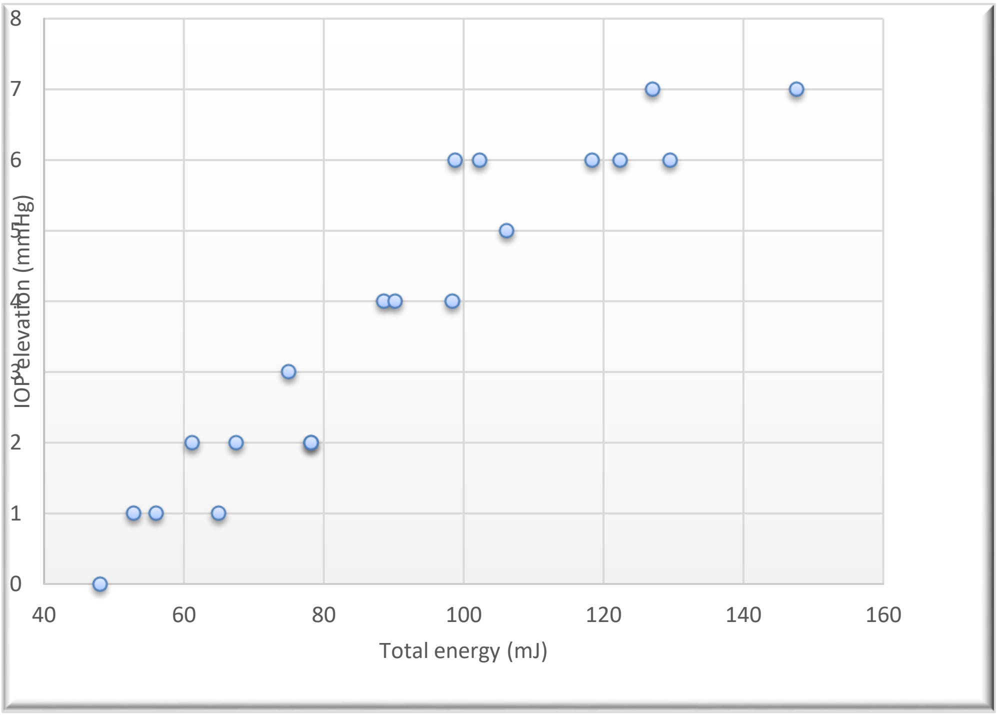

Fig 3-3 Effect of laser energy on IOP

Table 3-3 effect of total energy (in mJ) on IOP (in mmHg)

	IOP Pre YAG	IOP 3hr post	Diff. in IOP	Total energy (mJ)

			(mmHg)	
Case1	14	16	2	78.2
Case2	13	16	3	75
Case3	19	24	5	106.2
Case4	11	15	4	90.2
Case5	19	23	4	98.4
Case6	15	17	2	67.5
Case7	13	19	6	118.4
Case8	20	26	6	122.4
Case9	14	15	1	65
Case10	17	18	1	56
Case11	14	16	2	78.2
Case12	11	17	6	129.5
Case13	13	17	4	88.6
Case14	16	16	0	48
Case15*	14	15	1	52.8
Case16*	14	16	2	61.2
Case17[+]	18	24	6	98.8
Case18[+]	16	23	7	147.6
Case19[-]	17	23	6	102.3
Case20[-]	15	22	7	127

3-4 Effect of capsulotomy on visual acuity (VA)

Visual acuity is documented prior to and 1 week after procedure using Snellen chart (table 3-4) with total no. of no corrected vision of 4 eyes (20%), 1-line correction 3 eyes (15%), 2-line correction of 8 eyes (40%) and 3-line correction of 5 eyes (25%) as shown in figure 3-4. Improvement of visual acuity is related to density of PCO prior to procedure while those who didn't improve their acuity (20%) had either diabetic retinopathy (2 eyes), high astigmatism (1 eye) or had good BCVA from start (1 eye). Visual acuity improvement is due to clearance of the visual axis rather than changing in refraction due to backward movement of IOL and hyperopic shift [41]. Fortunately, all patients were satisfied with result even that with 9/9 VA who had no acuity progression he describes contrast improvement.

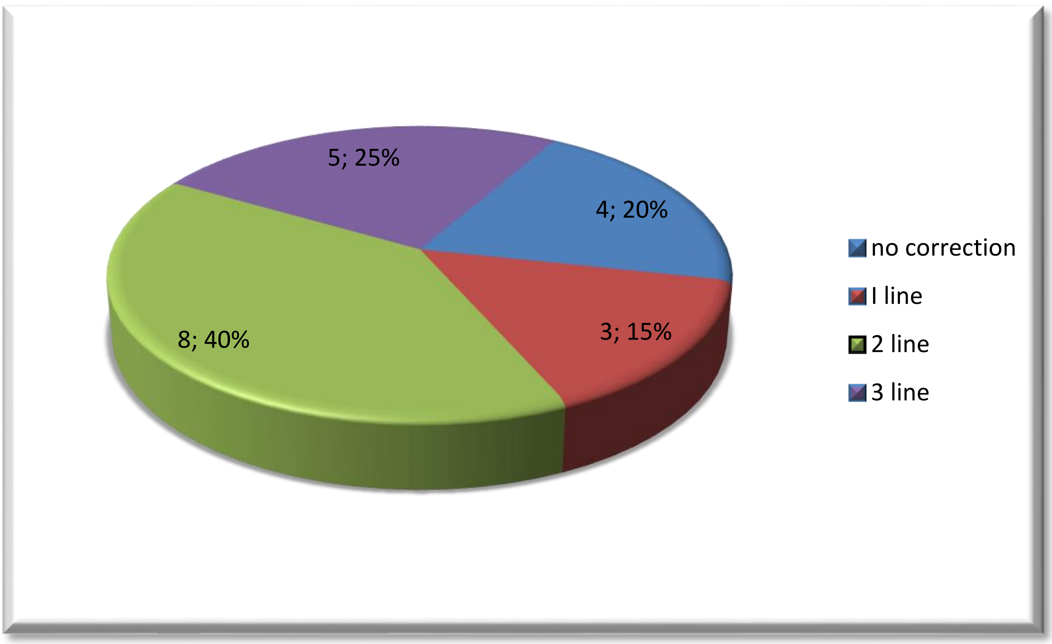

Fig. 3-7 visual acuity improvement after capsulotomy

Table 3-4 effect of capsulotomy on VA, [*,+,-are bilateral cases]

	Pre YAG Visual acuity	1 week post YAG	notes
Case1	6/18	6/6	3 line correct
Case2	6/24	6/12	2 line
Case3	6/9	6/9	No correction
Case4	6/24	6/15	2 line
Case5	6/36	6/36	Astigmatism
Case6	6/60	6/36	2 line
Case7	6/12	6/12	DMO
Case8	6/12	6/9	1 line
Case9	6/36	6/18	2 line
Case10	6/18	6/9	2 line
Case11	6/18	6/18	DRP
Case12	6/24	6/12	2 line
Case13	6/60	6/24	3 line
Case14	6/48	6/36	1 line
Case15*	6/24	6/9	3 line
Case16*	6/18	6/6	3 line
Case17[+]	6/18	6/12	1 line
Case18[+]	6/18	6/9	2 line
Case19[-]	6/12	6/6	2 line
Case20[-]	6/36	6/12	3 line

3-5 Conclusion

- Posterior capsule opacification is responsible for decreased visual acuity after cataract surgery for many of pseudophakic patients.
- Nd: YAG laser capsulotomy is relatively a safe procedure with relatively non clinically significant complication.
- IOP elevation after procedure is common and spike rarely exceed 7 mmHg.
- The IOP elevation is mostly related to total energy used.
- No effect of post-operative period on IOP spike and most presentation is in the second year post surgery.
- Visual acuity improved significantly after Nd: YAG laser capsulotomy in patients with healthy retina and minimal post cataract astigmatism.

3-5 Recommendation

- This study strongly recommends for the use of minimal energy required to perform capsulotomy.
- No need for ocular hypotensive drugs pre or post laser capsulotomy in non-glaucomatous patients.
- No need for redo refraction or changing spectacles after capsulotomy

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