بسم الله الرحمن الرحيم
LASER IRIDECTOMY

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LASER = Light Amplification by Stimulated Emission of Radiation.

HISTORY

- In 1956, Meyer-Schwickerath reported the use of the light energy of the xenon arc photocoagulator to create iridotomies (high incidence of corneal and lenticular opacities).

- Subsequently, the ruby laser was used to create iridotomies in rabbits and humans.

- Zweng and colleagues, L'Esperance and Kelly, and Patz, in their pioneering work with continuous-wave argon laser (454 to 514 nm) energy, adapted it to be delivered through a slit-lamp system.

- Argon laser became popular in the 1970s.
HISTORY

- By the early 1980s, argon laser iridectomy had replaced the traditional surgical iridectomy.

- During the late 1980s the Nd:YAG laser became the laser of initial choice for performing iridectomies.

- In 1984 the first reports of the successful performance of an iridectomy using the Nd:YAG laser were reported.

- In 1987, Tomey and colleagues reported on 271 consecutive patients (373 eyes) in whom Nd:YAG laser iridectomy had been performed.
Tomey and colleagues believed that the Nd:YAG laser offered the following advantages:

- lower energy level;
- lower incidence of spontaneous closure of the iridotomy;
- less inflammation;
- Fewer required applications; mean number of applications = 6 (73 with the argon laser);
- Absence of thermal injury to the cornea, lens, and retina;
- Efficacy with opaque corneas;
- Effectiveness independent of iris color.
Laser Iridotomy

Indications

- Acute angle-closure glaucoma with pupillary block
- Chronic angle-closure glaucoma with pupillary block
- Subacute angle-closure glaucoma
- Acute angle-closure glaucoma; in fellow eye
- Aphakic or pseudophakic pupillary block

- IOP elevation and angle closure with dilation
- Partial-thickness incisional surgical iridectomy
- Before laser trabeculoplasty in eyes with narrow angles

- Uveitis with 360° posterior synechiae
- Positive provocative test result

A small percentage of patients with narrow angles develop angle closure glaucoma.

- Differentiating a pupillary block in aphakia or pseudophakia from ciliovitreal block
- Nanophthalmos
- Malignant glaucoma
Laser Peripheral Iridotomy

Indications

Note:

- In angle closure glaucoma without pupillary block, an iridectomy is not helpful or indicated (for example in uveitis (without posterior synechiae), neovascular glaucoma, iridocorneal endothelial syndrome).

- A surgical iridectomy is done only if a laser iridectomy cannot be performed.

- In patients with acute angle-closure glaucoma in one eye, 50 to 75 percent of the fellow eye will develop an angle closure episode within five years.
Note:

- An iridotomy is not necessary as a prophylactic measure in all individuals with narrow angles.

- A small percentage of patients with narrow angles develop angle closure glaucoma.

- Which individuals with narrow angles will develop angle closure glaucoma??

- If performing provocative tests:
  1. An IOP increase of 8 mmHg or more with gonioscopic evidence of angle closure is considered positive.
  2. An asymmetric pressure rise between the two eyes with a corresponding degree of angle closure is also considered positive of angle closure glaucoma.
PREOPERATIVE PREPARATION

The important aspects of preoperation involve the maintenance of the:
- Clearest cornea,
- Constricted pupil,
- Control of inflammation and intraocular pressure (IOP).
1 hour before laser, the eye is routinely pretreated with topical:
- Apraclonidine
- Pilocarpine 2%

- The miotic constricts the pupil and promotes penetration of the laser energy by placing the iris on stretch and making it thinner.

- Miotic reduces the contraction of the iris and pupil peaking, which sometimes is seen as the iris is treated with argon laser energy.

- A small pupil also reduces the possibility of laser energy inadvertently going through the pupil and striking the retina.
The use of Contact Lens greatly facilitates the ability to penetrate the iris and has improved the success rate in achieving iridectomies.

The Abraham lens consists of a modified Goldmann-type fundus lens with an 8-mm hole trephined into its periphery and a 66-D plano convex button bonded into the trephine hole.

The Wise lens has a 103-D button. All front surfaces are covered with an antireflective coating.

The gonioscopic solution reduces heat buildup and decreases the incidence of corneal burns.
Fundus lens with a high plus button eccentrically placed. The Abraham lens has a +66 D button, and the Wise lens has a +103 D button.
Relative power density and spot size at the cornea and iris using an Abraham iridectomy lens. Courtesy of R. Abraham
SURGICAL TECHNIQUE

- Both the surgeon and patient should be as comfortable as possible.
- A Velcro head strap helps to keep the patient well positioned with the forehead against the head bar.
- An elbow rest is helpful to steady the surgeon's arm and reduce fatigue.
- A patient's shirt collar button may be released and tie loosened, and patients should be cautioned not to hold their breath.
- The laser room should be well ventilated to ensure patient comfort.
- A drop of topical anesthesia is used in all patients.
- Retrobulbar anesthesia is not necessary.
The contact lens is placed on the eye with the trephined hole superiorly. The location of the iridectomy should be in the mid periphery of a constricted iris, about one third the distance from the limbus to the pupil, usually between the half past 10 and half past 1 o'clock positions (under the upper lid).

If temporal treatment is being performed, it is important to aim the argon laser beam away from the macula.

The aiming beam should be perpendicular to the contact lens surface and through the center of the lens button.
Superonasal location of iridectomy site at the half past 10 o'clock position in the left eye, about one third the distance from the limbus to the pupil.
Argon Laser Iridectomy

- Many authors recommend a variety of techniques to facilitate the performance of an argon iridectomy.

- Some of these include placing stretch burns in a circle (drumhead technique) and then placing penetrating burns in the center of the circle.

- Stretch burns usually are placed with a 20-μm spot size and a 0.2-second duration, using 200 to 400 mW of power.

- A well-accepted standard technique using the argon laser is to begin initial treatment with a 50-μm spot size and a 0.2-second duration, with about 850 mW of power.
Argon Laser Iridectomy

- The easiest irides to penetrate with the argon laser are:
  - Hazel irides.
  - Light brown irides.

- The most difficult are:
  - Light blue irides with minimal pigment.
  - Thick dark brown irides.
Argon Laser Iridectomy

- Light blue irides require a different technique:
  - A power setting of **800 to 1000 mW** and duration of **0.2 to 0.5 seconds** is used with a **50 μm** spot size.

- The clinician looks for an *iris freckle* or an *iris crypt* that would make penetration easier.

- The signal that the laser beam has penetrated the pigment epithelium is a **stream of pigment clumps** carried by the posterior chamber aqueous humor into the *anterior chamber* in a mushroom-cloud configuration.
Argon Laser Iridectomy

- Most of the argon laser treatment is directed toward enlarging the iridectomy and cleaning the pigment out from its edges.

- The edges of the initial penetration site are treated with laser energy to enlarge the actual opening and reduce the chance of subsequent closure from pigment proliferation.
<table>
<thead>
<tr>
<th>Iris Color</th>
<th>Spot Size (μm)</th>
<th>Power (mW)</th>
<th>Duration (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazel</td>
<td>50</td>
<td>850</td>
<td>0.2</td>
</tr>
<tr>
<td>Brown</td>
<td>50</td>
<td>850</td>
<td>0.2</td>
</tr>
<tr>
<td>Thick brown</td>
<td>50</td>
<td>1000–1500</td>
<td>0.02–0.05</td>
</tr>
<tr>
<td>Blue</td>
<td>50</td>
<td>1000</td>
<td>0.2–0.5</td>
</tr>
</tbody>
</table>
Argon Laser Iridectomy

Endpoint

- The endpoint of treatment is the direct visualization of the anterior lens capsule with the slit lamp.
- Transillumination is not a good technique to determine the patency of an iridectomy.
- After the iridectomy:
  - The central anterior chamber depth usually is not affected;
  - Deepening of the peripheral anterior chamber is a reliable sign that the iridectomy has achieved its functional purpose.
- In eyes with light blue irides, the Nd:YAG laser has distinct advantages and has been a major improvement.
A. Extensive transillumination defect in blue iris nasally.

B. Iris of same patient with iridectomy much smaller than the transillumination defect because of intact iris stroma.
Nd:YAG Iridectomy

**Settings**

- **Recommended settings** for the Nd:YAG laser range from 3 to 7 mJ per burst and from **one to three pulses** per burst.

- It is **safest** to begin with a **single pulse** of approximately 4 to 6 mJ.

- In **thick brown irides**, using **two to three pulses per burst** often is helpful.

- Eyes with **thick brown irides** are more difficult to penetrate:
  - It can be helpful to thin out a cryptlike area with the argon laser and then punch through with the Nd:YAG laser energy.
  - In a few cases, the **reverse procedure** is followed: The Nd:YAG laser is initially used, and the iridectomy opening can be completed with **argon laser** energy.
Nd:YAG Iridectomy

Notes:

- In patients who are on anticoagulant therapy or have bleeding disorders, it is advisable to use argon laser energy.

- Bleeding from the iridectomy site is rare with the argon laser because the tissue destruction involves thermal coagulation.

- Bleeding at the iridectomy site is common with the use of Nd:YAG laser energy because the photodisruption process does not coagulate the iris vessels.
Bleeding from a patent Nd:YAG iridectomy site.
POSTOPERATIVE TREATMENT

- The major postoperative treatment involves monitoring and controlling:
  - IOP.
  - Inflammation.

- 76% of patients had a maximal elevation of IOP in the first hour, whereas 16% peak at the second hour, and 8% reached maximal elevation during the third hour.

- 31% of the Nd:YAG laser-treated eyes and 34% of the argon laser-treated eyes had an IOP rise greater than 8 mmHg above baseline.

- We routinely monitor IOP:
  - 1 hour after a laser iridectomy procedure.
  - If there has been a pressure spike, the patient is seen the next day;
  - Otherwise, the patient is seen between 5 and 7 days later, at which time the second eye can undergo laser treatment if necessary.
POSTOPERATIVE TREATMENT

- To reduce post laser iridectomy pressure spike:
  - **Apraclonidine** and **miotics** if they have not been used in the last 2 hours,
  - Instilling a **beta blocker** if not contraindicated,
  - Considering the use of a topical **carbonic anhydrase inhibitor** if there is significant cupping and field loss.

- No significant differences in postoperative IOP spikes have been found between the two types of lasers.
POSTOPERATIVE TREATMENT

- Topical **steroids** are used to control **iritis**, which is seen in all patients.

- The usual treatment schedule is **one drop of prednisolone acetate** four times a day, and this usually can be discontinued by **1 week postoperatively**.
POSTOPERATIVE TREATMENT

- **Miotics** are used if there is a question about the **patency of the iridectomy**.

- If there is a patent iridectomy, the **pupil** is **dilated** on an **early postoperative visit** to prevent the formation of **posterior synechiae**.

- **Gonioscopy** always should be done on the **first postoperative visit** to assess the effect of the iridectomy on the angle configuration.
COMPLICATIONS OF SURGERY

**Corneal Changes:**

- Epithelial and endothelial burns with argon laser iridectomies.
  - Those usually are **transient** but can **impair the ability** to complete an iridectomy.

- **Focal endothelial cell loss**: Nd:YAG iridectomies can cause **cell loss** if the disruption takes place **less than 1 mm** from the corneal endothelium. (Five eyes of **three patients** developed **corneal decompensation**).
COMPLICATIONS OF SURGERY

Lens Opacities

- Focal anterior subcapsular lens opacities at the iridectomy site frequently are seen with argon laser iridectomies and also can be found after Nd:YAG iridectomy.

- Long-term follow-up demonstrates that the Treatment parameters of one or two bursts and less than 6 mJ reduce the incidence of lens opacities in monkeys.

- It also is critical to focus on the anterior iris stroma and to perform the YAG iridectomy peripherally, where the patient's convex lens is further away from the pigmented epithelium of the iris.
Closure of the Iridectomy

- Closure of a patent laser iridectomy may be either immediate or delayed.
- If late closure occurs, it usually occurs by 6 weeks and is a result of pigment proliferation.
- Blue irides treated with the argon laser had a 35% incidence of re-treatment, whereas brown irides had only a 15% re-treatment rate.
A. Iridectomy site has been closed by pigment proliferation.
B. Iridectomy reopened after a second laser treatment.
COMPLICATIONS OF SURGERY

Diplopia and Glare

- By placing the iridectomy under the upper lid, these complications are significantly reduced.
- However, some iridectomies have been placed inferiorly with no problems.
- If the iridectomy is located right at the border of the upper lid margin, these symptoms seem more likely to occur.
THE END
Indications for Surgery Designed to Prevent an Attack of Primary Angle-Closure Glaucoma

- Nd:YAG peripheral iridotomy should be performed in any patient in whom the ophthalmologist considers that the anterior chamber angle is capable of occlusion and in whom there are not compelling features suggesting that performing an iridotomy is inappropriate.

- Characteristics of an occludable anterior chamber angle are shown in Table 3.
Table 3. Characteristics of an Occludable Anterior Chamber Angle

- Presence of a peripheral anterior synechia usually superiorly, especially superonasally
- Associated shallow anterior chamber
- Absence of signs indicating other cause for peripheral anterior synechia (keratic precipitates, signs of previous trauma, neovascularization of the iris or angle, deep anterior chamber)
  - Angular approach to the anterior chamber angle less than 10 degrees
- Plateau iris configuration
- Iris insertion anterior to ciliary body
Characteristics of an Occludable Anterior Chamber Angle

- Patients who are hyperopic, are older adults, and have developed cataracts are especially likely to have occludable angles.
- Mechanisms and predispositions to angle-closure glaucoma are listed in Table 4.
- Not all types of angle-closure respond favorably to iridectomy or iridotomy.
- Only those with a pupillary-block type of mechanism will be helped (all those glaucomas secondary to the mechanisms listed in Table 4, A and B, with the exception of 3 C, and in some cases 3 E).
- Aspects of the history, such as seeing halos around lights in the dark, are suggestive of attacks of angle-closure Table 5.
- Signs of the angle-closure glaucomas are listed in Table 6.
### Table 4. The Angle-Closure Glaucomas

- **Anatomical features (inherited or congenital)**
  - Small anterior segment
    - Hyperopia
    - Nanophthalmos
    - Microcornea
    - Microphthalmos
    - Retinopathy of prematurity
    - Hereditary narrow angle
  - Anterior iris insertion
    - Eskimos
    - Asians
    - Black Africans
  - Shallow anterior chamber
    - Women (as opposed to men)
    - Older adults
    - Plateau iris syndrome
    - Loose or dislocated lens
    - Large lens
Large lens

- Obstruction of aqueous humor at pupil
- Normal iris-lens contact
- Contact between iris and pseudophakos, vitreous, or other materials such as silicone
- Adhesion between iris and other material (lens, pseudophakos, vitreous)
- Obstruction of aqueous humor posterior to pupil or traumatic angle damage and adhesions secondary to surgery
- Ciliary block (malignant glaucoma, aqueous misdirection)
- Anterior rotation of ciliary body
- Retinal vein occlusion
- Other obstruction to venous outflow
- Cyclitis (as follows cyclophotocoagulation)
- Choroidal effusion
- Scleral buckling
- Anterior displacement of the lens-iris diaphragm
- Parasympathomimetic agents (miotics)
- Aqueous misdirection
- Pressure from the posterior segment
  - Tumor
  - Expanding gas
  - Angioma, and others
- Loose or dislocated lens
Anterior displacement of the lens-iris diaphragm

Parasympathomimetic agents (miotics)

Aqueous misdirection

Pressure from the posterior segment
  - Tumor
  - Expanding gas
  - Angioma, and others

Loose or dislocated lens
PROVOCATIVE TESTS

- Occasionally patients consulting for routine examination and having narrow angles may present a particularly difficult therapeutic decision for the ophthalmologist.

- Patients predisposed to angle-closure glaucoma often may be recognized before angle closure occurs.

- A family history of angle-closure glaucoma and hyperopia are risk factors for angle-closure glaucoma.
PROVOCATIVE TESTS

- The gonioscopist must judge whether the narrow angle is occludable and whether the patient is thereby at risk of developing angle-closure glaucoma.

- When in doubt, an angle judged potentially occludable by gonioscopy should be treated with Nd:YAG laser iridotomy prophylactically in view of the marked safety of the procedure and the potentially devastating consequences of later damage from severe angle-closure glaucoma.
PROVOCATIVE TESTS

- Provocative tests today have become largely obsolete because they are not reliable and because laser iridotomy is effective in eliminating the future possibility of primary angle closure in suspected cases.

- In past years when the diagnosis of occludable angles required a surgical iridectomy with all the inherent risks of intraocular surgery, provocative tests were used in an attempt to verify the ophthalmologist's clinical judgment of occludability of the angles.

- A negative provocative test is inconclusive and does not assure that angle closure cannot develop.

- Angles can vary in depth depending on the degree of aqueous production, which may vary depending on many factors.

- Angles will become more narrow with increased aqueous production and wider with decreased production.
PROVOCATIVE TESTS

- Fluid intake can increase aqueous production, which, in turn, can increase angle narrowness.
- Also, angle depth can vary with the size of the pupil at the times of examination indicating variation in the degree of relative pupillary block resulting from different pupillary sizes.
- In addition, angles often become more narrow with advancing age.
- Positive provocative tests can occur after several negative ones and need to be repeated periodically.
- Prophylactic iridotomy should be done if a high risk of developing acute angle-closure glaucoma exists, despite a negative provocative test.
- This is especially true in a noncompliant patient, a potentially unavailable patient, a patient with poor access to glaucoma care, and a patient who is physically or mentally disabled.
PROVOCATIVE TESTS

- Therefore, provocative tests do not, with sufficient accuracy, predict future angle-closure cases.
- The medical literature supports their inaccuracy, and this is supported by the distressingly large number of anecdotal reports of patients with serious angle-closure attacks days or weeks after negative provocative tests.
- In addition, provocative tests carry the real risk of iatrogenically precipitating angle closure, which then does not respond to therapy.
- Provocative tests are presented here for those rare situations where a laser iridotomy is impossible due either to the lack of equipment or the inability of the patient to cooperate with laser treatment.
- Several pharmacologic or physiologic provocative tests have been used to produce angle closure.
The Prone Dark Room Provocative Test

- The most widely used and most physiologic test is the prone dark room test, which simulates situations experienced in normal life.
- It is also the most easily reversed and, therefore, the safest test. Gonioscopy is performed before the test in both eyes.
- The test is designed to produce maximal normal dilation of the pupils and allow enough time for angle closure and increased intraocular pressure to develop.
- After recording initial intraocular pressure, the patient is placed in a dark room with patches or a blindfold covering both eyes.
- The patient is then asked to sit at a table with head facing down on the table in a dark room for at least 1 hour.
- The patient must stay awake during the test to avoid sleep-induced miosis.
PROVOCATIVE TESTS
The Prone Dark Room Provocative Test

- The face down position is important because it promotes forward displacement of the lens and may increase any tendency toward angle closure.
- Sixty to ninety minutes later, the pressure is measured and gonioscopy is repeated.
- It is important to minimize exposure to light before performing post-dark room examination.
- An increase in intraocular pressure of 8 mmHg or more is considered positive.
- On gonioscopy, crowding of the angle by the iris sustains the diagnosis and calls for prophylactic laser iridotomy. An asymmetric increase in intraocular pressure even lower than 8 mmHg, consistent with an asymmetry in the angle width between the two eyes, should be considered positive.
- More than 50% of these tests may yield negative results.
- This does not rule out the possibility of developing angle-closure glaucoma, and patients should be informed of the symptoms and asked to have yearly examinations.
The Mydriasis Test

- The mydriasis test, a pharmacologic test, can be performed by instilling a drop of 0.5% or 1% tropicamide or other mydriatic agent in an eye that has previously been tested for pressure and angle appearance.

- When mid-dilation is achieved 5 to 10 minutes later, tonometry and gonioscopy are done and repeated at 15-minute intervals for 1 hour after the initial pretest pressure.

- As with the prone-dark room test, a positive test is indicated by a rise in pressure of 8 mmHg or more and angle closure evident on gonioscopy.

- Some cases of open-angle glaucoma may yield false-positive results due to a decreased facility of outflow with cycloplegia and mydriasis.

- Therefore, gonioscopy is necessary to confirm the diagnosis.

- A negative test is inconclusive.
The Mydriasis Test

- The following precautions are necessary when using this test because one may precipitate a severe angle-closure attack that may require prompt surgical intervention: (1) test one eye only at a session and (2) use a weak mydriatic agent, such as 0.5% or 1% tropicamide with a relatively short duration of action.

- The patient should be warned and instructed to recognize acute angle closure symptoms since they may appear after the patient has returned home and the pupil recovers from dilation.

- The mydriasis test is nonphysiologic because it involves the use of physician-introduced pharmacologic agents.
The Triple Test

- A provocative test proposed by Kirsch involves using a water load, followed by a mydriatic agent, followed by a miotic.
THE FELLOW EYE IN ANGLE-CLOSURE GLAUCOMA

- In angle-closure glaucomas, the fellow eye has a 75% chance of developing angle closure.

- If gonioscopy reveals a similarly narrow angle in the fellow eye, a prophylactic laser iridotomy should be performed in that eye.

- The procedure is safe and will prevent angle closure in almost all cases.

- In some instances, the fellow eye in angle-closure glaucoma may be evaluated while the primary eye is under treatment with carbonic anhydrase inhibitors and hyperosmotic agents.

- In this situation, the anterior chamber angle of the fellow eye may not appear to be as narrow as is expected.
THE FELLOW EYE IN ANGLE-CLOSURE GLAUCOMA

- The observer may be puzzled by the difference between the two eyes and may be led to conclude that the fellow eye is not capable of angle closure and is not suitable for prophylactic iridotomy.

- Later, when medical therapy for the primary eye is withdrawn, the anterior chamber angle of the fellow eye may be found to be narrow and closure may actually occur.

- Usually, the explanation for the temporary discrepancy between the angles in the two eyes is that in the fellow eye the anterior chamber angle was widened artificially by the medical therapy used for the primary eye.

- It is important to be aware of the potential deception and to not be misled by it.
MULTIPLE OCULAR DISEASES

In complex cases with multiple ocular diseases where the angles are narrow, it is wiser to eliminate the possibility of angle-closure glaucoma as a complicating factor.

Examples include eyes about to undergo scleral buckling surgery; narrow angles in the presence of central retinal vein occlusion; and eyes with uveitis where miosis and posterior synechiae might precipitate angle-closure glaucoma.

In such cases where the angles appear narrow and are judged occludable by the gonioscopist, Nd: YAG laser iridotomy should be performed to eliminate the possibility of angle-closure glaucoma.
PRIMARY ANGLE-CLOSURE GLAUCOMA WITHOUT PUPILLARY BLOCK

- The majority of primary angle-closure glaucomas are triggered by a relative pupillary block phenomenon in which pressure rises in the posterior chamber pushing the iris forward.
- A peripheral iridotomy equalizes the pressure in the anterior and posterior chambers and eliminates relative pupillary block.
- The iris moves slightly back and the angle reopens.
- Infrequently, eyes with well-documented primary angle closure will not respond to peripheral iridotomy.
- These are rare syndromes with peculiar features deserving separate consideration.
PLATEAU IRIS CONFIGURATION AND SYNDROME

- This relatively rare condition is a form of primary angle-closure glaucoma in which the plateau configuration of the iris (described earlier under anatomic considerations) is primarily responsible for the angle closure.
- In plateau iris, little or no relative pupillary block is present.
- After spontaneous or pharmacologic pupil dilation, the peripheral iris crowds and occludes the angle.
- Clinically, this entity presents as acute or subacute angle-closure glaucoma in individuals of either sex.
- An attack of angle-closure glaucoma may follow spontaneous or pharmacologic mydriasis.
- Gonioscopy shows plateau iris configuration.
- The angle will be closed when the pupil is dilated, but the angle will reopen when the pupil is made miotic with miotic therapy or strong light.
- Laser iridotomy should be performed on such eyes to eliminate the presence of any degree of relative pupillary block.
PLATEAU IRIS CONFIGURATION AND SYNDROME

In some such eyes, the angle will retain its plateau configuration but will widen enough to prevent reclosure with mydriasis after iridotomy.

No further therapy is needed other than periodic observation to be sure the angles remain open as expected.

We term this group of eyes as having plateau iris configuration.

Other eyes after iridotomy will not only retain their plateau iris configuration, but also retain the ability of the angle to reclose with mydriasis after iridotomy.

In these eyes with plateau iris, future closure after laser iridotomy may be prevented by chronic miotic eye drops or gonioplasty, which usually lasts years or permanently, to eliminate the peripheral narrowsness of the angle 45.
PLATEAU IRIS CONFIGURATION AND SYNDROME

- Periodic gonioscopic examination is recommended for these eyes. We term this group as having plateau iris syndrome\textsuperscript{46}.

- The differential diagnosis of plateau iris syndrome includes entities with persistent elevated pressure despite iridotomy.

- One should consider extensive peripheral anterior synechiae, imperforate or occluded iridectomy, intraepithelial cysts of the iris and ciliary body, combined mechanism glaucoma, and malignant glaucoma.
NANOPHTHALMOS

- Nanophthalmos, or dwarf eye, is a rare, refractory, and potentially devastating form of primary angle-closure glaucoma.
- It is a rare congenital malformation resulting from arrest in development after closure of the embryonic fissure.
- The nanophthalmic eye is grossly normal but reduced to two thirds of normal ocular volume on average.
- It is a bilateral condition usually without coexisting systemic or ocular abnormalities 47.
- The axial length is between 15 and 20.5 mm with reduced equatorial and transverse diameters.
- The crystalline lens, however, is normal in size leading to a crowded, shallow anterior chamber.
- The lens to eye volume ratio is four to eight times larger in nanophthalmic eyes as compared with normal eyes 48.
- High hypermetropia is the rule; however, emmetropia and, rarely, myopia have been described49.
NANOPHTHALMOS

- The smaller the eye, the more likely it is to have difficulty from the typical nanophthalmic sequellae of angle-closure glaucoma, uveal effusion, and exudative retinal detachment, and the more likely it is to exhibit a poor response to conventional therapy for angle-closure glaucoma.

- Eyes close to the borderline range for axial length in nanophthalmos (e.g., 19 to 22 mm) do not all behave with the adverse characteristics of nanophthalmos.

- However, any eye with a short axial length should be carefully observed for stigmata of nanophthalmos to attempt to avoid the disastrous consequences of characteristic nanophthalmic ocular behavior.
NANOPHTHALMOS

- Histologically, the sclera is abnormally thick and the collagen fibrils are irregularly arranged 50, 51.
- There is an increased pulse amplitude in nanophthalmic eyes perhaps due to impaired drainage through the vortex veins 48, 52.
- The choroid is thick and tends to thicken with time, often eventually progressing to uveal effusion with ballooning choroidal elevation and nonrhegmatogenous exudative retinal detachment.
- The thickened abnormal sclera shows reduced permeability to proteins causing an osmotic gradient, which further contributes to the tendency toward uveal effusion 53.
- The fundus may rarely demonstrate macular hypoplasia and retinal pigment epithelial changes but is usually normal 54, 55.
Nanophthalmos may be sporadic but can be inherited as an autosomal recessive or autosomal dominant trait 47,56,57.

Frequently, many patients within one family are bilaterally blind from angle-closure glaucoma.

In our experience, many of our patients have a parental family history of consanguinity 52,57.

Systemic abnormalities are usually absent.

However, one case each of cryptorchidism and Hallermann-Streiff syndrome coexisting with nanophthalmos have been reported 58,59.

Nanophthalmic patients usually display normal ocular function, other than hyperopia, with an open angle and relatively deep anterior chamber during the early years of life.
Later, in the third to sixth decades of life, the anterior chambers tend to shallow. Several factors may contribute to this shallowing, including crystalline lens enlargement with consequent anterior chamber crowding.

The iris takes on a classic “vesuvian” configuration named for its appearance, which is reminiscent of a volcano. This is secondary to enlargement and anterior displacement of the lens.

Also, choroidal thickening develops often with resulting choroidal effusions occupying posterior volume in the small globe.
NANOPHTHALMOS

- This further causes shallowing of the anterior chamber. Choroidal engorgement may be due to impairment of venous drainage through the vortex veins, which worsens with advancing years because of increasing inelasticity of the thickened sclera.\(^{60, 61}\).

- Reduced scleral permeability may also lead to impairment of transscleral exit of choroidal fluid, also contributing to increased intraocular pressure and shallow anterior chamber.\(^{53, 62}\).

- The result is the gradual onset of angle-closure glaucoma often in the third to sixth decades of life in nanophthalmic patients.

- Angle closure develops, either acute, subacute, or chronic, with subsequent synechial angle closure.
NANOPHTHALMOS

Advances in evaluation of these patients have occurred in the past two decades.

Of value is the added information from refined waterbath B scan ultrasonography, high resolution anterior segment ultrasound biomicroscopy, and high resolution MRI.

The waterbath B scan ultrasound allows evaluation of the choroid, the sclera, and the posterior structures.

High resolution anterior segment B scan biomicroscopy allows remarkably detailed images of the peripheral iris, ciliary body, and other anterior structures in nanophthalmos.
NANOPHTHALMOS

High resolution MRI produces extremely detailed differentiation of the choroid, sclera, and anterior ocular structures in nanophthalmos.

Hopefully these instruments will further elucidate the diagnosis and treatment of this disease.

If nanophthalmic patients are treated without recognition of the special nanophthalmic form of angle-closure glaucoma present, disastrous results can occur.

Such patients develop a flat anterior chamber resistant to all forms of therapy; gradual opacification of the cornea and crystalline lens due to apposition of these structures in the anterior segment; large space-occupying posterior choroidal effusions; and exudative retinal detachments.

The common course is blindness and pain from elevated pressure, unresponsiveness to all conventional forms of therapy, and the occurrence of similar events in the fellow eye resulting in bilateral blindness.
Once angle-closure glaucoma has occurred, if conventional surgery such as incisional surgical iridectomy or a filtering procedure is employed to lower the intraocular pressure, there is usually a marked increase in choroidal effusion and exudative retinal detachment.

In some such cases, the retina is found the next day in a Y-fold behind the crystalline lens) Fig. 17. (In other cases, the crystalline lens has been forced by the massive choroidal effusion through the filtering sclerostomy into the subconjunctival space.

Once the eye has reached this condition, the prognosis for salvage is poor but occasionally successful in the hands of an experienced retinal surgeon.
nanophthalmos

For the ophthalmologist, it is important to identify these small eyes as nanophthalmic before angle closure occurs and treat them with a specific series of special approaches.

Initially, we believe that nanophthalmic eyes should be treated at the first sign of significant narrowing of the anterior chamber with Nd: YAG laser iridotomy to eliminate any current or future element of pupillary block.

This should be performed bilaterally.

As further progressive narrowing of the anterior chamber occurs, as it will even in the absence of pupillary block, gonioplasty can be used to widen the peripheral angle and prevent closure of the angle) Fig. 18; see Table 6. (As the angle becomes progressively more and more narrow, gonioplasty can be applied to the narrowest quadrants of the angle, often at separate sessions, before closure actually occurs to widen the angle and delay the onset of closure) Figs. 19 and. (20 Fig. 18.

Nanophthalmic eye with laser iridectomy at the 11 o'clock position and multiple circumferential gonioplasty burns used to widen the anterior chamber angle successfully.
Fig. 19. Goniophotograph of a nanophthalmic angle before treatment with laser gonioplasty. Note the absence of the angle structures visible.

Belcher CD, Thomas JV, Simmons RJ: Photocoagulation in glaucoma and anterior segment disease, p 133. Baltimore, Williams & Wilkins, 1984

Fig. 20. Goniophotograph of a nanophthalmic angle after treatment with laser gonioplasty.

Note the widening of the angle with structures now visible to the scleral spur.

Belcher CD, Thomas JV, Simmons RJ: Photocoagulation in glaucoma and anterior segment disease, p 133. Baltimore, Williams & Wilkins, 1984
In months or years, in most cases, further shallowing of the anterior chamber will gradually occur despite the aforementioned laser therapies.

Further intervention must then be entertained for imminent angle closure and rising intraocular pressure.

Medical therapy can be employed to lower intraocular pressure. These include beta-blockers, alpha 2 agonists, and topical or oral carbonic anhydrase inhibitors; however, medical therapy is usually only temporarily effective.

Miotics and mydriatics are usually ineffective in altering the anterior chamber depth or altering the anterior chamber angle width.
Fig. 1. Anterior chamber angle width. Cross-sectional diagram of a deep anterior chamber with a nearly flat iris plane, minimal apposition between the iris and lens at the pupil, and a wide-open angle entrance to the filtration area. In this type of eye, aqueous passes easily from the posterior chamber through the pupil into the anterior chamber and out through the filtration area. (Kolker AE, Hetherington J Jr: Becker and Shaffer's Diagnosis and Therapy of the Glaucomas, p 42. St. Louis, CT Mosby, 1970)
Fig. 2. Anterior chamber angle width. A Shallow anterior chamber with a more anteriorly located lens than is shown in Figure 1. Apposition of the lens and iris in the pupillary zone is increased, producing a relative pupillary block that interferes with aqueous flow from the posterior to the anterior chamber. The pressure differential between the posterior and anterior chambers is increased. Kolker AE, Hetherington J Jr: Becker and Shaffer’s Diagnosis and Therapy of the Glaucomas, P 42. St. Louis, CV Mosby, 1970 (
Fig. 3. Anterior chamber angle width. Extremely narrow anterior chamber angle entrance with a mid-dilated pupil and a lax peripheral iris. Increased pressure in the posterior chamber pushes the peripheral iris forward where it lies near the filtration area; at this stage, it does not block outflow of aqueous or increase intraocular pressure). Kolker AE, Hetherington J Jr: Becker and Shaffer's Diagnosis and Therapy of the Glaucomas, p 43. St. Louis, CV Mosby, 1970 (}
Fig. 4. Anterior chamber angle width. The angle has closed and the iris now lies against the trabecular meshwork, obstructing outflow. If closure has occurred around a significant portion of the circumference of the angle, intraocular pressure will rise. Kolker AE, Hetherington J Jr: Becker and Shaffer's Diagnosis and Therapy of the Glaucomas, p 43. St. Louis, CV Mosby, 1970.