Gonioscopy: An Essential Skill to Combat Glaucoma Blindness

[1]Dr. Kirti Singh, [2]Dr. Arshi Singh

1. Glaucoma Services, Guru Nanak Eye Centre, Maulana Azad Medical College, New Delhi, India
2. L.V. Prasad Eye Institute, Bhubaneswar, India

Gonioscopy is the name given to the technique of viewing angle of anterior chamber and structures therein, utilizing specialized lenses. The technique owes its existence to a serendipity by Alexios Trantas who viewed angle structures in a case of keratoglobus in 1907, by indenting the limbus with his finger and a direct ophthalmoscope. He coined the term 'gonioscopy' with Gonia meaning "angle" and skopein "observe" in Greek[1]. Goniolens was first invented by Maximilian Salzmann in 1914, using a contact lens to neutralize corneal optics. This lens was further refined by Koeppe in 1919, by steepening its curvature. Gonioscope was developed by Toroncoso and given its final form by Hans Goldman in 1938. For nearly a century gonioscopy has remained an essential tool in management of glaucoma cases, but the technique has been extremely underutilized, due to lack of training in this essential skill.

RELEVANCE IN INDIAN CONTEXT

Glaucoma is the second leading cause of blindness in adult population of India, of which primary angle closure glaucoma (PACG) is the more blinding entity. Population based studies like APEDS (Andhra Pradesh Eye Disease Study), Aravind comprehensive eye survey (ACES), Chennai glaucoma study (CGS) have reported PACG accounting for twice as much blindness as POAG. A startling aspect highlighted by both CGS and APEDS was, that of the patients previously diagnosed with glaucoma, almost two-third were being treated as POAG due to lack of gonioscopy being performed at the treating centre[2]. Keeping in mind the natural history of primary angle closure disease, almost 1/4th patients with primary angle closure glaucoma suspect (PACS) progress to primary angle closure (PAC), and 1/4th PAC cases further progress to blinding Primary angle closure glaucoma (PACG) over a period of 5 years[3,4]. This relentless progression to blindness could be halted by a peripheral iridectomy in time, which is only possible if gonioscopy is done in all cases of glaucoma. Keeping these facts in perspective, it is imperative that gonioscopy is performed in all glaucoma suspects or those presenting with high intraocular pressure. Clinical examination of anterior chamber depth by flashlight test, van Herick test or anterior segment ocular coherence tomography (ASOCT) do not predict occludable angles reliably enough to be considered as alternative to gonioscopy[5].

OPTICAL PRINCIPLE

When light rays pass from medium with greater index (read aqueous, cornea) to lesser index (read air), the angle of refraction (r) exceeds angle of incidence (i). When this refractive angle equals 90 degrees, the i is said to have reached the critical angle. The critical angle for air cornea interface is 46^0 and since light rays exiting from anterior chamber exceed it, they get reflected back (internal reflection), precluding angle visibility. Elimination of corneal optics by replacing the air interface with a contact lens, having similar refractive index to cornea, neutralizes this internal reflection. Gonioscopy uses such a contact lens and by refracting or reflecting rays from the angle makes the structures therein, visible. In direct gonioscopy the rays refracted through the steep goniolens do not achieve the critical angle, and thus exit out of eye. In indirect gonioscopy light from angle is reflected by a mirror, to exit 90 degrees to contact lens-air interface (Figure 1).

The differences between Direct gonioscopy (using goniolens) and Indirect gonioscopy (using gonioprism) are tabulated in (Table 1).

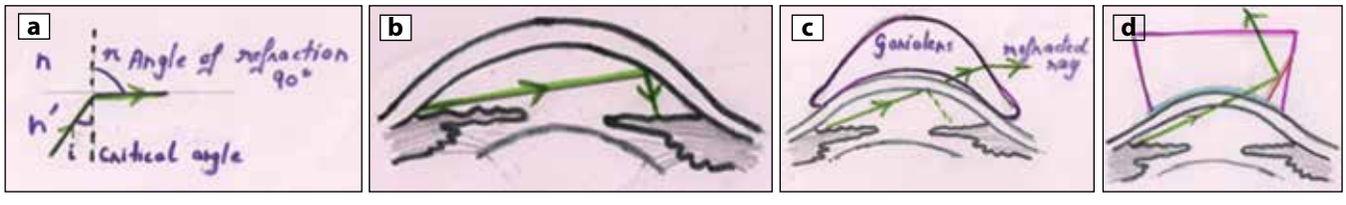

Figure 1: *Optical principles of gonioscopy;* ***a:*** *Ray diagram of light ray passing from denser to lighter refractive index;* ***b:*** *Light rays originating from angle of anterior chamber undergo* ***total internal reflection*** *by corneal surface;* ***c:*** *Rays of light emerging through Koeppe lens;* ***d:*** *Rays of light emerging through Goldmann single mirror gonioscope*

Table 1: Comparision of Direct and Indirect Gonioscopy		
	Direct gonioscopy	**Indirect gonioscopy**
Instrument	Goniolens (Figure 2) a. Prototype: Koeppe 14-16mm (50D) b. Surgical lenses: Hoskin, Barkan, Thorpe, Swan Jacob c. Smaller lens (for infants & preterms): Richardson Shaffer, Layden	Gonioprism a. Goldman single / double / three mirror b. 4 mirror -With handle Posner - Fixed handle Zeiss - Detachable Unger holding forceps - Sussman - hand held
View	Direct- angle seen as it is	Indirect - opposite angle seen
Angle view	Panoramic - 360 degrees simultaneously	One / two / four quadrant seen
Ease of viewing	Good, as examiner looks down over the convex iris	Needs manipulation due to iris convexity obscuring angle- "over the hill phenomenon"
Patient position	Supine	Sitting
Coupling fluid	Saline /none	Methylcellulose/ saline for 1, 2, 3 mirror lenses, Normal tears alone suffice for 4 mirror
Additional instrument	Hand held slit lamp or an operating microscope	Slit lamp optics
Ease	Cumbersome & rarely used	Easy & commonly used
Indications	Children - angle examination under GA or during goniotomy procedure	Diagnostic: Angle closure disease , angle anomalies Therapeutic: Break acute angle closure attack, laser /surgical procedures of angle

INDIRECT GONIOSCOPY (GONIOPRISM)

Goldman family

The prototype is Goldman lens with the single mirror / double mirror or three mirror. The latter is infrequently used for gonioscopy due to its weight and size. The smallest mirror is the gonioscopy mirror.

Four mirror family

This includes Zeiss (with removable Unger fork, Posner (fixed handle) and Sussman (no handle) Difference between two types is given in (Table 2).

TYPES OF GONIOSCOPY

a. Direct and Indirect gonioscopy with goniolens or gonioprism respectively
b. Static gonioscopy and Dynamic (manipulative) gonioscopy with Goldmann lenses
c. Forbes Indentation gonioscopy with 4 mirror lenses only[7].

Static gonioscopy: In this method gonioscopy is done in a dimly lit room, using a narrow slit beam with patient looking straight ahead. It needs to be remembered that diagnosis of occludable angle is made by static gonioscopy.

Manipulative gonioscopy: In this gonioscopy the narrow angle recess is brought into view by making patient look in direction of mirror, which enables examiner to look down into angle recess over the convex iris - "over the hill view". This maneuver is done to look for additional features or abnormalities in the angle, after its occludability has been assessed by static gonioscopy. Tilting or pushing gonioscope tangentially on sclera, towards the angle which needs to be viewed, pushes aqueous into opposite part of angle, making it slightly wider than it really is and thereby enhancing visibility. Thus manipulative gonioscopy can be done by two manoeuvres - first make patient look in direction of mirror or examiner pushes gonioscope towards angle which needs to be viewed.

Indentation gonioscopy: This can be performed with 4 mirror gonioscope only. The small diameter and flatter radius of curvature of the 4 mirror lens, ensures smaller, central area of contact, thereby permitting indentation (central corneal compression) to be easily done. This gonioscopy is done for diagnostic purpose to differentiate appositional (iridotrabecular contact ITC) from synechial closure (peripheral anterior

Table 2: Differences between Goldmann and 4 mirror gonioscopes		
	Goldmann lenses	**4 mirror lenses**
Diameter	12 mm (larger, touches limbus)	9 mm (smaller, remains inside limbus)
Mirror	-Single mirror with 62^0 angulation -Double or three mirror with 59^0 angulation	-Four mirror -Angulation of each mirror is 64^0
Radius of curvature	7.38 mm (steeper)	7.85 mm (flatter), closer to corneal curvature
Coupling fluid	Required - methylcellulose, lubricating jelly or saline	Not required - natural tears suffice for coupling
Angles viewed	Opposite quadrant, so rotation of gonioscope required to view entire angle	Opposite, but presence of 4 mirrors ensure all 4 quadrants become visible with slight tilting of the gonioscope only
Learning curve	Easier initially (can be done in uncooperative patient aided by viscous coupling fluid holding lens on the eye)	Difficult initially (tear fluid being the bridge, these lenses do not stabilize the globe and patient squeezing can distort viewing)
Speed	Slower	Rapid, once initial learning curve mastered
Type of gonioscopy	Static and Manipulative	Static and Indentation

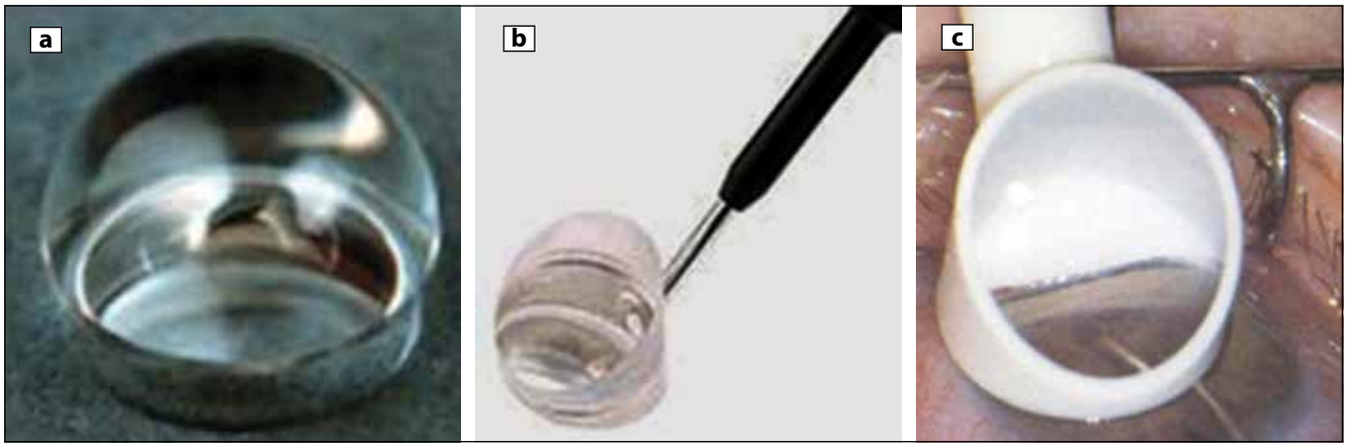

Figure 2: *Direct gonioscopy lenses;* ***a:*** *Koeppe lens;* ***b:*** *Swan Jacob surgical goniolens;* ***c:*** *Swan lens in situ (Courtesy Dr G Spaeth, Wills Eye Hospital, Philadelphia, USA).*

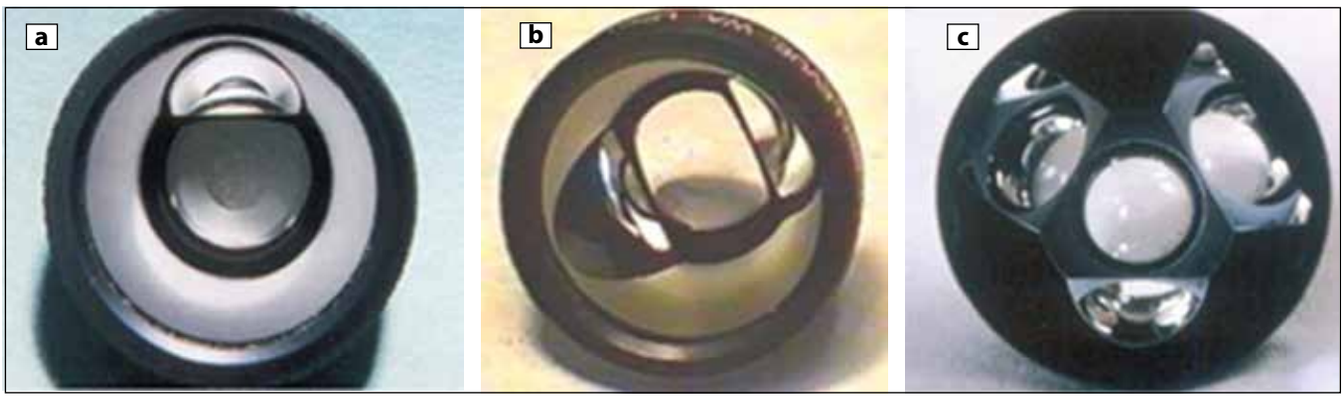

Figure 3: ***a:*** *Goldmann single mirror lens;* ***b:*** *Goldmann two mirror lens;* ***c:*** *a. Goldmann three mirror lens (infrequently used for gonioscopy, shortest mirror is the gonioscopy mirror).*

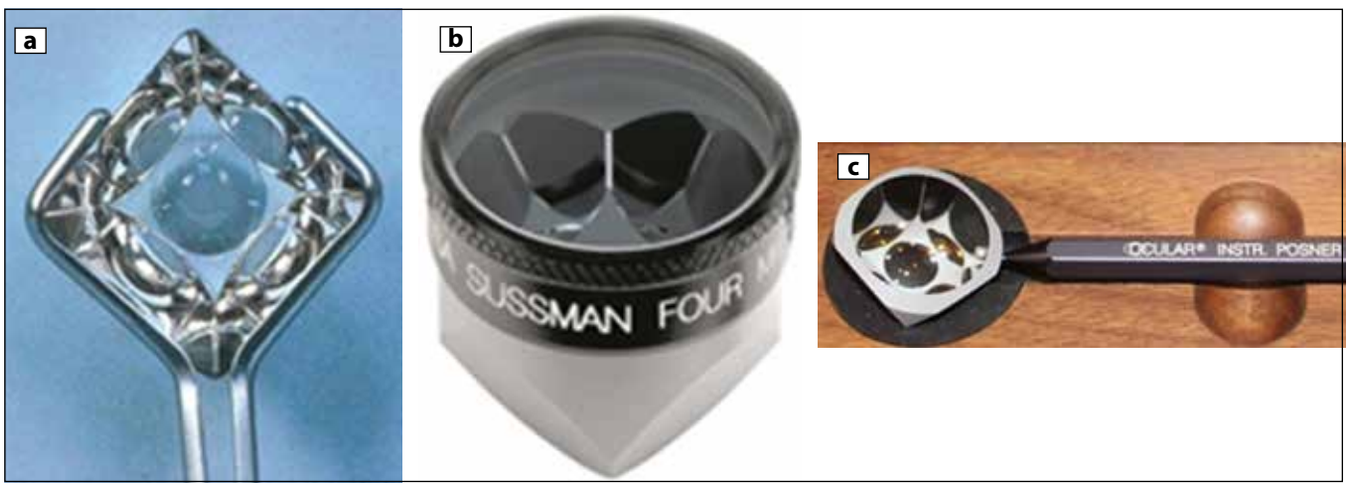

Figure 4: ***a:*** *Zeiss four mirror lens with Unger fork;* ***b:*** *Sussman hand held gonioscope;* ***c:*** *Posner 4 mirror with handle*

synechiae), the former will break and latter will not (Figure 5). It is also used as a therapeutic measure to break acute attack of angle closure glaucoma by displacing aqueous humor against the iris tissue.

Before going further it is worthwhile to recapitulate the currently accepted staging of primary angle closure disease (PACD) as given by International Society of Geographical and Epidemiological Ophthalmology (ISGEO) classification. Gonioscopy is essential in order to categorize the angle closure disease patient into these 3 stages, which then determine further management and prognosis.

- *Primary angle closure suspect (PACS):* At risk cases. Iridoctrabecular contact (ITC) between peripheral iris and posterior trabecular meshwork, with greater than or equal to 270 degrees of post pigmented trabecular meshwork not visible on Static gonioscopy[8]. The European Glaucoma Society

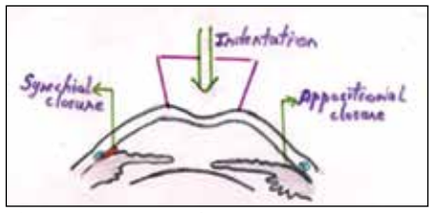

Figure 5: *Indentation gonioscopy differentiating appositional from synechial closure.*

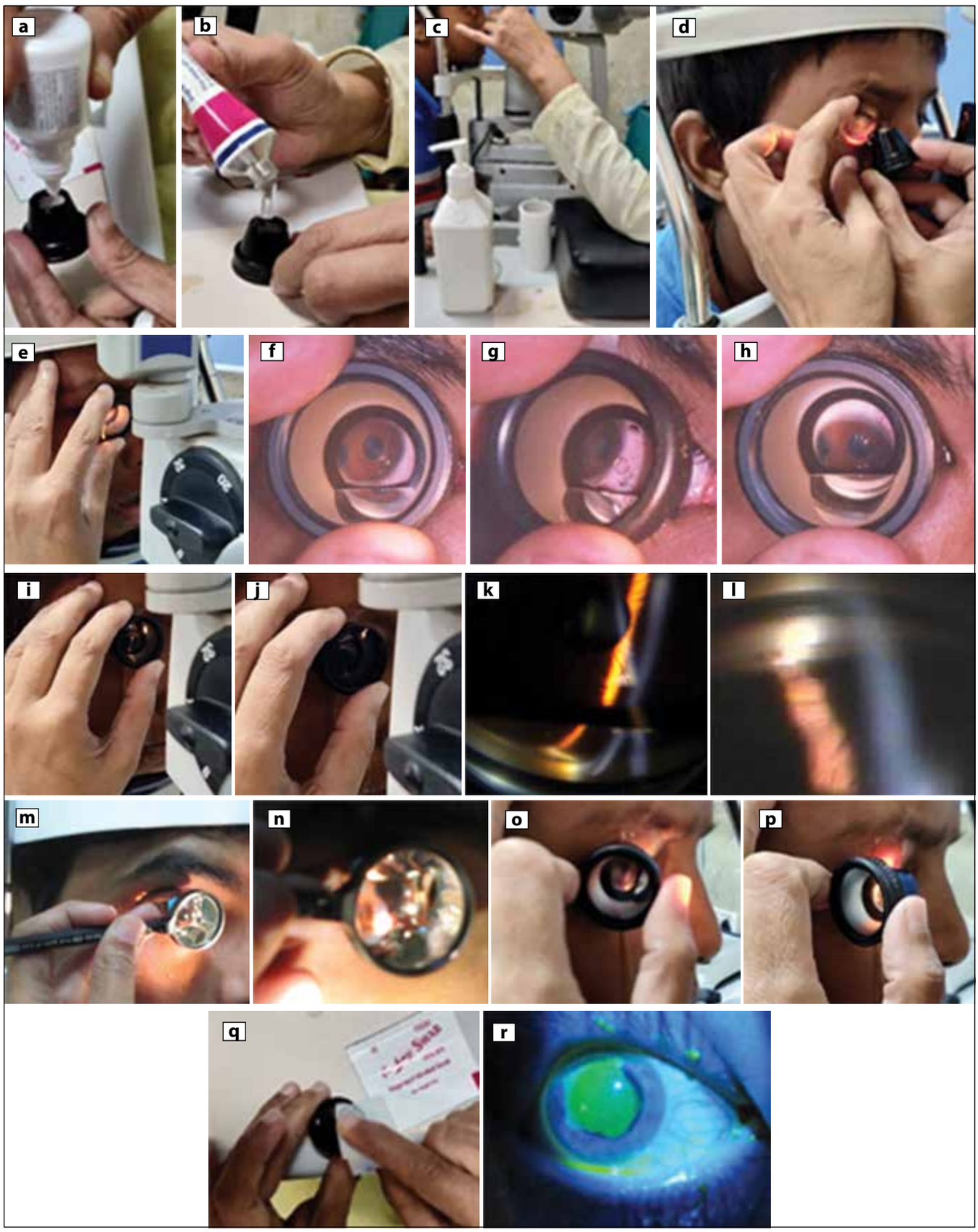

Figure 6 a- r: *Procedure of gonioscopy (see text).*

guidelines however give the figure of 180 degrees ITC[9]. The intraocular pressure (IOP) is normal and optic nerve head shows no damage. Such an angle is an occludable angle and warrants prophylactic treatment[10].

- *Primary angle closure (PAC):* Occludable angle with features of prior trabecular obstruction on Indentation gonioscopy eg Peripheral anterior synechiae/ pigmentation (in absence of prior surgery/comorbidity). The other features range from increased IOP, iris whorling or atrophy, sphincter atrophy, glaukomflecken.
- *Primary angle closure glaucoma (PACG):* Features of PAC and optic nerve damage with or without visual field defects. The IOP may or may not be high at time of examination.

PROCEDURE OF GONIOSCOPY (Figure 6)

- After explaining procedure to patient, the eyes are anaesthetized with 1-2 drops of 2% topical xylocaine applied into the lower cul-de-sac.
- The gonioprism is removed from case, washed with saline, wiped with soft tissue (Figure 6a).
- The concave part is filled with lubricating gel or saline, avoiding air bubbles (Figure 6b).
- Patient is seated on slit lamp and lights in the room are dimmed. Gonioprism is held between index finger & thumb while supporting the elbow on arm rest (Figure 6c).
- Patient is asked to open both eyes and look upwards. Lower lid is pulled downwards creating a pouch (Figure 6d).
- Lower rim of gonioscope is gently inserted into the lower cul-de sac, it is then smoothly slid forward onto the cornea. Gonioscope is then held with three fingers of one hand, leaving other hand free to operate slit lamp.
- Slit beam is then brought from at an angle to illuminate the gonioprism keeping the slit beam parallelopiped co-axial (Figure 6e).
- The gonioscope placement needs to be checked. The edge of mirror should be at limbus for the angle structures to be viewed (Figure 6f,g). depict wrong positioning and (Figure 6h) is the correct position.
- The slit beam needs to be kept long initially to get an overview of the angle, (Figure 6i) then reduced to least illumination & magnification to confirm occludability (Figure 6j) Around 2-3 mm beam length suffices.
- Patient is asked to look straight ahead. The gonioscopy algorithm is followed and starts from checking the pupillary margin, iris surface for any pseudoexfoliation material, sphincteric atrophy, iris atrophy / nodules.
- Then beam width is then shortened to view the angle, ensuring that the slit beam does not cross pupil to prevent "on off phenomenon". Fig 6 k depicts long beam crossing the pupil and would result in artificial widening of angle subsequent to light induced pupil constriction.
- It needs to be kept in mind that the angle viewed in the mirror is 180° away but not crossed.
- The inferior angle is viewed first as it is usually wider and more pigmented due to gravitational settling and aqueous circulation. This makes identification of structures easier in the inferior angle (viewed by mirror placed superiorly) (Figure 6l).
- Lens is then rotated to examine all quadrants. Clockwise examination is preferred for ease of remembering pathological changes according to the clock hours. Initial procedure is done with low magnification for a wider view, increased magnification is resorted to for detail.
- The anterior chamber angle width and structures are then identified by static gonioscopy. In case the entire angle structures are not visible, manipulative gonioscopy (if using Goldmann gonioscopes) or indentation gonioscopy (if using 4 mirror gonioscopes) is resorted to, in order to see the entire angle (Figure 6m,n).
- The examination is terminated by gently rolling the lens off the eye by a clockwise motion aided by asking patient to squeeze lids (Figure 6o,p). It should anti clockance never be pulled off the eye in the z axis.
- Lens is then washed with saline or running tap water. It is then sterilized by wiping it with 70% isopropyl alcohol (Figure 6q).
- Alternatively it can be soaked in 1:10 bleach solution for 5-10 minutes or 2% Glutaraldehyde for 5 minutes, followed by thorough rinsing.
- It must be ensured that the alcohol, disinfecting solution is dried and rinsed off with saline prior to being used in next patient. (Figure 6a) Placing the gonioscope with traces of alcohol on the anaesthetized eye can cause epithelial abrasion while removing it. As the eye is anaesthetized, patient will not complain of pain immediately. Such a complication is noted when patient presents with epithelial defect a few hours after the examination (Figure 6r).

The algorithm of evaluating gonioscopy findings in sequence is

I. Angle width and last structures visible
II. Peripheral iris configuration/ insertion
III. Trabecular meshwork pigmentation
IV. Abnormal structures visible like synechiae, blood vessels, pseudo exfoliation material

I. Angle width and last angle structure visible

- The first structure which needs to be identified is the Schwalbe's Line. This thin, glistening white, sometimes pigmented line represents termination of Descemet's membrane. It is localized by creating a narrow slit and tracing the two linear reflections of external and internal corneal reflexes, the corneal wedge. The intersection of the two reflections or termination of corneal wedge is the Schwalbe's line (Figure 7). Difficult to see in younger patients, it often acquires a smattering of pigment with age.
- The next structure to be identified is the Trabecular meshwork. This translucent, light grey structure acquires varying degrees of pigmentation with age, pathology, surgery, post laser or surgery. It is divided into two parts - the anterior 1/3 non pigmented trabecular meshwork (ATM) and post 2/3 pigmented trabecular meshwork (PTM), the latter being the filtering part. Schlemm's Canal (SC) is covered by the pigmented, filtering portion of TM and is only clearly visible if filled with blood (Figure 8).
- This is succeeded by the Scleral spur. Scleral spur is a thin, whitish prominent band. It is the anterior most projection of sclera where the longitudinal muscle of ciliary body is attached.
- Next structure visible is the Ciliary body band. This greyish brown structure, is broader in inferior and temporal angle. It's width depends on iris insertion and is wider in myopic eyes.
- Last structure to be identified is the Fuch's last roll of iris (Figure 9).

GRADING OF ANGLE

Many methods exist for angle grading namely - Shaffer, Schie, Spaeth, Kanski Shaffer. To prevent confusion it is preferable to individually label the last structure visible on both static and manipulative gonioscopy. As depicted in the figure below (Figure 10).

The different gradings in use are - Shaffer (most popular) (Figure 11), Spaeth (most detailed), Schei (reverse of Shaffer, with occludable angle being Grade IV). Table 3 details the different

Figure 7: *Corneal wedge denoting Schwalbe's line*

Figure 8: *Schlemm's canal filled with blood in Sturge Weber glaucoma case*

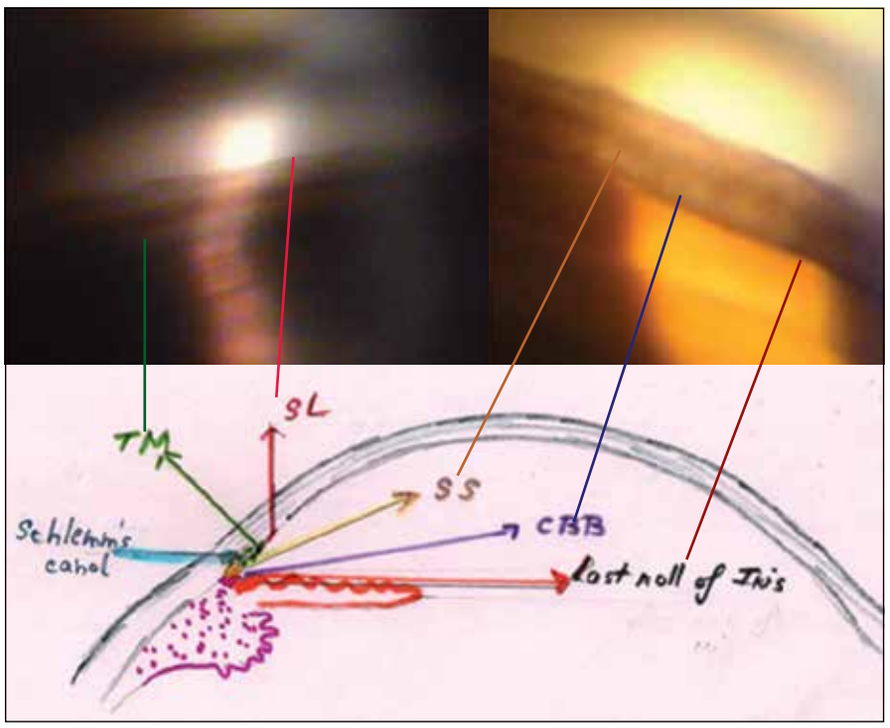

Figure 9: *Labelled diagram of angle structures in a widely open angle*

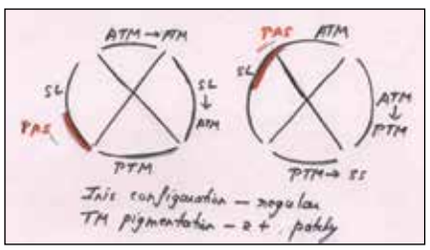

Figure 10: *Gonioscopy diagram (The Goniogram). The symbol → implies structure visible after doing manipulation. In the Fig above SL→ ATM, means Schwalbe's line was visible on static gonioscopy and anterior trabecular meshwork became visible only post manipulation indentation.*

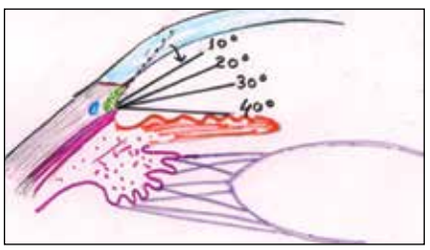

Figure 11: *Angle width (approximate geometry) in 4 grades of Shaffer classification*

classifications.

The following gonio pictures detail the different grades of Shaffer classification on angle. For sake of image clarity, while taking the gonioscopic photographs, the authors have taken the liberty to make the slit beam little longer, in actual practice it needs to be short and not traverse the pupil (Figures 12 ,13,14,15).

Spaeth grading system further details the angle based on iris insertion, iris configuration and trabecular pigmentation (Table 4)

II Iris peripheral configuration and insertion

This is the next aspect to be looked for. Peripheral iris insertion has been described by G. Spaeth as b, p, f, c (Figure 16,17).

B is *anteriorly bowed* (convex configuration) iris and is seen in pupil block glaucoma and hypermetropes. It is graded 1-4 with 4 being severe iris bombé.

F is *flat iris*, previously called as *regular iris*

C is *concave iris* with posterior bowing, previously called *queer iris*. It is seen in pigment dispersion syndrome, myopia, aphakia, subluxated lens.

P is *plateau iris* configuration - planar in centre with iris root angulating forward in periphery due to anteriorly situated ciliary process. The look is of a sudden curve in the iris and this can be clearly demonstrated by Ultrasound biomicroscopy (UBM) (Figure 18). The anteriorly situated ciliary processes cause bunching of peripheral iris presenting as classical "double hump/ sine wave" sign on gonioscopy (Figure 17d).

The other aspect of iris to be checked is iris insertion. It is denoted as A, B, C, D, and E as explained in (Figure 19).

Classically high iris insertion is seen in patients with juvenile open angle glaucoma.

III Trabecular meshwork pigmentation:

While assessing trabecular meshwork pigmentation, two aspects are important - the intensity or grade of pigmentation and pattern of pigmentation Figure 20 gives the pictures of different grades of pigmentation.

While assessing pigmentation it must be confirmed that the trabecular meshwork (TM) is affected, as sometimes Schwalbe's line can be more pigmented. Called as Sampaolesi line, this pigmented Schwalbe's line is seen in pigment dispersion syndrome or pseudoexfoliation syndrome (Figure 21c). It is important to understand this, otherwise mistaking the pigmented Schwalbe's line for Trabecular meshwork, would erroneously label a closed angle as open. Location of corneal wedge should be resorted to, in such situations. Excess pigmentation of trabecular meshwork should initiate search for other signs of pigment dispersion or pseudoexfoliation glaucoma like Krukenberg spindle or/ and iris transillumination defects.

This undescores the other aspect of pigmentation in angle - pattern of pigmentation. Figure 21 clearly depicts this.

IV. Other structures - abnormal/ normal

The last thing to be looked at is presence of abnormal structures like synechiae, new blood vessels, pseudo exfoliation material or broad ciliary body band.

Table 3: Different classification systems of angle structure grading

Angle recess in degrees & structures visible *Shaffer Kanski classification* [11]	**Risk of closure**	**Shaffer classification**	**Spaeth classification**	**Schei classification**
0^0: Irido-corneal contact or Dipping of beam Do indentation gonioscopy to differentiate appositional vs synechial closure	Closed angle	Grade 0	Grade A	Grade IV
0-10^0: Schwalbe line or anterior trabecular meshwork (non-functional part) visible	Closure possible	Grade 1	Grade B	Grade III
10-20^0: Posterior trabecular meshwork (functional part) visible (Extent : 90^0/180^0 PTM visible= PACS)*	Narrow, closure possible	Grade 2	Grade C	Grade II
25-35^0: Scleral spur visible	Closure impossible	Grade 3	Grade D	Grade I
35-45^0: Ciliary body visible	Closure impossible	Grade 4	Grade E	Grade 0
**PACS of ISGEO classification*				

Table 4: Spaeth grading system

Angular approach	**Iris insertion ABCDE**	**Peripheral iris configuration F B P C** **Old**	**New**	**Trabecular meshwork pigmentation**
Range 0 - 45^0	A. Anterior to Schwalbe's line	R regular	F flat	0 no pigment
	B. Between Schwalbe's line			1+ minimal
	C. Scleral Spur visible	S steep	B bowed anteriorly	2+ mild
			P plateau iris	
	D. Deep with ciliary body visible	Q queer	C concave	3+ moderate
	D. Extremely Deep with > 1 mm ciliary body visible			4+ intense
In Spaeth's scheme the angle is written as D 40^0, c, 2+ TMP (D = deep insertion, 40^0 = angle recess, c = concave iris configuration, 2+ TMP = grade of TM pigmentation)				

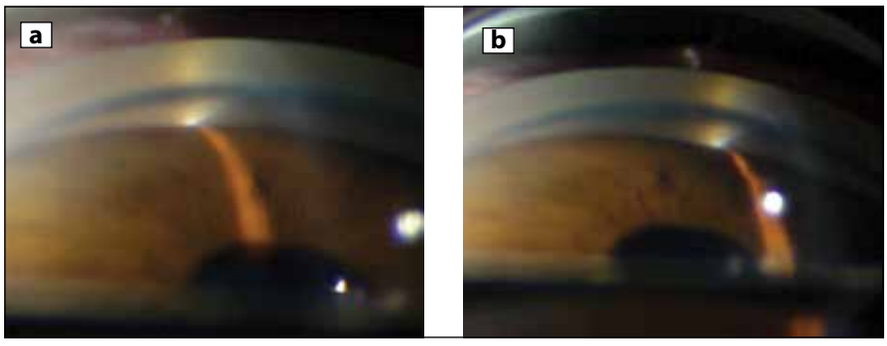

Figure 12a,b: *Shaffers Grade 0: Dipping of beam. This is an occludable angle and requires manipulative & indentation gonioscopy to see the structures.*

SYNECHIAE

Synechiae in the angle are of two types - peripheral anterior synechia (PAS) or goniosynechiae. Peripheral anterior synechia are coarse adhesions between iris and peripheral cornea. The characteristics of PAS are: broad pigmented structures that tent the iris and adhere anywhere, sometimes reach the Schwalbe's line, obscure scleral spur or trabecular meshwork, inhibit movement of the iris and flow of aqueous. Their presence implies pupil block or persistent shallow anterior chamber in the past (Figure 22).

Goniosynechiae on the other hand are fine pigmented bands which bridge the angle recess. They also can adhere to any level including Schwalbe's line and imply prior attacks of angle closure (Figure 23a).

Iris processes are delicate, lacy, thread like structures which wrap around the iris base. They are seen in young patients and of two types - V and W. The V type are common and reach the scleral spur or trabecular meshwork. The uncommon W type reach till Schwalbe's line and are seen in secondary developmental glaucoma like Axenfield Reiger syndrome (Figure 23b). Iris processes are often physiological and occur in almost 35 % of normal patients and wither with age. They never reach the Schwalbe's line and do not inhibit flow of aqueous (Figure 23c).

NEOVASCULARIZATION

Presence of new blood vessels in the angle need to be differentiated from normal vessels. Abnormal blood vessels are fine, superficial, extend beyond the scleral spur to arborize on trabecular meshwork. They run diagonally or follow erratic patterns on the iris surface. Normal vessels on the other hand, follow a circumferential or radial pattern and never arborize. Normal vessels become visible in cases of iris atrophy and they do not cross the scleral spur. Neovascularization of angle (NVA) often, but not always, coexists with neovascularization of iris (NVI), thus presence of NVA necessitates a re-look to rule out iris rubeosis (Figure 24).

CILIARY BAND WIDENING

Gonioscopy aids in diagnosis of various manifestations of ocular trauma like angle recession, cyclodialysis and iridodialysis (Figure 25).

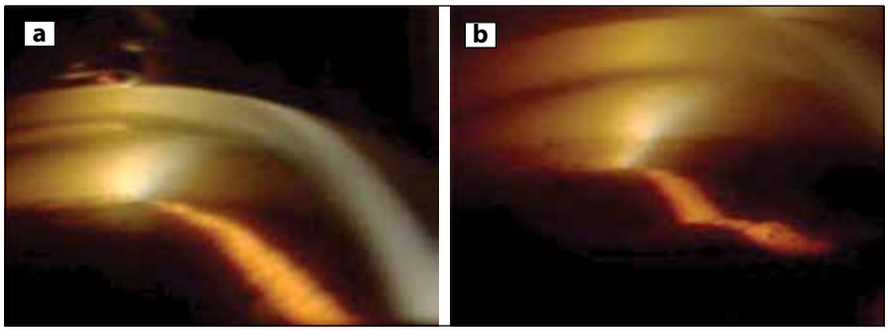

Figure 13: *Shaffers - Grade 1 (10^0)* ***a:*** *Anterior trabecular meshwork visible, in places post trabecular meshwork also visible;* ***b:*** *Post manipulation angle structures till scleral spur becomes visible. This is an occludable angle.*

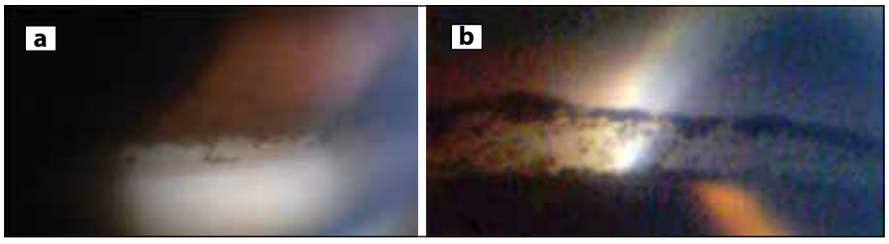

Figure 14: *Shaffers Grade 3. a. Scleral spur is visible in places Presence of* ***a:*** *goniosynechiae and* ***b:*** *dense patchy pigmentation of Schwalbe's Both cases require peripheral iridectomy, despite being non-occludable.*

Figure 15: *Shaffers grade 4 (45^0) Wide open angle. Ciliary body visualized with ease.*

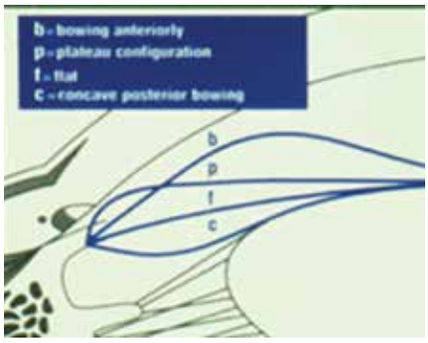

Figure 16: *Peripheral iris curvature (courtesy Prof G Spaeth).*

POSTERIOR EMBRYOTOXON

Prominent anteriorly displaced Schwalbe's line, often pigmented, occurs in Axenfeld Rieger syndrome (Figure 26). The condition has other stigmata like iris atrophy, corectopia, iridocorneal adhesions, dental abnormalities, maxillary hypoplasia etc.

GONIOSCOPY POST TRABECULECTOMY

Gonioscopy retains its usefulness as a diagnostic modality in cases of bleb failure post trabeculectomy. The most common cause of bleb failure is subconjunctival fibrosis (external cause of failure), rarely the inner sclerostomy gets blocked by iris tissue, blood clot or vitreous (internal cause of failure). Gonioscopy comes to the rescue in this scenario by ruling out the latter cause, namely internal ostium blockade. Therefore whenever the peripheral iridectomy is not clearly visible in scenarios of flat bleb, diagnostic gonioscopy needs to be done. (Figure 27). In case of internal ostium block, the iris tissue needs to be physically removed from ostium combined with needling of bleb for reviving the failed trabeculectomy. The reader must try and do gonioscopy after trabeculectomy to familiarize with the open sclerostomy look. In situations of Glaucoma drainage device surgery (GDD) gonioscopy helps in locating the tube, more so when it has retracted (Figure 28).

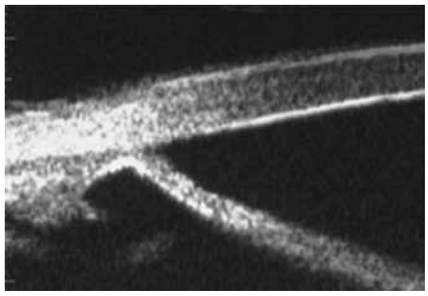

Figure 18: *Ultrasound biomicroscopy of plateau iris. Note peripheral bowing of iris of p configuration, due to anteriorly placed ciliary process. (Courtesy Prof G Spaeth).*

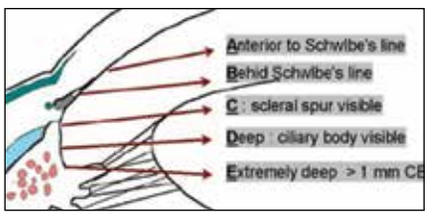

Figure 19: *Iris insertion patterns (courtesy Prof G Spaeth).*

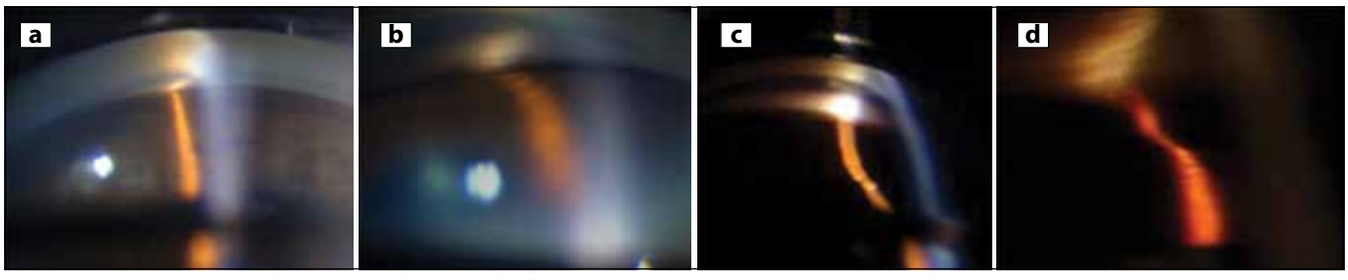

Figure 17: *Peripheral iris configuration;* ***a:*** *Flat or regular;* ***b:*** *Bowed or Convex;* ***c:*** *Concave or Queer* ***d:*** *Plateau (Sine wave sign)*

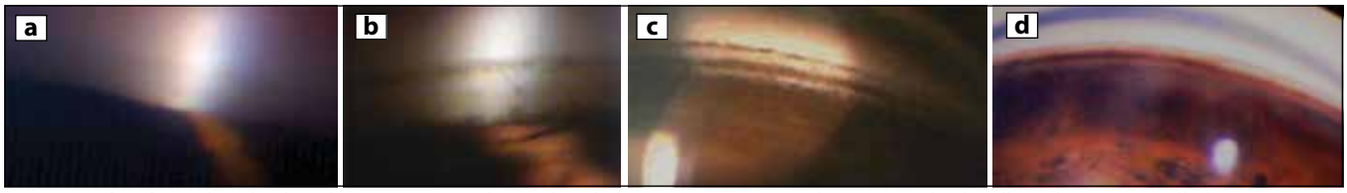

Figure 20a,b,c,d: *Grades of trabecular pigmentation from nil to dark pigmenation. Densely pigmented Schwalbe' s line in c is called as Sampoelesi line. Diffuse trabecular meshwork pigmenation as in c is sometimes called as Mascara line.*

Figure 21 a: *Highly pigmented Schwalbe's line with Patchy pigmentation and a paler trabecular meshwork;* ***b:*** *Moderately pigmented Schwalbe's line with Patchy pigmentation In both a, b angle closure glaucoma is a strong possibilty and other eidence of prior attacks - like glaucomflecken, iris atrophy would need to looked for* ***c:*** *Schwalbe line is diffusely pigmented, and this pigmentation is more than that seen in Trabecular meshwork . The Schwalbe line is the picture b is Sampoelsei line.*

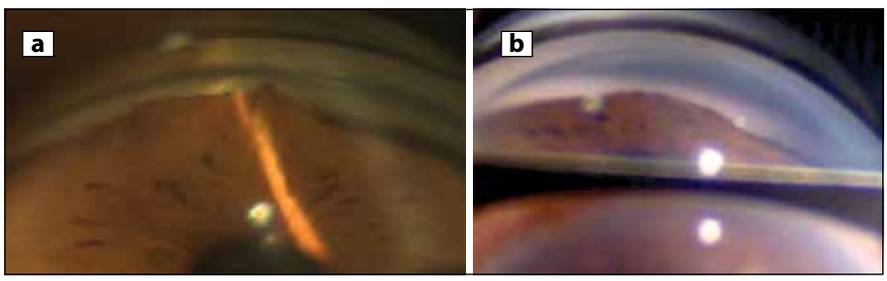

Figure 22a,b: *Peripheral anterior synechiae.*

Figure 23a: *Goniosynechia;* ***b:*** *Iris processes V type;* ***c:*** *Iris processes W type.*

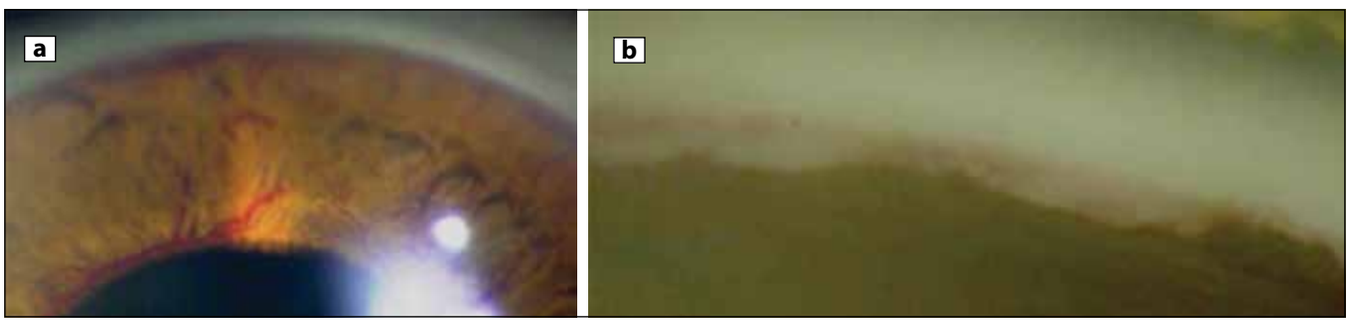

Figure 24a: *Rubeosis iridis & neovascularization angle;* ***b:*** *Neovasculrization of angle on Gonioscopy*

CONTRAINDICATIONS TO PERFORMING GONIOSCOPY

a. Perforated globe
b. Active infection -corneal ulcer, conjunctivitis
c. Corneal surface disease not permitting adequate placement of gonioscope

CLINICAL PEARLS AND CAVEATS

- During work up of a glaucoma case, gonioscopy is done after tonometry, since manipulations during gonioscopy may reduce the IOP by phenomenon of pseudofacility.
- Gonioscopy needs to be repeated at 2-3 yearly intervals, since crystalline lens growth makes angle anatomy dynamic[13].
- Perform gonioscopy in a relatively dark room, as photopic pupil response will constrict pupil and arte-factually open angle.
- Hyperopic patients are more likely to have narrow anterior chamber angles.
- Structures are seen of opposite angle

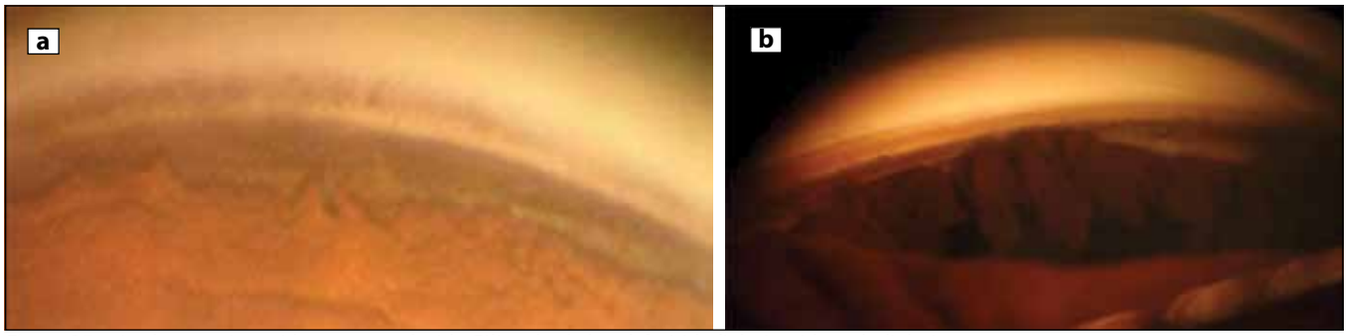

Figure 25a: *Angle recession with presence of wide Ciliary body band;* ***b:*** *Iridodialysis with cyclodialysis*

Figure 26: *Posterior embryotoxon - Anteriorly displaced Schwalbe line Axenfeld Reiger. Note obscuration of scleral spur due to high insertion of iris Behind Schwalbe's line (B).*

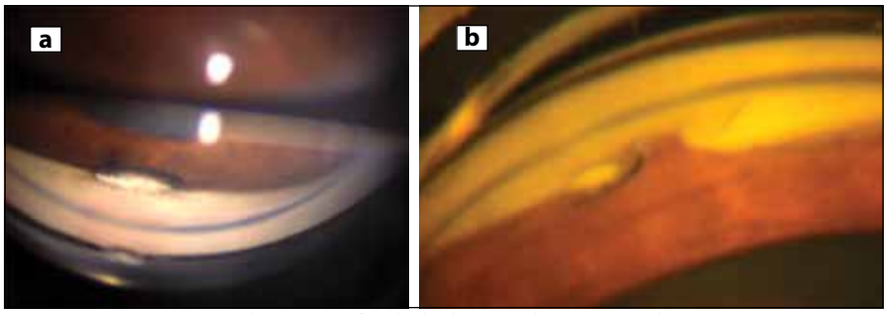

Figure 27a: *Patent inner sclersostomy;* ***b:*** *Blocked inner sclerostomy with iris tissue.*

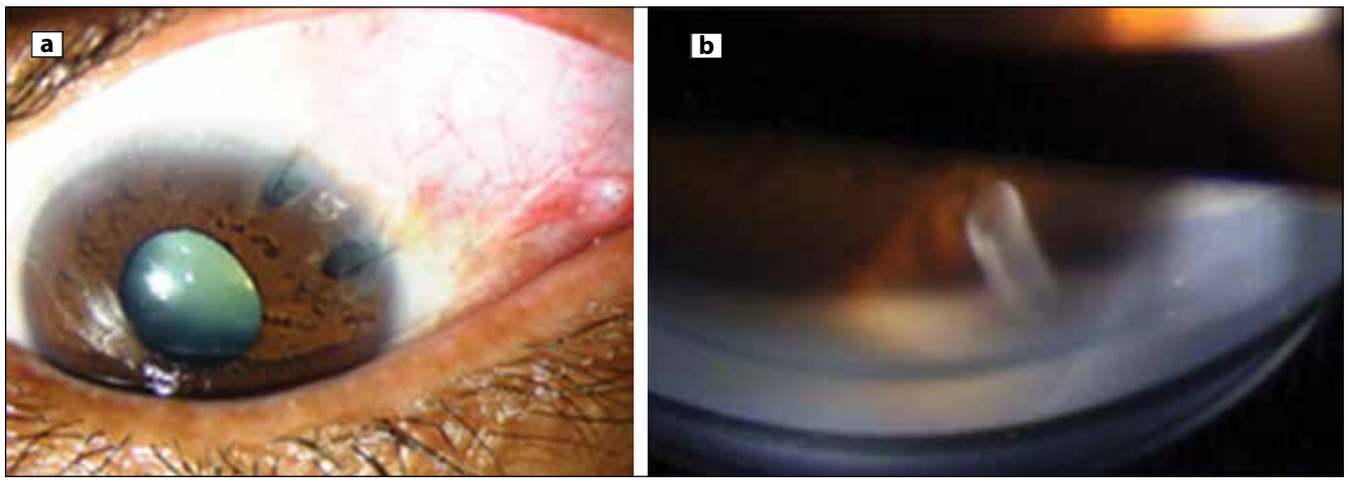

Figure 28a,b: *Tube shunt position and patency confirmed on Gonioscopy.*

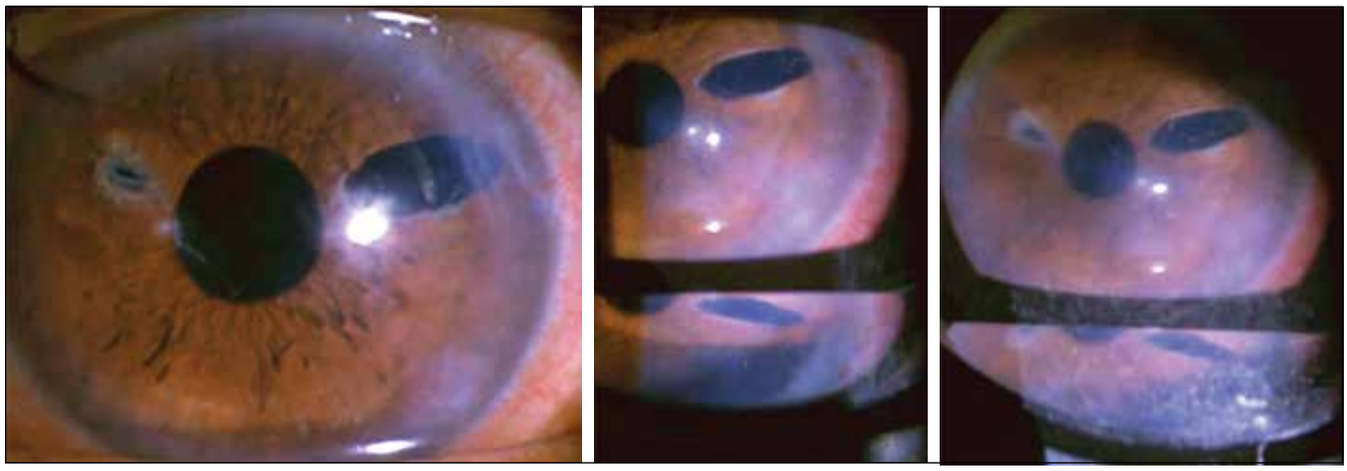

Figure 29: *Note a large surgical PI in temporal aspect of this eye. Through the gonioscope mirror the PI is visible in same direction, not crossed.*

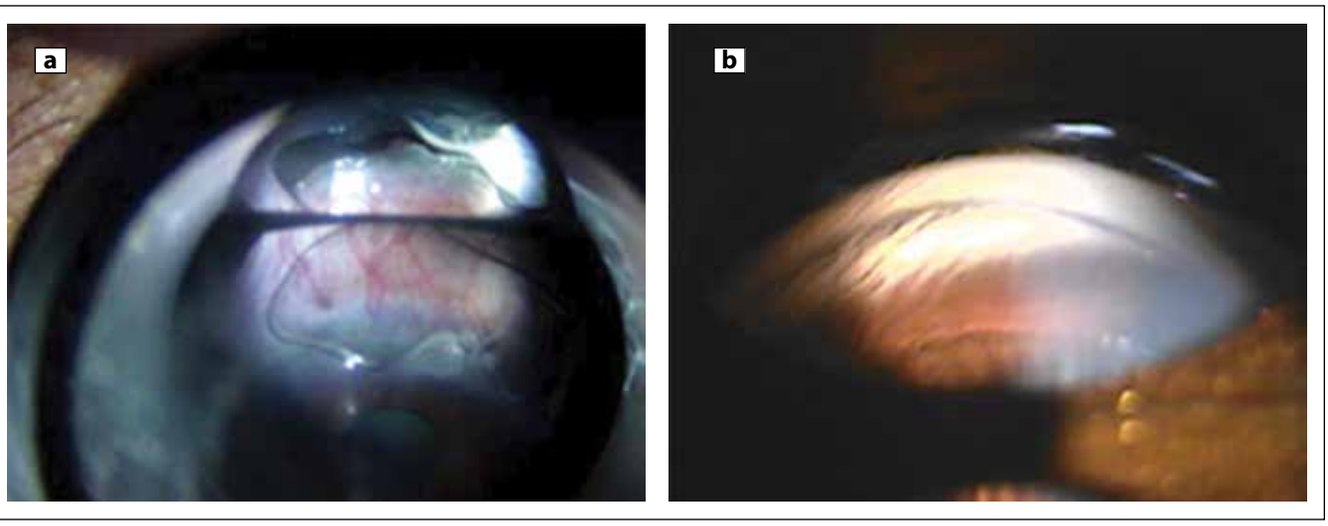

Figure 30a: *Air bubbles entrapped between gonioscope and ocular surface* ***b:*** *Excess pressure generates Descemet's folds.*

but are not crossed (Figure 29).

- Air bubbles often enter in the space between eye and gonioscopy lens. Tilting and rocking of lens can get rid of the small bubbles. If this fails lens removal and reinsertion is required (Figure 30a).
- Excess pressure on the gonioprism will generate folds on Descemet's, making visualization difficult and also falsely deepen the angle (Figure 30b).

REFERENCES

1. Gonioscopy and other techniques. In: Allingham RR, Damji K, Freedman S , Moroi S, Shafranov G, Eds. Shields textbook of glaucoma. 5th edition. Philadelphia PA : Lippincott Wiliams & Wilkins; 2005 , pg 59-71
2. Ronnie G, Ve R S, Velumuri L, Asokan R, Vijaya V Importance of population-based studies in clinical practice. Indian J Ophthalmology 2011, 59(7): 11-18
3. Thomas R, George R, Parikh R, Muliyil J, Jacob A. Five year risk of progression of primary angle closure suspects to primary angle closure: a population based study. Br J Ophthalmol. 2003; 87 (4):450-4.
4. Thomas R, Parikh R, Muliyil J, Kumar RS. Five-year risk of progression of primary angle closure to primary angle closure glaucoma: a population-based study. Acta Ophthalmol Scand. 2003;81 (5):480-5.
5. Thomas R, Thomas S, Chandrashekhar G. Gonioscopy. Indian J Ophthalmology 1998, 46(4): 255-261
6. Thomas R, George T, Braganza A, Muliyil J The flashlight test and Van Herick's test are poor predictors for occludable angles. Aust NZ J Ophthalmol 1996;24:251-56
7. Forbes M. Gonioscopy With Corneal Indentation A Method for Distinguishing Between Appositional Closure and Synechial Closure. Arch Ophthalmol. 1966;76(4):488-49
8. Foster PJ, Buhrmann R, Quigley HA, Johnson GJ. The definition and classification of glaucoma in prevalence surveys. Br J Ophthalmol. 2002, 86(2):238-42.
9. European Glaucoma Society Terminology and Guidelines for Glaucoma, 4th Edition - Chapter 2: Classification and terminology Supported by the EGS Foundation. http://dx.doi.org/10.1136/bjophthalmol-2016-EGSguideline.002 accessed on October 2018
10. Friedman DSW, R. N. Consensus on Angle-closure and Angle-closure Glaucoma. AIGS/WGA Consensus Series 2008
11. Glaucoma. In Bowling B Ed. In: Kanski's clinical ophthalmology. A systematic approach. 8th edition place. Elsevier 2016, pg 310-316.
12. Schuman JS, Joshi D, Gamell LS. The angle of anterior chamber. In: Kahook M Y, Schuman Eds. JS. Chandler & Grant's Glaucoma. 5th edition. SLACK incopr, N Jersey 2013 pg 51-80.
13. Dueker D and Al Jadan I. Clinical In Eds Albert DM, Miller JW. 3rd edition Saunders evaluation of the glaucoma patient. Albert Jakobiec's Principles and Practice of Ophthalmology. Elsevier. Philadelphia. 2008 pg 2485-6.

Correspondence to:
Dr. Kirti Singh
Glaucoma Services, Guru Nanak Eye Centre,
Maulana Azad Medical College,
New Delhi, India