2.6 Iris and Pupil

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2.6.1 Introduction

The two most important attributes of the iris are its *regulatory* function, controlling the amount of light reaching the retina,[1] and its *barrier* function, separating the two main chambers of the eye.[2] In addition, the iris has a cosmetic function, whose significance should not be underestimated. Restoration of the injured iris to its normal anatomy is one of the most neglected aspects of ocular traumatology.

The presence of major iris damage is an indicator of ciliary body trauma: if traumatic aniridia is found, the risk of eventual phthisis increases.

2.6.2 Evaluation

Major abnormalities are easily seen with the naked eye, especially if the iris is light colored. A penlight is used to compare the injured iris' color with that of the fellow eye.[3]

1 Examination of the iris always includes examination of its aperture, the pupil.
2 Dividing the globe into anterior and chambers is especially important in an aphakic or pseudophakic eye filled with silicone oil.
3 Heterochromia is obviously impossible to diagnose without inspecting the fellow eye. Color difference is much more difficult to notice at the slit lamp since the two eyes cannot be viewed simultaneously.

The slit lamp remains the most important diagnostic tool. The iris must be inspected for the presence of wounds, membranes, and IOFBs, as well as for its shape (i.e., iridodialysis). Examination of the pupil is crucial (see Chap. 1.9 and Table 2.6.1), and includes evaluation both static (e.g., shape) and dynamic components (e.g., reaction to light). Inflammation, which always accompanies trauma, makes the pupil small[4] and may make it appear "muddy" due to swollen vessels and protein debris.

If an abnormality such as an irregular pupil size or iris discoloration is found, the ophthalmologist must ask the patient about preexisting conditions (previous injury, drug use) and diseases (uveitis). If necessary, an old photograph should be used for comparison to determine whether a heterochromia is congenital or a sign of siderosis. A greenish iris discoloration is often observed in (pre)phthisical eyes.

2.6.3 Specific Conditions

2.6.3.1 Mydriasis

Whether caused by central (third nerve palsy) or local (i.e., sphincter muscle damage, retroiridal scarring) pathology or other etiologies [6], the condition requires surgical correction if it results in photophobia that compromises vision. If mydriasis represents a major cosmetic problem for the patient, this is also an indication for corrective surgery.

Scarring usually occurs in the context of anterior PVR, and treatment of the mydriatic pupil should be addressed during vitrectomy. The goal is to remove the scar tissue that lines the pars plana, ciliary body, and the back surface of the iris. If the lens is present, it must be sacrificed. Endoscopy-assisted vitrectomy offers several advantages traditional viewing cannot match (see Chap. 2.20). Complete scar removal is not always possible, and even if it is, return of iris/pupil mobility is not guaranteed.

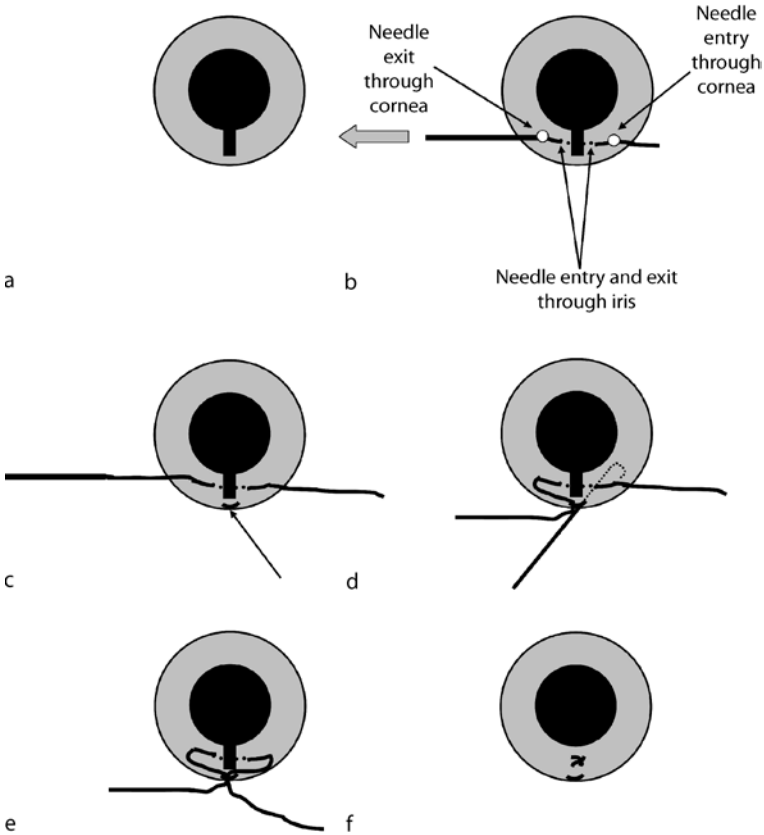
4 Unless the inflammation is being treated.

Table 2.6.1 Evaluation of the pupil in patients with eye injury

Variable	Comment
Size	Should be within normal range, depending on the power of the illumination, and not differ from the size of the uninjured fellow eye. In case of anisocoria, the pupil may be miotic or mydriatic. If miotic, the differential diagnosis includes synechia and Horner's syndrome; if mydriatic, consider: Preexistent condition (pharmacological, synechia, siderosis) Parasympathetic nerve damage (typically after a contusion) Adie's syndrome Third-nerve palsy
Position	Should be central; if dislocated, the cause can be iris or vitreous prolapse (see Chap. 2.4), or iridodialysis
Shape	Should be round; if not, the most likely cause is posterior synechia or iridodialysis
Color	Should be black;[1] a pupillary membrane causes color change, as does a cataract
Reaction to accommodation	The pupil should constrict
Reaction to direct light	The pupil should constrict – if lacking a reaction, it must be determined whether this is due to a problem with afferentation (no perception of light), efferentation (injury to the parasympathical system), or there is a local cause (injury to the sphincter muscle or the presence of posterior synechia)
Reaction to indirect light	Consensual (Fig. 1.9.1)

[1] Except, of course, if the illumination is coaxial (red reflex)

If a radial laceration causes the dysfunction of the sphincter muscle, a single transcameral suture [10] is usually sufficient to restore anatomy and function (Fig. 2.6.1).


Needle exit through cornea
Needle entry through cornea
Needle entry and exit through iris
a
b
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e
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Fig. 2.6.1 Transcameral suture for damaged iris sphincter muscle.[1] The initial step is to assure that there is no synechia; if there is, this must be broken before suture introduction (see Chap. 2.5). **a** The iris lesion may involve the pupillary margin or may be more peripheral. **b** A long, straight or curved needle is used to enter the AC through the cornea at a convenient location but outside the visual axis. The needle enters the torn iris on both sides of the lesion, and exits the cornea on the opposite side (*thick arrow*). Do not enter/exit the AC in the limbus; it is easier to catch the suture later during the procedure if the suture is in an area with greater AC depth. Once the suture has been pulled through, the needle is cut off. **c** A paracentesis is made somewhere in the middle plane between the two needle entry/exit points, over the iris lesion (*arrow*). As described in Chap. 2.5, the angle of the paracentesis must allow easy maneuvering as well as watertightness without suture. The paracentesis should not be far away from where the knot will be (see below). **d** A hook fashioned at the tip of a hypodermic needle or a vitrectomy forceps is used to engage the two sutures above the iris and pull them out from the AC through the paracentesis. **e** The sutures are tightened. The iris must be sufficiently loose because it will be tented as the suture is tightened. This is the reason why the paracentesis must be strategically placed, and placed *after*, and not before, the sutures are introduced into the iris. If the iris is rigid or the lesion is wide, *intraocular suture tightening* may have to be performed or the lesion is treated only partially.[2] *Internal* tightening of the knot requires a paracentesis on both sides. The suture enters the AC via one paracentesis, picks up the iris as described above, and exits the AC through the other paracentesis. The suture is then partially withdrawn[3] and tied using the loop: the knot is formed inside the AC, without tenting the iris. The needle is then pulled back through both paracenteses and the entire procedure is repeated. An alternative is not to bring the iris edges in apposition but leaving a small gap between them. **f** The iris is left to slide back in place; the suture remains visible, but the gap in the iris should disappear or become very small. If need be, additional sutures may be introduced in the same way. The procedure can also be performed in a phakic eye, after first carefully injecting cohesive viscoelastics under the iris

[1] Viscoelastics are typically not necessary, although the surgeon should apply them if the AC gets shallow.

[2] A description of these two techniques are given here, but neither is shown.

[3] The needle remains outside the eye.

Transcameral needles are not easy to use (Fig. 2.6.2). The needle's path through the cornea acts as a fulcrum; the more forward the needle's position in the AC is, the smaller a movement with the needle holder is needed to cause in a large movement of the needle's tip. To make needle use easier, the surgeon should either bring the needle's entry point as close to its intracameral target as possible, or use another instrument (e.g., a vitrectomy forceps) to guide the needle inside the AC.

Cave

Any suture placed into the iris must provide a permanent lock: there is no iris healing. The suture material must be nonabsorbable [10/0 or 9/0 polypropylene on a straight (STC-6) or curved (CIF-4) needle][5] and the knot must be made very secure. The suture must not exert undue tension on the iris to avoid "cheesewiring."

If the sphincter muscle is completely nonfunctional, an iris cerclage (purse string) suture should be used (Fig. 2.6.3).

2.6.3.2 Laceration/Coloboma

Surgery should be considered if the lesion prevents proper pupillary function, visual disturbance[6], or causes a significant cosmetic problem. The surgical technique is identical to the one described above for sphincter muscle damage (Fig. 2.6.1).

2.6.3.3 Iridodialysis

The pathognomic sign of the condition – tearing of the peripheral portion of the iris root from the ciliary spur – appears as a black slit at the limbus.[7]

5 Ethicon/Johnson & Johnson, New Brunswick, N.J. Every suture mentioned in this chapter is one of the two types described above.

6 Monocular diplopia, photophobia.

7 It is usually visible to the naked eye, although the slit lamp is often needed to confirm the diagnosis. If the iridodialysis is large enough, a red reflex is apparent where it should not be (Fig. 2.7.2).

An iridodialysis also deforms the shape of the pupil. Angle recession and glaucoma are common associated pathologies.

Surgical reconstruction is recommended if the condition causes visual disturbance (monocular diplopia, glare, photophobia). The treatment concept is based on the McCannel suture [8]. A double-armed suture is used in either of the two techniques (Fig. 2.6.4).

2.6.3.4 Acute Traumatic Aniridia: "the Case of the Missing Iris"

It is not uncommon to find the iris completely extruded in severe ruptures. It is also possible that the iris is not actually lost, it is just rolled up and pulled posteriorly by fibrin initially and scar tissue subsequently ("pseudoaniridia"). The earlier such an iris retraction is discovered, the easier its unrolling is. If done before scar tissue develops, careful pulling on the iris at the pupillary margin with vitrectomy forceps introduced through a paracentesis is often able to reestablish the iris diaphragm. Pulling of the iris back to its normal position is not without risk.

- If scarring has already started, the iris can be torn from its root.
- If the pulling is too forceful, severe bleeding may occur.
- If the forceps holding the iris is squeezed too strongly, the pupillary margin can be seriously damaged.

Sutures may be necessary to maintain the recreated smaller pupil (see above).

Controversial

It is not always possible to explain how the iris can disappear after a severe rupture. Often there is no sign of iris extrusion, nor is the iris found during surgery. One must presume an acute dissolution of the tissue, although it is difficult to comprehend how this can occur so instantly.

For true traumatic aniridia, some type of correction is advised because of the associated photophobia and/or cosmesis. The options range from the simple to the complex (Fig. 2.6.5; Table 2.6.2), including prostheses that also have built-in refractory correction (IOL).

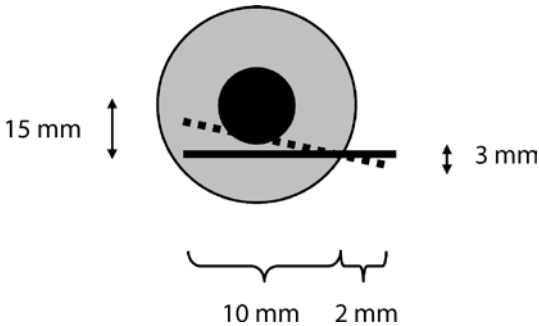
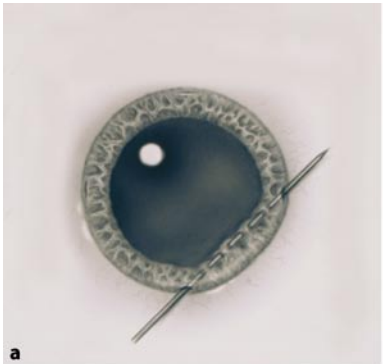


Fig. 2.6.2 The difficulties using a long transcameral needle. If the needle is 10 mm long inside and 2 mm outside the AC, a 3-mm movement at its external end with the needle holder results in a 15-mm movement of the needle's tip in the AC. Because in real life this is three-dimensional – not two-dimensional – the difficulty is even greater than what this schematic drawing suggests

Fig. 2.6.3 Purse string suture to constrict a wide, nonreactive pupil. **a** Three or four paracenteses are created. A long, straight needle is used to enter the AC through one paracentesis. The needle catches the iris at the pupillary margin several times before exiting at the next paracentesis. **b** The needle is then turned around and returned through the same paracentesis to catch the iris as described above. This is repeated until the needle arrives at the initial paracentesis. During entry, the needle must be wiggled inside each paracentesis tunnel so that corneal tissue does not get caught with the suture. **c** The suture is tied and the suture/iris released back into the AC. A 27-g needle inserted through the paracentesis toward which the straight needle is advancing helps guide the straight needle and makes the otherwise difficult procedure easier. **d** Preoperative picture. **e** Postoperative picture (Courtesy of B. Hamill, Houston, TX)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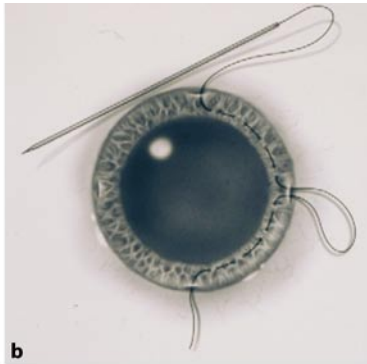
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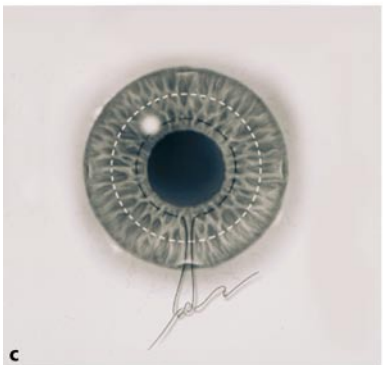
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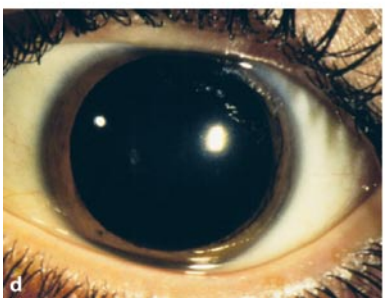
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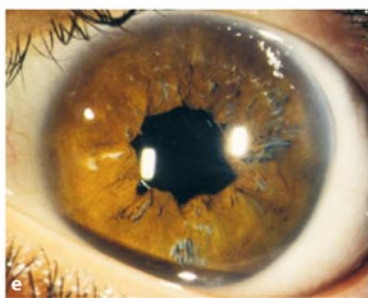
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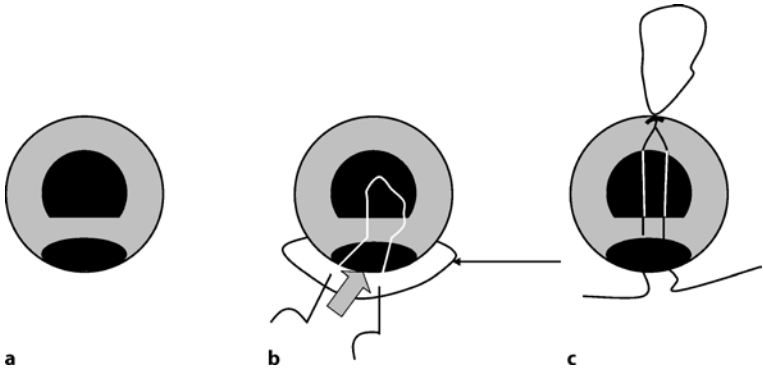

Fig. 2.6.4 Suturing of an iridodialysis.[1] **a** The iris root is torn and the pupil is deformed. **b** Direct suturing. A half-thickness scleral bed is prepared next to the iridodialysis area (*arrow*), then a limbal wound is created (*block arrow*). A double-armed suture with curved needles is used to first catch the iris root and to pass into the scleral bed.[2] The needles are cut, the suture is tightened, and the scleral bed closed. More than one suture may be necessary. **c** Transcameral suturing. A paracentesis is created at a convenient location (90–180° away). A straight double-armed suture is passed through the incision, carefully avoiding the capture of corneal tissue with the needle (see above). The needles are passed through the iris root then exit the sclera at 1 mm from the limbus, cut away, and the suture is tightened. The knot is compressed (see Chap. 2.2) and turned into the scleral channel

[1] The conjunctiva is not shown here.

[2] Both needles go through iris first and sclera second.

Fig. 2.6.5 Corrective options for traumatic aniridia.[1] **a** Aniridia ring to be placed in the capsular bag (it also serves as a capsular tension ring). Implantation and proper dialing of *two* devices reconstitute the iris. **b–d** Combined iris/IOL prostheses. **b** This implant can be placed in the bag or sutured into the bag; it has an inferior "iridectomy" in case silicone oil is also used. **c,d** The iris prosthesis is colored. **c** A prosthesis for scleral fixation. **d** This implant can be placed in the bag or sutured into the bag. **e** Preoperative image. This 38-year-old woman ruptured her eye 13 years after RK surgery, and lost both the lens and the iris. **f** Postoperative image 3 months after implantation of an Ophtec device (model 311 sutured into the sulcus) (Photographs E and F courtesy of M. Price, Indianapolis, IN)

[1] **a** and **b**: Morcher GmbH, Stuttgart, Germany; **c** and **d**: Ophtec, Groningen, Netherlands

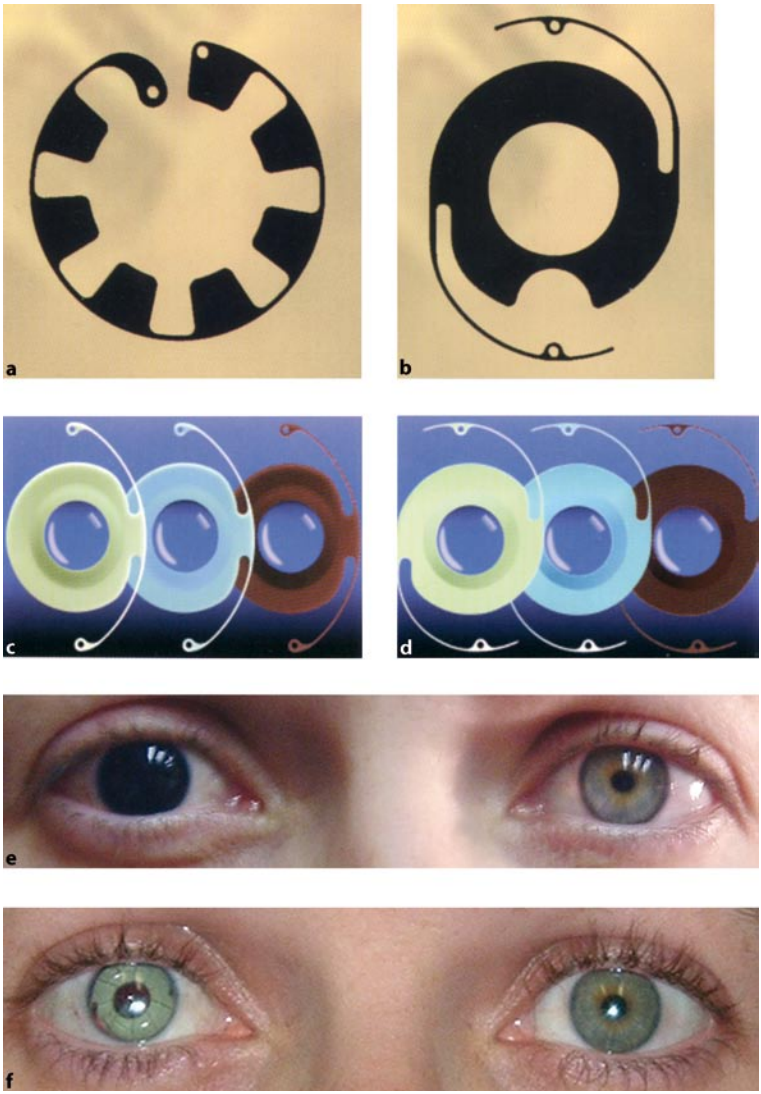
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Table 2.6.2 Management options for traumatic aniridia

Option	Comment
Iris print contact lens [5]	Simple and easily reversible but has all the limitations associated with contact lens wear
Corneal tattooing [1, 4]	Simple and effective; permanent; epithelium healing over the tattooed region, however, may be slow. Various techniques have been described for the introduction of the pigments [6], and the color of the new "iris" can also be customized
Implants (iris prosthesis) [2, 3, 7, 9, 11]	Various devices are available; they may be used for partial or total loss of the iris, and certain types combine an IOL as well (Fig. 2.6.5). Various materials, including Gore-Tex paired with silicone[2], are available, and the color can also be customized. The major disadvantage is that a large incision is required for insertion

[2] HumanOptics AG, Erlangen, Germany

2.6.3.5 Prolapse

Regarding prolapse, see Chap. 2.4 for details.

2.6.3.6 Iritis

Inflammation of the iris is a consequence of virtually any eye injury. Its most important complication is synechia formation (see Chap. 2.5). The treatment of traumatic iritis is straightforward:

- Topical *corticosteroids*; use prednisolone acetate, hourly if the inflammation is severe, and do not taper it too early. The suspension needs to be shaken properly beforehand.
- If a very severe uveitis is present, the corticosteroid may be injected subconjunctivally.[8] If systemic administration is necessary,[9] start with a bolus (100 mg/day), taper quickly, then use 20 mg/day for 3 months.

8 The effect of this injection lasts longer than an intravitreal one.
9 In the exceptional, severe cases, which involve the posterior uvea as well.

- *Cycloplegics*; homatropin is usually sufficient, although scopolamide or even atropine may be necessary.

DO:

- reconstruct the iris if it cannot serve as a divider between the AC and the vitreous cavity or if the pupil lost functionality
- remember that sutures in the iris will not be supported by scar formation; the sutures must permanently hold the tissue on their own

DON'T:

- constrict the pupil to too small a size, especially if posterior segment surgery is expected
- give up too easily if iris is not found after the injury; it may be "hidden" underneath

Summary

The iris plays important functional and anatomical roles in the eye. Restoration of the diaphragm and of an operational pupil should be one of the goals of trauma management.

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