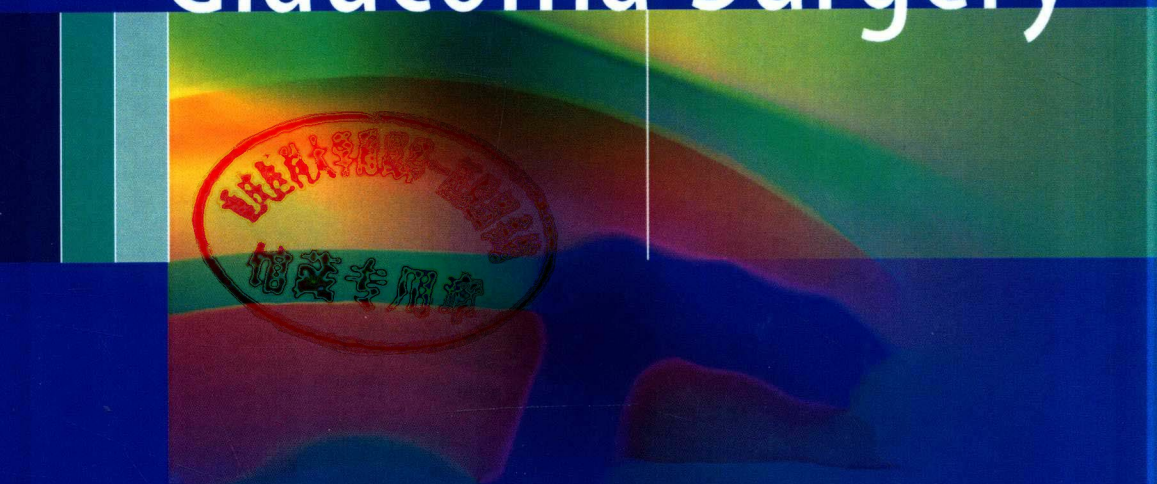
Managing Complications in Glaucoma Surgery



Francis Carbonaro
K. Sheng Lim
Editors

Springer

Francis Carbonaro • K. Sheng Lim
Editors

Managing Complications in Glaucoma Surgery

Springer

Editors
Francis Carbonaro, MD, PhD, FRCOphth.
Mater Dei Hospital
Msida
Malta

K. Sheng Lim, MBChB, FRCOphth, MD
St Thomas' Hospital
London
UK

ISBN 978-3-319-49414-2 ISBN 978-3-319-49416-6 (eBook)
DOI 10.1007/978-3-319-49416-6

Library of Congress Control Number: 2017933708

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

Glaucoma Laser

1

Jason Cheng, Mariana Cabrera, Jacky W.Y. Lee,
and Yvonne M. Buys

1.1 Lasers That Increase Aqueous Outflow: Argon Laser Trabeculoplasty

1.1.1 Introduction

Argon laser trabeculoplasty (ALT) was first introduced in 1979 by Wise and Witter (Coakes 1992). Despite its clinical efficacy in intraocular pressure (IOP) lowering, its use is limited by scarring of the trabecular meshwork, which may potentially restrict retreatment.

1.1.2 Procedure

ALT is usually performed with topical anesthesia under direct visualization using a gonioscopic lens. Initially, only 180° of the meshwork is treated. Around 40–50 laser spots are aimed at the anterior half of the trabecular meshwork to reduce the chance of peripheral anterior synechiae (PAS) formation. The laser spot size is 50 μm and the initial laser energy of 800 mW is titrated until minimal bubble formation in the pigmented trabecular meshwork is seen. After 4–6 weeks, IOP is reassessed and the remaining half of the trabecular meshwork may be treated if needed. Topical steroids are usually given for the first week after ALT (Weinreb and Wilensky 1984).

J. Cheng (✉)
Khoo Teck Puat Hospital, Yishun, Singapore
e-mail: jdcheng@gmail.com

M. Cabrera • Y.M. Buys
Department of Ophthalmology and Vision Sciences, University of Toronto, Toronto, Canada

J.W.Y. Lee
Dennis Lam & Partners Eye Center, Hong Kong, China

F. Carbonaro, K. Sheng Lim (eds.), *Managing Complications in Glaucoma Surgery*,
DOI 10.1007/978-3-319-49416-6_1,

1.1.3 Efficacy and Outcomes

In one of the largest randomized controlled trials involving 3608 subjects, comparing ALT versus Timolol 0.5 % as primary treatment for open-angle glaucoma (OAG), ALT lowered the IOP by 9 mmHg compared to a 7 mmHg drop in those using medication alone. At 2 years, 44 % of ALT-treated eyes did not require additional interventions compared to 30 % in the medication group. By 7 years, the ALT group continued to have lower IOPs and less visual field progression compared to the medication group. The authors concluded that ALT had a similar efficacy to Timolol 0.5 % (Glaucoma laser trial 1991). In the literature, the range of IOP reduction is from 13 % to 32 % in OAG eyes (Stein and Challa 2007). In comparison with selective laser trabeculoplasty (SLT), a meta-analysis has concluded that the IOP-lowering effects between the two lasers were similar or at least one was not inferior to the other (Wong et al. 2015).

1.1.4 Complications

1.1.4.1 Intraoperative Complications

Hyphema can occur from inadvertent laser shots to the iris root or as a result of blood reflux from the Schlemm's canal. Pain may be experienced during the laser treatment despite the application of topical anesthetic agents, and vasovagal syncope has been a reported complication of ALT (Weinreb and Wilensky 1984).

1.1.4.2 Early Postoperative Complications

Immediately following ALT treatment, the protein and inflammatory mediator contents in the anterior chamber are increased. As a result of trabecular meshwork blockage by extracellular debris and swelling, the IOP may rise by 5 mmHg in 34 % of patients and up to 10 mmHg in 12 % of patients following treatment (Coakes 1992). The IOP spike usually occurs anywhere from 2 to 4 hours after ALT and is associated with the use of higher laser energies, 360° as opposed to 180° treatments, and more posterior laser applications (Coakes 1992). IOP spikes may be prevented with a topical alpha-adrenergic agent, whereas the control of the inflammation with topical steroids does not seem to alter the course of IOP elevations (Coakes 1992).

A degree of anterior uveitis is present in all patients after ALT, although it is often self-limiting and transient in nature. The prescription of a topical steroid is a common practice after ALT (Coakes 1992).

1.1.4.3 Late Postoperative Complications

Anterior chamber inflammation and too posteriorly placed laser shots may lead to PAS formation, which can occur at an incidence of 12 %–47 % after ALT (Coakes 1992; Weinreb and Wilensky 1984; Wong et al. 2015). In histological analysis of eyes treated with ALT, it was found that the trabecular beams were severely distorted together with the loss of the trabecular endothelial cells and the formation of a cellular sheet that extends from the Schwalbe's line to the anterior aspect of the trabecular meshwork (Coakes 1992).

Other less common late postoperative complications reported in the literature include corneal endothelial damage, unexplained visual field loss in two elderly patients, and even a rare case of presumed sympathetic ophthalmia in an aphakic eye with uveitis at 1 year after ALT (Juhas 1993; Coakes 1992; Weinreb and Wilensky 1984).

1.2 Lasers That Increase Aqueous Outflow: Selective Laser Trabeculoplasty

1.2.1 Introduction

Selective laser trabeculoplasty (SLT) was first described by Latina and Park in 1995. It is performed using a frequency-doubled (Q-switched) Nd:YAG laser (Wong et al. 2015). It selectively targets melanoctyes in the trabecular meshwork and only delivers 1 % of the energy used in the former ALT technology. As SLT does not induce any trabecular meshwork scarring, repeated treatments are possible. In 2001, the United States Food and Drug Administration approved the use of SLT for the treatment of OAG.

1.2.2 Procedure

As with ALT, SLT is performed under topical anesthesia using a gonioscopic lens. An initial energy of 0.8 mJ is used with titration in energy level until bubble formation is just visible in the trabecular meshwork. The laser spot size is 400 μm and the duration is 3 ns. Nonoverlapping laser shots are applied to 180°–360° of the trabecular meshwork. A higher total laser energy has been associated with a greater chance of IOP reduction (Lee et al. 2015). Postoperative eye drops may vary from a weak topical steroid, topical nonsteroidal anti-inflammatory, to no postoperative eye drops.

1.2.3 Efficacy and Outcomes

In a recent meta-analysis of randomized controlled trials on the use of SLT in the treatment of OAG, it was reported that the range of IOP reduction varies from 6.9 to 35.9 % at ≥12 months post-SLT among patients newly diagnosed with glaucoma to those who were already on maximally tolerated topical antiglaucoma medications. Wong et al. concluded that SLT is noninferior to ALT and topical antiglaucoma medication in terms of IOP reduction and achieving treatment success. The amount of medication reduction is also similar between SLT and ALT (Wong et al. 2015). Koucheki et al. reported a similar rate of IOP reduction among primary open-angle glaucoma (POAG), pseudoexfoliation, and pigmentary glaucoma patients; however, those with diabetes had a lower amount of IOP reduction following SLT. Pigmentary

glaucoma has been reported to be associated with more complications including significant pressure spikes following SLT; occasionally requiring surgical intervention (Koucheki and Hashemi 2012).

1.2.4 Complications

1.2.4.1 Intraoperative Complications

Throughout the literature, SLT seems to be a relatively safe procedure without many severe intraoperative complications (Wong et al. 2015). Some potential complications during the procedure may include corneal abrasion, subconjunctival hemorrhage, hyphema, and ocular pain. Some patients may experience an ipsilateral headache or photophobia after the laser (Klamann et al. 2014; Wong et al. 2015).

1.2.4.2 Early Postoperative Complications

The majority of side effects of SLT are mild and transient including: anterior uveitis, IOP spikes, conjunctivitis, corneal edema (Fig. 1.1), visual blurring, and only one case report of choroidal effusion and three case reports of cystoid macular edema (Klamann et al. 2014; Wong et al. 2015).

Given the lower energy used in SLT as compared to ALT, the majority of anterior uveitis after SLT settles within 3 to 5 days (Lee et al. 2014a). Koucheki et al. reported an inflammatory rate of 42.6 % in OAG eyes (Koucheki and Hashemi 2012). Jinapriya et al. compared the use of artificial tears, prednisolone acetate 1 %, or ketorolac tromethamine 0.5 % eye drops four times per day for 5 days following SLT and found that the use of an anti-inflammatory medication for a short period of time after SLT did not affect the IOP-lowering efficacy of the laser (Jinapriya et al. 2014).

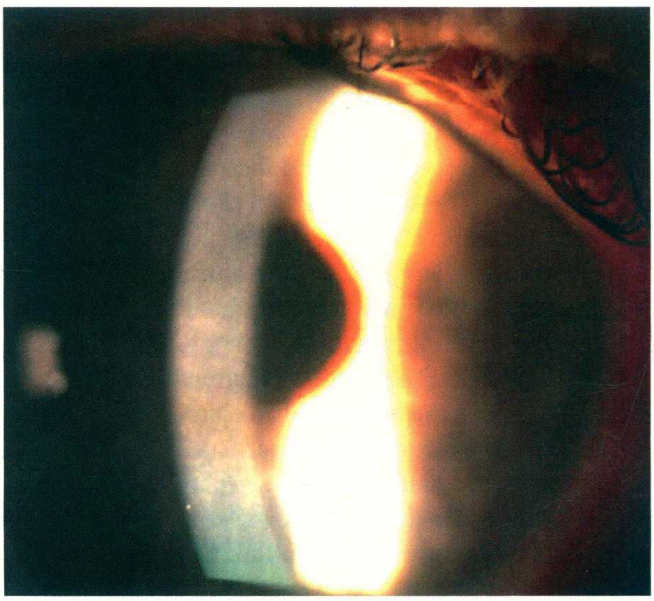


Fig. 1.1 Corneal edema after SLT (Taken from a case report by Moubayed et al. (2009))

Similar to ALT, IOP spikes can occur within 1 to 2 hours of the procedure with spikes >5 mmHg in about 10 % of patients and spikes >10 mmHg in 3 % following SLT (Barkana and Belkin 2007). Similar to ALT, a topical alpha-adrenergic agent may be used as prophylaxis before or immediately after the procedure. However, it should be noted that increased trabecular meshwork pigment has been associated with significant IOP spikes necessitating urgent filtration surgery, thus, lower energies or perhaps less invasive laser trabeculoplasties like MicroPulse Laser Trabeculoplasty (MLT) may be considered in these cases (Koucheki and Hashemi 2012).

1.2.4.3 Late Postoperative Complications

Given the close proximity of the cornea to the trabecular meshwork, potential damage to the cornea following SLT needs to be considered. Moubayed et al. were the first to report a case of permanent corneal edema progressing into bullous keratopathy following SLT (Moubayed et al. 2009).

Knickelbein et al. reported four cases that developed corneal edema and subsequent corneal thinning and hyperopic shift, with two cases requiring contact lens wear. Although the cause of this rare complication remains unknown, it may be associated with myopia (Knickelbein et al. 2014).

Figure 1.2 from Ong and Ong illustrates a marked increase in dark spots/patches on specular microscopy following SLT reported in two patients with pre-SLT corneal pigment. Thus, the corneal endothelium should be examined for pigment deposition, corneal guttatae, or evidence of compromise prior to SLT (Ong and Ong 2013). Lee et al. (2014a) from Hong Kong investigated 111 eyes of 66 Chinese OAG subjects treated with SLT. They measured the endothelial cell count using a

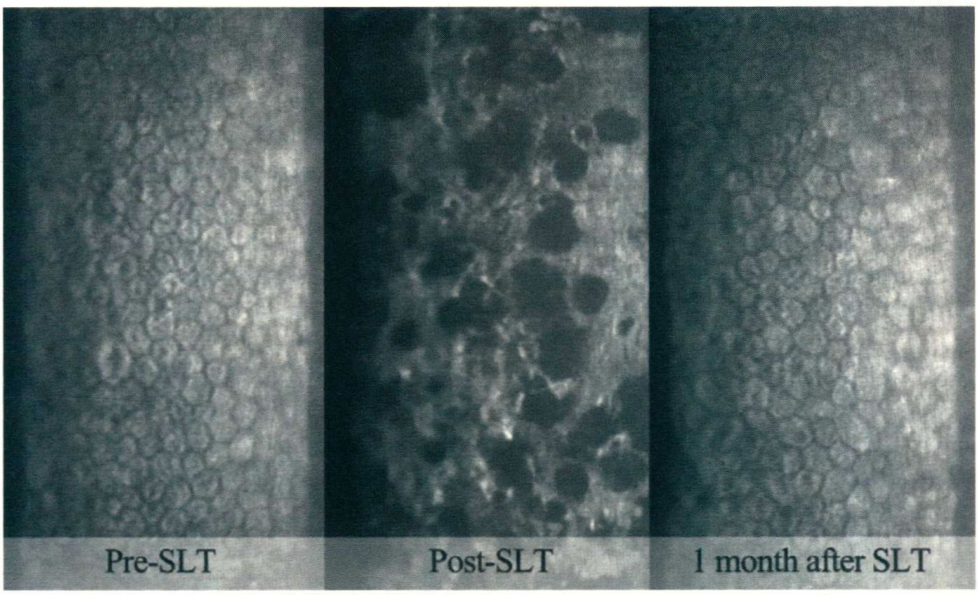


Fig. 1.2 The corneal endothelium of a patient before and after SLT showing a marked increase in dark spots/patches on specular microscopy (Taken from a case report by Ong and Ong (2013))

specular microscopy, central corneal thickness (CCT) videokeratography, and the spherical equivalent using a kerato-refractometer. Readings were taken before and at 1 month after SLT. The intraclass correlation coefficient (0.997) among these investigations was high, signifying excellent reproducibility of these measurements. The mean endothelial cell count was reduced by 4.5 % from baseline (2465.0 ± 334.0 cells/mm^2) at 1 week (2355.0±387.0 cells/mm^2) after SLT (p = 0.0004). At 1 month (2424.0 ± 379.4 cells/mm^2, p = 0.3), the endothelial cell count returned to baseline levels. The authors attributed inflammatory cell attachment and microscopic endothelial cell edema as the causes of the apparent reduction in endothelial cell count as both of these conditions can affect the accuracy of cell counts with specular microscopy. On slit-lamp examination, none of the subjects had any clinically visible corneal edema. In a recent randomized controlled trial that compared SLT versus prostaglandin analogs in the treatment of primary angle closure glaucoma in subjects that had at least 180° of angle opening, the 6-month endothelial cell loss was 4.8 % from baseline (p = 0.001) (Narayanaswamy et al. 2014). This was in contrast to the 4.5 % transient reduction in the study by Lee et al. (2014a). The differences in angle opening among the two study populations could have accounted for the permanent damages documented by Narayanaswamy et al. (2014) since a narrower angle can predispose the corneal endothelium to absorb a greater amount of dissipated laser heat.

In Lee et al.'s study (Lee et al. 2014a), CCT decreased 1.1 % from 549.4 ± 37.6 μm at baseline to 543.9 ± 40.2 μm at 1 week (p = 0.02). By 1 month, CCT was back to baseline level (p = 0.2). Laser heat dissipation could have led to a thermal-induced corneal stromal contraction in the collagen fibers. When the keratocytes get replenished, the CCT returns to its original thickness. There was no evidence of clinically visible scarring on the cornea in the 111 OAG eyes that received SLT treatment. There were also no statistically significant changes in the spherical equivalent following SLT. Thus, in cases with angle closure elements, the potential risks of corneal damage should be discussed with patients prior to treatment.

The rate of peripheral anterior synechia formation following SLT is around 2.86 % or less which is significantly less than that reported after ALT (Wong et al. 2015). Damji et al. published the only randomized controlled trial comparing the safety of ALT versus SLT (Damji et al. 2006). A comparison in the side effects of these two lasers is summarized in Table 1.1. Table 1.2 summarizes complications of SLT reported in a recent meta-analysis (Wong et al. 2015).

Key Points

- Intraocular pressure spikes can occur 1 to 2 hour after the procedure. Topical alpha-adrenergic agent may be used as prophylaxis before or after the procedure.
- Increased trabecular meshwork pigment has been associated with extreme intraocular pressure spikes. Therefore, lower energy with close monitoring is recommended in these patients.

Table 1.1 Comparison of complications between ALT and SLT from a randomized controlled by study by Damji et al. (2006)

Complications	ALT ($n = 87$) (%)	SLT ($n = 89$) (%)
IOP spike > 6 mmHg	3.4	4.5
PAS formation	1.2	1.1
ALT retreatment within 1 year	5.7	3.4
SLT retreatment within 1 year	4.6	6.7
Trabeculectomy within 1 year	8.0	9.0
Glaucoma drainage device within 1 year	0.0	1.1
Cyclophotocoagulation within 1 year	0.0	1.1

PAS peripheral anterior synechiae, *ALT* argon laser trabeculoplasty, *SLT* selective laser trabeculoplasty, *IOP* intraocular pressure

Table 1.2 Frequencies of SLT complications

Complications	Percentage or number of cases
Side effects reported by case series:	
Transient IOP rise	0–62 %
With prophylactic/empirical treatment	0–28.8 %
Anterior chamber inflammation	0–89.3 %
Eye pain/discomfort	0–58 % (up to 65.7 % if redness included)
Peripheral anterior synechiae	0–2.86 %
Headache	4 %
Photophobia	3–96.7 %
Hyphema	0 %
Pigment dispersion	0 %
Conjunctival hyperemia	9–64 %
Corneal haze	0–0.2 %
Corneal abrasion	0.65 %
Corneal endothelial dark/white spots	50 %
Cystoid macular edema	0 %
Side effects from case reports:	
High IOP spikes (IOP 26–65 mmHg)	4 cases
Bilateral anterior uveitis following single eye SLT	1 case
Hyphema	2 cases
Corneal edema/haze/thinning	4 cases
Diffuse lamellar keratitis	1 case
Cystoid macular edema	3 cases
Severe iritis with choroidal effusion	1 case

Taken from a meta-analysis by Wong et al. (2015)

1.3 Lasers That Increase Aqueous Outflow: Micropulse Laser Trabeculoplasty and Titanium-Sapphire Laser Trabeculoplasty

1.3.1 Introduction

MicroPulse Laser Trabeculoplasty (MLT) can be delivered using a diode (810 nm) or a 532 nm/577 nm laser. The MLT technology makes use of a 15 % on and 85 % off duty cycle to minimize the thermal damage to the surrounding tissues. Although ALT causes damage and scarring to the trabecular meshwork and SLT destroys melanocytes through heat, MLT neither destroys nor scars the trabecular meshwork (Fudemberg et al. 2008).

Titanium-sapphire laser trabeculoplasty (TLT) is an emerging subtype of laser trabeculoplasty that uses a 790 nm laser (SOLX, Inc., Waltham, Massachusetts, USA) to emit near-infrared energy in pulses ranging from 5 to 10 ms.

1.3.2 Procedure

Similar to ALT and SLT, MLT is performed under topical anesthesia. However, the gonioscopic lens of MLT has a built-in, visible, inner reference guide that allows the surgeon to deliver exactly 10 confluent laser shots per clock hour for a total of 120 shots over 360°. The spot size is 300 μm, treatment duration 300 ms, and an initial power of 1000 mW. There are no visible endpoints in MLT, hence, the energy is only titrated down if the patient experiences pain during the procedure. No anti-inflammatory medications are required after MLT.

For TLT, the wavelength is 690 nm with energies of 30–80 mJ at pulse duration of 7 ms. The spot size is smaller than SLT or ALT at 200 μm. The laser is aimed at the pigmented trabecular meshwork and 50 nonoverlapping shots may be applied to 180° of the pigmented trabecular meshwork. The endpoint is the formation of bubbles or the visible bursting of pigments from the trabecular meshwork.

1.3.3 Efficacy and Outcomes

Gossage reported the 2-year data after treatment of 532 nm MLT in 18 POAG eyes. Three laser energies of 300 mW, 700 mW, and 1000 mW were used and at 4 months, those receiving 1000 mW had the greatest amount of IOP reduction of 30 %. At 24 months, the amount of IOP reduction in the group receiving 1000 mW treatment was 24 % (Gossage 2015).

There are very few studies reporting the efficacy of TLT. A 15-month pilot study with 37 subjects, reported that TLT-treated eyes had a mean IOP reduction of 32 % as compared to 25 % in the ALT group (Goldenfeld et al. 2009).

1.3.4 Complications

1.3.4.1 Intraoperative Complications

There are no reported intraoperative complications from MLT in the literature. In theory, the risk of intraoperative bleeding and pain should be less than in ALT and SLT due to the shorter duration of laser action from the duty cycle technology.

1.3.4.2 Early Postoperative Complications

Fea et al. (2008) reported on the safety of the 810 nm MLT in 32 eyes of 20 patients with OAG. The inferior 180° of the trabecular meshwork was treated and a Kowa FM 500 flare-meter was used to measure anterior chamber reaction at baseline and at 3 h, 1 day, 1 week, and 12 months after MLT. Only one patient (5 %) was found to have an increase in flare after MLT. The same patient, who had a history of pigmentary glaucoma, developed an IOP spike of 34 mmHg requiring oral acetazolamide treatment for 2 days. Otherwise, MLT was well tolerated apart from burning or heat sensation that was reported in four (20 %) of the patients.

In a prospective series in Hong Kong by Lee et al. using a 577 nm MLT in the treatment of OAG, only 7.5 % of treated OAG eyes had a mild and self-limiting anterior uveitis that resolved without medication. There was no corneal edema detected on slit-lamp examination and no recorded IOP spikes at day 1, 1 week, or 1 month after MLT (data pending publication). As MLT is still a relatively new technology; only gaining popularity in the early 2010s, larger-scale, randomized studies are warranted before its long-term safety in comparison with its predecessors can be determined.

For TLT, the IOP spike rate has been reported to be around 11 %.

1.3.4.3 Late Postoperative Complications

At present, the longest study involving the use of MLT in OAG is 2 years. There are no reported late postoperative complications in the literature (Fudemberg et al. 2008).

In a study of 18 patients with OAG treated with TLT, none of the patients developed PAS nor were there any reported long-term complications over a 2-year period.

1.4 Lasers That Increase Angle Width: Laser Peripheral Iridotomy

1.4.1 Introduction

Angle closure glaucoma is an optic neuropathy secondary to raised intraocular pressure (IOP) due to closure of the drainage angle. A number of different factors contribute to primary angle closure, including pupillary block, thickened iris root, cataract, and plateau iris configuration. Peripheral iridotomy removes the

pupillary block mechanism by allowing aqueous to flow from the posterior chamber to the anterior chamber, by-passing the pupil. Laser peripheral iridotomy (LPI) has now essentially replaced the surgical iridectomy.

LPI is indicated for acute primary angle closure, the fellow eye in acute primary angle closure glaucoma if the angle is felt to be occludable, primary angle closure (angle closure with evidence of peripheral anterior synechia or raised IOP, but no glaucomatous optic neuropathy), primary angle closure glaucoma (primary angle closure with glaucomatous optic neuropathy) and primary angle closure suspects (angle closure in at least two quadrants of trabecular meshwork without any of the above findings). There is some evidence that LPI can be helpful in phacomorphic glaucoma and pigment dispersion syndrome.

1.4.2 Procedure

Table 1.3 summarizes the technique of LPI. The iridotomy needs to be of sufficient size to allow aqueous flow and pressure equalization between the anterior and posterior chambers. Mathematical modeling using Navier–Stokes equations suggests that a peripherial iridotomy length of 50 μm would reduce the pressure differential to under 1 mmHg (Silver and Quigley 2004). It has been proposed that a minimum diameter of at least 150 μm is necessary to add in a safety margin to account for posttreatment iris edema, fibrosis, pigment epithelial proliferation, or pupil dilatation (Fleck 1990).

Table 1.3 Recommendations on technique of performing laser peripheral iridotomy (LPI) at different stages

Stage of procedure	Recommendations on technique of performing LPI
Pretreatment	Constrict pupil with 1–4 % pilocarpine 3 drops over 10–30 min Topical anesthesia such as tetracaine or alcaine
Treatment	Use iridotomy contact lens such as Abraham (+66D button) or Wise (+103D button) Placement of iridotomy at either side of 12 o'Clock or just above or below 3 or 9 o'clock
Optional pretreatment – argon laser for dark iris	Stage 1: spot size 50um, duration 0.1 s, power 100–200 mW around 15–25 shots Stage 2: spot size 50um, duration 0.1 s, power 500–700 mW around 15–25 shots
Nd:YAG settings	Power: 1–5 mJ Spot size and duration is fixed
Posttreatment	A single dose of topical Brimonidine 0.2 % and steroid may be administered to reduce postlaser pressure spike and inflammation Topical steroids can be prescribed 4 times a day for 1 week IOP should be checked 1 h after LPI Iridotomy should be checked for size and patency Gonioscopy should be repeated to document change in angle post iridotomy

1.4.3 Complications

1.4.3.1 During Laser Iridotomy Procedure

Bubbles may form during the laser and may obstruct the visualization of the iridotomy site. The size and likelihood of bubbles is related to the argon laser power. Therefore, starting with a lower power, then increasing the power in stage 2 is recommended (see Table 1.3) (de Silva et al. 2007). The 12 o'clock position for LPI placement should be avoided as this is where bubbles congregate. If bubbles form they are absorbed rapidly and are of no consequence.

Argon laser corneal epithelium burns manifest as milky white spots, whereas corneal endothelial burns appear as opacities. Nd:YAG laser injury to the cornea appears as star-shaped bursts. These corneal injuries occur due to poor focusing. A mobile eye, shallow anterior chamber, or cloudy cornea can increase the risk of corneal injury. In the event of an injury, the procedure may need to be abandoned or a new LPI location chosen where the anterior chamber is deeper and there is less corneal clouding. Corneal epithelial burns recover after 1–2 days. Direct endothelial cell damage is not reversible but usually remains localized. Routine LPI for primary angle closure suspects does not appear to increase the risk of endothelial cell loss. A Singaporean study comparing the endothelial cell count after LPI to the fellow untreated eye found that both groups had a reduced endothelial cell count (3.6 % and 3.2 %, respectively) at 3 years, but the difference between both groups was not statistically significant (Kumar et al. 2013). There have been reports of focal and generalized corneal edema, Descemet's membrane detachment, and even delayed corneal decompensation.

Anterior chamber bleeding is a common complication of LPI. Up to 36 % of patients develop this complication. Fortunately, it is often self-limiting and stops with gentle pressure on the eye applied with the contact lens (Jiang et al. 2012; Golan et al. 2013). If bleeding continues the iris vessel can be cauterized with the argon laser. The view may be compromised by the blood clot. The surgeon may wish to choose an alternative LPI site or wait for the blood to resolve, usually after 20–30 min. Anterior chamber bleeding can cause blurred vision for several days, elevation of IOP, and corneal endothelial blood staining. The risk of bleeding can be reduced by avoiding iris vessels and using pretreatment with argon laser (de Silva et al. 2012). Stopping antiplatelet therapy does not reduce the incidence of bleeding (Golan et al. 2013).

1.4.3.2 Postlaser Iridotomy Complications

The most common complication after LPI is postlaser IOP elevation, the incidence of which varies from 5.7 %–40 % depending on the definition of an IOP spike. A pressure spike usually occurs within the first 1 hour after LPI. The largest prospective study of primary angle closure suspects receiving LPI was from China. Of the 734 eyes, 9.8 % had an IOP spike of >8 mmHg, and only 0.54 % had an IOP >30 mmHg after 1 h. 0.82 % continued to have raised IOP at 2 weeks (Jiang et al. 2012). In another study that included both primary angle closure and angle closure suspects (therefore patients with angle pathology), the incidence of a postlaser IOP spike of more than 30 mmHg was higher at 7.2 % (Lee et al. 2014b). Some studies suggest that the energy used correlates to IOP spikes (Jiang et al. 2012), although other

studies did not confirm this correlation (Lee et al. 2014b; Golan et al. 2013). A higher starting IOP is a risk factor for IOP spikes. Pre- and/or posttreatment with brimonidine 0.2 % or apraclonidine 0.5 % is helpful in preventing IOP spikes (Yuen et al. 2005). If the IOP is over 30 mmHg at 30–60 min after LPI medical management should be initiated. Topical beta blocker or oral acetazolamide can be considered. In rare cases, the IOP may not be controlled medically and filtration surgery may be required.

Mild iritis is a very common complication but usually resolves with topical steroids within a day. Cycloplegics are rarely required but posterior synechia may develop. In patients with active or known uveitis the inflammatory response from LPI can be severe. Intensive topical steroids and even systemic steroids may be necessary. Iridotomy closure may occur and repeated LPI attempts under steroid cover may be required.

Unusual visual symptoms have been reported following LPI such as diplopia, lines, shadows, or ghost images. Linear dysphotopsia is thought to be most specific to LPI. A Canadian study found that it occurs in around 6.8 % of eyes after LPI. A superior LPI is 3.6 times more likely to cause linear dysphotopsia than a temporally placed LPI (Vera et al. 2014). Partially or completely covered LPI by the eyelid was four times more likely to have these symptoms than an uncovered LPI. This is thought to be due to the prismatic effect of the tear film at the lid margin. However, a large, prospective Chinese study found visual acuity and retinal staylight measurements to be the same in both the LPI and the untreated control eye. They also found that subjective glare and visual symptoms did not differ significantly among those with LPI that were uncovered, partially covered, or completely covered. There was no association between size of LPI and glare symptoms (Congdon et al. 2012).

The difference in findings between the Chinese and Canadian studies may be cultural. Nevertheless, it is important to inform patients about this potential complication and to give patients time as many will adapt to this symptom. In the event that the patient is unable to tolerate the symptoms, an opaque contact lens or corneal tattooing can be considered. Other rare complications include retinal burns, macular hole, retinal detachment, choroidal effusion, malignant glaucoma, cataract formation, and zonular weakening.

Key Points

- Pretreatment with argon laser is helpful in dark iris patients to reduce risk of bleeding and pigment release.
- Iris bleeding can be stopped by applying pressure on the eye with the contact lens. Persistent bleeding can be cauterized using argon laser.
- Stopping antiplatelet therapy does not reduce the incidence of iris bleeding.
- Intraocular pressure spikes are common and alpha-agonist prophylaxis is helpful. Intraocular pressure should be checked 30–60 min after the procedure and managed accordingly.
- Iritis is common and topical steroids should be given to all patients.
- The iridotomy location should be uncovered by the eyelid to reduce the risk of dysphotopsia.

1.5 Lasers That Increase Angle Width: Argon Laser Iridoplasty

1.5.1 Introduction

Argon laser iridoplasty (ALP) is a procedure to open an appositionally closed angle. Laser peripheral iridotomy (LPI) is the definitive treatment for pupil block, but ALP can be helpful in other causes of angle closure such as plateau iris.

ALP can be useful in the acute setting when the cornea is cloudy, the anterior chamber is very shallow and the eye is inflamed. LPI may be difficult to perform in this setting and ALP can temporarily relieve the high IOP. Once the IOP is reduced, the cornea can clear, the eye is less inflamed, and the patient is more comfortable. All published data have reported a good success rate at breaking the acute attack (Ritch et al. 2007). At this point, the surgeon can decide to proceed with either LPI or lens extraction. Studies have shown that primary ALP is as effective as medical treatment in the management of acute angle closure glaucoma and acute phacomorphic glaucoma (Lam et al. 2002; Lee et al. 2013).

ALP may also be helpful for the management of chronic angle closure, plateau iris syndrome, nanophthalmos, peripheral anterior synechiae, lens related angle closure, and choroidal effusion-related angle closure. Recently, ALP has been reported to help reshape and realign the pupil centrally in decentered multifocal intraocular lenses. There are reports where this has improved distance and near vision (Solomon et al. 2012).

1.5.2 Procedure

ALP is performed under topical anesthesia in the outpatient setting. Pilocarpine 1–4 % is given three times over 10–30 min. Topical glycerin can be used in extreme cases to clear corneal edema in acute glaucoma if iris detail is not visible. Argon laser settings are 500 μm spot size, 0.5 s duration, and 200–400 MW power. An Abraham or Weiss iridotomy contact lens should be used. The aiming beam is focused on the peripheral iris close to the limbus. The aim is to create large contracting burns. The power should be reduced if there is any bubble formation or popping noises. The laser applications should be one to two spot sizes apart and never adjoining. Postoperative brimonidine 0.2 % or apraclonidine 0.5 % should be given immediately. The IOP should be checked 30–60 min after the procedure and posttreatment steroids given four to six times a day for 5–7 days.

1.5.3 Complications

Mild iritis is a common finding. The inflammation is usually transient and responds well to topical steroids. In severe cases, peripheral anterior synechiae, anterior chamber fibrin, or hypopyon can occur. In the inflamed eye or in known uveitic