

Preliminary results of CO₂ laser-assisted sclerectomy surgery (CLASS) in the treatment of advanced glaucoma in a Chinese population

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Abstract

To evaluate the efficacy and safety of CO₂ laser-assisted sclerectomy surgery (CLASS) in Chinese patients with advanced glaucoma. Patients with advanced glaucoma who were candidates for glaucoma filtration surgery were included. The intraocular pressure (IOP) and number of antiglaucoma medications were documented before surgery and at all postoperative clinic visits. All intra- and postoperative complications were documented. The primary outcome measures were the changes in IOP and medication use before and after the procedure as well as complications from the procedure. The secondary outcome measure included the CLASS success rate.

Twenty patients (23 eyes) underwent CLASS between November 2014 and September 2015. Nineteen eyes had primary open-angle glaucoma, 2 eyes had primary angle-closure glaucoma, and 2 eyes had uveitic glaucoma. One patient was lost to follow-up. The mean age of subjects was 68.1 ± 11.9 years. IOP was significantly reduced at 1 day and 1 week after CLASS. At 6 months, the IOP and number of medications were significantly reduced by 19.0% and 38.2%, respectively (both $P < 0.0001$). One patient had intraoperative trabeculo-Descemet membrane perforation. Two patients required laser goniopuncture and 2 required needling between 3 and 6 months postoperatively. The overall success rate was 81.8% at 6 months.

CLASS achieved a modest IOP reduction in the early postoperative period and was overall a safe procedure for advanced glaucoma.

Abbreviations: CLASS = CO₂ laser-assisted sclerectomy surgery, IOP = intraocular pressure, PACG = primary angle-closure glaucoma, POAG = primary open-angle glaucoma, TDM = trabeculo-Descemet membrane.

Keywords: CO₂ laser-assisted sclerectomy surgery, glaucoma, intraocular pressure, nonpenetrating, surgery

1. Introduction

Glaucoma is a progressive optic neuropathy, resulting in loss of the retinal nerve fiber layer leading to visual field loss and visual impairment. Elevated intraocular pressure (IOP) is a major risk factor for glaucoma progression.^[1,2] Medical, laser, or surgical treatments are directed to IOP in order to minimize glaucoma progression.

While conventional trabeculectomy remains the gold standard filtration surgery for IOP lowering, it is associated

with various potential vision-threatening complications, including hypotony, suprachoroidal hemorrhage, endophthalmitis, wipe-out (snuff syndrome), malignant glaucoma, and cataract development.^[3–5]

Nonpenetrating deep sclerectomy is known to have a higher safety profile when compared with trabeculectomy.^[6,7] This surgical procedure has the advantage of minimizing the sudden drop in IOP by allowing the filtration of aqueous humor from the anterior chamber through an intact trabeculo-Descemet membrane (TDM) without entering the anterior chamber. However, the manual procedure is technically demanding. It requires dissection of superficial and deep scleral flaps, unroofing of the Schlemm canal, and exposure of the juxtacanalicular trabeculum to allow for effective aqueous percolation. The most common intraoperative complication of this procedure is perforation of the thin TDM during the sclerectomy dissection.^[8,9] However, if the tissue is not dissected deep enough, effective percolation may not be achieved.

CO₂ laser has the characteristic of photoablating dry tissues, coagulation of bleeding vessels, with complete absorption of the laser energy when exposed to fluids.^[10,11] CO₂ laser-assisted sclerectomy surgery (CLASS) is an enhanced adaptation of manual deep sclerectomy by using a CO₂ laser to ablate the scleral tissue leaving a thin membrane just enough for aqueous seepage, but without entering the anterior chamber since the laser energy is absorbed once there is seepage of aqueous.

The aim of this study was to investigate the efficacy and safety of CLASS in Chinese patients with advanced glaucoma.

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2. Methods

This study was approved by the Ethics Committee of Hospital Authority of Hong Kong. Written informed consent was obtained from all patients before the surgical procedure. Provision of the CO₂ laser system and adapter was provided by Lumenis and IOptima, respectively.

Patients were recruited between November 2014 and September 2015 at Caritas Medical Centre, Hong Kong. Inclusion criteria included adult patients age 18 years or above with primary open-angle glaucoma (POAG), primary angle-closure glaucoma (PACG), or uveitic glaucoma; cup-to-disc ratio of ≥ 0.7 ; and IOP ≥ 22 mm Hg despite maximally tolerated antiglaucoma medications. The exclusion criteria included those with recent intraocular surgery except cataract surgery or laser trabeculoplasty within 6 months, follow-up less than 6 months, and those with aphakia.

2.1. Surgical procedure

This prospective clinical case series study assesses the outcome of CLASS surgery among patients having advanced glaucoma with suboptimal IOP control despite maximally tolerated antiglaucoma eye drops.

All surgeries were performed by a single glaucoma surgeon using the AcuPulse CO₂ laser system (Lumenis, Yokneam Industrial Park, Hakidma 6, Yokneam, Israel) with adapter (IOPtiMate; IOptima, Tel Aviv, Israel) with the following steps:

1. Topical anesthesia with lignocaine gel.
2. A limbal-based conjunctival flap was created and sclera was exposed.
3. A 1/3 partial thickness limbal-based scleral flap measuring 5×5 mm² was created.
4. The desired scanning area and the shape was set, the laser beam was focused.
5. The CO₂ laser beam was applied over posterior scleral bed to form a reservoir to allow fluid overflow.
6. The CO₂ beam was then applied over the surgical limbus to reveal the underlying Schlemm canal and trabecular meshwork until fluid percolation was seen.
7. The laser energy was set at 20 W per pulse.
8. A significant amount of fluid is percolating from a wide zone along the treatment area was ensured before the scleral flap was repositioned.
9. The conjunctiva was closed with a 8-0 Vicryl sutures.
10. A total of 0.1 mL of mitomycin C (0.4 mg/mL) was injected subconjunctivally.
11. Topical dexamethasone 0.1% and chloramphenicol 0.5% 4 times a day was prescribed postoperatively for 4 weeks.
12. Topical antiglaucomatous medications were prescribed when IOP > 21 mm Hg.
13. Goniopuncture with yttrium aluminium garnet laser or needling was performed at least 3 months after the procedure when the IOP was > 21 mm Hg on 2 or more clinical visit despite medications.

2.2. Outcome measures

The primary outcome measures included the changes in IOP and medication use before and after the procedure as well as the safety profile including any intraoperative or postoperative complications. Goldmann applanation tonometry was used for IOP

measurement. The secondary outcome measure included the CLASS success rate. The preoperative and postoperative Snellen best-corrected visual acuity (BCVA) was obtained. Fixed combination medications were counted as 2 types of antiglaucoma medications.

2.3. Statistical analysis

Statistical analyses were performed using one-way analysis of variance with Tukey multiple comparison test comparing preoperative and postoperative data. The dataset passed normality testing with the D'Agostino and Pearson omnibus normality test. A *P* value ≤ 0.05 was considered as statistically significant. All means were expressed as mean \pm standard deviation.

The success rate of CLASS surgery was defined as an IOP ≤ 21 mm Hg at 6 months despite medications, laser goniopuncture, or needling. The Snellen BCVA was expressed in decimal acuity and converted to logarithm of the minimal angle of resolution (log MAR) units for statistical analyses.

3. Results

3.1. Baseline characteristics

Twenty patients (23 eyes) were recruited. One patient was lost to follow-up and excluded from the analysis. The mean age of subjects was 68.1 ± 11.9 years with 19 eyes having POAG, 2 eyes with PACG, and 2 eyes with uveitic glaucoma. Seven eyes (31.8%) were pseudophakic at the time of receiving CLASS. All recruited cases had advanced glaucoma with an average cup-to-disc ratio 0.82 ± 0.14 . The duration of use of antiglaucomatous medications was 5.52 ± 2.80 years. Six eyes have failed previous trabeculectomy. The preoperative mean BCVA was 0.66 ± 0.14 log MAR.

3.2. IOP and medication reduction

The average preoperative IOP was 24.1 ± 1.5 mm Hg whilst on 3.4 ± 1.1 types of antiglaucoma medications. At 6 months, the IOP and number of medications were significantly reduced by 19.0% and 38.2%, respectively (both *P* < 0.0001). The changes in IOP and medication at each time point following CLASS have been summarized in Table 1 and Fig. 1.

3.3. Complications, success rate, and BCVA

One patient had iris prolapse with TDM perforation without shallow anterior chamber during the use of CO₂ laser intraoperatively. There were no postoperative complications

Table 1
IOP and medication changes following CLASS.

	Percentage of IOP reduction (mean IOP in mm Hg)	Percentage of medication reduction (mean number of medications)
Pre-CLASS	0 (24.1 ± 1.5)	0 (3.4 ± 1.1)
1 d post-CLASS	43.3% (13.5 ± 6.0)*	–
1 wk post-CLASS	29.0% (17.1 ± 7.0)*	–
1 mo post-CLASS	15.8% (20.3 ± 7.8)	–
3 mo post-CLASS	12.0% (21.1 ± 7.7)	52.9% (1.6 ± 1.7)*
6 mo post-CLASS	19.0% (19.6 ± 7.4)*	38.2% (2.1 ± 1.7)*

CLASS = CO₂ laser-assisted sclerectomy surgery, IOP = intraocular pressure.

*Statistically significant (*P* < 0.0001 , compared to pre-CLASS).

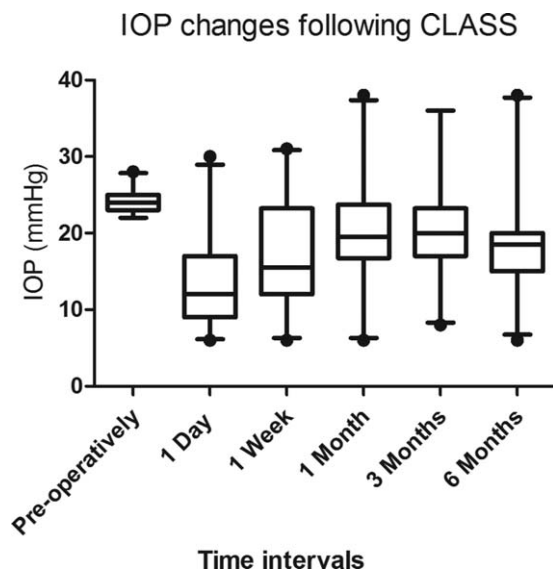


Figure 1. Intraocular pressure changes following CO₂ laser-assisted sclerectomy surgery.

including wound leak, hypotony, shallow anterior chamber, choroidal detachment, choroidal hemorrhage, or endophthalmitis. Four eyes required postoperative enhancement procedures including laser goniopuncture (2 eyes) and needling (2 eyes) at between 3 and 6 months postoperatively. The success rate of CLASS at 6 months was 81.8%. The BCVA postoperatively at 6 months was $0.74 \pm 0.14 \log \text{MAR}$ and was not statistically significant compared to preoperative BCVA ($P > 0.05$).

4. Discussion

Deep sclerectomy is a nonpenetrating filtering procedure that can effectively reduce IOP and has fewer risks than nonpenetrating techniques.^[12,13] The main drawback of deep sclerectomy is the technically challenging dissection of the deep lamella and the unroofing of the TDM without perforation. CLASS is much less technically demanding for deep dissection compared with the manual technique. Since CO₂ laser energy is absorbed when exposed to aqueous, controlled dissection of the scleral tissue is achieved with a lower risk of perforation as the laser would cease to ablate once aqueous seepage is achieved.

In a prospective single-arm nonrandomized study involving 15 eyes with either POAG or pseudoexfoliation glaucoma, the preoperative IOP of $27.3 \pm 4.2 \text{ mm Hg}$ was lowered to $15 \pm 3.7 \text{ mm Hg}$ at 6 months, yielding an average IOP reduction of 45.1%.^[14] In another prospective, nonrandomized, noncomparative, multicenter study, CLASS was conducted in POAG and pseudoexfoliative glaucoma, showing a medication reduction from 2.5 ± 1.3 medications to 0.1 ± 0.4 at 6 months and 0.6 ± 0.9 at 12 months ($P < 0.001$).^[11] Similar to our study, the numbers of antiglaucoma eye drops were significantly reduced by 54.3% at 3 months and 38.5% at 6 months. In our study, the IOP reduction was 19.0%, and the medication reduction was 38.2% at 6 months. The lower percentage of IOP drop in our present study may be caused by a number of factors. The recruited cases in our study were advanced glaucoma patients with chronic use of multiple antiglaucoma medications for more than 5 years. With a longer duration of disease, the eyes are more hyperemic at the time of surgery, leading to greater inflammatory reaction and a

higher scarring tendency. One-third of our cases have previous failed trabeculectomy with scarring, leading to limited conjunctival space for CLASS. In addition, the clinical response of Chinese eyes to laser may differ from that of Caucasians. As this was one of the first studies of using CLASS in Chinese eyes, we adopted the laser settings as per our Caucasian counterparts but differences in response to laser energy may result in more inflammation and scarring in the early postoperative period as noted by the statistically similar IOP at 1 to 3 months as compared to the preoperative baseline. Therefore, the energy level may need to be titrated and further optimized when applied to Chinese eyes. The use of a larger partial thickness scleral flap and a spacer in the scleral bed may also help to increase fluid percolation. The understanding of the transient climbing of IOP between 1 and 3 months after CLASS is also important for surgeons managing postoperative CLASS patients to avoid earlier reintervention within 3 months as the IOP is expected to decline from 3 to 6 months postoperatively. For those with a persistently high IOP after 3 months, enhancement procedures like laser goniopuncture or needling may be initiated.

Intraoperatively, effective and smooth aqueous percolation was ensured before scleral flap was repositioned. However, 1 patient had intraoperative perforation with iris prolapse. Theoretically, the emerging aqueous should have prevented the ablation by the laser, thus avoiding perforation. A plausible explanation for this unique complication was perhaps that the laser applications were delivered too quickly not allowing enough time for adequate aqueous to fill the sclera bed to absorb the laser energy leading to the ruptured TDM in this case. Therefore, it is recommended that the CO₂ laser should be applied with a time interval of around 2 to 3 seconds between each application to allow for the laser energy to dissipate and for adequate aqueous percolation. Greifner et al similarly reported 2 cases of macroperforation with iris prolapse. They postulated that the working energy of the CO₂ laser was too high when performing the deep ablation steps. Therefore, it is also recommended to reduce the laser energy when ablating closer to the TDM.^[15]

There were no device-related postoperative complications. The most significant complications typical to penetrating glaucoma surgeries including persistent hypotony, choroidal effusion, and shallow or flat anterior chamber were absent in our study. In accordance with other CLASS studies, the reported complications were mostly graded as mild and transitory with no serious postoperative complications.^[11]

The present pilot study has several limitations. It has a limited follow-up period; however, reporting of the early postoperative results were clinically relevant as there was a transient climbing of IOP between 1 and 3 months, followed by IOP reduction from 3 to 6 months after CLASS, unlike with traditional trabeculectomy. Therefore, it is advisable to avoid early reintervention within 3 months after CLASS surgery. The present study sample size is relatively small, in spite of that, statistically significant reductions in both IOP and medications were demonstrated after the CLASS procedure. A randomized prospective study with larger sample size and longer follow-up will be necessary to further evaluate the long-term safety and efficacy of CLASS procedure. Furthermore, our study population had a case-mix of different glaucoma subtypes with histories of previous surgeries, while it may not have been the most ideal in a research sense, which is the most representative of real-life situations. Moreover, the study may not be generalizable to different populations, ethnicities, or severity of glaucoma. This preliminary study serves to report the early postoperative IOP changes after CLASS. As visual field loss takes

time to progress, it shall be included for analysis in future studies reporting the long-term outcomes. CLASS is a nonpenetrating procedure in which aqueous percolates through the TDM, where it collects within the scleral bed and diffuses into the subchoroidal and subconjunctival space. It would be ideal if a postoperative ultrasound biomicroscopy (UBM) was performed to provide investigative confirmation on the aqueous outflow pathway but unfortunately UBM is not a routine practice for posttrabeculectomy patients in our institution.

To the best of our knowledge, this is the first pilot study of using CLASS in a Chinese population with advanced glaucoma under the operation of a single surgeon. CLASS effectively reduced IOP and medication use in the early postoperative period, although IOP reduction was not statistically stable until after 3 months. It has a high safety profile as surgical treatment of moderate-to-advanced glaucoma. Longer follow-up is warranted to assess its sustainability.

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