



**SAFETY AND EFFICACY OF DIODE
LASER
CYCLOPHOTOCOAGULATION IN
THE TREATMENT OF GLAUCOMA
AT GROOTE SCHUUR HOSPITAL**

Master of Medicine in Ophthalmology

University of Cape Town

MMED CANDIDATE

Dr Ingrid Coetzee

Student number - CTZING001

Contact number - 083 725 9414

Email address - ingridg@bgc.co.za

SUPERVISOR

Prof Nagib du Toit

Contact number – (021) 404 3534

Email address – nagib.dutoit@uct.ac.za

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DECLARATION

I, Ingrid Daniela Coetzee, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Signed by candidate

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ABSTRACT

Objective

The primary objective of the study is to determine the efficacy of diode laser cyclophotocoagulation in terms of the amount of intraocular pressure (IOP) drop achieved in glaucoma patients at Groote Schuur Hospital. The secondary objective is to determine the safety of the procedure by analysing the complications that arose as a result of the cyclodiode treatment.

Methods

A retrospective file review was conducted on the diode laser cyclophotocoagulation (cyclodiode) procedures done at Groote Schuur Hospital Eye Clinic over a one year from 1 January 2014 to 31 December 2014. All the patients who received cyclodiode therapy at Groote Schuur Eye Clinic during this time period were included. There were no exclusion criteria. Data was collected on age, gender, laterality of procedure, pre-procedure visual acuity (VA), pre-procedure IOP, post-procedure VA at 3, 6 and 12 months, post-procedure IOP at 3, 6 and 12 months, medication pre- and post-procedure, type of glaucoma, prior glaucoma surgery, total number of laser spots applied, average laser power used (mW), number of laser sessions received and complications of the procedure documented at 3 months post procedure. Data analysis was performed using Microsoft Excel 2016.

Results

There were 64 eyes treated over the 12-month period. Neovascular glaucoma was the most common glaucoma (44%). There was a significant difference between the pre- and the post-treatment IOP at each of three ($p < 0.00001$), six ($p = 0.00026$), and 12 months ($p = 0.0012$) (paired samples t-test) with a mean IOP drop of 10mmHg. There was no significant difference between the visual acuity before and after treatment at three months ($p = 0.13$) (paired samples t-test). There was a significant difference between the visual acuity before and after treatment at six months ($p = 0.0078$) and at 12 months ($p = 0.0083$) (paired samples t-test). Before treatment, 98% of patients were receiving anti-glaucoma medical treatment and at three months after treatment, the number of eyes on medical treatment had decreased to 90% of the patients. This decrease was not significant ($p = 0.06$) (chi-squared test). The mean number of three anti-glaucoma medications being used remained unchanged but the number of patients receiving oral anti-glaucoma treatment

decreased from 59% to 37% post-procedure. No complications were found in 60% at 3 months post-procedure.

Conclusion

Transscleral cycloidiode is a safe procedure with a mean IOP decrease exceeding 10mmHg. Although this may not be enough to allow the cessation of all anti-glaucoma medication, it is often enough to allow the cessation of oral anti-glaucoma medication.

ACKNOWLEDGEMENTS AND CONTRIBUTIONS

I would like to acknowledge the input from my supervisor and co-supervisor during the study and for the assistance with compiling this thesis.

I would also like to acknowledge our co-author, Sheila Lubega, who assisted with the research data collection.

LIST OF TABLES

Table one: Types of glaucoma

Type of glaucoma	Number (%)
Neovascular glaucoma	28 (44%)
Primary open angle glaucoma	18 (28%)
Secondary open angle glaucoma	14 (22%)
Primary closed angle glaucoma	2 (3%)
Secondary closed angle glaucoma other than neovascular glaucoma	1 (1.5%)
Congenital glaucoma	1 (1.6%)

Table two: Mean IOPs before and after treatment

	Mean IOP (mmHg)
Pre-treatment (64 eyes)	36 (SD +/- 14.6)
After 3 months (52 eyes)	21 (SD +/- 15.7)
After six months (36 eyes)	23 (SD +/- 13.2)
After 12 months (33 eyes)	22 (SD +/- 12.7)

Table three: Mean LogMAR visual acuity before and after treatment

	Mean LogMAR visual acuity (+/- SD)
Pre-treatment (64 eyes)	2.2 (SD +/- 1.1)
After 3 months (53 eyes)	2.1 (SD +/- 1.0)
After 6 months (42 eyes)	2.2 (SD +/- 1.0)
After 12 months (37 eyes)	2.0 (SD +/- 1.1)

Table four: Complications after treatment

Complication	Number (%)
None	32 (60%)
Loss of vision more than one line	12 (23%)
Intraocular inflammation	4 (8%)
Hypotony (IOP <5mmHg)	2 (4%)
Hyphaema	3 (6%)
IOP spike	1 (2%)

TABLE OF ABBREVIATIONS

Abbreviation	
IOP	Intraocular pressure
POAG	Primary open-angle glaucoma
PACG	Primary angle-closure glaucoma
VA	Visual acuity

CHAPTER 1: Introduction and Literature Review

1.1 Introduction

Glaucoma is a common ocular condition in which the intraocular pressure (IOP) within the eye is too high causing eventual damage to the optic nerve. As such the main aim of treatment is to lower the intraocular pressure in order to limit or prevent irreversible damage to the optic nerve.

The first-line treatment of glaucoma is medical therapy in the form of intraocular pressure lowering eye drops and/or systemic medications. Failing this the next option would be various surgical procedures, some more invasive than others.

Diode laser cyclophotocoagulation is a non-invasive procedure that destroys the part of the eye responsible for producing and secreting the water inside the eye called aqueous humour and thereby reducing intraocular pressure. It is a procedure which has been available for many years and has been proven to be safe and effective in lowering the intraocular pressure.

Groote Schuur Hospital eye clinic currently uses diode laser cyclophotocoagulation for a certain group of patients with glaucoma not responding to other treatment modalities, patients with previous failed glaucoma surgery and those presenting with painful, blind eyes. It has however been noted that diode laser cyclophotocoagulation is being used more and more as a primary modality to lower intraocular pressure either as definitive treatment or as a temporizing measure prior to safely performing glaucoma surgery. In our setting with poor patient follow-up, relatively limited resources and often reluctance to accept surgical treatment options, this may become a valuable option in the future.

Since there is currently no universal treatment protocol for diode laser cyclophotocoagulation, it is necessary to evaluate the efficacy of the diode laser cyclophotocoagulation protocol used at Groote Schuur Hospital at present in terms of the amount of intraocular pressure drop and compare this to the known success rates noted in previous studies. Evaluation of the safety of the procedure done at Groote Schuur Hospital by looking at the complications experienced will also allow a comprehensive assessment of our current protocol. If diode laser cyclophotocoagulation at Groote Schuur Hospital is shown to be a safe and effective procedure, management protocols could be adjusted accordingly

to provide a more comprehensive and accommodating service to the glaucoma patients presenting to our facility.

1.2 Literature search strategy

The PubMed Health database was used to perform a search of the relevant literature in peer reviewed journals. The search was conducted using the following keywords: cyclophotocoagulation, cyclodiode, glaucoma + treatment, diode laser cyclophotocoagulation

1.3 Literature review

1.3.1 Introduction

Glaucoma is a characteristic optic neuropathy diagnosed by identifying specific structural changes and functional loss¹ and is the leading cause of irreversible blindness worldwide.² In 2010 it was estimated that 60.5 million people worldwide were affected by primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG).³ The World Health Organisation's most recent estimation is that 4.5 million people worldwide are blind from glaucoma, accounting for approximately twelve percent of global blindness.¹ When looking at the prevalence of blindness in Africa specifically, the literature from Lewallen et al suggested that in 2001 Africa had a blindness prevalence rate of approximately one percent.⁴ A more recent review by Naidoo et al found this prevalence rate to be slightly higher in 2010 with a rate of 1.3% reported.⁵ The top 3 causes of blindness identified in this region of the world are cataract, glaucoma and trachoma⁴, with glaucoma being reported as the leading cause of global irreversible blindness.^{2,3} This emphasises the magnitude of glaucoma as a clinical entity worldwide and in Africa and highlights the importance of adequate prevention and treatment of this disease.

1.3.2 Glaucoma treatment

There is very little known at this stage about primary prevention of glaucoma, however there are many options available when treating glaucoma with the aim of halting the disease process and preventing irreversible visual field loss and blindness.¹ Medical therapy remains first-line treatment

followed by the various invasive and non-invasive surgical options available. One of the non-invasive surgical options for treating glaucoma is diode laser cyclophotocoagulation.

1.3.3 Diode laser cyclophotocoagulation

Diode laser cyclophotocoagulation (cyclodiode) is a cyclodestructive procedure that lowers intraocular pressure by destroying part of the ciliary body in the eye responsible for aqueous secretion and thereby reducing aqueous production.⁶ Ciliary body ablation or cyclodestruction as a glaucoma treatment modality has been used for many decades and has been described as a treatment option since the 1930s.⁷ The past nine decades have seen advances in various cyclodestructive techniques with the aim of focusing the necessary energy at the correct tissues with as minimal collateral damage as possible.⁷ This in turn decreases the likelihood of complications and increases the efficacy of the procedure with postoperative outcomes closer to the other available invasive and non-invasive glaucoma treatment modalities.⁷

The original cyclodestructive techniques involved cyclodiathermy and cryotherapy.⁸ Various studies done in the 1940s and 1950s showed poor outcomes using cyclodiathermy in terms of safety as well as suboptimal clinical response.⁷ Cryotherapy was then tried as a cyclodestructive technique by Bietti in 1950 and was found to be more effective and less destructive than cyclodiathermy but still with many associated complications.⁷ Laser photocoagulation of the ciliary body or cyclophotocoagulation is a newer method now used for ciliary body ablation. Initially this was done using xenon arc photocoagulation in 1961⁷, followed in the 1970s by ruby laser which was subsequently surpassed a year later by 1064-nm neodymium/YAG laser.^{7, 9-11} Diode laser was introduced in 1984, with good results shown a few years later in the 1990s.⁷ The latest method involves using an 810-nm semiconductor diode laser.^{9, 11} Diode laser cyclophotocoagulation is the ideal method at present due to the selective absorption of the 810-nm wavelength by the uveal melanin as well as deeper ciliary body ablation and lower complication rates.^{9, 11-14} When comparing the three main types of lasers used for cyclodestruction, diode laser seems to be preferred due to its cost, efficiency and easy portability.⁷

Diode laser cyclophotocoagulation can be delivered through various ways in order to achieve the desired effect of lowering intraocular pressure. Transscleral semiconductor diode laser or cyclodiode

involves the use of light energy emitted from a semiconductor solid state diode laser system to ablate the ciliary body.⁷ This light energy emitted is near the infrared spectrum at 810nm which is strongly absorbed specifically by melanin containing structures, such as the pigmented ciliary body epithelium.⁷ It is delivered using a continuous delivery of diode laser to destroy the ciliary body and thereby reduce aqueous production and, in turn, intraocular pressure.^{2,7} The intraocular pressure lowering effect of transscleral cyclodiode has been shown to be closely correlated with the number of laser spots applied; this at the expense of potentially increasing complications based on the fact that an increased number of laser spots results in an increased amount of laser power used in the eye with a possible increase in complications.² Collateral damage to the surrounding structures within the eye is thought to be the possible reason for the severity of these complications.²

A more recently developed technique of micropulse transscleral cyclophotocoagulation is showing promise and offers a variation to the well-known technique of traditional transscleral cyclodiode laser.^{2,7,15} With this technique short (microsecond), multiple repetitive bursts of laser energy are delivered to the tissue being targeted during the “on-cycle”.^{2,7,15} These bursts of energy build up to a photocoagulative state in the melanin containing tissues such as the pigmented epithelium of the ciliary body, whilst the non-pigmented tissues never attain this coagulative state due to their lower absorption rate of the energy.^{2,7} The “on-cycles” are followed by “off-cycles” during which time the surrounding tissues have time to cool and remain below the coagulative threshold, which in turn is believed to prevent collateral damage to the surrounding tissues with the hope of further decreasing associated complications.^{2,7,15}

Another technique of diode delivery is endoscopic cyclophotocoagulation where the ciliary processes are ablated using continuous-wave 810nm diode laser and direct endoscopic visualisation of the ciliary processes.⁷ Since this process involves either a limbal incision or pars plana approach, it is often done as a combined procedure in patients requiring anterior or posterior segment surgery for other related or unrelated reasons.⁷

Looking specifically at the method of diode delivery used at Groote Schuur Hospital eye clinic at present, transscleral cyclodiode laser is performed using a G-probe with a fibreoptic pit which emits the necessary diode laser energy.^{7,9} The G-probe is positioned at the limbus and designed in such a way that when positioned correctly the fibreoptic pit is in the correct position to direct the laser

energy onto the ciliary processes and ablate them.⁷ The usual technique used with this method is “pop titrated” laser delivery where the laser energy applied is titrated up or down depending on whether or not a “pop” is heard. The “pop” sound heard represents micro-explosions of the ciliary process after adequate energy has been applied and absorbed by the tissue.^{7, 16} The other available method is using fixed energy laser delivery where the energy is fixed at 2000mW (72J).¹⁶

1.3.4 Success and efficacy of diode laser cyclophotocoagulation

There is no universal definition of success, which makes a comparison of success rates from different studies problematic. A literature search and review conducted by the American Academy of Ophthalmology was published in 2001 and included literature from the years 1968 to 2000. This review noted that the success rate of achieving an IOP below 22mmHg after diode laser cyclophotocoagulation in adults ranged between 70% and 81%.¹³ A review of more recent articles between the years of 2008 to 2017 showed a success rate of achieving an IOP below 22mmHg of between 61% and 87%.^{11, 12, 17-20} There is a more recent study by Bendel et al that suggests that higher success rates of above 88% with less postoperative complications may be achieved by performing transscleral cyclodiode laser in an operating theatre.²¹ This is believed to be due to better monitored anaesthesia resulting in improved patient tolerability and thus more accurate laser burn applications.²¹ There are recent studies that have reported on the safety and efficacy of micropulse cyclodiode laser compared to the traditional continuous wave transscleral diode laser, and although few in number, they have shown micropulse to be as safe and effective as the traditional cyclodiode delivery method.²

1.3.5 Indications for diode laser cyclophotocoagulation

Transscleral cyclophotocoagulation has typically been reserved for eyes with refractory glaucoma and potentially poor visual prognosis.⁷ It has however been noted that diode laser cyclophotocoagulation is being used more and more frequently as a primary or secondary surgical procedure on eyes with various types of glaucoma to lower IOP either as definitive treatment or as temporizing measure prior to safely performing glaucoma surgery.^{11, 22, 23} Promising results have also been shown on eyes with good presenting vision and good expected visual potential.^{24, 25}

The current indications for the use of diode laser cyclophotocoagulation at Groote Schuur Hospital eye clinic are patients with refractory glaucoma, failed glaucoma surgery cases, and those presenting with painful, blind eyes. The follow-up and care of a patient who has undergone penetrating glaucoma surgery is extremely intensive and often involves further multiple interventions to ensure bleb functioning and success of the procedure. In our setting with poor patient follow-up and compliance, as well as relatively limited resources, expanding the indications for diode laser cyclophotocoagulation and including it as a primary or secondary treatment modality or even as a treatment option on eyes with good presenting vision may become an option in the future for the management of our glaucoma patients.

1.3.6 Complications of diode laser cyclophotocoagulation

Some of the main known complications of all cyclodestructive procedures include hypotony, suprachoroidal haemorrhage, prolonged ocular inflammation, postoperative pain, visual loss, phthisis bulbi and retinal detachment. These have however been shown to be a less frequent occurrence when specifically using diode laser cyclophotocoagulation as opposed to the other cyclodestructive modalities.^{6,9,13,26} Complications specific to diode laser cyclophotocoagulation are potential conjunctival surface burns as well as the increased perilimbal pigmentation associated with this.¹³

1.3.7 Rationale for research

Since there is currently no internationally accepted definitive treatment protocol for diode laser cyclophotocoagulation^{9,16}, our primary aim is to evaluate the efficacy of the diode laser cyclophotocoagulation protocol currently used at Groote Schuur Hospital in terms of the amount of IOP drop with each treatment session and compare this to known success rates as discussed above. Evaluation of the safety of the procedure done at Groote Schuur Hospital by looking at the complications experienced will be our secondary aim and will allow a comprehensive assessment of our current protocol. If diode laser cyclophotocoagulation at Groote Schuur Hospital is shown to be a safe and effective procedure, management protocols would be adjusted accordingly to provide a more comprehensive and accommodating service to the glaucoma patients presenting to our facility.

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CHAPTER 2: Publication-ready Manuscript

SAFETY AND EFFICACY OF DIODE LASER CYCLOPHOTOCOAGULATION IN THE TREATMENT OF GLAUCOMA AT GROOTE SCHUUR HOSPITAL

AUTHORS

1. Dr Ingrid Coetzee

MBChB (UCT), Dip Ophth (SA), FC Ophth (SA)

Principle author

Registrar in Department of Ophthalmology, Groote Schuur Hospital, Cape Town

University of Cape Town

Email: ingridg@bgc.co.za

Address: P O Box 23502, Claremont, Cape Town, 7735

2. Sheila Lubega

Final year medical student at University of Cape Town

Co-author

3. Prof Nagib du Toit

MBChB, DipOphth(SA), FRCS(Ed), FCOphth(SA), MMed, PhD

Supervisor and co-author

Associate Professor / Consultant Ophthalmic Surgeon

Division of Ophthalmology (Dept of Surgery)

University of Cape Town / Groote Schuur Hospital

INTRODUCTION

Glaucoma is a characteristic optic neuropathy diagnosed by identifying specific structural changes and functional loss¹ and is the leading cause of irreversible blindness worldwide.² In 2010 it was estimated that 60.5 million people worldwide were affected by primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG).³ The World Health Organisation's most recent estimation is that 4.5 million people worldwide are blind from glaucoma, accounting for approximately twelve percent of global blindness.¹ When looking at the prevalence of blindness in Africa specifically, the literature from Lewallen et al suggested that in 2001 Africa had a blindness prevalence rate of approximately one percent.⁴ A more recent review by Naidoo et al found this prevalence rate to be slightly higher in 2010 with a rate of 1.3% reported.⁵ The top 3 causes of blindness identified in this region of the world are cataract, glaucoma and trachoma⁴, with glaucoma being reported as the leading cause of global irreversible blindness.^{2,3} This emphasises the magnitude of glaucoma as a clinical entity worldwide and in Africa and highlights the importance of adequate prevention and treatment of this disease.

There is very little known at this stage about primary prevention of glaucoma, however there are many options available when treating glaucoma with the aim of halting the disease process and preventing irreversible visual field loss and blindness.¹ Medical therapy remains first-line treatment followed by the various invasive and non-invasive surgical options available. One of the non-invasive surgical options for treating glaucoma is diode laser cyclophotocoagulation or cyclodiode.

Transscleral cyclophotocoagulation has typically been reserved for eyes with refractory glaucoma and potentially poor visual prognosis.⁶ It has however been noted that diode laser cyclophotocoagulation is being used more and more frequently as a primary or secondary surgical procedure on eyes with various types of glaucoma to lower IOP either as definitive treatment or as temporizing measure prior to safely performing glaucoma surgery.⁷⁻⁹ Promising results have also been shown on eyes with good presenting vision and good expected visual potential.^{10,11}

The current indications for use of diode laser cyclophotocoagulation at Groote Schuur Hospital eye clinic are patients with refractory glaucoma, failed glaucoma surgery cases, and those presenting with painful, blind eyes. The follow-up and care of a patient who has undergone penetrating glaucoma surgery is extremely intensive and often involves further multiple interventions to ensure

bleb functioning and success of the procedure. In our setting with poor patient follow-up and compliance, a reluctance to fully accept invasive surgical options, as well as relatively limited resources, expanding the indications for diode laser cyclophotocoagulation and including it as a primary or secondary treatment modality or even as a treatment option on eyes with good presenting vision may become an option in the future for the management of our glaucoma patients.

Since there is currently no definitive treatment protocol for diode laser cyclophotocoagulation worldwide^{12, 13}, our primary aim is to evaluate the efficacy of the diode laser cyclophotocoagulation protocol currently used at Groote Schuur Hospital, with the secondary aim being the safety of the procedure.

METHODS

A retrospective file review of the diode laser cyclophotocoagulation procedures done at Groote Schuur Eye Clinic from 1 January 2014 to 31 December 2014 was conducted and quantitative data was collected. This was conducted after obtaining ethical approval from the University of Cape Town's Faculty of Health Sciences Human Research Ethics Committee. The inclusion criteria included all patients over the age of 13 years old who received diode laser cyclophotocoagulation therapy at Groote Schuur Hospital Eye Clinic over this 12-month period. Data including gender, age, pre- and post-procedure visual acuity at three, six and 12 months, pre- and post-procedure intraocular pressure at three, six and 12 months, type of glaucoma, prior glaucoma surgery, number of laser spots applied, total laser power used, number of cyclodiode sessions given and complications experienced at three months post-procedure was collected. The data was entered into an excel spreadsheet and analysed using the excel 2016 data analysis software. The paired samples t-test and chi-squared test were used to test significance of associations.

RESULTS

There were 64 eyes treated over the 12-month period in 2014.

Thirty-three (52%) were male and 31 (48%) were female.

The age range of the patients was 15 to 90 years, with a mean age of 61 years (SD +/- 14.3 years).

Table one shows the types of glaucoma in the treated eyes.

Table one: Types of glaucoma

Type of glaucoma	Number (%)
Neovascular glaucoma	28 (43.8%)
Primary open angle glaucoma	18 (28.1%)
Secondary open angle glaucoma	14 (21.9%)
Primary closed angle glaucoma	2 (3.1%)
Secondary closed angle glaucoma other than neovascular glaucoma	1 (1.6%)
Congenital glaucoma	1 (1.6%)

Thirty-seven eyes (58%) did not undergo previous surgery and 27 eyes (42%) did undergo previous surgery.

Forty-eight eyes (76%) had one laser treatment session, 13 eyes (21%) had two laser treatment sessions, and two eyes (3%) had three laser treatment sessions. The mean number of laser spots applied at each session was 17, and the mean laser power setting used was 1953mW.

With loss to follow-up, 52 patients were reviewed after three months, 36 after six months, and 33 after 12 months.

Table two shows the mean pre-treatment IOP and the mean post treatment IOP after three, six, and 12 months.

Table two: Mean IOPs before and after treatment

	Mean IOP (mmHg)
Pre-treatment (64 eyes)	36 (SD +/- 14.6)
After 3 months (52 eyes)	21 (SD +/- 15.7)
After six months (36 eyes)	23 (SD +/- 13.2)
After 12 months (33 eyes)	22 (SD +/- 12.7)

There was a significant difference between the pre-treatment IOP and the post-treatment IOP at each of three months ($p < 0.00001$), six months ($p = 0.00026$), and 12 months ($p = 0.0012$) (paired samples t-test) with a mean IOP drop in excess of 10mmHg. Success in our study is defined as IOP post-treatment of less than 22mmHg. This is based on the definition of success in most of the studies included in our literature review. At 3 months post procedure, 71% of eyes had an IOP of less than 22mmHg.

Before treatment, 62 of 63 eyes (98%) were receiving anti-glaucoma medical treatment. No data was available for one patient. At three months after treatment, the number of eyes on medical treatment had decreased to 47 of 52 eyes (90%), and this decrease was not significant ($p = 0.06$) (chi-squared test). The mean number of three anti-glaucoma medications being used remained unchanged. Patients receiving oral anti-glaucoma treatment decreased from 58.7% to 36.5% post-procedure.

For analysis, the Snellen visual acuities were converted to LogMAR visual acuities.¹⁴

Table three shows the mean pre-treatment visual acuities and the mean post-treatment visual acuities after three months, six months, and 12 months.

Table three: Mean LogMAR visual acuity before and after treatment

	Mean LogMAR visual acuity (+/- SD)
Pre-treatment (64 eyes)	2.2 (SD +/- 1.1)
After 3 months (53 eyes)	2.1 (SD +/- 1.0)
After 6 months (42 eyes)	2.2 (SD +/- 1.0)
After 12 months (37 eyes)	2.0 (SD +/- 1.1)

There was no significant difference between the visual acuity before and after treatment at three months ($p = 0.13$) (paired samples t-test). There was a significant difference between the visual acuity before and after treatment at six months ($p = 0.0078$) and at 12 months ($p = 0.0083$) (paired samples t-test).

Visual acuity decreased in 15.4%, 25% and 30% of patients at three, six and 12 months post-treatment respectively. Visual acuity improved in 7.7%, 5.6% and 3% of patients at three, six and 12 months post-treatment respectively. The visual acuity decreased to no light perception in 4 (8%) patients at three, six and 12 months post-treatment.

Table four shows the complications documented after treatment.

Table four: Complications after treatment

Complication	Number (%)
None	32 (60%)
Loss of vision more than one line	12 (23%)
Intraocular inflammation	4 (8%)
Hypotony (IOP <5mmHg)	2 (4%)
Hyphaema	3 (6%)
IOP spike	1 (2%)

There were 60% of patients who experienced no complications. Of the 40% who experienced complications, 23% involved loss of vision or more than one Snellen line. The remaining 17% had milder complications which resolved with the appropriate treatment.

DISCUSSION

Transscleral cyclo diode treatment was effective in reducing the intraocular pressure, with a drop in the mean IOP from 36mmHg before treatment to 21mmHg after three months. This drop in IOP was sustained in the patient group followed up over the following nine months. It should however be noted that there was a loss of data due to loss of follow-up or incomplete case notes in 19 patients (29%). It was safe to use, with 60% of patients experiencing no complications and 17% experiencing mild complications which were not sight-threatening.

Evaluating the success and efficacy of diode laser cyclophotocoagulation when looking at previous studies on this subject is problematic. There is no universal definition of success which makes the

comparison of success rates difficult. However, the majority of the literature reviewed base their success rate on achieving an IOP of below 22mmHg after the procedure. This was thus the success rate we used in our study. A literature search and review conducted by the American Academy of Ophthalmology which was published in 2001 noted that the success rate of achieving an IOP below 22mmHg after diode laser cyclophotocoagulation in adults ranged between 70% and 81%.¹⁵ A review of more recent articles between the years of 2008 to 2018 also showed a success rate of achieving an IOP below 22mmHg of between 61% and 87%.^{6, 7, 16-20} In our case series, 71% of eyes had an IOP below 22mmHg at three months which was sustained over the following nine months. This success rate is notably comparable to those found in our literature review.

Whilst it would be most desirable for patients not to need anti-glaucoma medication after treatment, disappointingly 90% of eyes remained on adjuvant medical treatment after cyclodiode. Similar to the results reported in a study by Bloom et al, the percentage of patients not requiring anti-glaucoma medication increased from 1.6% pre-treatment to be 9.6% post-treatment.²¹ Reducing and, if possible, stopping anti-glaucoma medications is desirable in all patients in order to increase compliance and limit potential side effects of the treatment. The oral anti-glaucoma medications in particular have the most unwanted side effects when compared to topical meds and thus decreasing the need for their long-term use is attractive to both the ophthalmologist and patient. Previous studies have shown variable results in terms of the decrease in percentage of patients requiring oral anti-glaucoma medications pre- and post-treatment. The figures from our literature review range from 45% to 10% decrease in number of patients on oral medication.^{20, 22, 23} We found similar results in our study with 59% of patients requiring the use of oral anti-glaucoma medication prior to treatment with cyclodiode, and only 37% remaining on oral medication after treatment.

The main potential complications of all cyclodestructive procedures include hypotony, suprachoroidal haemorrhage, prolonged ocular inflammation, postoperative pain, visual loss, phthisis bulbi and retinal detachment.^{12, 15, 24, 25} In this study, most eyes (60%) had no complications from the cyclodiode at 3 months post-procedure. Only four eyes (8%) had documented intraocular inflammation which was successfully treated with topical medication, and 12 (23%) patients experienced loss of vision of more than one Snellen line. This leaves 77% of patients having either no change in visual acuity or an improvement in vision at 3 months post-procedure. All of these figures are comparable to the international literature included in our review.^{8, 11, 21} Of the 12 patients with

loss of visual acuity, nine patients experienced the loss of vision only with no other documented complication related to the procedure that could explain the visual loss. The three remaining patients experienced loss of vision plus either intraocular inflammation or hyphaema which could account for this. Of the nine patients with documented loss of vision of more than one Snellen line, five patients had a poor prognosis pre-procedure Snellen visual acuity of count fingers or worse. The remaining four patients had Snellen visual acuities of better than 6/24 with known uveitis, pseudoexfoliation or primary angle-closure glaucoma. It would have been helpful to quantitatively document, through visual field or optic nerve head OCT tests as well as a full clinical examination, if the visual loss in these patients was part of the natural progression of the glaucoma or due to another identifiable cause. There were four patients (8%) whose visual acuity decreased at 3 months post procedure to no light perception. All of these patients had neovascular glaucoma with poor presenting visual acuities. One had a presenting VA of hand movements and the remaining three had initial VA of light perception.

The main weaknesses with our study are its retrospective nature, with all the problems and limitations implicit in that, and lack of information recorded to try explain the reasons for visual loss post-procedure. Another limitation was unfortunately that 14 patients (22%) were lost to follow-up in the 12-month period after the procedure and 17 patients (27%) had case notes that were either incomplete or missing.

There are a number of considerations in planning appropriate strategies for glaucoma management in middle income and low income African countries. Patients with cataracts (often termed “white blindness” because of the white pupil present), which is, happily, the commonest cause of blindness in Africa, may be effectively treated and cured of their blindness with cataract surgery. Patients with chronic glaucoma (often termed “black blindness” because of the black pupil present), which is the second leading cause of blindness in Africa, present more of a challenge. The reason for this is multifaceted and complex. Glaucoma in Africans often has an earlier onset plus a more aggressive course requiring close lifelong follow-up, regular visits and strict IOP control.^{4, 11} Medical treatment is a problem. The lack of availability of medication plus the cost of medication, as well as poor patient understanding are likely to result in poor compliance with inadequate intraocular pressure control and subsequent progression of disease.^{11, 26} Surgical treatment also poses a problem. Patients often have low acceptance of glaucoma surgery and may have difficulty understanding and accepting the differences between their glaucoma causing “black blindness” and their neighbour’s cataract or

“white blindness”. This in turn leads to them not understanding fully why the surgery they underwent for their glaucoma did not “cure them” of their blindness and improve their visual functioning when compared to the cataract surgery which restored vision to their neighbour.^{11, 26} This could not only result in a negative marketing impact on cataract surgery, but also on the willingness of patients to undergo often very necessary glaucoma surgery in order to preserve their remaining visual function. Many African eye surgeons are also often reluctant to offer patients the necessary glaucoma surgery for fear of the possibility of encountering the known complications that can occur with these surgeries and for fear of being seen to worsen the patient’s visual functioning.¹¹ The well documented propensity of black African eyes to fibrosis and failure of the drainage bleb after conventional drainage surgery, especially if antimetabolites are not used as an adjunct, supports this fear.^{11, 27, 28}

The ideal “silver bullet” for the management of glaucoma would be a safe, inexpensive, technically simple “once off” intervention that adequately permanently lowers the intraocular pressure, and that can be done as an outpatient procedure as soon as the diagnosis is made, obviating the need for life long medical treatment, obviating any risk of confusion with cataract surgery, and obviating the risk of failure or other complications after conventional drainage surgery and eliminating patient fears of surgical intervention. Some form of laser treatment might most closely approximate this ideal.

Transscleral cyclodiode laser treatment therefore could have a potential role as first line treatment for chronic glaucoma in middle-income and low-income countries such as those found in Africa. The specific advantages being its small size, portability, low cost to run and ease of use, together with the convenience of less post-procedural complications and a less intensive follow-up schedule required when compared to conventional incisional glaucoma surgery.⁹ Notwithstanding the fact that it is generally reserved for the treatment of eyes with end stage disease in which more conventional medical treatment or surgery is ineffective in controlling the intraocular pressure⁶, there are some proponents for its use as a first line treatment.^{6, 8, 9} This is particularly true for patients with primary open angle glaucoma in which the highest success rates have been found by numerous authors when using transscleral cyclodiode as a primary treatment modality.⁹ This finding is of great significance for African countries where the highest prevalence of POAG exists¹¹ and where a procedure such as transscleral cyclodiode may be more widely accepted than invasive surgery. A recent study by Abdull et al¹¹ conducted in Nigeria echoed these promising findings and

confirmed that transscleral cyclodiode was safe and effective, as well as better accepted by patients as the primary treatment in seeing eyes with POAG in their setting. This finding could have positive implications in South Africa, where the ethnicity, cultural beliefs of a great proportion of the population and resource scarcity closely match those of the Nigerian population.

CONCLUSION

In our case series, we have found transscleral cyclodiode laser treatment to be a safe procedure in lowering the intraocular pressure with a comparable success rate to previous authors of 71%. The mean IOP decrease seen in our patients exceeded 10mmHg and although this may not be enough to obviate the need for anti-glaucoma medication, it is often enough to allow the cessation of oral anti-glaucoma medication with its undesirable systemic side-effects. Our case series shows that the transscleral cyclodiode protocol currently used at Groote Schuur Hospital is effective and safe. With this knowledge it will be possible to further look into expanding our indications for cyclodiode procedures and possibly start using the procedure more frequently as a primary treatment modality.

Further research looking into the long-term complications and elaborating on the causes of visual loss in these patients is warranted. A prospective study to assess the use of cyclodiode as a primary treatment modality at Groote Schuur Hospital would also be of great use in this setting where poor follow-up and compliance, as well as a lack of understanding into the disease process necessitates a relatively simple, cheap and effective treatment modality where follow-up is less critical.

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APPENDICES

APPENDIX A: Data capture form

CASE NUMBER		CODING
FILE NUMBER		
GENDER		
AGE		
SIDE		
PRE-OP VA		
PRE-OP IOP		
POST-OP VA 3/12		
POST-OP VA 6/12		
POST-OP VA 12/12		
POST-OP IOP 3/12		
POST-OP IOP 6/12		
POST-OP IOP 12/12		
MEDS PRE-OP	BETAGAN ALPHAGAN LUMIGAN COMBIGAN DUOTRAV GANFORT DIAMOX OTHER	
MEDS POST-OP 3/12	BETAGAN ALPHAGAN LUMIGAN COMBIGAN DUOTRAV GANFORT DIAMOX OTHER	
TYPE OF GLAUCOMA		
PRIOR GLAUCOMA SURGERY		
TOTAL SPOTS APPLIED		
TOTAL LASER POWER (mW)		
NUMBER OF SESSIONS		
COMPLICATIONS	LOV > 1 SNELLEN LINE HYPOTONY (IOP<5) SUPRACHOROIDAL HX IOP SPIKE INTRAOC INFLAMMAT PAIN HYPHAEMA NONE	

APPENDIX B: Departmental Research Committee approval letter



UNIVERSITY OF CAPE TOWN

Department of Surgery

Departmental Research Committee

Dr Timothy Pennel

D24 Office, Groote Schuur Hospital,
Observatory 7925, South Africa

Tel (021) 406 6168/6232/6227 Fax (021) 448 6461

Email: tim.pennel@uct.ac.za

1st December 2016

Dr I Coetzee

Department of Surgery
Groote Schuur Hospital
University of Cape Town

Dear Dr Coetzee

RE: PROJECT 2016/088

PROJECT TITLE: Safety and efficacy of diode laser cyclophotocoagulation in the treatment of glaucoma at groote schuur hospital

The above proposal has been reviewed by the Department of Surgery Research Committee. I am pleased to inform you that the committee approved the scientific merit of the study, and endorse the protocol for submission to the relevant ethics committee.

Please use the above project number in all future correspondence.

Yours sincerely

A handwritten signature in black ink, appearing to read 'T Pennel'.

DR TIMOTHY PENNEL

CHAIRMAN: RESEARCH COMMITTEE

APPENDIX C: Human Research Ethics Committee approval letter



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



Room E53-46 Old Main Building
Grootte Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: sumayah.ariel@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

12 February 2018

HREC REF: 026/2018

Dr I Coetzee
c/o Prof du Toit
Division of Ophthalmology
J-Floor, OMB

Dear Dr Coetzee

PROJECT TITLE: SAFETY AND EFFICACY OF DIODE LASER CYCLOPHOTOCOAGULATION IN THE TREATMENT OF GLAUCOMA AT GROOTE SCHUUR HOSPITAL (MMED CANDIDATE - DR I COETZEE)

Thank you for your response letter, addressing the issues raised by the Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 28 February 2019.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student: Dr I Coetzee will also be involved in this study.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate Institutional approval, where necessary, before the research may occur.

Yours sincerely


PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

South African Ophthalmology Journal guidelines for authors



The SA Ophthalmology Journal is a peer-reviewed scientific journal and the official mouthpiece of the Ophthalmological Society of South Africa. It appears on a quarterly basis.

- 1 A cover sheet is to be submitted with each manuscript. It should contain the title of the manuscript, the names of all authors in the correct sequence, their academic status and affiliations. The main author should include his/her name, address, phone and email address.
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- 8 Tables should carry Roman numerals, I, II etc., and illustrations Arabic numbers 1, 2 etc.
- 9 References should be numbered consecutively in the order that they are first mentioned in the text and listed at the end in numerical order of appearance. Identify references in the text by Arabic numerals in superscript after punctuation, e.g. ...trial.¹³
- 10 The following format should be used for references:

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Kaplan FS, August CS, Dalinka MK. Bone densitometry observation of osteoporosis in response to bone marrow transplantation. *Clin Orthop* 1993;294:173-78.

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- 13 Authors should declare any interests, financial or otherwise, regarding the publication of their article. 🗨️