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Research Article

Gonio-Assisted Trabecular Lavage with Deep Sclerectomy Augmented with Mitomycin C in Silicon Oil Induced Secondary Open Angle Glaucoma

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Abstract

Introduction and Objective: Silicon oil induced glaucoma is major problem that needs more efforts to establish a safe and effective surgical technique. The aim of this study was to detect the safety and efficacy of gonio-assisted trabecular lavage with deep sclerectomy augmented with MMC in secondary open angle glaucoma cases resistant to medical treatment after silicon oil removal.

Methods: The study included 31 eyes of 31 patients with secondary open angle glaucoma refractory to silicon oil removal and maximal tolerable medical treatment. Gonio-assisted trabecular lavage in conjunction with deep sclerectomy augmented with MMC was done for all cases. Thirty months was the follow up period. IOP reduction and its stability were the primary outcome while safety was the secondary outcome of this study.

Results: The mean age was 54.65 ± 13.04 years. 17 (54.8%) of patients were male while 14 (45.2%) were female. Diabetic retinopathy was the indication of vitrectomy in 21 (67.7%) of patients while rhegmatogenous retinal detachment was the indication in 10 (32.3%) of cases. Complete success rate was met in 15 (48.7%) of patients while 12 (38.7%) achieved qualified success otherwise 4 (12.9%) completely failed. IOP decreased from 36.00 ± 5.69 preoperatively to 14.96 ± 1.65 at 30 months postoperatively $p < 0.001$. Anti-glaucoma treatment decreased from 3.56 ± 0.51 preoperatively to 2.5 ± 1.09 postoperatively $p < 0.001$. The mean visual acuity was not significantly changed from 0.15 ± 0.12 preoperatively to o.14 ± 0.10 post-operatively $p > 0.05$. Complete loss of vision was not met in any case of the study.

Conclusion: Trabecular lavage in conjunction with deep sclerectomy augmented with MMC can provide a safe, effective and favorable long-term outcome maneuver in controlling silicon oil induced secondary open angle glaucoma after silicon oil removal.

Keywords: *Deep Sclerectomy; Mitomycin C; Silicon Oil Induced Glaucoma; Trabecular Lavage; Gonio-Puncture; Silicon Oil Induced Glaucoma*

Abbreviations

SOAG: Secondary Open Angle Glaucoma; MMC: Mitomycin C; BCV: Best Corrected Visual Acuity; OCT: Ocular Response Analyzer; UBM: Ultrasound Bio-Microscopy; SST: Sub-Scleral Trabeculectomy; GDDS: Glaucoma Drainage Devices; SLT: Selective Laser Trabeculoplasty; TDM: Trabeculo-Descemet's Membrane

Introduction

Pars plana Vitrectomy surgery that became widely used nowadays for management of complicated retinal detachment as well as proliferative diabetic retinopathy associated with tractional retinal detachment may be a precursor for glaucoma [1,2]. Retinal tamponed is vital in surgical management of complicated retinal detachment (3). Silicon oil appears as the most widely used adjunctive retinal tamponed due to its buoyant force and high surface tension, However it is associated with a higher risk of glaucoma than others [3,4]. Secondary glaucoma is a major common complication of silicon oil itself or even after silicon oil removal that may be transient or persistent [3,5]. A range between 2.2% to 83.3% was the incidence of silicon oil induced glaucoma according to literature [6-9]. The exact mechanism of silicon oil induced glaucoma is not well known but different mechanisms can be proposed to explain pathogenesis and consequent mode of treatment [5]. Primarily, Mechanical obstruction of aqueous outflow as result of posterior overfilling as well as anterior chamber filling produces secondary open angle glaucoma [3,10]. Secondarily, pupillary block by silicon produces secondary angle closure glaucoma [11,12]. Thirdly, silicon micro droplets may migrate into trabecular meshwork and its denaturation producing secondary open angle glaucoma [3,8,13,14]. Lastly, inflammation as well as acceleration of preexisting glaucoma may be the exact mechanism of silicon-induced glaucoma [7,13,15]. Silicon oil removal constitutes the main goal in the first two mechanisms [13]. The last two mechanisms those are most commonly met in cases of secondary open angle glaucoma (SOAG) after silicon oil removal [3,13]. Traditional trabeculectomy with or without mitomycin C (MMC) have the risk of severe hypotony, choroid as well as retinal detachment that may be due to absence of vitreous gel or any alternative retinal tamponade [13,16]. High failure rate due to conjunctival scaring as well as escaped silicon under conjunctiva may also make glaucoma drainage devices is the main concern in this category of patients [16-19]. In this current study, Gonio-assisted trabecular lavage conjugated with deep sclerectomy augmented with MMC may present an effective as well as safe alternative surgical solution for this type of cases.

Patients and Methods

Research design and setting

A prospective randomized interventional study included 31 eyes of 31 patients of SOAG to emulsified silicon oil and underwent silicon oil removal. These patients were referred to glaucoma clinic aiming for surgery as maximal tolerated medical treatment was not able to control IOP (IOP ≥ 21 mmHg). The study was established a as well as all procedures and follow up visits were done at the research institute of ophthalmology (RIO) in the ministry of scientific research in Egypt during the period from September 2016 to May 2018. The study was performed in accordance with the tenets of the declaration of Helsinki of 1975 (1983 revision). The research committee of the research institute of ophthalmology approved the protocol of the study. All patients received a through explanation of the procedures used in the study, and they signed an informed consent prior to treatment.

Preoperative evaluation

All patients were evaluated concerning best corrected visual acuity (BCVA) assessment with Snellen's chart converted to log MAR, detailed slit lamp examination of anterior segment and gonioscopy with Goldman 3 mirror, IOP measurement with Goldman's applanation tonometer.

Detailed fundus examination with binocular indirect ophthalmoscopy as well as 90 diopter bio-microscopic examinations had done to evaluate optic nerve head and retina. B scan ultrasonography had performed for all patients to confirm and document that the retina was intact in all quadrants.

An examination of angle of anterior chamber by anterior segment OCT with Fourier domain RTVue-100 OCT machine (OCT Optivue, inc. Fermont, CA, USA) and ultrasound biomicrosopy (UBM), (UBM, 840 Zeiss-Humphery Medical Instrument).

Inclusion criteria

An open anterior chamber angle as detected by gonioscopy and anterior segment OCT and UBM. Attached retina and choroid after silicon oil removal as detected clinically and documented by B scan ultrasonography. Eyes with Silicon oil droplets floating in anterior chamber or impacted in angle of anterior chamber after careful silicon oil removal.

Exclusion criteria

Cases with rubeosis irides, Secondary angle closure glaucoma with any degree, preexisting glaucoma or previous glaucoma surgery in addition to patients who did not completed the follow up schedule were excluded from the study.

Surgical technique

The same surgeon (HH) did all operative procedures. Surgery was performed under local peribulbar anesthesia consisting of 4 - 6 ml of 0.75% bupivacaine, xylocaine (lidocaine HCL 4%), 50 IU hyaluronidase and sedation.

The globe was immobilized with 4-0 nylon suture beneath the tendon of the superior rectus muscle. A fornix based conjunctiva peritomy of 5 - 6 mm was fashioned at the 12 o'clock position of the superior limbus through blunt dissection maneuver. A 5 x 5 partial thickness scleral flap was created and dissected up to 1 mm through clear cornea with the use of crescent blade. Cellulose sponge soaked with MMC 0.4 mg/ml (Mitomycin 10 mg Kyowa Hakko Kogyo Co., Ltd, Tokyo, Japan) was applied over the scleral bed under tenon's capsule and two applied under scleral flap for three minutes, then vigorous irrigation with saline was done.

Two angled side ports were created with an MVR blade at 4 and 10 clocks in clear cornea while the surgeon was sitting in the superior-nasal in right and superior- temporal position in left eye. The anterior chamber was filled with methyl cellulose. A Swan Jacoup autoclavable gonio-prism, (Ocular, Washington USA) was applied over the cornea for visualization of the angle. Irrigation aspiration cannulas, 21 G with 0.35 mm aspiration and 0.5 mm irrigation ports connected to phaco machine introduced into the anterior chamber. Anterior chamber wash was performed initially and then direct irrigation of the trabecular meshwork under direct visualization with gonio-prism followed by aspiration was performed until no visible silicon bubbles or inflammatory debris were seen in in the angle. Another two side ports were created with an MVR blade at 2 and 8 clocks in clear cornea while the surgeon was sitting in the superior temporal in right and superior-nasal position in left eye and irrigation aspiration and gonio-assisted lavage was performed as before. By this way the angle was circumferentially explored and washed. Hydration of side ports was performed with saline. Viscoelastic was injected if the globe is too soft to manipulate and complete the deep sclerectomy process.

The deep flap borders were outlined 1 mm within the edge of the superficial flap and up to 90% of scleral thickness using a super blade No 15.

The deep flap was fashioned and dissected anteriorly over trabeculo- Descemet's membrane. The deep scleral flap was excised using super blade no 15. Schlemm's canal was de-roofed with blunt micro forceps. The scleral flap was closed with 10/0nylon sutures one in each quadrant. The conjunctiva was closed with 8/0 polyglactin continuous suture.

Post-operative medication

The postoperative medication included Moxifloxacin 0.5% eye drops 4 times daily for three weeks and prednisolone acetate 1% 6 timed daily for 2 weeks and then tapered gradually over 4 weeks according to the sequence of post-operative inflammation.

Success criteria

Success was defined as IOP is more than 5 and less than 21with or without treatment. Complete success was defined as IOP more than 5 and less than 21 without treatment. Achievement of the previous results with treatment was graduated as qualified success rate. Failure was defined as IOP less than 5 or more than21 with maximal tolerated anti glaucoma treatment.

Follow up and manipulation

All cases were followed at 1, 3, 6, 12, 18, 24 and 30 months respectively. IOP, glaucoma medications, visual acuity, cup disc ratio and fundus examination were documented.

Gonio-puncture was done when IOP became more than 21 mmHg. It was performed using Q switched single shot solid state LASER (Visulas YAG III, Carl Zeiss Meditec Oberkochen, Germany) with an energy ranged between 2 - 3 mJ, 1 - 5 shots were required. Goni-assisted trabecular lavage was repeated when gonioscopy has revealed any silicon bubbles or inflammatory debris on trabecular surface.

Statistical analysis

The data were described statistically in terms of mean ± standard deviation (± SD) and range, or frequencies (number of cases) and percentages when appropriate. Comparison between pre- and post-operative IOP was done using paired t test. Within-group Comparison of numerical variables was done using repeated measures analysis of variance (ANOVA) test with multiple 2-group comparisons. For comparing, Chi-square test was performed. Correlation between various variables was done using Spearman rank correlation equation. P-values that were less than 0.05 were considered statistically significant. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows.

Results

The study included 31 eyes of 31 patients. 17 (54.8%) was male while 14 (45.2) was female. Mean age of patients was 54.65 ± 13.04 years.

The BCVA changed from 0.15 ± 0.12 preoperatively to 0.14 ± 0.10 post-operatively but this change was non-significant $p > 0.05$.

Incidence of SOAG according to type of silicon was 87.1% in silicon 1000 in comparison with 12.9% in silicon 5000.

The complete success rate was 48.4% (21 eyes), while 32.3% (10 eyes) were qualified success rate and 12.9% (4 eyes) was the failure rate (Table 1).

		Frequency	Percent%
Valid	Complete success	15	48.4
	Qualified success	12	38.7
	Failure	4	12.9
	Total	31	100.0

Table 1: *Probability success rate.*

IOP significantly decreased from 36 ± 5.69 pre-operatively to be 6.06 ± 6.68,13.71 ± 4.02,13.75 ± 2.63,14.04 ± 1.91,14.70 ± 1.85,14.85 ± 1.72,14.96 ± 1.65,14.96 ± 1.65 in the 1,3,6,9,12,18,24 and 30 months respectively $p < 0.01$.

Paired sample test of IOP reduction was summarized in table 2.

Paired Samples Test									
Mean		Paired Differences					t	df	p value
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Upper	Lower				
Pair 1	IOP-Pre - IOP-1m	19.935	6.455	1.159	17.568	22.303	17.196	30	0.000
Pair 2	IOP-Pre - IOP-3m	22.290	6.084	1.093	20.059	24.522	20.400	30	0.000
Pair 3	IOP-Pre - IOP-6m	21.643	6.326	1.195	19.190	24.096	18.104	27	0.000
Pair 4	IOP-Pre - IOP-9m	21.222	6.387	1.229	18.696	23.749	17.265	26	0.000
Pair 5	IOP-Pre - IOP-12m	20.556	6.500	1.251	17.984	23.127	16.431	26	0.000
Pair 6	IOP-Pre - IOP-18m	20.407	6.356	1.223	17.893	22.922	16.682	26	0.000
Pair 7	IOP-Pre - IOP-24m	20.296	6.268	1.206	17.817	22.776	16.824	26	0.000
Pair 8	IOP-Pre - IOP-30m	20.296	6.268	1.206	17.817	22.776	16.824	26	0.000

Table 2: *Paired sample test for pre and post-operative IOP.*

Anti-glaucoma treatment significantly decreased from 3.56 ± 0.51 to 2.50 ± 1.09 $p < 0.01$. The mean of reduction was 1.06 ± 0.77, $p < 0.01$ (Table 3).

			IOP-Pre
Spearman's rho	IOP reduction	Correlation Coefficient	0.939
		p value	0.000
		N	27
	Preoperative treatment	Correlation Coefficient	0.291
		p value	0.112
		N	31
	Need of PO medication	Correlation Coefficient	0.738
		p value	0.000
		N	27
	Postop treatment	Correlation Coefficient	-0.172
		p value	0.525
		N	16
	Gonio-puncture	Correlation Coefficient	0.420
		p value	0.019
		N	31
	Repeated lavage	Correlation Coefficient	0.420
		p value	0.019
		N	31

Table 3: *Spearman's test for coefficient correlation between preoperative and postoperative parameters.*

Gonio-puncture was performed in 10 (32.2%) of cases, 3 (30%) of them at three months and one (10%) at 6 months. IOP returned to normal range below 21 mmHg in 6 (60%) of cases while failure was met in 4 (40%) of cases.

Repeated gonio-assisted trabecular lavage was performed in 10 (32.2%) of cases, 3 (30%) of them at three months and one (10%) at 6 months. IOP returned to normal range below 21 mmHg in 6 (60%) of cases while failure was met in 4 (40%) of cases.

There is a significant correlation between the preoperative IOP and all of the post-operative results as IOP reduction, need for gonio –puncture, repeated lavage, post- operative treatment as well as preoperative treatment (Table 3).

The higher the preoperative IOP the more the need for preoperative medications ($p < 0.01$) and the more the postoperative reduction of IOP ($p < 0.01$), as well as the more the need for gonio-puncture and repeated lavage, ($p < 0.01$).

A negative correlation had detected between preoperative IOP and post- operative treatment with no significance $p > 0.05$.

Discussion and Conclusion

Glaucoma is one of the common complications of posterior segment surgery. Silicon oil has been increasingly used as a tamponade in vitrectomy surgery [10,20].

Emulsification of silicon oil in micro globules had detected as a precursor for elevation of IOP [14]. Micro globules may be responsible for mechanical obstruction as well as toxicity of the trabecular meshwork [5]. SOAG may appear even before emulsification of silicon [5].

In our current study we found that, silicon (1000 centistoke) is more liable to be emulsified and producing secondary glaucoma than highly purified silicon (5000 centistoke). This result coincides with previous studies that concluded that liability of silicon oil for emulsification is determined by its purity as well as its viscosity. Petersen and Ritzau-tondrow., *et al.* detected in their study that (1000 centistoke of silicon) oil is more liable to cause elevation of IOP than (5000 centistoke) of silicon [21]. On controversy to our results, Stinson and small found no demonstrable difference between both of them in inducing glaucoma [22].

In our study we found that diabetics are, more liable for incidence of silicon-induced glaucoma that may coincides with the study done by Hender., *et al* [10]. This may be due to more compromised blood aqueous barrier that may aggravate the inflammatory reaction in diabetics. Oxidative stress may also contribute in pathogenesis [2]. Against this results Jabbour., *et al.* in a study included 260 eyes concluded that eyes with rhegmatogenous retinal detachment treated with vitrectomy seems to have the highest rate of IOP elevation. This may be explained by prevalence of high myopia among these patients while diabetes was found to be a protective factor against IOP elevation [23].

Treatment of silicon induced SOAG is still controversial. Medical treatment is the first line of treatment but its efficacy is variable as success rate was detected between 30 and 78% according to literature [7,22].

Early silicon oil removal may reverse the mechanical obstruction of trabecular meshwork and establishment of SOAG. In one study (185 of 198 cases) 93.4% of patients had normalization of IOP after silicon oil removal [14], while IOP elevation was persistent in all cases in another study, 62 eyes after silicon removal and 10 of 11 after removal of emulsified silicon [24,25].

Surgical option is the only line of treatment in cases of SOAG resistant to medical treatment after silicon removal. It has to be directed to the underling mechanism as well as the type of secondary glaucoma. There are different options for management of secondary open angle glaucoma such as traditional subscleral trabeculectomy (SST) with or without MMC, selective laser trabeculoplasty (SLT) or Glaucoma drainage devices (GDDs) [13,26-30].

Traditional Surgical treatment as SST faces multiple operative challenges. Conjunctiva dissection may be technically difficult and liable for multiple button holes due to scaring and recession from prior posterior segment operation or operations. These challenges may threaten the next created bleb and make it unlikely to succeed even with addition of antimetabolites. Trabeculectomy procedure may also be technically difficult due to absence of vitreous support. Postoperative complications such as choroid and retinal detachment may be a common concern with traditional SST surgery [31]. These serious drawbacks were avoided in our current study making this maneuver as a safe and effective alternative.

Selective laser trabeculoplasty (SLT) may be an option for management of these cases with a high success rate 91% as detected by Alkin., *et al.* but limited number of cases (11 cases) and short follow up duration appeared as limitations of this study [26].

GDDs constitutes another option for treatment of this kind of glaucoma but risk of failure is increased as a result of liability of escape of silicon via tube into the body of valve [19] makes it the last choice by many surgeons. Hypotony still constitutes a problem in addition to difficult positioning of the plate especially in presence of scleral buckle if present, more endothelial loss with touch by the tube and risk of corneal decompensation as the corneal endothelium was affected by repeated surgeries and interventions [30].

In our study we tried to do deep sclerectomy augmented with MMC in conjunction with trabecular lavage with irrigation aspiration by phaco machine. In this study we tried to direct treatment to the site of pathology by removing remnants of silicon bubbles as well as inflammatory debris from the surface of trabecular meshwork under direct visualization with gonio-prism.

In our study we tried to complete deep sclerectomy as first step in the operation but spontaneous rupture of trabeculo- descmmet's membrane (TDM) and iris prolapse occurred. This may be related to high fluctuation of IOP and fluid turbulence induced by irrigation in the anterior chamber that can't be tolerated by the thin TDM. Peripheral iridectomy as well as conversion to traditional trabeculectomy was done and these cases were excluded from the study. Decision was taken to do trabecular lavage after creation of superficial flap and then creation of deep flap and de-roofing of Schlemm's canal was done.

In our study a significant positive correlation was detected between the value of IOP and post -operative reduction as well as the need for gonio-puncture and repeated trabecular lavage and wash. This correlates with and can be explained by the studies that revealed silicon oil induced SOAG was caused by silicon bubbles which may be partially due to mechanical obstruction of the trabecular meshwork while toxicity and fibrosis may be the main cause with neglection and long contact between silicon and trabecular meshwork [3,13].

In this current study, Success was achieved in 87.1% of cases (complete success 48.4% and qualified success 38.7%) while failure is the end result in 12.9% of cases. These results are valuable in comparison with traditional trabeculectomy which was 35.7% and 67% in Ahmed valve implantation, in addition to the safety and less complications [30,31].

Transscleral cyclophotocoagulation may provide an option for treatment of this type of glaucoma patients with a success rate 66 - 82% after one year according to literature [28,29]. It constitutes the least desirable line of treatment due to high failure rate as well as need for multiple sessions by some authors [27] in addition to high liability for visual loss [29,33]. In comparison with the results of our study, our surgical technique provides better long-term results, less liability for visual loss as well as avoiding repeated sessions.

Gonio-puncture was done and gonio-assisted trabecular lavage was repeated in 10 cases (32.0%) of cases with uncontrolled IOP (more than 21 mmHg) postoperatively. IOP became well controlled (less than 21 mmHg) in (60%) of them while failure was met in 40% of cases. This coincides with the study done by Anand., *et al.* that included 150 eyes with deep sclerectomy 106 of them underwent goniopuncture. In this study success was achieved in 49.7% of cases. They concluded that covering of TDM is the main cause of failure. This explains our higher success rate as in our study the laser beam was directed towards the anterior edge of TDM to avoid iris prolapse in gonio-puncture site [34].

Addition of YAG and or argon laser trabeculoplasty to pull the iris root away from the site of gonio-puncture had done to improve success rate in our current study. Our results coincided with the study done by Di Matteo., *et al.* in which success rate was 62% at 2 years [35].

All intraoperative, early and late postoperative complications were mild and treated effectively and safely without altering the long-term impact of the patients or results of the study. Complete loss of vision was not met in any case of this study

Corneal edema that may be related to high IOP, repeated surgery, prolonged contact with silicon, anterior chamber inflammation due to underlying pathology as diabetic changes and repeated intraocular surgeries. No major complication was met as retinal, choroid detachment or severe hypotony which is more common with traditional trabeculectomy as mentioned in literature [13].

The limitation of this study is the absence of control group and relatively small number of cases as well as strict to cases with open angle only, however this study may be an initial step for achievement of a safe and effective surgical technique for management of silicon induced SOAG resistant to medical treatment and silicon oil removal.

To our knowledge this is the first report about using irrigation aspiration with phacoemulsification machine for trabecular lavage to remove remnants of silicon and inflammatory debris in conjunction with deep sclerectomy augmented with MMC for management of silicon oil induced secondary OAG.

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Confect of Interest

There is no conflict of interest to be declared.

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