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Long-term visual field changes after femtosecond laser-assisted cataract surgery in glaucoma patients, case series

Daniela Alvarez-Ascencio *, Carolina Prado-Larrea, Jesus Jimenez-Roman, Rafael Castañeda-Diez

Glaucoma Department, Asociación para Evitar la Ceguera en Mexico, Mexico City, Mexico

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ABSTRACT

Purpose: To assess the short and long-term changes in Visual Field (VF) Mean Deviation (MD), Visual Field Index (VFI), and intraocular pressure (IOP) after femtosecond laser-assisted cataract surgery (FLACS) in glaucomatous eyes.

Materials and methods: Interventional, prospective case series. Patients with glaucoma, who required cataract surgery were included. All patients underwent a complete ophthalmologic assessment and Visual Fields. FLACS was performed in all patients by a single experienced surgeon. IOP was measured during surgery immediately before and after pretreatment suction docking. Changes from baseline in VF MD and VFI, IOP, visual acuity (VA), and number of glaucoma medications were evaluated up to one-year follow-up.

Results: Fourteen eyes of 11 patients were included. Eighty-five percent were female, with a mean age of 74.2 ± 7.9 years. Nine (64.3%) and 5 (35.7%) were diagnosed with primary angle closure glaucoma (PACG) and primary open angle glaucoma (POAG), respectively. We found a slight IOP reduction after the docking phase during FLACS in both glaucoma subtype groups. No significant changes in visual field mean deviation (MD) and visual field index (VFI) were found from baseline to 12 months after surgery in both groups. A significant reduction in IOP values was found in all cases from baseline up to one year follow up. No significant changes were observed in BCVA and number of topical glaucoma medications after one year in both groups.

Conclusion: In our patients, there was an IOP reduction immediately after suction docking FLACS pretreatment. Mean IOP at final follow-up showed a reduction from baseline. There was no change in VF MD and VFI from baseline to final one-year follow-up. FLACS appears to be well tolerated in early and moderate glaucoma and appears to be a safe tool for glaucoma patients undergoing cataract surgery. Similar results to traditional surgery can be obtained with the advantages of femtosecond laser precision.

1. Introduction

Glaucoma is the leading cause of irreversible blindness worldwide.[1] A high percentage of glaucoma patients have preexisting cataracts; also, glaucoma medications, lasers and surgical procedures are known to be cataractogenic, so a large number of these patients will require cataract extraction, glaucoma surgery, or a combined procedure over time.[2]

The first Femtosecond Laser-Assisted Cataract Surgery (FLACS) was performed in 2008[3] and since its introduction its use has become widespread as a safe tool with benefits such as decreasing loss of endothelial cells, a well-centered and predictable capsulorrhexis, better intraocular lens (IOL) position, and less phacoemulsification energy and time requirements, among others.[4,5,6]

The use of FLACS in glaucoma is an encouraging prospect, but very few studies on the safety of this technology on glaucoma patients are available. Glaucoma patients can have several characteristics that make cataract surgery more challenging: ocular surface disease, presence of filtering blebs, narrower anterior chambers, fragile zonules, small or poorly dilating pupils, and unpredictable behavior of the anterior capsule, among others. Another aspect of these patients is that many of them will require glaucoma surgery or have had it, which adds to the complexity of cataract surgery, either alone or in combination.

During FLACS, the eye is stabilized by a suction docking system. The application of vacuum for a docking system was studied for laser in situ keratomileusis (LASIK) and it has been suggested, that it transiently increases IOP to more than 90 mmHg in non-glaucomatous eyes.[7,8] An

* Corresponding author.
E-mail address: alvarezdann@gmail.com (D. Alvarez-Ascencio).

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ex vivo study suggested that femtosecond liquid docking systems create a minimal IOP rise, which was also reported in other studies of FLACS in eyes with no history of glaucoma or ocular hypertension, where only a transient mild IOP increase was shown.[9,10] Recent FLACS studies comparing healthy and glaucomatous eyes show that both glaucomatous and non-glaucomatous eyes presented an initial IOP spike on the first day after surgery, followed by a sustained IOP reduction, that was greater and persisted longer in eyes with glaucoma.[11,12]

The superiority of FLACS compared to manual phacoemulsification cannot be determined with the evidence available today.[13] Considering the characteristics of glaucoma patients, and the added risk of IOP rising during the docking procedure in these eyes with an additional vulnerability to IOP changes, we find it is important to assess the short and long-term outcomes of FLACS in patients with glaucoma.

In the present study, we report the short and long-term changes of intraocular pressure (IOP) after FLACS in glaucomatous eyes and their postoperative evolution regarding visual field (VF) mean deviation (MD) and visual field index (VFI), IOP, Best-Corrected Visual Acuity (BCVA), and number of glaucoma medications, with a one-year follow-up.

2. Patients and methods

An interventional prospective case series study was conducted in the Glaucoma Department of Asociación Para Evitar la Ceguera en México (APEC), a tertiary care ophthalmology center. The study was approved by the Institutional Review Board and the Ethics Committee of the hospital and followed the guidelines of the Helsinki Declaration.

Patients with a glaucoma diagnosis who required cataract surgery were consecutively recruited. Inclusion criteria included diagnosis of primary or secondary open or angle-closure glaucoma and vision impairing cataract (BCVA $<$ 20/40). Patients with history of previous ophthalmological surgery of any kind, corneal or conjunctival alterations (severe ocular surface disease, allergic conjunctivitis, chronic scarring conjunctivitis, keratoconus) VA Hand Movement (HM) or worse, brunescent cataracts, eyes with phacodonesis, pupils that dilated less than 6.5mm, patients that could not comply with follow up appointments, or that refused to sign an informed consent to participate, were excluded from the study.

Eligible patients underwent a comprehensive ophthalmological examination. Intraocular pressure was taken preoperatively and postoperatively in every visit with Goldmann Applanation Tonometer (GAT). Preoperative glaucoma medications used were registered and classified by class, based in the Terminology and Guidelines for Glaucoma 2nd Edition, Table IX, Monotherapy. Patients performed Humphrey 24–2 white-on-white VF, using the SITA-Standard algorithm with a size III stimulus; MD and VFI were recorded preoperatively, and postoperatively on day 1, month 1, month 3, month 6 and month 12. Changes from baseline in VF were confirmed in at least two consecutive reliable tests. VA was assessed using the Snellen chart preoperatively and in every follow-up visit.

Femtosecond laser (LenSx Laser System, Alcon Laboratories, Inc.) anterior capsulotomy and lens fragmentation were completed in all patients, a contact docking interface was used for 1.5 minutes. All cataract extractions were performed by a single experienced surgeon (R. C.D.). IOP was recorded during surgery using a Schiötz indentation tonometer immediately before and after suction docking, prior administration of a topical anesthetic (tetracaine 0.5g) with the patient in a supine position. Schiotz tonometer calibration was checked before every use, IOP measurements were taken with the 5.5 g weight and the 15 g weight to confirm, and if they did not match the measurements were repeated.

Data regarding IOP, VF MD and VFI, BCVA, and glaucoma medications were collected preoperatively and during the follow-up using a computerized database (Microsoft Excel).

2.1. Statistical analysis

Descriptive statistical analysis was performed using the Stata© software version 15.1 (StataCorp. 2015, Stata Statistical Software: Release 15. College Station, Texas, US: StataCorp LP.) The normal distribution of variables was assessed with Shapiro - Wilk test and $p < 0.05$ was considered significant. The continuous variables were expressed as means ± standard deviation (SD) or median and interquartile range (IQR). The categorical variables were expressed as number (n) and percentages (%).

3. Results

Fourteen eyes of 11 patients were included. Most of them were female (9, 81.8%) with a mean age of 74.4 ± 8.2 years (range: 57–87 years). Nine (64.3%) and 5 (35.7%) were diagnosed with primary angle-closure glaucoma (PACG) and primary open-angle glaucoma (POAG), respectively. Demographic and baseline clinical characteristics are summarized in Table 1. No complications were recorded during the surgeries.

Regarding short-term IOP changes, we found a slight reduction in values after the docking phase in both glaucoma subtype groups (Table 2).

No clinically significant changes were observed in BCVA and number of topical glaucoma medications from baseline to one year after FLACS in both glaucoma subtype groups.

There were 5 patients that “decreased” their BCVA after surgery at the end of follow-up. They are patients number 3, 4, 8, 10, and 13 shown in Table 4. These patients developed posterior capsular opacification that decreased their vision after it had initially increased after surgery. At the 12 months follow-up, these patients had not been treated with yag capsulotomy.

Regarding IOP, a significant mean reduction in values was found in all cases at last follow-up (Table 3). Table 4 shows changes from baseline in BCVA, IOP, number of medications, MD, and VFI individually in every patient. In both groups, an increase in IOP at day 1 after FLACS was found; however, IOP values showed a reduction at month 1 that was maintained until the las follow-up at 12 months after the surgery. (Fig. 1).

No significant changes in VF MD or VFI were found from baseline to 12 months after surgery in both groups. A median of −3.27dB (IQR: −8.24, −3.19 dB) to a median of −3.99dB (IQR: 10.8, −1.23dB) of MD, and a median of 93% (IQR:84,99%) to 92% (IQR: 81,94) of VFI in PACG group, while a median of −5.8 dB(IQR: 6.26, −3.05dB) to a median of −3.99dB (IQR: 10.8, −1.23dB) of MD, and a median of 92.5% (IQR:

Table 1
Demographic and baseline clinical characteristics (n = 14 eyes).

Characteristic	Value
Age (years), Mean ± SD (range)[a]	74.4 ± 8.2 (57–87)
Gender, n (%)[a]	
Female	9 (81.8)
Glaucoma subtype, n (%)	
Primary angle closure glaucoma	9 (64.3)
Primary open angle glaucoma	5 (35.7)
Baseline best-corrected visual acuity (LogMAR), Median (IQR)	0.3 (0.18–0.4)
Baseline sphere (D), Mean ± SD	1.4 ± 1.8
Baseline cylinder (D), Mean ± SD	0.04 ± 1.26
Baseline intraocular pressure (mmHg), Median (IQR)	15.5 (14-17)
Baseline number of topical glaucoma medications, Median (IQR)	1 (1-3)
Baseline visual field mean deviation (dB), Median (IQR)	−4.5 (−8.24–−3.05)
Baseline visual field index (%), Median (IQR)	93 (84–99)

Abbreviation: D: diopter, IQR: interquartile range, SD: standard deviation.
[a] Considering the total number of patients (n = 11).

Table 2
Intraocular pressure before and after docking phase in FLACS, according to glaucoma subtype.

	Primary angle closure glaucoma (n = 9 eyes)	Primary open angle glaucoma (n = 5 eyes)
Before docking, Median (IQR)	17.3 (15–19)	18 (18–19)
After docking, Median (IQR)	16 (12–18)	16.5 (15-17)

Abbreviation: FLACS: femtosecond laser-assisted cataract surgery, IQR: interquartile range.

Table 3
Changes in visual acuity, intraocular pressure, and number of glaucoma medications before and one year after FLACS, according to glaucoma subtype.

	Primary angle closure glaucoma (n = 9 eyes)		Primary open angle glaucoma (n = 5 eyes)	
	Baseline	Final	Baseline	Final
Best-corrected visual acuity (LogMAR), Median (IQR)	0.2 (0.18–0.3)	0.3 (0–0.3)	0.4 (0.4–0.6)	0.3 (0.3–0.3)
Intraocular pressure (mmHg), Median (IQR)	16 (14-16)	12 (12-13)	15 (15–19)	12 (11-15)
Number of glaucoma medications, Median (IQR)	1 (0–1)	0 (0–1)	1 (1-1)	1 (0–3)

Abbreviation: FLACS: femtosecond laser-assisted cataract surgery, IQR: interquartile range.

79,96.5%) to a median of 88% (IQR: 86–96%) of VFI in POAG group (Fig. 2 and Fig. 3).

4. Discussion

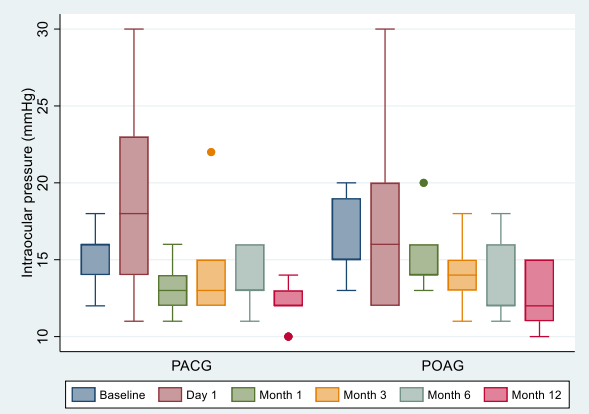
Cataract surgery is a very common procedure in patients with glaucoma. To this day, the debate continues whether FLACS is equivalent or superior to manual cataract surgery. When we think about performing FLACS in patients with Ocular Hypertension, Glaucoma, or with a Glaucoma risk factor, we must consider that this procedure has the added step of suction docking during pretreatment, which has been reported in several studies to raise IOP.[10,11,12] In our study, we assess short and long-term VF changes, IOP changes, and long-term outcomes when using the femtosecond laser pretreatment in patients with mild to severe glaucoma.

In our patients, we found similar surgical outcomes to those published with traditional manual cataract surgery regarding IOP, BCVA, and VF, with the added advantage of femtosecond laser precision.[13]

Suction was well tolerated in glaucomatous eyes during surgery, showing no significant mean IOP raise immediately after suction docking, in fact, our patients showed a slight IOP decrease immediately after docking. The only time point where there was a mean IOP increase was in day 1 postoperatively, and after that, mean IOP was reduced from baseline and maintained until last follow-up. This contrasts with previous studies of FLACS performed in glaucomatous eyes, however, there are several differences between our study and the previous studies including Femtosecond Laser system used, the inclusion of healthy or glaucomatous eyes, and type of tonometer used for IOP measurements.[10,11,12,14]

In a prospective study by Darrian-Smith and cols, 143 eyes (30% with glaucoma) were studied by measuring IOP with a rebound tonometer before and after suction docking during FLACS with Catalys Precision Laser System with Liquid Optics Interface (Abbott Medical Optics, Inc.). Their results showed a transient IOP increase from baseline that was significantly higher in glaucomatous eyes; after removal of suction, the IOP levels decreased in both groups, but remained above preoperative values and were higher in eyes with history of glaucoma.[11]

In contrast, a retrospective case series study conducted by Shah and cols evaluated the long term IOP changes in 504 eyes, of which 278 had glaucoma, after FLACS. They reported that both control and glaucomatous eyes had an initial IOP rise, followed by a sustained reduction from baseline up to 3 years follow up, this decrease was greater and lasted



Abbreviation: PACG: Primary angle closure glaucoma, POAG: Primary open angle glaucoma

Fig. 1. Intraocular pressure at the different study time points by glaucoma subtype.

Table 4
Changes from baseline in visual acuity, intraocular pressure, number of glaucoma medications, mean deviation and visual field index in all patients.

Cases	BCVA (LogMAR)		IOP (mmHg)		Topical medication(n)		Visual field MD (dB)		VFI(%)	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
1	0.3	0	18	12	1	0	−3.27	−1.77	99	97
2	0.4	0	14	12	1	0	−3.19	−2.37	99	98
3	0.3	0.6	16	13	1	0	−8.24	−3.69	90	94
4	0.2	0.5	12	14	1	1	−9.84	−8.49	84	78
5	0.2	0.2	15	10	0	0	−18.58	−18.61	48	42
6	0.1	0	12	10	0	0	−7.69	−6.56	82	81
7	0.6	0.3	20	15	1	1	−5.8	−3.99	94	86
8	0.1	0.3	19	15	1	3	−0.94	−0.42	99	98
9	1	0.3	16	14	0	2	−3.22	−4	95	93
10	0.18	0.3	17	13	1	2	−2.75	−3.58	93	92
11	0.4	0	15	11	1	0	−3.05	−1.23	91	96
12	0.4	0.3	13	10	1	0	−14.59	−12.86	67	71
13	0.1	0.3	16	12	3	1	−0.49	−3.94	99	88
14	0.7	0.7	15	12	3	3	−6.26	−10.8	NA	88

Abbreviation: BCVA: Best-corrected visual acuity, MD: Mean deviation, NA: Not available, IOP: intraocular pressure, VFI: Visual field index.

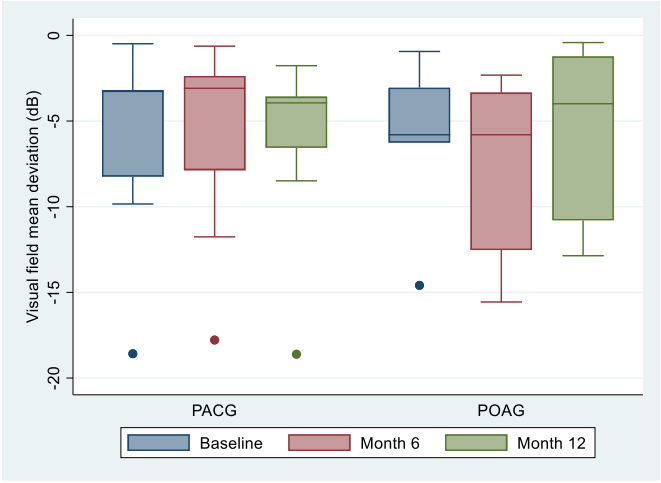


Fig. 2. Visual field mean deviation at the different study time points by glaucoma subtype.

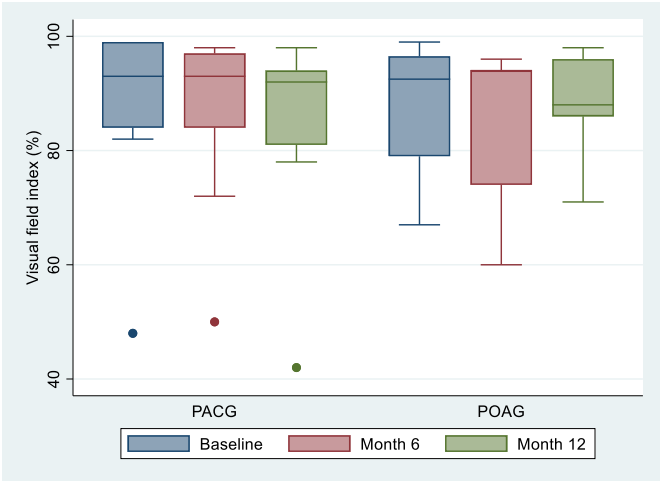


Fig. 3. Visual field index at the different study time points by glaucoma subtype.

longer in eyes with glaucoma than in control eyes.[12] These results are similar to what we saw on our patients regarding IOP behavior.

When comparing FLACS suction docking IOP outcomes, we must consider that different femtosecond systems will have different characteristics, therefore, they are not totally comparable to one another; even in the same femtosecond system, different types of suction docking interfaces can have different outcomes in IOP changes.[14]

The patients with angle-closure glaucoma of our study were pretreated effectively with no problems regarding their smaller anterior chamber. No complications that have been previously reported in FLACS, like incomplete capsulotomy, tears in anterior capsule or posterior capsule ruptures were recorded during any of these surgeries.[15,16,17]

A major concern of exposing a glaucomatous eye to increased IOP during a procedure is favoring the progression of the disease. In our study, IOP was assessed immediately after suction docking and it was lower than the baseline, but the IOP *during* the actual docking procedure was not measured. Over the one year of follow-up, our patients did not show progression of disease in worsening of VF MD or VFI or in BCVA reduction, the median values of the three parameters remained unchanged. There were five patients that showed a BCVA reduction at final follow-up, these patients developed posterior capsular opacification that decreased their vision after surgery. Of these, four patients did not show disease progression in visual field functional testing (Table 4). Only one patient (Table 4) showed a decrease in both BCVA, MD, and VFI at final follow up. To our knowledge, progression of glaucoma measured with VF after FLACS has not been evaluated in previous studies.

There are several limitations to our study. A small sample with no control group allows for a descriptive case series instead of a more thorough statistical analysis. A larger sample, with a longer follow-up, along with a control group would allow an analysis that could give us more conclusive results regarding the safety and outcomes of Femtosecond Laser surgery regarding progression in patients with glaucoma.

The use of a Schiotz tonometer for the pre and post docking IOP measurements instead of using another applanation method such as Tonopen® or Perkins® tonometer could be regarded as a significant limitation because it has a lower correlation to GAT. However, at the time of the study, the only hand-held tonometer available for use in our Operating Room was the Schiotz, which is the reason this was the chosen method. All the other IOP measurements mentioned in the study were taken with GAT.

Another limitation of this study is that the Mean Deviation (MD) and Visual field index (VFI) range included is not wide enough to include a sufficient number of advanced glaucoma to make the findings generalizable to this group of patients.

5. Conclusion

Our study illustrates that FLACS appears to be a safe alternative to traditional manual cataract surgey in early and moderate glaucoma patients regarding short and long-term IOP changes, VF MD and VFI, and BCVA. Further research and a larger sample, control group, and with long-term follow-up is needed to increase our knowledge regarding the use of this technology in these patients.

6. Clinical significance

The advent of new technology is always an exciting prospect, but with new technology come new possible complications and challenges. Patients with glaucoma must be considered a separate group when thinking about cataract extraction because of the added complexities that a lot of them can present. Although it is widely used, the safety and efficacy of FLACS have not been properly studied in the glaucoma population, which could be potentially benefited by the optimization of cataract extraction with the precision of laser technology or could be harmed by IOP elevation during suction docking. In this study, we present a small sample of patients with mild to severe glaucoma who underwent FLACS and illustrate their postoperative evolution up to 1 year follow up regarding BCVA, IOP, number of glaucoma medications, and functional evolution of the disease with VF MD and VFI.

Patient consent

Written patient consent for participation in this study was obtained.

Declaration of competing interest

The authors have no conflicts of interest.

All authors attest that they meet the current ICMJE criteria for Authorship"List the funding sources. If there are none, state, “No funding or grant support".

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