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Original Article

Visual outcomes with femtosecond laser-assisted cataract surgery versus conventional cataract surgery in toric IOL insertion

Carmen L Oakley MBBS,[1] Shaun Y Ewe MBBS,[1] Penelope L Allen PhD[1,2] and Brendan J Vote FRANZCO[1]
[1]Tasmanian Eye Institute, Launceston and [2]Rural Clinical School, University of Tasmania, Tasmania, Australia

Abstract

Background: To evaluate the visual outcomes of femtosecond laser-assisted cataract surgery (LCS) compared with phacoemulsification cataract surgery (PCS) in patients undergoing Toric IOL insertion.

Design: A non-randomized, single surgeon, prospective, comparative cohort case series

Participants: Patients undergoing LCS and PCS between January 2012 and July 2014 at a single center.

Methods: The LCS group underwent femtosecond laser pretreatment for the anterior capsulotomy and lens fragmentation. Otherwise standard phacoemulsification surgery and foldable toric intraocular lens insertion proceeded.

Main Outcome Measures: Best corrected visual acuity (BCVA), uncorrected visual acuity (UCVA), pre and post operative cylinder and mean absolute refractive error.

Results: A total of 418 eyes from 323 patients were included in the study; with 95 eyes in the PCS group and 323 in the LCS group. There were 243 (75.5%) LCS eyes with a pre-operative BCVA of 20/40 or better and 54 (56.8%) in the PCS group ($p < 0.001$). For post-operative BCVA, 315 (97.5 %) LCS and 81 (85.3%) PCS eyes had a BCVA of 20/40 or better ($p = < 0.001$). However, there was no significant difference for change in BCVA between the groups (mean gain in EDTRS letter 11.0 for LCS and 10.3 for PCS $p = 0.64$) or in MAE (mean 0.56D PCS vs 0.65D LCS $p = 0.18$).

Conclusion: In patients receiving toric intraocular lenses, there is similar improvement in terms of letters gained with LCS and PCS. Overall, there is no additional benefit for patients undergoing LCS in this cohort.

Key words: femtosecond laser, toric intraocular lens, visual outcomes.

Introduction

The introduction of femtosecond laser to cataract surgery has introduced new variables when evaluating refractive outcomes in patients following cataract surgery. The precise and reproducible capsulotomy which can be achieved through the use of the femtosecond laser theoretically allows for increased lens stability postoperatively.[1,2] This was previously assessed in a prospective study looking at patients undergoing femtosecond laser cataract surgery with standard intraocular lenses, which found better predictability of the IOL power calculation, supporting the hypothesis.[3]

Toric intraocular lenses require precise positioning in order to gain the maximum benefit with every degree of off axis rotation of the lens producing a 3.3% reduction in cylinder power. Intraocular lens tilt also induces astigmatism and changes the effectivity of the lens. It has been postulated that by providing a precise and consistent capsulotomy femtosecond laser capsulotomy may afford more

■ **Correspondence:** A/Professor Brendan Vote, Launceston Eye Institute, 36 Thistle St West, South Launceston, Tasmania, Australia, 7249.
Email: eye.vote@me.com

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precise intraocular lens positioning through more consistent effective lens position.[4–6] However if capsulotomy integrity is compromised this may have a negative impact on effective lens positioning.[7,8]

This study aims to evaluate the visual outcomes in patients receiving toric IOL while undergoing femtosecond laser cataract surgery (LCS) compared with conventional cataract surgery (PCS).

METHODS

We conducted a prospective, consecutive comparative cohort study of LCS and PCS performed by a single surgeon between January 2012 and July 2014. Ethics approval was granted by the Tasmanian Human Research and Ethics Committee (HREC H12534) and study performed in accordance to the declaration of Helsinski and its subsequent revisions.

All consecutive patients planning to undergo LCS or PCS with insertion of a posterior chamber toric intraocular lens (IOL), who were over the age of 18, were enrolled in the study. All patients were given the option to have LCS at an out of pocket expense of AUD $750 (approx $500 USD) unless contraindicated. Absolute contraindications for LCS included corneal scarring and intracorneal ring inlays. Relative contraindications for LCS included eyes with previous trauma, small pupil, floppy iris syndrome, and intumescent cataract and narrow palpebral fissures; with these patients more likely to undergo PCS.

All patients underwent baseline preoperative assessment including anterior and posterior segment examinations. The preoperative assessment and surgical technique used in our study have been previously detailed.[9] Femtosecond laser-assisted cataract surgery involved anterior capsulotomy and lens fragmentation only (no corneal incisions) using the Catalys Precision Laser System with Liquid Optics interface (Abbott Medical Optics, Santa Ana, CA). Conventional cataract surgery involved manual capsulorhexis. All other aspects of the procedure were the same, with standard phacoemulsification and lens extraction.

The horizontal and vertical axis was marked pre operatively, with the patient in an upright position. The axis for placement of the lens was then marked intra operatively with a Mendez ring and Bores marker (Katena, Denville, NJ), and the lens aligned with these marks. The same surgeon treated all patients in this study. Patients were followed up a minimum of 6 months post-operatively, and underwent subjective refraction and best corrected visual acuity testing.

Surgical and outcome data was extracted from the patient management system and entered onto an Excel spreadsheet, then imported into IBM SPSS (Version 21) (IBM Corporation, 1989, 2012, Armonk New York) for analysis. All eyes with a post-surgery BCVA of 20/120 or worse were excluded from the study, given likely significant ocular co-morbidity. Eyes with incomplete follow-up were also excluded from analysis. Differences in mean refractive error (difference between refractive aim and post op spherical equivalent, MAE) were investigated using the independent *t*-test and best-corrected visual acuity (BCVA) was investigated using the Chi-square test. Differences in ETDRS letters between groups were investigated using independent and paired *t*-tests were used to investigate pre-post surgery outcomes. All tests were two-sided, and differences were accepted at $p < 0.05$ significance level.

RESULTS

A total of 418 eyes (210 left and 208 right) from 325 patients (205 women and 120 men) were included in the study. Ninety-three patients had surgery on both eyes. Mean age was 71 years (SD 9.9, range 35–95).

There were 95 eyes in the PCS group and 323 in the LCS group. There was no difference in the proportion of women in each group (68.4% in PCS and 61.4% in LCS $\chi^2(1) = 1.25$, $p = 0.26$). Mean age in the PCS group was 73 years (SD 8.8) and 71 years (SD 10.1) in the LCS group ($t_{(416)} = 1.89$ $p = 0.06$). A greater proportion of LCS eyes had a pre-operative BCVA of 20/40 or better (PCS: 56.8% [$n = 54$] vs LCS: 75.5% [$n = 243$] $\chi^2(1) = 12.4$, $p < 0.001$) (Table 1). The LCS group also had a better mean pre-surgery BCVA (PCS: 66 ETDRS letters [~20/50] vs LCS: 69 ETDRS letters [~20/40], $t_{(131)} = -2.86$, $p = 0.012$).

Three hundred and four eyes (72.7%) had uncorrected visual acuity (UCVA) of 20/40 or better post operatively. In the LCS group, 75.9% ($n = 245$) of patients had post operative UCVA 20/40 or better, compared with 62.1% ($n = 59$) in the PCS group ($\chi^2(1) = 6.99$, $p = 0.008$). Mean post-surgery UCVA letters was 72.0 (SD 9.4) [~20/32 Snellen equivalent] in the LCS group and 68.6 (SD 10.9) [~20/40 Snellen equivalent] in the PCS group ($t_{(416)} = -2.98$, $p = 0.003$) (Table 1). However, there was no significant difference in mean improvement in UCVA (LCS mean gain 2.6 letters (SD 13.1) vs PCS mean gain 2.9 letters (SD 15.4), $t_{(414)} = 0.24$, $p = 0.81$).

In regards to post-operative best corrected visual acuity (BCVA), 396 eyes (94.7%) had a post-surgery BCVA of 20/40 or better overall. There were 315 (97.5%) LCS eyes with a post-surgery BCVA of 20/40 or better compared to 81 eyes (85.3%) in the PCS group ($\chi^2(1) = 22.1$, $p < 0.001$). However, there was no significant difference between the groups for mean EDTRS letters gained (11.0 letter gained for LCS vs 10.3 letters gained for PCS, ($t_{(414)} = -.47$, $p = 0.64$)).

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Table 1. Pre and post-surgery visual outcomes PCS versus LCS group

	PCS ($n = 95$)	LCS ($n = 323$)	p-Value
	n (%) or mean (SD)	*n* (%) or mean (SD)	
Mean pre operative cylinder	1.64 (1.42)	1.36 (1.14)	0.09
Pre BCVA			
20/25 or better	8 (8.4)	46 (14.3)	*
20/32	19 (20.2)	75 (23.3)	
20/40	27 (28.4)	122 (37.9)	
20/50 to 20/100	36 (37.9)	65 (20.2)	
20/125 or worse	5 (5.3)	14 (4.3)	
Pre BCVA 20/40 or better	54 (56.8)	243 (75.5)	<0.001
Pre BCVA Mean ETDRS	65.7 (13.2)	69.4 (10.6)	0.012
Mean post op residual cylinder	0.57 (0.43)	0.52 (0.41)	0.29
Post UCVA group			
20/25 or better	21 (22.1)	105 (32.4)	*
20/32	17 (17.8)	73 (22.5)	
20/40	21 (22.1)	68 (20.9)	
20/50 to 20/100	31 (32.6)	70 (21.6)	
20/125 or worse	5 (5.2)	8 (2.4)	
Post UCVA 20/40 or better	59 (62.1)	245 (75.9)	0.008
Post UCVA Mean ETDRS	68.6 (10.9)	72.0 (9.4)	0.003
Post UCVA mean difference from baseline ETDRS	2.9 (15.4)	2.6 (13.1)	0.81
Post BCVA			
20/25 or better	45 (47.4)	238 (73.7)	<0.001
20/32	20 (21.1)	46 (14.2)	
20/40	16 (16.8)	31 (9.6)	
20/50	14 (14.7)	8 (2.5)	
Post BCVA			
20/40 or better	81 (85.3)	315 (97.5)	<0.001
20/50	14 (14.7)	8 (2.5)	
Post BCVA Mean ETDRS	76.0 (8.0)	80.3 (6.5)	<0.001
Post BCVA ETDRS gained	10.3 (13.0)	11.0 (10.8)	0.64
Mean absolute error	0.56 (0.50)	0.65 (0.49)	0.18

Note: 1 eye did not have a pre-surgery BCVA available.
*Could not calculate because of small expected cell frequencies.

There was no difference between the two groups in terms of mean pre-operative cylinder (PCS 1.64 Diopters (D) cylinder vs LCS 1.36D cylinder, $p = 0.09$). There was also no difference in mean post-operative residual cylinder (PCS 0.57 D vs 0.52 D LCS, $t_{(410)} = 1.1$, $p = 0.29$), with the mean cylinder significantly reduced in both groups (PCS pre-operative 1.64 D vs post-operative 0.56 D, $t_{(88)} = 6.8$, $p < 0.001$; LCS pre-operative 1.36 D vs post-operative 0.52 D, $t_{(296)} = 12.5$, $p < 0.001$). Additionally no significant difference in mean absolute refractive error existed between the two groups (mean 0.56D PCS vs 0.65D LCS ($t_{(365)} = -1.36$, $p = 0.13$). $p = 0.18$).

DISCUSSION

In this cohort, the results for improvement in mean ETDRS letters gained by patients in the two different groups were not statistically significant; despite the LCS group having better post-operative BCVA. This indicates that the theoretical benefit of precise capsulorhexis postulated to produce more stable and better alignment of toric intraocular lenses does not translate into an improvement in vision for the patients, above and beyond the improvement seen with PCS and toric intraocular lens implantation.

The results show that there is a trend towards a greater percentage of patients in the LCS group achieving UCVA 20/25 or better and 20/32 compared to the PCS group; however, because of small numbers we are unable detect a statistically significant result. When we combined the groups to 20/40 or better we were able to show a statistically significant difference in the proportion of patients achieving UCVA of 20/40 or better in the LCS group compared to the PCS group; however, the mean improvement in ETDRS letters was not significant. There were a greater percentage of patients with pre operative BCVA 20/40 or better in the LCS group, which may explain this discrepancy in the post operative visual outcomes results. There are a number of potential factors which may have resulted in the LCS group having better BCVA pre-operatively. All patients deemed suitable for femtosecond laser were offered the procedure, however at an out of pocket expense of $750. This may result in a selection bias with patients from lower socioeconomic backgrounds more likely to have PCS, and potentially more likely to have more advanced cataracts and potentially other ocular co-morbidities. This reflects difficulties inherent studying consecutive real world patients, where vision may be affected by a number of ocular co-morbidities, rather than cataract alone. We await randomized controlled trial data such as FEMCAT, to better address these selection biases.

In summary, LCS does not appear to result in improvements in UCVA, BCVA or refractive outcomes after toric IOL insertion, beyond that seen with PCS. The greater percentage of patients with post operative BCVA 20/32 or better in the LCS group most likely reflects a selection bias with differences between cohorts at baseline, rather than any additional benefit gained from LCS.

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