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A Comparative Cohort Study of Visual Outcomes in Femtosecond Laser-Assisted versus Phacoemulsification Cataract Surgery

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Purpose: To evaluate visual outcomes after femtosecond laser-assisted cataract surgery (LCS) with phacoemulsification cataract surgery (PCS).

Design: Prospective, multicenter, comparative case series.

Participants: Consecutive patients undergoing femtosecond LCS or PCS with intraocular lens insertion.

Methods: A total of 1876 eyes of 1238 patients (422 male and 772 female) who underwent cataract surgery between January 2012 and June 2014 were included in the study: 1017 eyes from center A and 859 eyes from center B. Cases underwent clinico-socioeconomic selection. Patients with absolute LCS contraindications were assigned to PCS; otherwise, all patients were offered LCS and elected on the basis of their decision to pay (the out-of-pocket cost for LCS). Demographic and postoperative data were collected to determine differences between groups.

Main Outcome Measures: Six-month postoperative visual and refractive outcomes. Masked subjective refractions were performed 2 to 6 months postoperatively.

Results: There were 988 eyes in the LCS group and 888 eyes in the PCS group. Baseline best-corrected visual acuity (BCVA) was better in LCS compared with PCS (20/44.0 vs. 20/51.5; $P < 0.0003$). Preoperative surgical refractive aim differed significantly between groups (LCS −0.28 vs. PCS −0.23; $P < 0.0001$). More patients who received LCS had Toric lenses implanted compared with PCS (47.4% vs. 34.8%; $P < 0.0001$). Postoperative BCVA was better after LCS (20/24.5 vs. 20/26.4; $P = 0.0003$) with a greater proportion of LCS cases achieving BCVA >20/30 (LCS 89.7% vs. PCS 84.2%; $P = 0.0006$) and 20/40 (LCS 96.6% vs. PCS 93.9%; $P = 0.0077$). However, PCS cases had more letters gained compared with LCS cases (13.5 vs. 12.5 letters; $P = 0.0088$), reflecting baseline BCVA differences. Mean absolute error was higher in LCS compared with PCS (0.41 diopters [D] vs. 0.35 D; $P < 0.0011$). The percentage of eyes within 0.5 D of error from preoperative aim refraction was higher in the PCS group (LCS 72.2% vs. PCS 82.6%; $P < 0.0001$).

Conclusions: Femtosecond LCS did not demonstrate clinically meaningful improvements in visual outcomes over conventional PCS. *Ophthalmology 2016;123:178-182 © 2016 by the American Academy of Ophthalmology.*

The development of femtosecond laser-assisted cataract surgery (LCS) has been predicted to bring advancements to conventional phacoemulsification cataract surgery (PCS) by improving its surgical safety profile and theoretically leading to better visual outcomes.

Femtosecond LCS is postulated to improve visual outcomes compared with PCS through a variety of mechanisms. Laser pretreatment reduces phacoemulsification ultrasound energy[1] and the potential for mechanical trauma to surrounding structures. Consequently, these may aid in minimizing prostaglandin-related inflammation[2] and cystoid macular edema (CME),[3] although we have previously suggested a possible safety signal for increased CME after LCS,[1,4] and others have reported no reduction in CME with femtosecond laser.[5] Reduced effective phacoemulsification time in LCS has been shown to reduce endothelial cell loss and corneal edema, which may improve early visual outcomes and hasten visual recovery; however, the benefits of reduced effective phacoemulsification time in LCS are potentially lost if laser corneal incisions are also performed.[6] Better precision of laser-performed capsulorhexis also may improve capsulotomy centration[7] and lens positioning,[8] thus potentially reducing optical aberrations and providing a more consistent effective lens position. Despite these theoretic benefits, early visual outcomes for LCS are similar and have not been demonstrated to be superior to PCS.[9–11] One recent publication did suggest a greater number of LCS cases obtained BCVA better than 20/25.[12]

The aim of this study was to compare the visual and refractive outcomes of LCS with PCS in a large prospective multicenter comparative cohort case series.

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Methods

Study Design

Cohort cases were obtained from 2 centers (Launceston Eye Institute, Launceston, Tasmania, Australia; Newcastle Eye Hospital, Newcastle, New South Wales, Australia) by 2 surgeons (P.E.J.D., B.J.V.). The study aimed to evaluate the visual and refractive outcomes between PCS and LCS. Laser cataract surgery was performed using the Catalys Precision Laser System (Abbott Medical Optics, Abbott Park, IL).

All vision data for the analysis were collected prospectively at both centers between March 2012 and June 2014. The study was approved by the Tasmanian Human Research Ethics Committee and was conducted in accordance to the tenets of the Declaration of Helsinki.

Intervention and Assessments

All consecutive patients aged more than 22 years who elected to undergo LCS or PCS along with intraocular lens insertion were enrolled in the study. Patients underwent a clinico-socioeconomic selection. All patients who had contraindications to LCS underwent PCS. Otherwise, all patients were offered LCS and elected on the basis of their own decision to pay an out-of-pocket cost for LCS ($750−$1000 Australian Dollars). Contraindications to LCS included age <22 years, poorly dilating pupils (<5 mm), and corneal scarring. All patients had a detailed explanation of the study and procedure and signed a written informed consent before the procedure. Biometry (axial length, keratometry, anterior chamber depth) was performed on all patients during a preoperative assessment visit using a partial coherence interferometer (Optical Biometer, AL-Scan, Nidek, Fremont, CA). The IOL lens power was calculated and selected using third-generation formulae (Hoffer Q for axial lengths <22 mm, SRK/T for axial lengths >22 mm). Intraoperative aberrometry was not used in this study.

All patients underwent baseline preoperative assessment including anterior and posterior segment examinations. The preoperative assessment, laser parameters, and surgical technique used in our study have been detailed.[9]

All patients received topical antibiotic, steroid, and nonsteroidal drops to use 4 times per day for 4 weeks starting 2 days preoperatively. Patients were reviewed at 1 day, 1 month, and 6 months after surgery. Visual acuity measurement, tonometry, and slit-lamp examination were performed at each follow-up visit. Patients received an additional assessment of masked subjective refraction between 2 and 6 months postoperatively.

Outcome Measures

The primary outcome measures were the 6-month postoperative assessments for visual outcomes including best-corrected visual acuity (BCVA) and masked subjective refractive outcome comparison between groups. Spherical refractive accuracy was determined on the basis of the mean predicted absolute error, which is defined as the mean of the absolute difference between the predicted aim (preoperative spherical equivalent aim refraction) and the postoperative subjective refraction spherical equivalent. In addition, secondary outcome measures include uncorrected visual acuity at the 1-month postoperative visit.

Statistical Analysis

Results were entered into Microsoft Excel (Microsoft Corp, Redmond, WA) and then imported into SPSS Version 21 (SPSS Inc. Chicago, IL) for analysis. Descriptive statistics were used to analyze data distributions and frequencies of categoric variables.

Table 1. Baseline Demographics

	LCS (n = 988) (%) or Mean (SD)	PCS (n = 888) (%) or Mean (SD)	P Value
Age, yrs	72.1 (9.3)	73.6 (10.4)	NS
Gender			
Women	386 (60.0%)	409 (60.2%)	NS
Men	257 (40.0%)	268 (39.8%)	
Axial length	23.64 (1.52)	23.55 (1.51)	NS
Anterior chamber depth	3.16 (0.79)	3.19 (1.41)	NS
Pre K1	44.3 (1.72)	44.3 (1.81)	NS
Pre K2	43.3 (1.67)	43.24 (1.72)	NS
Toric IOL	47.4%	34.8%	<0.0001
Preoperative BCVA (logMAR)	0.34 (0.27) VA 20/44.0	0.41 (0.38) VA 20/51.5	<0.0001
Preoperative refractive aim	−0.28 (0.25)	−0.23 (0.25)	<0.0001

BCVA = best-corrected visual acuity; IOL = intraocular lens; LCS = laser-assisted cataract surgery; logMAR = logarithm of the minimum angle of resolution; NS = not significant; PCS = phacoemulsification cataract surgery; SD = standard deviation.

Pearson's chi-square test was used for the investigation of associations between categoric variables and surgical group (LCS vs. PCS). Independent *t* tests were used to investigate differences in means between groups, and paired *t* tests were used to investigate differences in pre-post measures. Differences were accepted at the $P < 0.05$ significance level.

Results

A total of 1933 eyes (1046 from Center A and 887 from Center B) of 1238 patients underwent cataract surgery during the study period. Fifty-seven eyes of 44 patients with preoperative BCVA <20/120 due to ocular comorbidities other than cataract were excluded from the analysis, leaving 1876 eyes (97.1% cohort remained). There were 988 eyes in the LCS group and 888 eyes in the PCS group. Preoperative mean BCVA was significantly worse in the PCS cohort compared with the LCS cohort (20/44.0 vs. 20/51.5; $P < 0.0001$). Preoperative refractive aim was significantly different between groups. There was a significantly higher rate of Toric IOL use in the LCS group than in the PCS group. Otherwise, both groups had similar demographics and metrics, with no other significant difference in comorbidities between groups (Table 1).

Visual Outcomes

The LCS group achieved a better mean postoperative BCVA compared with the PCS group ($P = 0.0003$). There was also a higher percentage of patients achieving BCVA ≥20/30 ($P = 0.0006$) and 20/40 ($P = 0.009$) or better in LCS compared with PCS. However, PCS showed a greater mean improvement (change in logarithm of the minimum angle or resolution) in BCVA than LCS ($P = 0.0175$) (Table 2).

The average uncorrected visual acuity tested after at least a 1-month postoperative period was similar between groups (Table 2). However, patients in the PCS group had more letters gained on average when compared with the LCS group (9.5 vs. 5.5 letters gained; $P < 0.001$). The percentage of patients achieving a visual acuity of 20/20 or better was higher in the PCS group compared with the LCS group (29.6% vs. 19.9%; $P < 0.001$).