



CHALLENGING CATARACT SURGERY IN VITRECTOMIZED EYES - COMPARING THE SURGICAL OUTCOMES OF FEMTOSECOND LASER ASSISTED CATARACT SURGERY VERSUS CONVENTIONAL PHACOEMULSIFICATION SURGERY: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Cataract formation is the most common long-term complication after vitrectomy, and cataract surgery in vitrectomized eyes is technically challenging because of altered ocular anatomy and increased risk of complications. Femtosecond laser-assisted cataract surgery (FLACS) may improve surgical precision and reduce intraoperative trauma compared with conventional phacoemulsification surgery (CPS). This systematic review compared the surgical outcomes of FLACS and CPS in vitrectomized eyes.

Method: A systematic review was conducted according to the PRISMA 2020 guidelines. PubMed, Cochrane Library and Science Direct were searched for RCTs, Clinical Trial, and observational

studies involving adults (≥ 18 years) with previous vitrectomy undergoing FLACS or CPS. We assessed risk of bias using RoB 2.0 and ROBINS-I. Our outcomes were the visual acuity, ultrasound energy, Endothelial Cell Condition, surgery time, intraoperative and postoperative complication.

Results: We included 4 studies. Visual acuity improved in both groups, with comparable final corrected distance visual acuity. FLACS consistently reduced ultrasound energy requirements, cumulative dissipated energy and operative time. Higher postoperative endothelial cell density and lower endothelial cell loss were also reported with FLACS. Intraoperative complications, including posterior capsule rupture, dropped nucleus, anterior capsule tear, zonular dialysis, and silicone oil migration, occurred predominantly in the CPS group, whereas FLACS-related events were mainly limited to incomplete capsulotomy. Early postoperative corneal edema was less frequent with FLACS, while rates of cystoid macular edema, posterior capsule opacification, and anterior chamber inflammation were generally comparable.

Conclusion: FLACS provides superior intraoperative efficiency, better endothelial preservation, faster early visual recovery and a favorable safety profile compared with CPS in vitrectomized eyes, although final visual outcomes remain similar. Larger high-quality randomized studies are required to confirm these findings.

Keywords: femtosecond laser-assisted cataract surgery; conventional phacoemulsification; vitrectomy; vitrectomized eyes.

INTRODUCTION

Cataract formation is the most frequent long-term complication following vitreoretinal surgery, with the incidence after pars plana vitrectomy (PPV) reported to reach nearly 100% in some patient populations. These post-vitrectomy cataracts are typically characterised by accelerated nuclear sclerosis, which is resulted from increased exposure of the crystalline lens to intraocular oxygen following removal of the vitreous body, together with the prolonged interval between vitrectomy and cataract extraction.¹ Consequently, cataract surgery in eyes that have previously undergone vitrectomy represents important clinical challenge in ophthalmic practice.²

Compared with routine cataract surgery, cataract extraction in vitrectomized eyes is technically more demanding and is associated with a higher risk of both intraoperative and postoperative complications. The increased density of the lens nucleus frequently requires greater phacoemulsification energy, which may contribute to excessive corneal endothelial cell loss and impact on postoperative corneal clarity. Furthermore, the absence of vitreous support results in a deeper and less stable anterior chamber, while weakened zonular integrity and increased posterior capsule mobility further complicate surgical manipulation.²

Femtosecond laser-assisted cataract surgery (FLACS) has emerged as an advanced surgical technique designed to improve the precision and reproducibility of several key steps of cataract surgery, including anterior capsulotomy, lens fragmentation, and corneal incision creation.³ Compared with conventional phacoemulsification cataract surgery (CPS), FLACS has demonstrated greater capsulotomy accuracy, reduced zonular stress, lower phacoemulsification energy requirements, and decreased endothelial cell loss.⁴ However, based on our present understanding, there is still an absence of study assessing the surgical outcomes of FLACS versus CPS in cataract patients who undergo vitrectomy previously.

The objective of this study is to determine the surgical outcomes of femtosecond laser-assisted cataract surgery (FLACS) compared to Conventional Phacoemulsification Surgery (CPS) in vitrectomized eyes.

METHODS

The systematic review were undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.

Eligibility Criteria

Studies were selected applying the following inclusion criteria: (1) Randomized Controlled Trial, Clinical Trial Studies or observational studies (2) Age $\geq$ 18 years (3) cataract with previous history of vitrectomy (4) intervention with FLACS (5) CPS as a control.

Our selection process excluded case reports, case series, review papers, animal-based studies and secondary reviews.

Search Strategy

We searched databases: PubMed, Cochrane and Science Direct, using MeSH terms to form the following search strategy: (Cataract) AND (Vitrectomy) OR (Post-vitrectomy) OR (Postvitrectomy) OR (Vitrectomized eye) AND (FLACS) OR (femtosecond laser-assisted cataract surgery) AND (phacoemulsification) OR (conventional phacoemulsification).

Study Selection

Three authors independently conducted the screening and data collection. Screening passed by 2 processes: (1) title and abstract screening and (2) full-text screening. Three authors from each performed title and abstract screening of each study, the study was included if it seemed eligible for inclusion according to our inclusion criteria, then the same three authors performed full-text screening of each study included from the title and abstract screening phase. Disparities during the decision process were resolved by discussion between the three authors. The fourth author was consulted if disagreements could not be resolved.

Data Extraction

Three authors independently extracted the following data from the included studies: first author, date of publication, country, study design, study population, mean age, intervention, outcome and follow-up duration. Discrepancies were first discussed between the three authors. The fourth author was consulted if disagreements could not be resolved.

Quality Assesment

We assessed risk of bias in the included studies using the revised Cochrane ‘Risk of bias’ tool for randomised trials (RoB 2.0) and “ROBINS-I” for observational study. Three authors independently applied the tool to each included study, and recorded supporting information and justifications for judgements of Risk of Bias for each domain in RoB 2.0 (low; high; some concern) and ROBINS-I (low; moderate; serious; critical). Any discrepancies in judgements of risk of bias or justifications for judgements were resolved by discussion to reach consensus between the three authors, with a fourth author was consulted if disagreements could not be resolved.

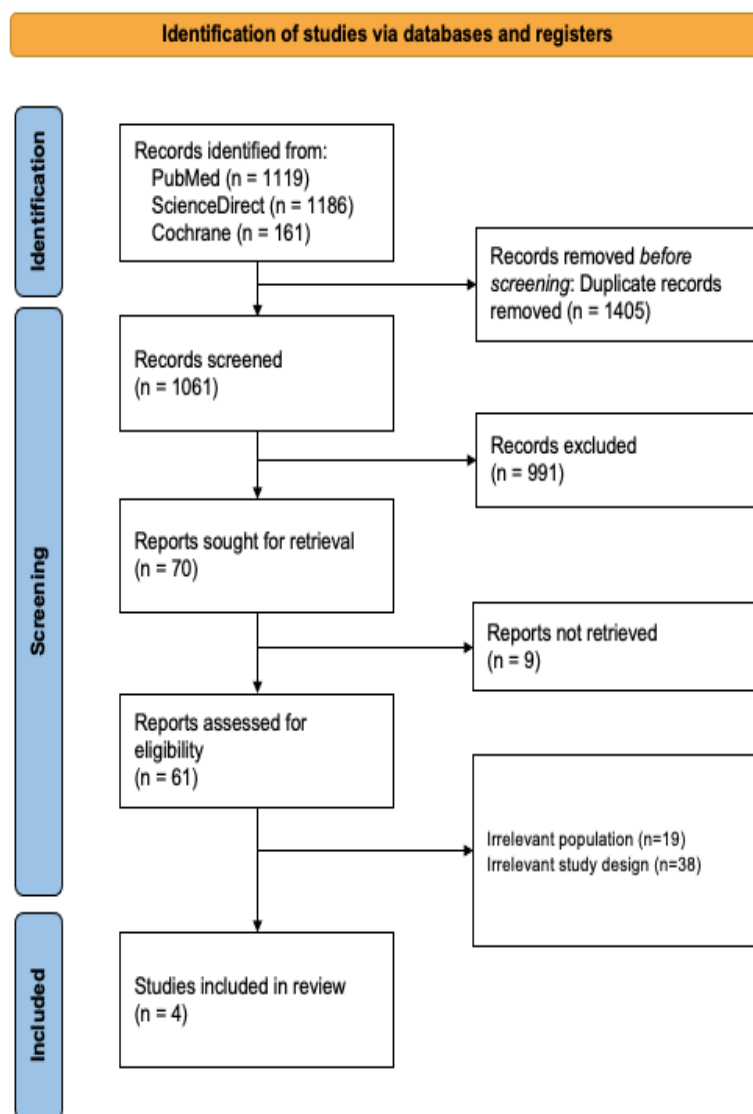


Figure 1. The process of entering the studies into the systematic review



Figure 2. Risk of Bias of the included studies

RESULTS

Search results and analysis of international databases from PubMed, Cochrane and Science Direct were limited based on the eligibility criteria. We found 2466 articles, after duplicates removal, we screened 1061 articles, only 4 were left and included, as shown in [Figure 1](#). The risk of bias of studies are summarized in [Figure 2](#). The characteristics of studies and the patients are summarized in [Table 1](#).

Surgery Outcomes

Visual Acuity

Visual outcomes improved postoperatively in both groups, with most studies reporting no significant difference in final Corrected Distance Visual Acuity (CDVA). However, FLACS was associated with faster early visual recovery, with significantly better visual outcomes observed on the first postoperative day and in patients with hard nuclei at 1 week in some studies. [Table 2](#)

Ultrasound Energy & Surgery Time

FLACS consistently reduced intraoperative ultrasound energy requirements, with significantly lower average ultrasound energy or cumulative dissipated energy compared with CPS. Additionally, shorter effective phacoemulsification time and reduced operative time were reported in the FLACS group. [Table 2](#)

Table. 1 Summary of Included Studies

No	Authors	Country	Study design	Mean Age	Study population	Study intervention	Follow up	Outcome
1.	Wen et al, 2025 ⁵	China	Randomized Controlled Trial	FLACS group: 53 years CPS group: 52 years	Cataract with previous history of PPV surgery	FLACS group: 47 eyes CPS group: 45 eyes	3 months	• Intraoperative complications • Average Phacoemulsification Energy (AVE) • Effective phacoemulsification time (EPT) • BCVA (Best Corrected Visual Acuity) • IOP (Intraocular Pressure) • ECD (Endothelial Cornea Density)

2.	Asif et al, 2024 ⁶	India	Clinical trial	FLACS group: 37 years CPS group: 39 years	Cataract with previous history of vitrectomy surgery	FLACS group: 60 CPS group: 60	3 months	• Intraoperative ultrasonic Cumulative Dissipated Energy (CDE) • Intraoperative and postoperative complications • Endothelial Cell Count (ECC) and Central Corneal Thickness (CCT)
3.	Cai et al, 2022 ⁷	China	Randomized Controlled Trial	FLACS group: 60 years CPS group: 61 years	Cataract with previous history of PPV surgery	FLACS group: 45 CPS group: 41	3 months	• Intraoperative and postoperative complications. • Endothelial Cell Count (ECC) and Central Corneal Thickness (CCT)

4.	Wang et al, 2017 ⁸	New Zealand	Retrospective Study	FLACS group: 61 years CPS group: 66 years	Cataract with previous history of vitrectomy surgery	FLACS group: 25 CPS group: 25	FLACS group: mean follow up time 4.5 months CPS group: mean follow up time 34.4 months	• Visual Outcome • Intraoperative and postoperative complications • Cystoid Macular Oedema
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Endothelial Cell Density (ECD) & Endothelial Cell Loss (ECL)

FLACS demonstrated with higher postoperative endothelial cell density and lower endothelial cell loss reported during follow-up. [Table 2](#)

Intraoperative Complication

FLACS demonstrated a comparable or favorable safety profile compared with CPS, with no consistent evidence of increased intraoperative complications. Wen et al. reported similar intraoperative complication rates between two groups, with no severe complications such as nucleus drop, expulsive choroidal hemorrhage or retinal detachment observed. In contrast, Wang et al. and Cai et al. reported intraoperative complications predominantly in the CPS group, including dropped nucleus, posterior capsule rupture, anterior capsule tear, and zonular dialysis, although some differences did not reach statistical significance. In the FLACS group, reported intraoperative events were mainly related to incomplete capsulotomy, with no major adverse events documented. Additionally, Asif et al. observed intraoperative silicone oil migration into the anterior chamber in the CPS group but not in the FLACS group, with no iatrogenic posterior capsular defects in either group. [Table 3](#)

Postoperative Complication

FLACS was associated with a lower incidence of early corneal edema in some studies. Wen et al. reported significantly less corneal edema on postoperative day 1 in the FLACS group, while Asif et al. observed a lower incidence of corneal edema in FLACS, although the difference was not statistically significant.

Table 2. Summary of Surgical Outcomes

Study Authors (Year)	Visual Outcome	Ultrasound Energy	Surgery Time	Endothelial Cell Condition
Wen et al., 2025	Both groups showed postoperative visual improvement. FLACS provided better visual outcomes on postoperative day 1 ($P < 0.05$), but no significant differences were observed at 1 week, 1 month, or 3 months (all $P > 0.05$).	FLACS reduced average ultrasound energy by 20.64% compared with CPS ($P < 0.05$).	FLACS reduced effective phacoemulsification time by 35.91% compared with CPS ($P < 0.05$).	At 3 months, FLACS showed higher Endothelial Cell Density (ECD) and lower Endothelial Cell Loss (ECL) than CPS ($P < 0.01$).
Asif et al., 2024	Mean CDVA was comparable between groups. However, FLACS achieved faster visual recovery.	Cumulative dissipated energy was significantly lower in FLACS than CPS (8.11 vs. 15.83 percentage-seconds; $P = 0.012$).	FLACS had a shorter operative time than CPS (8.13 ± 1.88 vs. 9.73 ± 1.86 min; $P < 0.05$).	FLACS demonstrated higher postoperative ECD and lower ECL ($P = 0.001$).
Cai et al., 2022	Final CDVA was comparable between groups. In hard nuclei cases, FLACS achieved	Not reported	Not reported	ECD decreased significantly in both groups ($P < 0.001$). In hard nuclei cases,

	better CDVA at 1 week postoperatively ($P < 0.05$).			FLACS maintained higher ECD throughout follow-up ($P < 0.01$ to $P < 0.05$).
Wang et al., 2017	No significant difference in postoperative visual acuity between groups.	Not reported	Not reported	Not reported

Table 3. Summary of Complication

Study Authors (Year)	Intraoperative Complications	Postoperative Complications
Wen et al., 2025	Intraoperative complication were comparable between FLACS and CPS ($P > 0.05$). No severe complications, including nucleus drop, expulsive choroidal hemorrhage, or retinal detachment, occurred in either group.	Postoperative day 1 corneal edema was significantly lower in the FLACS group than in the CPS group (23.4% vs. 44.4%, $P < 0.05$). All cases resolved within 1 week. Posterior capsule opacification (PCO) were comparable between groups ($P > 0.05$).
Asif et al., 2024	Intraoperative silicone oil migration into the anterior chamber occurred in 40% of CPS cases but was absent in the FLACS group. No iatrogenic posterior capsule defects occurred in either group.	Corneal edema on postoperative day 1 occurred less frequently in FLACS than CPS (6.6% vs. 26.7%, $P = 0.079$). No postoperative cystoid macular edema (CME) or visual axis opacification (VAO) occurred in either group. Preexisting posterior capsular plaque was observed in 14 eyes (CPS: 6/30; FLACS: 8/30).
Cai et al., 2022	CPS complications included nuclear drop ($n = 2$), anterior capsule tear ($n = 2$), zonular dialysis ($n = 3$), and posterior capsule rupture ($n = 2$).	No significant differences in anterior chamber cells and flare were observed between groups. In hard nuclei cases, FLACS showed fewer eyes with grade ≥ 2 AC cells and flare on postoperative

	FLACS complications included incomplete capsulotomy (n = 3).	day 1. Postoperative complications included raised IOP (CPS: n = 5; FLACS: n = 3) and subconjunctival hemorrhage (FLACS: n = 6).
Wang et al., 2017	Intraoperative complications occurred in 12% of CPS cases, including dropped crystalline lens (n = 2) and posterior capsule rupture (n = 1). No intraoperative complications occurred in FLACS, although the difference was not statistically significant.	CPS complications included retinal detachment (n = 1), raised intraocular pressure (IOP) (n = 1), CME (n = 5), and PCO (n = 12). FLACS complications included PCO (n = 4) and CME (n = 3).

Other postoperative inflammatory outcomes, including anterior chamber cells and flare, were generally comparable between groups, with potential benefits of FLACS observed in patients with hard nuclei. The incidence of posterior capsule opacification, cystoid macular edema, and other postoperative complications varied across studies but showed no consistent significant differences between FLACS and CPS. [Table 3](#)

DISCUSSION

Cataract formation is an almost inevitable complication following pars plana vitrectomy (PPV), with more than 80% of patients requiring cataract surgery within two years after the procedure.⁹ Cataract surgery in vitrectomized eyes is particularly challenging because of the altered ocular anatomy, including zonular instability, increased capsular fragility, reduced capsular elasticity and the absence of vitreous support, all of which increase the technical complexity of lens removal and intraocular lens (IOL) implantation.^{10, 11} This systematic review was conducted to compare the surgical outcomes of femtosecond laser-assisted cataract surgery (FLACS) and conventional phacoemulsification surgery (CPS) in vitrectomized eyes. Our study demonstrated that FLACS provides similar final visual outcomes while offering advantages in early visual recovery, reduced ultrasound energy use, shorter phacoemulsification duration, and improved endothelial protection compared with CPS.

Femtosecond laser technology automates critical surgical steps such as corneal incision creation, continuous curvilinear capsulorhexis, and lens fragmentation with high precision. By accurately determining the posterior capsule position and laser treatment depth, FLACS minimizes variability associated with manual surgical techniques and reduces the amount of ultrasound energy required during nucleus emulsification, thereby decreasing surgical trauma.¹² This study found that FLACS reduced ultrasound energy, shorter phacoemulsification duration, and improved endothelial protection compared with CPS. In line with previous Meta-analysis, Yeh et al. reported low energy FLACS statistically limited reduction in Endothelial Cell Count (ECC) and provided effective surgery time.¹³ Similarly, Wang et al. reported that FLACS significantly reduced endothelial cell

loss (ECL) at all postoperative follow-up periods up to six months and resulted in lower central corneal thickness (CCT).¹⁴

Post-vitrectomy cataract surgery outcomes are variable, with 20–77% of eyes achieving a visual acuity of 20/40 or better, depending on the underlying retinal pathology.^{15,16} Soliman et al. demonstrated that eyes with prior pars plana vitrectomy (PPV) had poorer pre- and postoperative visual acuity and were less likely to achieve 20/40 vision within 4–12 weeks after sequential cataract surgery than non-vitrectomized eyes.¹⁷ Our study reported no significant difference in final Corrected Distance Visual Acuity (CDVA). This finding is consistent with previous Meta-analysis, Narayan et al demonstrated no difference between FLACS and PCS in postoperative visual acuity.¹⁸

Another important finding of this review is that FLACS demonstrated a favorable safety profile despite the anatomical challenges encountered in vitrectomized eyes. Most reported intraoperative complications occurred in the CPS group, whereas complications associated with FLACS were generally limited to incomplete capsulotomy without significant adverse complication. Severe complications were uncommon in both surgical techniques, and no iatrogenic posterior capsular defects were reported. Xu et al. demonstrated that FLACS does not increase the incidence of intraoperative capsule tears, postoperative corneal edema, cystoid macular edema, or elevated intraocular pressure while significantly reducing the occurrence of Descemet membrane injury, intraoperative floppy iris syndrome (IFIS), and iris trauma.¹⁹

Although FLACS improves surgical precision and efficiency, its high acquisition and maintenance costs may limit widespread implementation, particularly in resource-limited healthcare settings.²⁰ Clinically, FLACS may represent the preferred surgical option for selected high-risk patients, particularly those with dense nuclear cataracts, compromised corneal endothelium, or surgical difficulty following vitrectomy.

Despite these promising result, several limitations should be acknowledged. Our Systematic Review exhibited small number of included studies, heterogeneity in study design and limited follow-up duration. In addition, variations in the indications for previous vitrectomy, cataract severity, surgeon experience, and FLACS platforms may have included in the study.

CONCLUSION

FLACS provides superior intraoperative efficiency, better endothelial preservation, faster early visual recovery, and a favorable safety profile compared with CPS in vitrectomized eyes, although final visual outcomes remain similar. Future studies should include large RCTs with longer follow-up periods to validate these findings and determine their long-term clinical significance. Further research should also evaluate the cost-effectiveness of FLACS, identify variations in the indications for previous vitrectomy and investigate retinal outcomes in vitrectomized eyes.

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