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Efficacy and Safety of FLACS Versus Conventional Phacoemulsification in Age-Related Cataract: A Systematic Review of Randomized Controlled Trials

Syifa Silviyah*, Darwin Gozali
Hermina Hospital Daan Mogot, Indonesia
Email: syifasilviyah@gmail.com*, ddgoze@yahoo.com

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Abstract

Age-related cataract is a leading cause of visual impairment worldwide. Femtosecond laser-assisted cataract surgery (FLACS) has been shown to reduce ultrasound energy exposure during cataract removal; however, the clinical significance of this reduction remains uncertain. This systematic review aimed to compare the efficacy and safety of FLACS with conventional phacoemulsification in adults with age-related cataract. PubMed and Scopus were systematically searched for randomized controlled trials (RCTs) published between January 1, 2023, and July 30, 2026. Two independent reviewers screened the retrieved records and assessed the risk of bias using the Cochrane Risk of Bias 2 (RoB 2) tool. Six RCTs involving 564 eyes met the inclusion criteria, and all were assessed as having some concerns regarding risk of bias. In one trial involving patients with dense cataracts, FLACS significantly reduced effective phacoemulsification time (4.42 vs. 6.14 seconds) and was associated with lower corneal endothelial cell loss at six months (12.8% vs. 16.08%). Conversely, another trial reported a longer overall procedural duration with FLACS when the laser pretreatment stage was included. Although some trials demonstrated faster early postoperative visual recovery following FLACS, longer-term visual acuity and refractive predictability were generally comparable between the two surgical techniques. Heterogeneity in cataract density, femtosecond laser platforms, surgical protocols, and follow-up durations limited direct comparisons across studies. Overall, FLACS may reduce ultrasound energy exposure and corneal endothelial cell loss, particularly in patients with dense cataracts. However, the available evidence did not demonstrate a consistent advantage in longer-term visual or refractive outcomes compared with conventional phacoemulsification. Larger, methodologically rigorous RCTs with standardized outcome measures and extended follow-up periods are warranted to further establish the comparative efficacy and safety of these surgical approaches.

INTRODUCTION

Age-related cataracts are among the leading causes of reversible blindness worldwide (Bobot et al., 2026; Liang et al., 2024; Qu et al., 2024). Cataract surgery aims to restore visual function and improve patients' quality of life by removing the opacified crystalline lens and implanting an intraocular lens (IOL) (Liang et al., 2024; Qu et al., 2024). Conventional phacoemulsification surgery (CPS) remains the standard surgical approach and uses high-frequency ultrasound energy and controlled fluidics to fragment and remove the cataractous lens (Xiao et al., 2026; Zhou et al., 2023). Several critical surgical steps, including clear corneal incision creation and continuous curvilinear capsulorhexis (CCC), are performed manually and

depend on the surgeon's technical expertise. Variations in surgical technique and intraoperative fluidics may contribute to mechanical stress, thermal injury, and endothelial cell damage (Altansukh et al., 2024; Léda et al., 2023). These factors can result in postoperative corneal edema, anterior chamber inflammation, and, less commonly, retinal complications associated with postoperative inflammatory responses (Chychko et al., 2026; Schwarzenbacher et al., 2024; Zhou et al., 2023).

Femtosecond laser-assisted cataract surgery (FLACS) was introduced to improve the precision and reproducibility of selected surgical steps through computer-guided laser technology (Aboumostafa et al., 2023; Casazza et al., 2025a). Using ultrashort near-infrared laser pulses, FLACS can perform anterior capsulotomy, lens fragmentation, and, depending on the platform and surgical protocol, corneal incisions before conventional phacoemulsification. Laser-assisted lens fragmentation may reduce the ultrasound energy required for nuclear emulsification and decrease intraocular mechanical manipulation, potentially minimizing surgical trauma and corneal endothelial injury. However, the extent to which these procedural advantages translate into clinically meaningful improvements remains uncertain (Huang et al., 2023).

Recent technological developments have introduced low-energy, high-frequency femtosecond laser platforms, including the FEMTO LDV Z8, which uses nanojoule-range pulse energies and is designed to minimize cavitation-related tissue disruption (Schwarzenbacher et al., 2024). Other platforms, such as the LENSAR Laser System, incorporate three-dimensional imaging and lens density assessment to support individualized fragmentation patterns (Ganesh et al., 2024). Despite these technological advances, the clinical necessity and cost-effectiveness of FLACS in routine cataract surgery remain debated (Schwarzenbacher et al., 2024; Slezak et al., 2023; Zhou et al., 2023). In patients with dense nuclear cataracts, laser-assisted fragmentation may reduce ultrasound energy requirements and potentially limit corneal endothelial cell loss (Ganesh et al., 2024). However, evidence that FLACS consistently prevents corneal incision burns or provides superior outcomes across all cataract grades remains insufficient. For patients with mild-to-moderate cataracts, contemporary conventional phacoemulsification techniques have generally demonstrated comparable longer-term visual acuity, refractive predictability, and corneal endothelial outcomes. Consequently, the clinical value of FLACS may depend on cataract density, surgical technique, laser platform characteristics, and patient-specific risk factors.

In adults undergoing surgery for age-related cataracts, conventional phacoemulsification relies on ultrasound energy to fragment the opacified crystalline lens before aspiration and IOL implantation. In contrast, FLACS incorporates laser-assisted pretreatment for selected surgical steps, particularly anterior capsulotomy and lens fragmentation. Prefragmentation of the crystalline lens may reduce cumulative ultrasound energy exposure, particularly in patients with dense nuclear cataracts or compromised corneal endothelial function. Nevertheless, reduced ultrasound exposure does not necessarily translate into superior postoperative outcomes. The central clinical question is whether these procedural advantages result in meaningful improvements in visual recovery, refractive accuracy, corneal endothelial preservation, or postoperative safety.

Previous systematic reviews and meta-analyses have suggested that the overall clinical advantages of FLACS over conventional phacoemulsification are limited. A Cochrane systematic review conducted by Narayan et al. (2023), which included 42 randomized controlled trials (RCTs) involving 7,298 eyes, found that FLACS and conventional phacoemulsification probably produced little or no difference in postoperative visual acuity, patient-reported quality of life, and intraoperative or postoperative complication rates. A subsequent meta-analysis by Lee et al. (2025), encompassing 46 randomized trials and 8,871 eyes, reported better corrected distance visual acuity following FLACS at one week postoperatively. However, no statistically significant differences were observed at subsequent follow-up assessments. These findings suggest that the timing of postoperative evaluation is an important consideration when interpreting the comparative efficacy of the two surgical approaches.

Individual RCTs have further demonstrated that cataract density and surgical workflow may influence the relative performance of FLACS and conventional phacoemulsification. In a trial involving 100 eyes with dense nuclear cataracts, Ganesh et al. (2024) reported a shorter effective phacoemulsification time with FLACS than with conventional surgery (4.42 vs. 6.14 seconds), accompanied by lower corneal endothelial cell loss at six months (12.8% vs. 16.08%). Similarly, a multicenter trial involving 126 patients conducted by Zhou et al. (2023) demonstrated that low-energy FLACS met the prespecified noninferiority criterion for corneal endothelial cell loss at three months. Nevertheless, the mean total procedural duration, including laser pretreatment and the interval before phacoemulsification, was longer with FLACS than with conventional surgery (14.2 vs. 10.8 minutes). These findings indicate that the comparative benefits of either technique may vary according to cataract severity, the outcomes assessed, and whether surgical duration includes the entire procedural workflow.

Despite the availability of previous evidence syntheses, uncertainty remains regarding the consistency of outcomes across cataract grades, femtosecond laser platforms, and postoperative follow-up periods. The Cochrane review by Narayan et al. (2023) included studies identified through May 2022, whereas the meta-analysis by Lee et al. (2025) searched the literature through January 2023. More recently, a platform-focused network meta-analysis by Zhang et al. (2026) extended its literature search through May 2024 and incorporated both randomized trials and observational cohort studies. Although these reviews provided valuable comparative evidence, differences in study eligibility criteria, surgical technologies, and outcome assessment periods limited their ability to clarify whether procedural advantages observed in recent RCTs consistently resulted in sustained clinical benefits. Accordingly, an updated synthesis focusing exclusively on direct randomized comparisons published after January 2023 is warranted to examine the clinical relevance and consistency of these findings.

Further investigation is particularly relevant because FLACS requires specialized equipment, additional procedural steps, and potentially greater resource utilization than conventional phacoemulsification. The Cochrane review by Narayan et al. (2023) identified two economic evaluations suggesting that FLACS may be less cost-effective than conventional phacoemulsification, while Zhou et al. (2023) demonstrated that total procedural time may increase when laser pretreatment is included. These considerations are especially important in health care systems facing substantial unmet demand for cataract surgery and limited surgical

resources. Therefore, determining which patient populations are most likely to benefit from FLACS is essential for supporting evidence-based surgical decision-making and appropriate resource allocation.

The distinctive contribution of this systematic review lies in its focused evaluation of direct randomized evidence published between January 1, 2023, and July 30, 2026, involving adults aged 40 years or older undergoing standalone cataract surgery for age-related cataracts. Unlike broader evidence syntheses that incorporated earlier trials or observational studies, this review specifically examined contemporary randomized comparisons and interpreted their findings according to cataract severity, femtosecond laser platform, and postoperative follow-up duration. Procedural outcomes, including effective phacoemulsification time, ultrasound energy exposure, and total surgical duration, were evaluated alongside postoperative outcomes, including corneal endothelial cell loss, visual acuity, refractive accuracy, and surgical complications. This approach aimed to distinguish technical improvements from clinically meaningful benefits and to identify the circumstances under which FLACS might offer advantages over conventional phacoemulsification.

The primary objective of this systematic review was to evaluate the comparative efficacy and safety of FLACS and conventional phacoemulsification in adults with age-related cataracts. Specifically, the review aimed to compare intraoperative ultrasound energy requirements and surgical duration; assess postoperative visual acuity, refractive predictability, and IOL positioning; and examine corneal and retinal outcomes, including endothelial cell loss, macular changes, and reported intraoperative and postoperative complications. Where sufficient data were available, differences in outcomes were further examined according to cataract grade, femtosecond laser platform, and follow-up duration to identify potential sources of clinical heterogeneity.

The findings of this review are expected to support evidence-based clinical decision-making by clarifying which benefits of FLACS are primarily procedural, which may contribute to early postoperative recovery, and which persist during longer-term follow-up. For ophthalmic surgeons, the synthesis may facilitate individualized surgical planning and more informed discussions with patients regarding the anticipated benefits and limitations of each technique. For health care institutions, the findings may inform assessments of the clinical value of femtosecond laser technology in relation to its operational requirements and resource implications. Furthermore, the review may guide future research by identifying methodological priorities, including standardized cataract density grading, consistent reporting of ultrasound energy and surgical duration, comprehensive assessment of postoperative complications, and sufficiently long follow-up periods to determine whether early procedural advantages translate into sustained improvements in visual function and surgical safety.

METHOD

A systematic literature search was conducted in PubMed and Scopus to identify studies published between January 1, 2023, and July 30, 2026. The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to age-related cataracts, femtosecond laser-assisted cataract surgery (FLACS), and conventional phacoemulsification (CPS), using Boolean operators.

Study selection was guided by the PICOS framework. Eligible studies included adults aged 40 years or older with age-related cataracts who underwent standalone cataract extraction with intraocular lens (IOL) implantation. The intervention was FLACS performed using any femtosecond laser platform, with conventional phacoemulsification serving as the comparator. Studies were included if they reported at least one efficacy outcome, including visual acuity, corneal endothelial cell loss, central corneal thickness, ultrasound energy parameters, total surgical duration, or IOL positioning, or safety outcomes involving intraoperative or postoperative complications. Only full-text parallel-group or paired-eye randomized controlled trials (RCTs) were included. Studies involving secondary, pediatric, traumatic, or post-vitrectomy cataracts were excluded.

After duplicate records were removed, two independent reviewers screened titles and abstracts for eligibility. Potentially relevant full-text articles were subsequently assessed against the predefined inclusion and exclusion criteria. Disagreements were resolved through discussion or consultation with a third reviewer. Data were extracted using a standardized form that captured baseline patient characteristics, cataract severity, surgical techniques, laser platforms, follow-up durations, and reported outcome measures.

Two reviewers independently assessed the risk of bias using the Cochrane Risk of Bias 2 (RoB 2) tool. The assessment covered five domains: bias arising from the randomization process, deviations from intended interventions, missing outcome data, outcome measurement, and selection of reported results. Discrepancies were resolved through consensus.

RESULT AND DISCUSSION

The systematic literature search across PubMed (153) and Scopus (243) databases initially identified 396 records. Following the removal of 143 duplicates, 253 unique titles and abstracts were screened, resulting in the exclusion of 225 non-relevant records. Full-text evaluation of the remaining 28 articles led to the exclusion of 22 reports due to ineligible population (1), intervention (2), comparator (1), outcome reporting (4), unavailable full-text (2), and non-randomized study designs (12). Ultimately, 6 randomized controlled trials (RCTs) met all inclusion criteria.

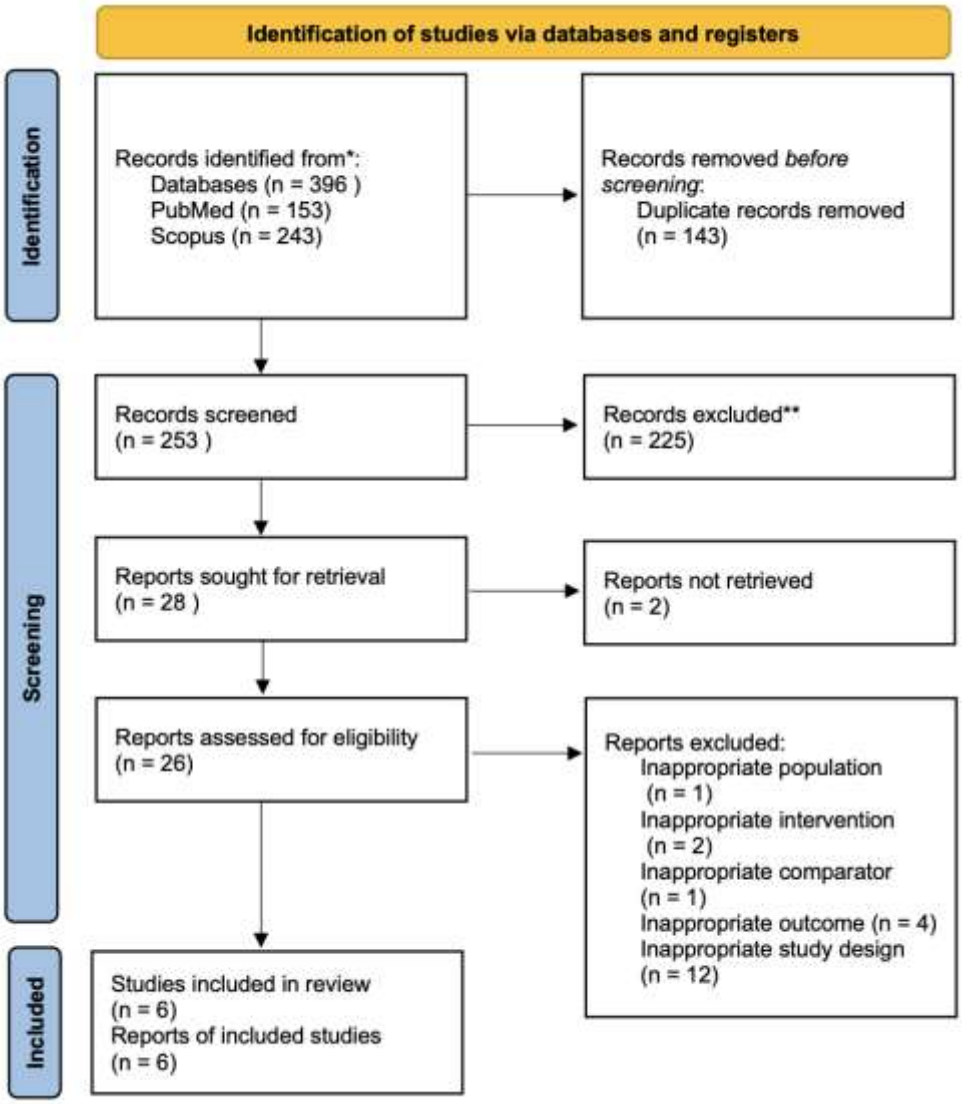


Figure 1. PRISMA Flowchart

The 6 included RCTs evaluated a total of 564 eyes (269 FLACS vs 295 conventional phacoemulsification). The primary characteristics of these trials are presented in Table 1.

Table 1. Characteristics of Included Randomized Controlled Trials

Study and Country	Study Design	Sample Size (Eyes / Patients)	FLACS Platform vs Phaco Machine	Cataract Grading (LOCS III)	Follow-up Duration	Evaluated Key Outcomes
Aboumostafa et al. (2023)	Prospective parallel-group RCT	40 eyes / 40 patients (20 FLACS vs 20 Manual)	Victus (Bausch & Lomb) vs Alcon Infiniti	Grade II-IV	1 month	BCVA, CCT, ECD, corneal edema grade
Zhou et al. (2023)	Multicenter prospective	126 eyes / 126	Low-energy	Grade 1-3 (86.3%	3 months	ECL, CDE, CCT change,

	parallel-group RCT	patients (63 FLACS vs 63 CP)	FEMTO LDV Z8 vs Centurion (Alcon)	Grade 1-2)		UDVA, CDVA, surgery time, SAEs
Schwarzenbacher et al. (2024)	Prospective randomized intraindividual paired-eye RCT	120 eyes / 60 patients (112 eyes / 56 patients completed)	Low-energy FSL vs Manual High-Fluidics Phaco	Grade 3	18 months	SD-OCT intraretinal sublayers (TRT, INL, ONL, OPL, PR), BCVA, CME incidence
Ganesh et al. (2024)	Prospective parallel-group RCT	100 eyes / 100 patients (50 FLACS vs 50 CPS)	LENSAR Laser System (3D AR + Custom Frag) vs CataRhex 3 (Oertli)	Dense cataracts (Grade ≥ 3.0)	6 months	TPT, EPT, surgical time, fluid volume, ECD, % ECL, Day 1 CCT, corneal edema, wound burn
Casazza et al. (2025b)	Prospective randomized bilateral paired-eye RCT	100 eyes / 50 patients (76 eyes / 38 patients completed)	Victus (Bausch & Lomb) vs OS4 (Oertli) + CT LUCIA 621P IOL	Age >21 years (bilateral cataract)	6 months	ACD, ACD shift, IOL tilt, IOL decentration, SEQ, BCDVA, UCDVA
Bobot et al. (2026)	Prospective parallel-group RCT	78 eyes / 78 patients (38 FLACS vs 40 CCS)	Low-energy FEMTO LDV Z8 vs CataRhex 3 (Oertli)	Grade 0-5 (FLACS 3.13 ± 0.81 vs CCS 2.33 ± 0.68)	6 weeks	EPT, UT, IT, BCVA (Day 1 to W6), ECD, % ECL, CCT, morphometry (CV, 6A)

Abbreviations: ACD: Anterior Chamber Depth; BCVA/BCDVA: Best-Corrected Distance Visual Acuity; CCT: Central Corneal Thickness; CDE: Cumulative Dissipated Energy; CME: Cystoid Macular Edema; CP/CPS/CCS: Conventional Phacoemulsification Surgery; ECD: Endothelial Cell Density; ECL: Endothelial Cell Loss; EPT: Effective Phacoemulsification Time; FLACS: Femtosecond Laser-Assisted Cataract Surgery; IOL: Intraocular Lens; LOCS III: Lens Opacities Classification System III; RCT: Randomized Controlled Trial; TPT: Total Phacoemulsification Time; TRT: Total Retinal Thickness; UDVA/UCDVA: Uncorrected Distance Visual Acuit

Methodological quality and risk of bias for each of the 6 included randomized controlled trials (RCTs) were systematically appraised using the Cochrane Risk of Bias 2 (RoB 2) framework.

Table 2. Risk of Bias 2 (RoB 2) Assessment of Included RCTs

Included Study	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Overall Risk of Bias Judgment
Aboumostafa et al. (2023)	Low Risk	Some Concerns	Low Risk	Low Risk	Low Risk	Some Concerns
Zhou et al. (2023)	Low Risk	Some Concerns	Low Risk	Low Risk	Low Risk	Some Concerns
Schwarzenbacher et al. (2024)	Low Risk	Some Concerns	Low Risk	Low Risk	Low Risk	Some Concerns
Ganesh et al. (2024)	Low Risk	Some Concerns	Low Risk	Low Risk	Low Risk	Some Concerns
Casazza et al. (2025b)	Low Risk	Some Concerns	Low Risk	Low Risk	Low Risk	Some Concerns
Bobot et al. (2026)	Some Concerns	Some Concerns	Low Risk	Low Risk	Low Risk	Some Concerns

Study Selection and Baseline Characteristics

Out of the initial search pool, exactly six randomized controlled trials (RCTs) ultimately met the inclusion criteria. Together, these studies represent a combined total of 564 eyes-269 assigned to FLACS and 295 to manual CPS. The patients participating in these trials spanned a broad age range, typically from 45 to 95 years old, and presented with varying degrees of age-related cataract severity. Furthermore, the investigators evaluated several different femtosecond laser platforms. For instance, the LENSAR system was specifically evaluated for dense cataracts, whereas other teams utilized the Victus platform or the low-energy, high-frequency FEMTO LDV Z8.

Risk of Bias Assessment

When evaluating the methodological quality using the Cochrane Risk of Bias 2 (RoB 2) tool, all six trials uniformly received an overall rating of "Some Concerns". This classification almost entirely stemmed from Domain 2, which assesses deviations from intended interventions. Because these are surgical trials comparing vastly different operative techniques, laser versus manual extraction, it is practically impossible to blind the operating surgeon. This lack of surgeon blinding introduces performance bias.

Intraoperative Outcomes and Surgical Efficiency

For dense nuclear cataracts (LOCS III Grade >= 3.0), FLACS demonstrated a significantly lower effective phacoemulsification time (EPT) (4.42 +/- 2.07 s vs. 6.14 +/- 3.62 s, $p < 0.001$) and active surgical microscope time (7.11 +/- 1.55 min vs. 8.18 +/- 2.36 min, $p < 0.001$) compared to CPS (Ganesh et al., 2024). Low-energy FLACS also resulted in a shorter EPT (1.01 +/- 0.91 s vs. 1.61 +/- 1.70 s, $p < 0.05$) (Bobot et al., 2026). That said, if the total time spent in the operating room is measured, factoring in the laser docking process and physically transferring the patient to the surgical microscope, one trial explicitly noted that FLACS took significantly longer overall (14.2 ± 7.6 min vs 10.8 ± 7.8 min, $p = 0.015$) (Zhou et al., 2023). However, total operating room time, including the laser docking process, was longer for FLACS (14.2 +/- 7.6 min vs. 10.8 +/- 7.8 min, $p = 0.015$). CPS was associated with three cases of clear corneal wound burns requiring suturing, whereas no wound burns were observed in the FLACS cohort (Ganesh et al., 2024).

Corneal Endothelial and Anterior Segment Safety

In dense cataracts, FLACS resulted in lower endothelial cell loss (ECL) at 6 months (12.8% vs. 16.08%, $p < 0.001$) (Ganesh et al., 2024). For soft-to-moderate cataracts, ECL and cell morphology metrics at 3 months (Zhou et al., 2023) and 6 weeks (Bobot et al., 2026) were comparable between the low-energy FLACS and CPS groups. CPS was associated with a higher incidence of early postoperative corneal edema and a greater increase in central corneal thickness (CCT) at Day 7 (9.2 um vs. 4.9 um, $p = 0.04$) (Aboumostafa et al., 2023; Zhou et al., 2023).

Visual Acuity, Refractive Predictability, and Capsular Stability

FLACS facilitated faster recovery of Best-Corrected Visual Acuity (BCVA) on postoperative Day 1 (Bobot et al., 2026). However, at 6 to 18 months, Uncorrected Distance Visual Acuity (UDVA) and BCVA did not differ significantly between the groups (Casazza et al., 2025b; Schwarzenbacher et al., 2024). Both techniques yielded comparable refractive predictability, with 94% to 98% of eyes within +/- 0.50 D of the target spherical equivalent at 6 months (Casazza et al., 2025b). Although FLACS demonstrated a smaller anterior chamber depth (ACD) shift between 1 and 6 months (0.12 +/- 0.12 mm vs. 0.27 +/- 0.16 mm, $p < 0.001$), IOL tilt and decentration at 12 months were not significantly different between the two methods (Casazza et al., 2025b).

Macular and Retinal Safety

Spectral-domain OCT showed a significant postoperative increase in total retinal thickness (TRT) in both groups ($p < 0.001$), peaking between 3 and 6 weeks. TRT remained elevated compared to baseline at 18 months in both groups. This subclinical thickening did not compromise visual acuity, and no cases of clinical pseudophakic cystoid macular edema (CME) were reported in either cohort (Schwarzenbacher et al., 2024).

In this systematic review, we synthesized primary evidence from six randomized controlled trials (RCTs), representing 564 eyes, to critically evaluate how femtosecond laser-assisted cataract surgery (FLACS) measures up against conventional manual phacoemulsification (CPS) for age-related cataracts. To ensure a robust clinical perspective, we analyzed our core findings in tandem with external literature focusing on ultrasonic energy mechanics, endothelial preservation, capsular stability, and retinal safety.

Femtosecond laser pre-fragmentation consistently reduces the intraoperative ultrasonic energy required. Looking at the primary trials, FLACS proved especially advantageous for eyes with dense nuclear cataracts (LOCS III Grade ≥ 3.0). The laser pretreatment achieved a statistically significant drop in effective phacoemulsification time (EPT), bringing it down from 6.14 ± 3.62 seconds in the CPS group to just 4.42 ± 2.07 seconds ($p < 0.001$) (Ganesh et al., 2024). Naturally, this efficiency translated into less time spent actively operating under the microscope (7.11 ± 1.55 minutes versus 8.18 ± 2.36 minutes, $p < 0.001$) (Ganesh et al., 2024). We noted similar success with low-energy, high-frequency laser platforms, which also yielded a significantly shorter EPT (1.01 ± 0.91 seconds vs 1.61 ± 1.70 seconds, $p < 0.05$) (Bobot et al., 2026). However, outcomes differ for mild-to-moderate cataracts (LOCS III Grade 1-2). In these cases, cumulative dissipated energy (CDE) demonstrated non-inferiority between low-energy FLACS and CPS (4.1 vs 4.5 percent-seconds, $p = 0.51$) (Zhou et al., 2023). Contextualizing this with external quasi-experimental data, we see a remarkably similar trend

where CDE for mild cataracts remained highly comparable regardless of the chosen technique (6.80 ± 0.55 vs 7.03 ± 0.57 percent-seconds, p = 0.80) (Léda et al., 2023).

Preserving ECD and minimizing early postoperative edema are essential for surgical safety. Among our included trials, implementing laser pre-chopping for dense nuclear cataracts drastically limited endothelial cell loss at the 6-month mark to 12.8%, compared to a much steeper 16.08% loss observed in CPS cases ($p < 0.001$) (Ganesh et al., 2024). Furthermore, the conventional phacoemulsification group was significantly more prone to corneal edema during the first day and week post-surgery (Aboumostafa et al., 2023). Because of this, FLACS managed to sustain a significantly higher ECD one month after the operation (2477.25 ± 175.46 cells/mm² vs 2265.70 ± 159.25 cells/mm², $p < 0.01$) (Aboumostafa et al., 2023). For soft-to-moderate cataracts, low-energy FLACS proved non-inferior regarding endothelial cell loss at both 3 months (Zhou et al., 2023) and 6 weeks (Bobot et al., 2026). Mechanistically, supporting literature provides a clear explanation for this phenomenon; external topographical evaluations confirm that while central endothelial cell loss is indeed lower following FLACS, the damage near the main clear corneal wound remains similar due to routine mechanical instrument manipulation (Altansukh et al., 2024). Additional external aqueous humor analyses reveal that FLACS initiates an early surge in pro-repair cytokines (FGF-basic, TGF-β2), pointing to a targeted wound-healing response that fortunately does not exacerbate clinical inflammation (Chychko et al., 2026).

Laser pretreatment accelerates early functional visual recovery. Based on the inclusion data, patients in the FLACS cohort experienced a significantly superior recovery of Best-Corrected Visual Acuity (BCVA) by Day 1 (0.91 ± 0.14 vs 0.70 ± 0.17, $p < 0.05$) (Bobot et al., 2026). Even with this early head start, long-term refractive predictability and IOL alignment (both tilt and decentration) ultimately 1073evelled out, remaining completely equivalent between the two techniques in randomized settings (Casazza et al., 2025b). Although eyes treated with FLACS exhibited a significantly tighter anterior chamber depth (ACD) shift from the first to the sixth month (0.12 ± 0.12 mm vs 0.27 ± 0.16 mm, $p < 0.001$), detailed assessments of rhexis roundness and IOL overlap could not provide a definitive structural explanation for this stability (Casazza et al., 2025b). Regarding optical quality, studies on FLACS with presbyopia or EDOF lenses report reduced higher-order aberrations (HOAs) and trefoil (Chang et al., 2023; Xu et al., 2023), while still delivering excellent visual acuity across all distances that rivals CPS cohorts (Qu et al., 2024; Xiao et al., 2026). Long-term capsular stability for modern hydrophobic IOLs has similarly been externally validated as secure and reliable across both surgical approaches (Casazza et al., 2025a).

Finally, turning our attention to the posterior segment, automated intraretinal layer segmentation via spectral-domain OCT highlighted a significant postoperative increase in total retinal thickness (TRT) for both groups ($p < 0.001$) (Schwarzenbacher et al., 2024). This thickening typically peaked between the third and sixth weeks. Interestingly, TRT remained persistently elevated and failed to retreat to pre-operative baseline measurements even 18 months post-surgery, pointing to a long-term structural tissue response that occurs regardless of the surgical technique utilized (Schwarzenbacher et al., 2024). From a strictly clinical perspective, however, this subclinical macular thickening did not compromise the patients' actual visual acuity (Schwarzenbacher et al., 2024). Moreover, neither the FLACS nor the CPS

cohorts recorded a single instance of clinical pseudophakic cystoid macular edema (CME) during the entire observation period (Ganesh et al., 2024). In terms of thermal safety, manual extraction of dense nuclei triggered three clear corneal wound burns; the FLACS cohort, by contrast, bypassed this complication entirely. This directly aligns with external studies verifying that FLACS remains highly safe for the retina, even in highly myopic eyes (Liang et al., 2024; Slezak et al., 2023) and does not trigger significant intraoperative miosis (Salgado et al., 2023). From a patient comfort perspective, supporting reports confirm that neither the surgical technique nor the timing of anesthesia administration in FLACS significantly affects postoperative pain perception (Cioana et al., 2024). Concerning patient comfort, supporting reports also establish that neither the surgical technique itself nor the specific timing of anesthesia administration during FLACS significantly alters a patient's postoperative pain perception. Ultimately, the current primary evidence base is constrained by modest trial sample sizes, restricted follow-up windows, and variations in laser energy configurations across different clinical centers, strongly emphasizing the need for larger prospective multicenter studies moving forward.

CONCLUSION

The evidence synthesized from recent randomized controlled trials indicates that femtosecond laser-assisted cataract surgery (FLACS) is a generally safe and effective alternative to conventional phacoemulsification for age-related cataracts. However, its clinical benefits appear to vary according to baseline cataract density, femtosecond laser platform, and surgical technique. In patients with dense nuclear cataracts (Lens Opacities Classification System III [LOCS III] nuclear opacity grade ≥3.0), laser-assisted lens fragmentation may offer procedural advantages by reducing ultrasound energy requirements and limiting corneal endothelial cell loss. Nevertheless, the available evidence does not conclusively demonstrate reductions in overall surgical duration or the elimination of thermal wound injury.

For patients with mild-to-moderate nuclear cataracts, low-energy, high-frequency FLACS platforms demonstrated corneal endothelial outcomes comparable to those of conventional phacoemulsification, with some trials reporting faster early postoperative visual recovery. Although FLACS may improve the reproducibility of anterior capsulotomy and contribute to greater stability of certain anterior segment parameters, these anatomical advantages did not consistently translate into superior refractive predictability. Longer-term corrected distance visual acuity and postoperative spherical equivalent outcomes were generally comparable between the two techniques. Furthermore, increases in retinal thickness relative to preoperative measurements were observed during follow-up in some studies; however, the available evidence was insufficient to establish whether these structural changes were associated with clinically significant differences in the incidence of pseudophakic cystoid macular edema.

Overall, FLACS may provide meaningful procedural benefits in selected patients, particularly those with dense nuclear cataracts, but its superiority over conventional phacoemulsification in routine cases involving mild-to-moderate cataracts remains unestablished. The limited number of included trials, methodological heterogeneity, and concerns regarding risk of bias warrant cautious interpretation of these findings. Future

research should prioritize large, adequately powered randomized controlled trials with standardized cataract density stratification, consistent outcome measurements, and extended postoperative follow-up. Comprehensive health economic evaluations are also needed to determine whether the potential clinical advantages of FLACS justify its additional costs and resource requirements compared with contemporary conventional phacoemulsification techniques.

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