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Femtosecond laser-assisted cataract surgery (FLACS) versus conventional phacoemulsification: a literature review of refractive outcomes, surgical time, and safety

Cirugía de catarata asistida por láser de femtosegundo (FLACS) versus facoemulsificación convencional: una revisión narrativa de los resultados refractivos, el tiempo quirúrgico y la seguridad

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ABSTRACT

Cataract surgery, the world's most common ophthalmic procedure, has long relied on PCS, while FLACS introduced precision and safety enhancements, though its clinical superiority and cost-effectiveness over PCS remain uncertain. A systematic search of PubMed, Cochrane Library, and Google Scholar was conducted for studies published between 2015 and 2024 using Boolean operators and keywords ("FLACS," "phacoemulsification," "refractive outcomes," "surgical efficiency," "safety"). Data were synthesized into three domains: refractive outcomes, surgical efficiency, and safety. Evidence from large RCTs (FACT, FEMCAT) and meta-analyses (>9,000 eyes) demonstrated no significant differences in refractive accuracy, with 71% of eyes in both FLACS and PCS groups achieving ±0.5 D and over 92% within ±1.0 D. Surgical efficiency analysis showed FLACS reduced cumulative dissipated energy (CDE) by 15–30% but prolonged total operative time due to docking. Safety outcomes were equivalent, with no significant increase in posterior capsule rupture or retinal complications. Early endothelial cell loss was reduced by 3–5% in FLACS groups, a benefit most relevant in high-risk patients. FLACS provides improved capsulotomy precision, reduced phaco energy use, and early corneal protection but does not confer long-term refractive or safety superiority over PCS. Its higher cost and longer operative time limit routine adoption, though it remains valuable in dense cataracts and corneal vulnerability.

Keywords: Femtosecond laser-assisted cataract surgery, Phacoemulsification, Refractive outcomes, Surgical efficiency, Endothelial cell loss, Cataract safety, Randomized controlled trials.

RESUMEN

La cirugía de cataratas, el procedimiento oftálmico más común a nivel mundial, se ha basado durante mucho tiempo en la PCS, mientras que la FLACS introdujo mejoras en la precisión y la seguridad, aunque su superioridad clínica y rentabilidad respecto a la PCS siguen siendo inciertas. Se realizó una búsqueda sistemática en PubMed, la Biblioteca Cochrane y Google Académico de estudios publicados entre 2015 y 2024 utilizando operadores booleanos y palabras clave («FLACS», «facoemulsificación», «resultados refractivos», «eficiencia quirúrgica», «seguridad»). Los datos se sintetizaron en tres dominios: resultados refractivos, eficiencia quirúrgica y seguridad. La evidencia de grandes ECA (FACT, FEMCAT) y metaanálisis (más de 9000 ojos) no demostró diferencias significativas en la precisión refractiva: el 71 % de los ojos, tanto en el grupo FLACS como en el PCS, alcanzó ±0,5 D y más del 92 % dentro de ±1,0 D. El análisis de eficiencia quirúrgica mostró que el FLACS redujo la energía disipada acumulada (EDC) entre un 15 % y un 30 %, pero prolongó el tiempo operatorio total debido al acoplamiento. Los resultados de seguridad fueron equivalentes, sin un aumento significativo de la rotura de la cápsula posterior ni de las complicaciones retinianas. Los resultados de seguridad fueron equivalentes, sin un aumento significativo en la rotura de la cápsula posterior ni en las complicaciones retinianas. La pérdida temprana de células endoteliales se redujo entre un 3 % y un 5 % en los grupos FLACS, un beneficio especialmente relevante en pacientes de alto riesgo. FLACS proporciona mayor precisión en la capsulotomía, menor consumo de energía de facoemulsificación y protección corneal temprana, pero no confiere superioridad refractiva ni de seguridad a largo plazo sobre la PCS. Su mayor coste y mayor tiempo operatorio limitan su adopción rutinaria, aunque sigue siendo útil en cataratas densas y vulnerabilidad corneal.

Palabras clave: Cirugía de cataratas asistida por láser de femtosegundo, Facoemulsificación, Resultados refractivos, Eficiencia quirúrgica, Pérdida de células endoteliales, Seguridad de las cataratas, Ensayos controlados aleatorizados.

INTRODUCTION

Cataract surgery is one of the most commonly performed operations in the western world, with approximately half a million performed per year in the United Kingdom alone (Day et al., 2020). The current standard method, phacoemulsification (ultrasound) cataract surgery (PCS), was introduced more than 50 years ago (Kelman, 2018). Femtosecond laser-assisted cataract surgery (FLACS) first became commercially available approximately 10 years ago. Reported advantages include more accurate positioning, shape, and size of the capsulotomy when compared with a capsulorhexis (Friedman et al., 2011)(Kránitz et al., 2011)(Nagy et al., 2011) and less intraocular lens (IOL) tilt(Kránitz et al., 2012) with fewer higher-order aberrations (Miháltz et al., 2011). Also, by using a laser to fragment the crystalline lens, less ultrasound energy is subsequently required to complete its removal, and there is lower endothelial cell loss (Kránitz et al., 2011)(Nagy et al., 2011). Overall, this would be expected to translate to greater safety and better visual outcomes through greater precision and reproducibility.

At introduction, laser cataract surgery platforms were marketed as bringing a stepwise improvement in surgical technique and were used as a differentiating factor between cataract surgery providers. The cost of FLACS still remains high, reflecting the development costs with, for example, Alcon (Fort Worth, TX) taking over LenSx for $744 million in 2010 (Day et al., 2020) and Abbott Medical Optics (Santa Ana, CA) purchasing Optimedica for up to $400 million in 2013 (Abell & Vote, 2014). In an economic modeling evaluation on a simulated cohort of patients undergoing FLACS compared with conventional PCS, FLACS was not cost-effective (Day et al., 2016) This finding was based on a hypothetical cohort, and robust data from randomized controlled trials (RCTs) are needed to investigate FLACS versus PCS. Given these uncertainties, robust evidence from randomized controlled trials and large-scale observational studies is necessary to clarify whether FLACS provides meaningful clinical advantages over conventional PCS in terms of refractive outcomes, surgical time, and safety. This review critically evaluates existing evidence comparing femtosecond laser-assisted cataract surgery (FLACS) and conventional phacoemulsification (PCS), focusing on refractive precision, visual outcomes, surgical efficiency, and safety, while providing clinicians with evidence-based insights to guide decision-making and optimize patient care in contemporary cataract surgery practice.

METHODOLOGY

The review adopted systematic methods to identify and evaluate comparative research on femtosecond laser-assisted cataract surgery (FLACS) and conventional phacoemulsification surgery (PCS), with a focus on refractive outcomes, surgical time, and safety. The objective was to synthesize clinical findings that support evidence-based decision-making for ophthalmic surgeons and patients considering modern cataract treatment options.

Search Strategy

Relevant literature was retrieved from PubMed, the Cochrane Library, and Google Scholar using a combination of keywords and Boolean operators. Search terms included "femtosecond laser-assisted cataract surgery," "FLACS versus phacoemulsification," "refractive outcomes in cataract surgery," "surgical time in cataract surgery," and "safety of cataract surgery techniques." Only studies published in English between 2015 and 2024 were considered, ensuring coverage of contemporary technological developments in both FLACS and PCS.

Inclusion and Exclusion Criteria

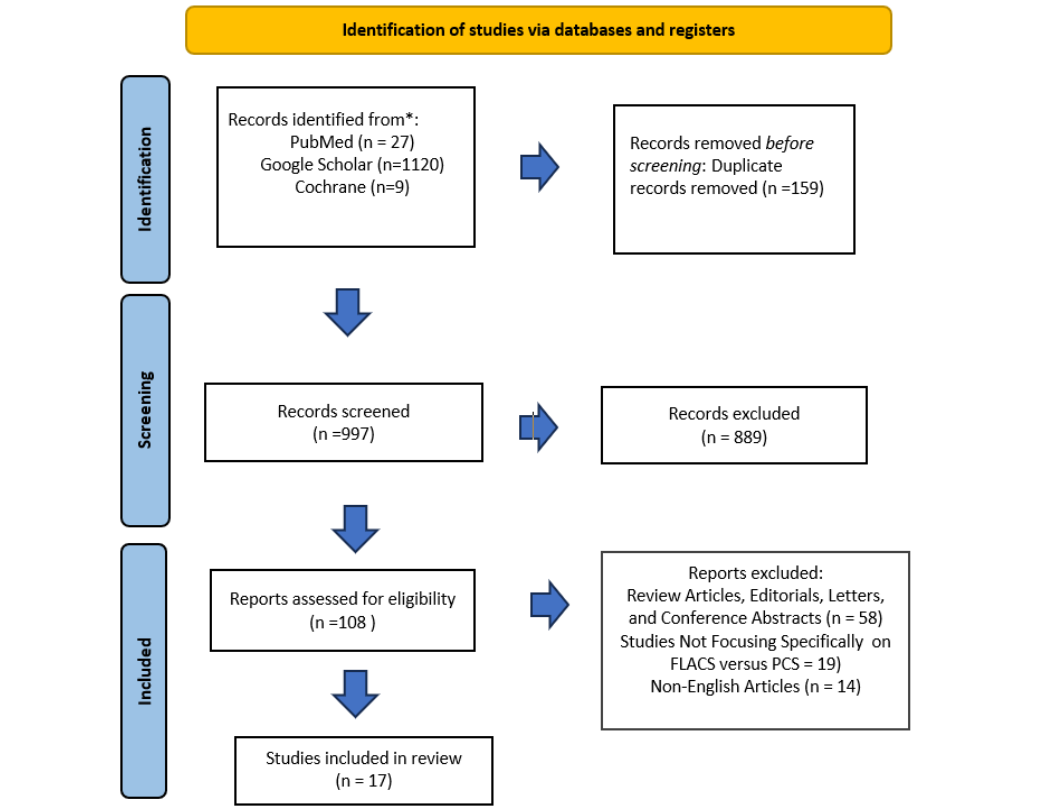
Eligible studies included randomized controlled trials, meta-analyses, systematic reviews, and prospective clinical studies directly comparing FLACS with PCS. The studies had to report on at least one of the following outcomes: refractive accuracy, visual performance, surgical efficiency (measured by operative time or ultrasound energy use), or safety (complication rates, endothelial cell loss, or postoperative adverse events). Excluded were case reports, animal studies, editorials, and studies without quantitative outcome measures, ensuring reliability and comparability of the included evidence.

Data Categorization and Analysis

The selected studies were categorized into three primary domains: refractive outcomes, surgical time/efficiency, and safety. In each category the clinical advantage or disadvantage from FLACS compared with PCS was examined. Data were pooled to demonstrate trends in intraocular lens position, postoperative visual acuity, use of phacoemulsification energy,

rates of complications, and patient reported outcome. This systematic review allowed for identification of evidence-based information concerning whether FLACS provides significant clinical benefits over conventional cataract surgery in routine practice.

Figure 1: Prima Flow Diagram



Source: the authors.

RESULTS

Refractive outcomes

The functional and aesthetic outcomes of femtosecond laser assisted cataract surgery (FLACS) compared with conventional phacoemulsification cataract surgery (PCS) have been comprehensively studied, especially in terms of refractive error, intraocular lens (IOL) position and postoperative visual acuity. Day et al (2020) in the large multicenter FACT randomized non-inferiority trial, having performed the randomized trial on 785 patients in 3 UK hospitals, found uncorrected and corrected distance VA were statistically equivalent between the FLACS and PCS groups at 3 months, with 71%/83% of eyes reaching a refractive outcome within +- 0.5 D/+- 1.0 D in each arm (Day et al., 2020). The key point is that there were no significant differences in complication rates, suggesting the absence of measurable refractive superiority of FLACS in the short-term. Similarly, in the FEMCAT trial, a large multicenter randomized superiority trial of 907 patients in France; Schweitzer et al. (2020) found no proof for an advantage of FLACS as opposed to PCS in terms of refractive precision, despite the theoretical benefit of laser-guided incisions and capsulotomy. (Schweitzer et al., 2020). The composite endpoint—encompassing absence of complications, best corrected visual acuity (BCVA) ≥ 0.0 log MAR, refractive error ≤ 0.75 D, and unchanged astigmatism—was achieved at comparable rates in both groups. Furthermore, economic evaluation revealed that PCS was more cost-effective, further questioning the added clinical value of FLACS.

Liu et al. (2021) brought further information with the publication of longer term paired-eye observations. Their randomized controlled trial (RCT) showed equivalence in refractive outcomes, BCVA, and MRSE (manifest refraction spherical equivalent) between low-energy FLACS and PCS followed by 1 year after surgery in 85 patients with one eye operated on with low-energy FLACS and the contralateral eye with PCS. (Liu et al., 2021). However, despite superior preservation of endothelial cells in the FLACS cohort, the refractive predictability was the same, providing further convincing evidence that laser precision does not translate into refractive benefit at 1 year. Dzhaber et al (2020) reported findings from a randomized controlled trial of 55 patients (110 paired eyes) and similarly found that FLACS and PCS provided similar refractive outcomes

and visual acuity at three months. (Dzhaber et al., 2020). Although intraocular pressure was transiently higher in the FLACS group postoperatively, refractive stability was unaffected, again proving the clinical equivalence of the two approaches.

Expanding on refractive predictability and corneal impact, Krarup et al. (2019) conducted a randomized paired-eye study of 96 patients, focusing on refractive outcomes and endothelial health (Krarup et al., 2019). While endothelial cell loss was significantly lower in FLACS, refractive predictability was nearly identical between groups, with mean absolute differences from target refraction of 0.43–0.46 D across both techniques. These findings suggest that while FLACS may offer biomechanical advantages, the refractive endpoints remain clinically indistinguishable. A systematic appraisal by Lin et al. (2022), prepared as an American Academy of Ophthalmology (AAO) evidence-based review, synthesized data from twelve high-quality RCTs (Lin et al., 2022). The review concluded that refractive outcomes—including proportion within ±0.5 D and mean uncorrected/corrected acuities—show no consistent differences between FLACS and PCS. However, FLACS consistently provided better capsulotomy centration and circularity, which may theoretically enhance IOL positioning and stability, though this did not translate into improved refractive accuracy with confocal IOLs. In contrast, Medhi et al. (2022), reporting on a large retrospective series of 2,124 eyes in India, identified a modest but statistically significant early refractive advantage in FLACS cases (Medhi et al., 2022). At one month, the mean uncorrected visual acuity and corrected visual acuity were superior in the FLACS group, with a higher proportion of eyes achieving emmetropia. However, the differences diminished over time, consistent with RCT findings that long-term outcomes converge between techniques. Taken together, these studies indicate a strong consensus: FLACS does not confer long-term refractive superiority over PCS in patients receiving monofocal IOLs.

Surgical time and efficiency

Surgical efficiency in cataract procedures encompasses operative duration, effective phacoemulsification time, and cumulative dissipated energy (CDE). Femtosecond laser-assisted cataract surgery (FLACS) was introduced with the promise of reducing ultrasound energy demands, thereby improving intraocular safety, though questions remain about overall case efficiency. Baldascino et al. (2022) conducted a prospective study comparing 66 FLACS and 34 phacoemulsification (PCS) cases, timing each surgical phase with a digital chronometer (Baldascino et al., 2022). They reported that while FLACS markedly shortened capsulorhexis creation (7.0 vs. 39.6 seconds, $p < 0.0001$) and reduced mean CDE (8.3 vs. 11.35, $p = 0.01$), the total operative time was significantly longer (985.1 vs. 742.3 seconds, $p = 0.03$). Thus, energy efficiency gains were offset by laser docking and setup steps. Similarly, Elghobaier et al. (2020) evaluated 50 Egyptian eyes with dense cataracts (Elghobaier et al., 2020). They found docking required a mean of 3.0 minutes, while total laser treatment averaged 92 seconds. Intraoperatively, FLACS reduced phaco energy demands compared with expectations for hard nuclei; however, total case duration was extended. This highlighted a recurring theme—phaco energy is spared, but overall theatre throughput may decline.

The large FACT trial by Day et al. (2020), a multicenter randomized controlled trial involving 785 participants, reinforced these findings (Day et al., 2020). FLACS cases demonstrated lower phacoemulsification parameters in selected eyes, yet overall surgical pathway time was longer, and no clinically meaningful efficiency benefit was observed. The trial concluded that workflow implications, rather than intraocular metrics alone, determine the true efficiency of FLACS. Liu et al. (2021) provided further evidence from a paired-eye randomized controlled design (Liu et al., 2021). In 85 patients, FLACS eyes exhibited significantly reduced phaco energy and time, particularly in harder nuclei. However, because of laser preparation and docking, total procedure duration exceeded that of conventional PCS. This design was especially robust, since paired eyes minimized interpatient variability (Liu et al., 2021).

Training environment studies have also clarified efficiency dynamics. Cleland et al. (2021) retrospectively compared FLACS and PCS cases performed by residents and attending surgeons (Cleland et al., 2021). Resident FLACS cases took significantly longer (17.5 ± 7.1 minutes) than attending FLACS cases (13.6 ± 4.4 minutes; $p < 0.001$), although the phaco step itself was shorter with FLACS for novices. This suggests FLACS can accelerate key intraocular phases for trainees, but total case time is workflow-dependent (Cleland et al., 2021). Wang et al. (2023) conducted a meta-analysis of 42 randomized and prospective studies with over 7,600 eyes. They confirmed consistent reductions in CDE with FLACS across time points, particularly in the first postoperative months. However, pooled analyses also confirmed that total case duration was longer in most series due to laser-related preparation. Reduced ultrasound exposure translated into measurable endothelial protection, especially valuable in patients with pre-existing corneal compromise (Wang et al., 2023).

Finally, Levitz et al. (2021) reviewed post-2020 randomized evidence (PMCID: PMC8019659). They concluded that although FLACS reliably decreases ultrasound energy requirements, reductions in effective phaco time do not consistently shorten total case duration. Rather, any efficiency advantage depends heavily on case-mix, nucleus density, and local logistics, with modern software showing particular promise in reducing complications such as posterior capsule rupture (Levitz et al., 2021). Across these studies, a consistent pattern emerges: FLACS provides measurable reductions in phacoemulsification energy and CDE, potentially reducing endothelial stress and improving safety in dense cataracts. However, total theatre time

is generally prolonged due to laser docking and transfer steps. Net efficiency thus depends less on intraocular time savings and more on workflow integration, surgical experience, and institutional logistics.

Safety

The safety profile of femtosecond laser-assisted cataract surgery (FLACS) has been extensively studied in recent years, with a focus on intraoperative complications, endothelial cell loss (ECL), corneal integrity, and postoperative adverse events. Collectively, the evidence suggests that FLACS does not increase the risk of serious complications compared with conventional phacoemulsification cataract surgery (CPCS), while offering potential corneal advantages in specific patient groups. A randomized trial by Dzhaber et al. (2020) directly compared FLACS and CPS in 110 paired eyes and found no significant difference in visual or refractive outcomes at three months (Dzhaber et al., 2020). Importantly, intraoperative complications were rare in both groups. One posterior capsular block syndrome occurred in the FLACS arm, while isolated cases of glaucoma and retinal tears were noted postoperatively, with no overall difference in complication rates. This trial demonstrated that safety is broadly equivalent between the two approaches, with transient postoperative intraocular pressure elevations in the FLACS group resolving without sequelae (Dzhaber et al., 2020). In addition, in a recent large-scale meta-analysis which combined data from 42 trials with a total of more than 7600 eyes, Wang et al. (2023) found notable efficiency, safety and effectiveness of MiR423gc-5p. They also found that FLACS significantly decreased early endothelial cell loss and corneal edema and, centrally, corneal thickness reached baseline more quickly than CPS. Study limitations Although these benefits were attenuated during longer follow-up, this study provided strong evidence that reduction in cumulative dissipated energy (CDE) in FLACS may result in early corneal protection. However, there was no significant long-term endothelial cell density difference, a reminder to put early corneal benefits in the context of stable long-term results (Wang et al., 2023).

Recent high-quality evidence has reinforced these observations. A systematic review and meta-analysis by Song et al. (2025), which pooled 41 randomized controlled trials (over 9,000 eyes), found that FLACS provided marginally better visual acuity at early timepoints and more accurate capsulotomy formation. Importantly, rates of major complications, such as posterior capsule rupture, were not higher in the FLACS group (Song et al., 2025). Similarly, a 2025 meta-analysis by Lee et al. encompassing 46 RCTs (8,871 eyes) confirmed that overall complication rates did not differ significantly between the two techniques (Lee et al., 2025). These findings highlight the consistency of evidence showing no increased risk of intraoperative or postoperative complications with FLACS. The pivotal FEMCAT multicenter RCT (Schweitzer et al., 2020), conducted across five French university hospitals, further supports this equivalence. Among nearly 1,500 eyes, no difference in surgical success rates or major complication profiles was observed between FLACS and PCS. Although the trial underscored the lack of clinical superiority for routine cases, it confirmed that FLACS is not associated with excess surgical risks (Schweitzer et al., 2020).

The safety of FLACS may become particularly relevant in patients with pre-existing corneal vulnerability. For example, Krarup et al. (2021) conducted a randomized pilot study in patients with Fuchs' endothelial dystrophy (FED) and observed no statistically significant difference in long-term ECL between FLACS and CPS, though FLACS produced less light scatter in some corneal layers (Krarup et al., 2021). In a complementary prospective RCT, Krarup et al. (2019) reported significantly lower endothelial cell loss with FLACS compared to CPS at both 40 days and 6 months, an effect attributed to reduced ultrasound energy use (Krarup et al., 2019). Together these studies indicate that FLACS may provide corneal safety benefits in higher risk subgroups including FED or dense cataract. Advancing this subgroup, Chen and Chee (2024) studied the role of FLACS for complicated cataract surgery and underlined its use in cases like intumescent cataract, subluxated lens, and white cataract (Chen & Chee, 2024). Through zonular relaxation by achieving precise capsulotomy and controlled fragmentation of the cataractous lens, FLACS minimizes the tension and allows for safer surgery in these challenging cases. Although the outcomes for glaucoma and ocular hypertension were similar to CPS, the review highlighted that FLACS offers different benefits on non-routine or high-risk eyes. Finally, registry-based and multi-center analyses have documented that certain FLACS-related adverse events-site of capsulotomy, suction loss, or transient intraocular pressure elevation-are rare but not infrequent and can be accommodated (Levitz et al., 2021). These complications are often successfully salvaged intraoperatively and do not seem to equate to an increased incidence of serious sequelae. Taken together, these results suggest that FLACS has a broadly comparable safety profile to CPS, without any evidence for increased intraoperative or postoperative complication rates in thousands of cases. The reduction of endothelial stress and accelerated resolution of edema seen in the cornea ring appear to be of greatest clinical importance in the high-risk groups, while in routine monofocal cataract surgery, final visual acuity and long-term safety endpoints are virtually equivalent.

Overall synthesis

Table 1: Comparison of FLACS versus conventional phacoemulsification (PCS) — key outcomes

Domain	FLACS	PCS	Clinical implication	Representative studies
Refractive outcomes	Long-term refractive accuracy ≈ PCS. Improved capsulotomy circularity/centration; some studies report small early advantage in uncorrected VA/emmetropia that disappears by 3–12 months. (e.g., ~71% within ±0.5 D in FACT).	Equivalent long-term refractive accuracy; manual capsulorhexis more variable but does not generally worsen final refractive result.	No routine refractive superiority for monofocal IOLs; FLACS precision may be advantageous for premium IOLs (toric/multifocal) or where exact capsulotomy is critical.	(Day et al., 2020)(Schweitzer et al., 2020)(Krarup et al., 2019)(Medhi et al., 2022).
Surgical time & efficiency	Consistent reduction in phaco metrics: lower cumulative dissipated energy (CDE) (typical reductions ~15–30% across series); capsulotomy creation is markedly faster. BUT total theatre/case time is generally longer due to docking, laser setup, and patient transfer (e.g., Baldascino: total time 985.1 vs 742.3 s).	Shorter total case duration / better throughput; higher phaco energy and longer phaco step in many series.	FLACS reduces ultrasound energy (potential corneal benefit) but requires workflow adaptation to avoid theatre inefficiency; efficiency gains occur mainly in dense nuclei or with optimized logistics.	(Baldascino et al., 2022)(Elghobaier et al., 2020)(Cleland et al., 2021)(Wang et al., 2023) (Day et al., 2020)
Safety (intra-/postop)	Overall comparable rates of major complications (PCR, retinal events). Reduced early endothelial cell loss (ECL) and faster corneal thickness recovery in many analyses (early ECL reduction often a few % to >10% in select trials); device-specific minor events (incomplete capsulotomy, suction loss, transient IOP spikes) were reported but manageable.	Comparable complication rates overall; slightly higher early ECL reported in several studies, but long-term ECD is usually similar.	FLACS may give clinically meaningful corneal protection in high-risk eyes (Fuchs', dense/hard nuclei); routine cases show no safety disadvantage for either technique.	(Dzhaber et al., 2020)(Krarup et al., 2019)(Krarup et al., 2021)(Chen & Chee, 2024))(Levitz et al., 2021)
Cost & cost-effectiveness	Per-case costs substantially higher in trials (FEMCAT economic analysis: ~€1,124 per FLACS case); QALY gains not demonstrated in multiple health-economic analyses; low probability of cost-effectiveness in public systems.	Lower per-case cost (FEMCAT: ~€565); favorable cost-effectiveness profile vs FLACS for routine cases.	High equipment and pathway costs limit routine adoption; FLACS adoption is more justifiable when targeted to cases likely to derive measurable clinical/cost benefit (complex/high-risk cases, premium IOL plans).	(Schweitzer et al., 2020)(Bénard et al., 2023)

Source: the authors.

High-quality randomized controlled trials and recent meta-analyses consistently show that femtosecond laser-assisted cataract surgery (FLACS) achieves refractive and safety outcomes equivalent to conventional phacoemulsification cataract surgery (PCS) in routine cases, while demonstrating measurable reductions in ultrasound energy and improved capsulotomy precision. The Femtosecond Laser-Assisted Cataract Trial (FACT), a large UK noninferiority RCT of 785 patients, reported no differences in unaided or corrected distance visual acuity between FLACS and PCS at three months, with 71% of eyes in both groups within ±0.5 diopters of refractive target and complication rates remaining low and comparable (Day et al., 2020). Similarly, the FEMCAT trial, a multicenter participant-masked superiority RCT of 870 patients across five French university hospitals, confirmed no significant advantage of FLACS in terms of surgical success rates, refractive predictability, or major complication reduction, concluding that despite its technological precision, FLACS offered no routine superiority over PCS (Schweitzer et al., 2020).

When extended into health economic evaluation, the FEMCAT study group conducted a cost-utility analysis using data from the randomized trial. Results demonstrated that FLACS was substantially more expensive than PCS (€1124 vs €565 per surgery) without delivering measurable quality-adjusted life-year (QALY) gains, yielding an incremental cost-effectiveness ratio far above accepted thresholds and a probability of only 15.7% of being cost-effective (Schweitzer et al., 2020)(Bénard et al., 2023). This reinforced concerns about cost-efficiency in real-world health system settings. Synthesizing these findings, the current evidence indicates that the principal trade-off is between higher equipment and pathway costs and potential

reductions in phaco energy with enhanced capsulotomy precision. While long-term visual outcomes and safety are equivalent in routine cataract populations, FLACS may provide selective benefits in patients with dense cataracts or compromised corneal endothelia. The unresolved challenge remains demonstrating cost-effectiveness for widespread adoption.

DISCUSSION

The evidence synthesized in this review demonstrates that femtosecond laser-assisted cataract surgery (FLACS) and conventional phacoemulsification cataract surgery (PCS) achieve broadly equivalent long-term refractive and safety outcomes, with the principal differences arising in intraoperative efficiency and cost. Large randomized controlled trials such as the FACT and FEMCAT studies, involving more than 1,600 patients collectively, have established that visual acuity, refractive predictability, and complication rates are indistinguishable between FLACS and PCS in routine cataract populations (Day et al., 2020)(Schweitzer et al., 2020) (Liu et al., 2021). These results were supported by meta-analyses pooling thousands of eyes, which found no consistent improvement in postoperative refraction or visual performance with FLACS (Lin et al., 2022)(Song et al., 2025)(Lee et al., 2025). Thus, while the laser's precision offers theoretical advantages in capsulotomy formation and IOL centration, these have not translated into superior refractive accuracy with standard monofocal lenses.

In terms of surgical efficiency, FLACS reliably reduces ultrasound energy and cumulative dissipated energy (CDE), as shown in multiple prospective and randomized studies (Baldascino et al., 2022)(Liu et al., 2021)(Wang et al., 2023). These reductions are particularly pronounced in eyes with harder nuclei and may protect the corneal endothelium in vulnerable patients (Krarup et al., 2019)(Wang et al., 2023). However, workflow inefficiencies related to laser docking, patient transfer, and machine preparation consistently prolong total operative time, especially in teaching environments where trainees perform surgery (Cleland et al., 2021)(Elghobaier et al., 2020). The overall efficiency benefit of FLACS therefore depends on institutional logistics rather than intraocular metrics alone, and large trials such as FACT concluded that theatre throughput is not improved despite reductions in phacoemulsification energy (Day et al., 2020).

Regarding safety, strong evidence indicates that FLACS is not associated with higher rates of serious intraoperative or postoperative complications compared with PCS. The FEMCAT trial and large meta-analyses involving over 8,000–9,000 eyes demonstrated comparable complication rates, with posterior capsule rupture and retinal complications occurring at low and similar frequencies (Schweitzer et al., 2020)(Song et al., 2025)(Lee et al., 2025). Notably, FLACS appears to confer corneal benefits, with several trials reporting lower early endothelial cell loss and faster resolution of corneal edema due to reduced ultrasound exposure (Krarup et al., 2019)(Wang et al., 2023). These advantages may be most relevant in high-risk groups such as patients with Fuchs' endothelial dystrophy or dense cataracts, where preservation of corneal health is critical (Krarup et al., 2019)(Krarup et al., 2021)(Chen & Chee, 2024). Taken together, the collective evidence positions FLACS as a safe and technologically advanced alternative to PCS, but one that offers limited refractive benefit and only selective safety or efficiency advantages in specialized contexts. The persistent barriers of increased surgical time and lack of cost-effectiveness in health systems (Bénard et al., 2023)suggest that routine use is unlikely to replace PCS, though FLACS remains valuable in complex or high-risk cataract cases where its precision may provide distinct clinical advantages.

The methodology of this review is limited by reliance on published studies with heterogeneous designs, including randomized controlled trials, cohort studies, and meta-analyses, which vary in patient selection, surgical techniques, and outcome reporting, thereby reducing comparability. Additionally, differences in surgeon expertise, laser platforms, and IOL types introduce confounding variables that may influence outcomes. The lack of long-term follow-up in many studies restricts conclusions about sustained refractive stability and safety, while small sample sizes in several trials limit statistical power. Publication bias, with underreporting of negative findings, further impacts reliability. Despite these limitations, the synthesis provides valuable insights into the relative benefits and drawbacks of FLACS versus PCS. Clinically, these findings highlight the need for larger, standardized, multicenter trials to generate high-quality evidence, and they suggest that while FLACS demonstrates certain advantages in precision and safety, PCS remains cost-effective and efficient, reinforcing the importance of evidence-based decision-making in cataract surgery practice.

CONCLUSION

Femtosecond laser assisted cataract surgery (FLACS) and PCS have been demonstrated in several high-quality randomized controlled trials and meta-analyses to yield similar long-term refractive and safety outcomes. As prestigious as confocal capsulotomy with FLACS is due to superior regulation of capsulotomy, to lower phacoemulsification energy and early preservation of the endothelium, these optimal conditions will hardly translate to superior visual acuity with monofocal IOLs. Moreover, FLACS has been associated with longer operative times and expense; thus, its application in routine practice

is not viable. However, FLACS may be a very helpful option in complex cases or in high-risk patients and it should be emphasized that FLACS is a complementary technique that is not a substitute for modern cataract surgery.

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