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SYSTEMATIC REVIEW

Femtosecond laser-assisted cataract surgery (FLACS) versus conventional phacoemulsification in cataract management: a systematic review

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ABSTRACT

Background: Cataracts remain the leading cause of reversible blindness and visual impairment worldwide. While phacoemulsification surgery (PCS) remains a highly effective and safe procedure, its success can be influenced by associated complications. Femtosecond laser-assisted cataract surgery (FLACS) has emerged as an alternative, offering greater safety, efficacy, and predictability, particularly for complex cataracts. **Objective**: This study aims to compare FLACS with PCS to evaluate differences in outcomes such as uncorrected distance visual acuity (UDVA), best-corrected visual acuity (BCVA), endothelial cell density (ECD), endothelial cell loss (ECL), and intraoperative complications. **Materials and Methods**: Following PRISMA guidelines, a systematic review was conducted. Studies published between 2015 and 2021 were identified through databases including PubMed, ScienceDirect, and Cochrane Library. Included studies involved cataract patients undergoing either FLACS or PCS, with outcomes measured for visual acuity, corneal cell integrity, and surgical complications. **Results:** FLACS demonstrated faster recovery in UDVA and BCVA within the initial postoperative period compared to PCS, although visual acuity results were similar by three to 12 months. While short-term endothelial preservation was similar, FLACS was associated with slightly higher long-term ECL, suggesting that PCS may better preserve corneal health over time. Complications such as anterior capsule tears were more frequent in FLACS. However, serious events were rare across both groups. FLACS yielded more precise corneal incisions, which may contribute to more stable wound healing during the early recovery stage. **Conclusion:** FLACS offers advantages in early postoperative visual recovery. However, PCS may provide slightly better long-term endothelial preservation. Both techniques ultimately result in similar visual outcomes in the long term, with FLACS presenting unique yet manageable intraoperative risks.

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Highlights

1. FLACS demonstrates faster initial recovery in visual acuity compared to PCS, offering an early postoperative advantage for patients prioritizing rapid vision restoration.
2. While FLACS shows slight long-term endothelial cell loss, both FLACS and PCS ultimately deliver comparable visual outcomes, highlighting the potential advantage of PCS in corneal preservation over time.

BACKGROUND

Cataracts remain the leading cause of reversible blindness and visual impairment worldwide. This condition arises when the eye's lens, a transparent, biconvex structure essential for refracting and focusing light onto the retina, loses its transparency due to lens opacification (Lam et al., 2015; Liu et al., 2017). Cataract-related blindness is more prevalent among populations with lower socioeconomic status and in developing countries compared to developed nations (Lam et al., 2015), with an estimated incidence of 20 million people and only a small proportion of patients undergoing cataract surgery (Isaacs et al., 1996). The World Health Organization (WHO) estimated that approximately 95 million individuals were affected by vision impairment due to cataracts in 2014. Population-based studies indicate that the prevalence of cataracts increases with age, particularly among individuals over 80 years old (Liu et al., 2017). While the primary etiology of cataracts is age-related, numerous factors accelerate cataract development. Key contributors include diabetes, hypertension, smoking, and prolonged exposure to ultraviolet radiation (Davis, 2016). In addition to managing risk factors, surgical intervention remains the most effective treatment for cataracts, significantly improving quality of life and offering cost-effectiveness. In 2020, it was estimated that over 30 million individuals worldwide undergo cataract surgery annually (Alshamrani, 2018).

Surgery is an effective medical approach for treating cataract by inserting an intraocular lens (IOL) (Shahsuvaryan, 2016). However, providing a high-quality cataract surgery remains challenging, especially in developing countries. The aim is not only to restore vision by measuring their visual acuity but also to ensure a safe procedure. Suboptimal outcomes for visual acuity post-surgery remain common in developing countries (Lindfield et al., 2012). The replacement of clouded crystalline lens with an IOL is a standard procedure in cataract surgery. However, this procedure faces challenges due to comorbidities and the risk of complications (Roach, 2014).

Conventional phacoemulsification surgery (PCS), first introduced as a method for cataract removal, remains a highly effective and safe procedure. However, PCS is expensive and requires extensive surgical expertise. In cases of mature cataracts, this procedure can be challenging and have a higher risk of complications (Chang, 2005). Moreover, individual anatomical variations and associated complications can affect postoperative outcomes, including vision and refractive improvements (Toledo et al., 2022). Therefore, femtosecond laser-assisted cataract surgery (FLACS) has emerged as an alternative, offering greater safety, efficacy, and predictability, particularly for complex cataract cases (Lam et al., 2015; Toledo et al., 2022). Some benefits and outcomes of FLACS, however, remain uncertain. Therefore, this systematic review aims to compare FLACS with conventional phacoemulsification.

OBJECTIVE

This systematic review aims to compare the efficacy and safety of FLACS versus conventional phacoemulsification and to evaluate differences in outcomes.

MATERIALS AND METHODS

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) framework (Page et al., 2021).

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Eligibility criteria

To enhance the specificity of this review, inclusion and exclusion criteria were established prior to the literature search. The inclusion criteria comprised randomized controlled trials (RCTs) and observational studies published within the past 10 years. The sample population included cataract patients in general, including those with complications. The intervention involved patients undergoing FLACS compared to those undergoing phacoemulsification cataract surgery (PCS). The inclusion criteria were based on the PICOS framework: (1) population: patients diagnosed with cataracts and undergoing surgery; (2) intervention: FLACS; (3) comparison: patients undergoing phacoemulsification surgery; (4) outcome: uncorrected distance visual acuity (UDVA), best-corrected visual acuity (BCVA), endothelial cell density (ECD), endothelial cell loss (ECL), and intraoperative complications; and (5) study design: RCTs and observational studies. Exclusion criteria included: (1) studies irrelevant to the objective; (2) non-human trials and studies; (3) clinical trials; (4) articles written not in English; and (5) grey literature.

Search strategy

From September 1 to October 15 2024, two independent researchers (VSD and SD) conducted a systematic search of numerous databases including ScienceDirect, PubMed, Google Scholar, and the Cochrane Library. The search strategy used the following keywords: (“Cataracts” OR “cataract” OR “membranous”) AND (“Femtosecond Laser-Assisted Cataract” OR “Phacoemulsification” OR “Surgery”) AND (“Efficacy” OR “Safety” OR “complication”).

Data extraction and analysis

Two authors (VSD and SD) independently extracted the selected studies using a Google Sheet. The accuracy and eligibility of each study were assessed, followed by a critical evaluation. Any discrepancies that arose during the process were resolved through discussion.

Risk of bias assessment

The Cochrane Risk of Bias Tool 2 for RCTs was employed to assess the risk of bias in the included studies. The instrument assesses five domains: randomization process, deviations from intended interventions, incomplete outcome data, outcome measurement, and selection of reported results. Each study was categorized as having a low, moderate, or high risk of bias.

Outcome of interest

The outcomes analyzed included uncorrected distance visual acuity (UDVA), best-corrected visual acuity (BCVA), endothelial cell density (ECD), endothelial cell loss (ECL), and intraoperative complications.

RESULTS

Characteristics of included studies

The literature search followed the PRISMA guidelines, as shown in Figure 1. Initially, 526 articles were screened, narrowed down to 16 full-text articles assessed for eligibility. In total, 11 articles met the inclusion criteria and were analyzed, encompassing a total of 4,238 participants. The selected studies, published between 2015 and 2021, are summarized in Table 1. They include six RCTs and five cohort studies. The studies were conducted in various countries, including the United Kingdom (n = 2), France (n = 2), China (n = 3), the United States (n = 2), Singapore (n = 1), and Germany (n = 1). Follow-up durations ranged from preoperative assessments to postoperative evaluations conducted within a year.

Uncorrected distance visual acuity (UDVA)

This systematic review evaluates the efficacy of FLACS in comparison to PCS, with a focus on UDVA outcomes across various follow-up periods and clinical settings. The included studies were conducted in diverse institutions such as NHS hospitals in the United Kingdom, French university hospitals, and the Singapore National Eye Centre. UDVA was consistently used as a primary outcome measure. The findings showed significant improvements in UDVA postoperatively for both FLACS and PCS groups. Notably, the FLACS group demonstrated faster UDVA recovery during the early postoperative period, especially within the first month.

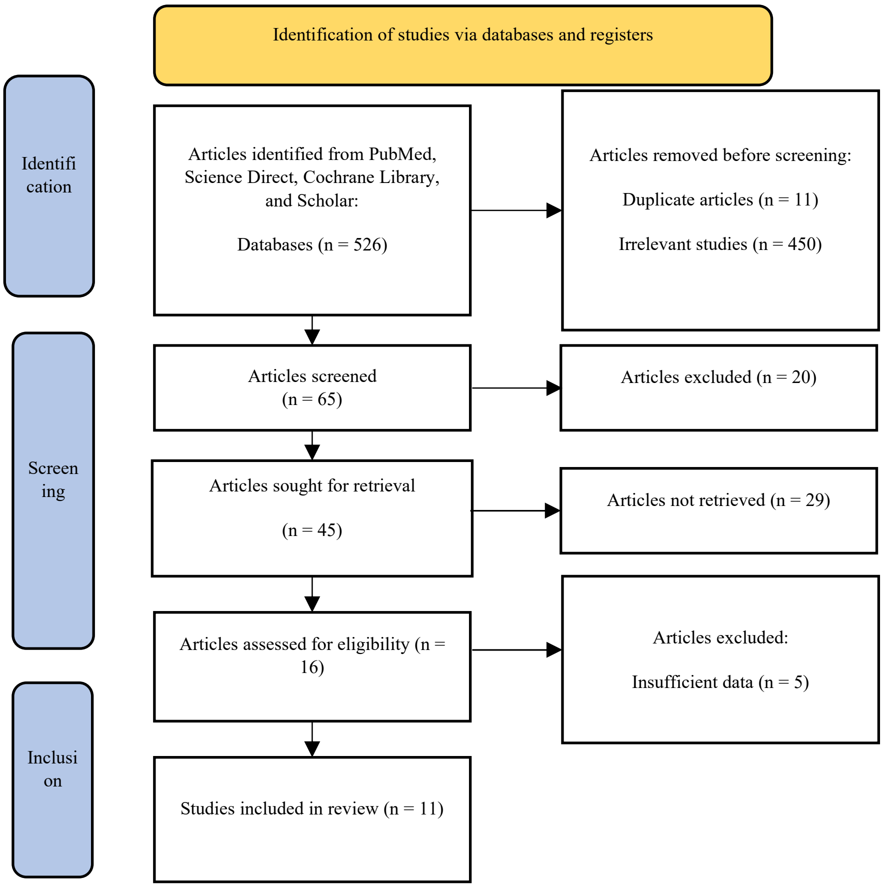

Figure 1. PRISMA flowchart

Wang et al. (2019) reported that FLACS patients achieved better UDVA in the initial week post-surgery than those undergoing PCS, although both groups exhibited comparable visual acuity at the one-month follow-up. Roberts et al. (2019) and Schweitzer et al. (2020) observed similar trends, with FLACS patients showing faster recovery in UDVA that generally evened out with PCS outcomes by the three- to 12-month follow-up, with no statistically significant differences observed at the later checkpoints. In summary, FLACS may provide a slight advantage in early visual recovery, which could benefit patients prioritizing rapid visual acuity restoration postoperatively. However, long-term outcomes suggest minimal difference between FLACS and PCS in UDVA outcomes by 3-12 months, indicating that both techniques ultimately yield comparable visual acuity in the long term.

Best-corrected visual acuity (BCVA)

This review assesses BCVA outcomes following FLACS compared to PCS across various postoperative follow-up intervals. The reviewed studies assessed BCVA using the logMAR scale, where lower values indicate better visual acuity. While both surgical techniques resulted in improved BCVA, FLACS showed variable advantages in early postoperative recovery, which tended to converge with PCS outcomes in the mid to long term.

Wang et al. (2019) found that patients undergoing FLACS achieved better UDVA in the initial week post-surgery than those undergoing PCS, although both groups exhibited comparable visual acuity at the one-month follow-up. Roberts et al. (2019) and Schweitzer et al. (2020) observed similar trends, with faster UDVA recovery among FLACS patients that generally evened out with PCS outcomes by

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the three to 12 months postoperatively, with no statistically significant differences observed at the later intervals. In summary, FLACS may provide a slight advantage in early visual recovery, which could benefit patients prioritizing rapid visual acuity restoration postoperatively. However, long-term outcomes suggest minimal difference between FLACS and PCS in UDVA outcomes by 3-12 months, indicating that both techniques ultimately yield comparable visual acuity in the long term.

In the early postoperative period, Crozafon et al. (2021) and Vasavada et al. (2019) observed that FLACS yielded slightly better BCVA outcomes than PCS. For example, at one week, Crozafon et al. (2021) reported BCVA values of -0.14 logMAR in the FLACS group versus -0.12 logMAR in the PCS group. Similarly, Vasavada et al. (2019) noted a difference of 0.089 logMAR for FLACS compared to 0.178 logMAR for PCS. Liang et al. (2024) also found FLACS to outperform PCS at one week (0.26 vs. 0.48 logMAR), indicating a more rapid recovery in visual acuity. However, Chee et al. (2021) and Vasavada et al. (2019) documented slight differences by the one-month mark, suggesting that initial advantages may decrease over time.

At longer-term follow-ups, such as three to six months, BCVA differences between FLACS and PCS groups were generally small and statistically insignificant. Schweitzer et al. (2020) reported that at three months, both FLACS and PCS groups achieved nearly identical BCVA outcomes (–0.21 vs. –0.23 logMAR, respectively). Similarly, Conrad-Hengerer et al. (2015) and Crozafon et al. (2021) observed small differences at six months, with both groups achieving comparable BCVA outcomes (e.g., -0.17 vs. -0.16 logMAR for FLACS and PCS, respectively).

In conclusion, FLACS may offer a slight BCVA advantage in the very early postoperative period. However, by three to six months, BCVA outcomes for FLACS and PCS generally align, demonstrating that both methods ultimately yield similarly favorable results for long-term visual acuity. This finding suggests that while FLACS may benefit patients seeking rapid visual recovery, long-term BCVA outcomes remain comparable across both surgical techniques.

Endothelial cell density (ECD)

This review examines ECD following FLACS compared to PCS at various postoperative intervals. ECD loss is a critical measure of corneal health post-surgery, as significant loss can compromise corneal transparency and visual quality. In the short-term follow-up at one month, Dzhaber et al. (2020) reported similar ECD values between FLACS and PCS groups, with FLACS at 2370 ± 580 cells/mm² and PCS at 2374 ± 527 cells/mm², suggesting comparable endothelial damage in both procedures initially. However, by the three-month mark, Dzhaber et al. (2020) observed a slightly higher mean ECD in the PCS group (2433 ± 526 cells/mm²) compared to the FLACS group (2374 ± 527 cells/mm²), indicating a minor difference in cell preservation favoring PCS.

At six months, results varied across studies. Vasavada et al. (2019) found that PCS maintained a slightly higher ECD (2246 ± 570.3 cells/mm²) than FLACS (2157 ± 392.7 cells/mm²). Similarly, Chee et al. (2021) reported a higher ECD for PCS at six months, with values of 2247 ± 376 cells/mm² for FLACS compared to 2513 ± 358 cells/mm² for PCS. These findings suggest a trend toward greater endothelial preservation in PCS compared to FLACS by six months postoperatively. In the long-term follow-ups, Day et al. (2021) noted changes in endothelial cell counts at both three and 12 months postoperatively. At three months, the FLACS group had a mean ECD loss of 242 cells/mm², compared to 200 cells/mm² in the PCS group. By 12 months, this trend continued, with FLACS showing a mean loss of 228 cells/mm², while PCS had a slightly lower mean loss of 175 cells/mm².

In summary, while both FLACS and PCS demonstrate similar endothelial cell loss initially, FLACS may be associated with slightly higher long-term endothelial cell loss. This finding may indicate a potential benefit of PCS in terms of corneal endothelial preservation, particularly for patients at higher risk of endothelial cell damage.

Endothelial cell loss (ECL)

In the early postoperative period at one month, studies reported mixed results. Dzhaber et al. (2020) reported a higher mean ECL for FLACS at 10.7 ± 20.0% compared to PCS at 6.8 ± 18.0%. Conversely, Chee et al. (2021) found that ECL in the PCS group (11.96 ± 4.1%) was notably higher than in the FLACS group (6.78 ± 3.62%), suggesting that FLACS may provide better early endothelial preservation in some cases. At three months postoperatively, Vasavada et al. (2019) observed similar ECL values between FLACS (9.76 ± 1.6%) and PCS (9.85 ± 1.1%), indicating small differences between the two techniques in endothelial cell survival during this period. However, Dzhaber et al. (2020) noted a higher ECL in FLACS (11.2 ± 17.9%) compared to PCS (8.0 ± 18.5%), suggesting a potential advantage for PCS in terms of endothelial preservation.

At six months postoperatively, the trend toward slightly higher endothelial preservation in PCS continued. Vasavada et al. (2019) reported an ECL of 7.55 ± 1.8% in the FLACS group, compared to 8.20 ± 0.87% in the PCS group. Conrad-Hengerer et al. (2015) also noted that ECL was lower in FLACS (7.5 ± 2.8%) compared to PCS (9.2 ± 3.1%), suggesting that both techniques are comparable but may exhibit minor differences based on individual study contexts. In summary, while both FLACS and PCS show similar trends in ECL over time, slight variations were observed across studies. Early postoperative differences may favor FLACS in certain cases, but PCS appears to offer slightly better long-term endothelial preservation in others.

Intraoperative complications

This review examines the incidence of eyes experiencing intraoperative complications in FLACS compared to PCS, synthesizing data from several studies to assess relative risks and safety profiles. Overall, anterior capsule tears were slightly more common in the FLACS group, with Schweitzer et al. (2020), Day et al. (2021), and Chee et al. (2021) reporting rates of 3% for FLACS compared to 2% for PCS. Similarly, Crozafon et al. (2021) noted an anterior capsule tear rate of 1.6% for FLACS within the first postoperative week, compared to 1.1% for PCS. Posterior capsule tears, whether accompanied by vitreous loss or not, were rare in both procedures, typically occurring at or near 0%. Crozafon et al. (2021) observed a posterior capsule rupture rate of 0.6% within the first week in FLACS, compared to 1.1% in PCS.

Intraoperative pupil constriction that required intervention occurred more frequently in FLACS, with Day et al. (2021) and Chee et al. (2021) both reporting a 3% incidence, whereas the rate in PCS was 1%. Additionally, incomplete laser capsulotomy, a complication unique to FLACS, was consistently reported at 4% by Schweitzer et al. (2020) and Chee et al. (2021). In terms of corneal edema and intraocular pressure (IOP), Crozafon et al. (2021) reported a higher incidence of corneal edema in PCS, with rates of 8.1% within one month compared to 4.6% in FLACS. Similarly, uncontrolled IOP within the first postoperative week was more frequent in PCS at 3.2%, compared to 1.0% in FLACS. Notably, posterior capsular block syndrome (PCBS), a rare but unique complication, was observed exclusively in the FLACS group by Dzhaber et al. (2020), occurring at a low rate of 1.5%.

In summary, while serious intraoperative complications, such as posterior capsule tears and zonular dialysis, are rare in both FLACS and PCS, FLACS is associated with a slightly higher risk of specific issues such as incomplete laser capsulotomy and anterior capsule tears. PCS, on the other hand, shows a slightly elevated rate of corneal edema and uncontrolled IOP shortly after surgery. These findings suggest that while both surgical techniques are safe, FLACS introduces distinct risks associated with laser-assisted steps.

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Table 1. Summaries of Included Studies

No.	References Study Design Center(s)	Follow-Up Duration Post-Surgery (Months/ Years)	Population Group	Sample Size (n)	Age (Mean ± SD)	Population Characteristics	Outcome of Interest			
							UDVA	BCVA	ECD	ECL
1.	Day, 2021 RCT UK (17)	3rd and 12th month	**FLACS**	393	68	**Pre-operative corneal astigmatism, n (%)** - < 0,75 dioptre: 194 (49) - 0,75 to<2.0dioptre: 163 (42) - ≥ 2.0 dioptre: 34 (8.7) **Habitual UDVA logMAR:** 0.61 (0.46) **endothelial cell count:** 2640 ± 334	**3 Months post-op** ● logMAR (imputed): 0.13 (0.23); n = 392 ● logMAR (complete case): 0.13 (0.23); n = 352 ● logMAR (per protocol): 0.13 (0.22); n = 334 **12 Months post-op** ● logMAR (study eye): 0.14 (0.22); n = 310 ● logMAR (both eyes open): 0.05 (0.16); n = 310	**3 Months:** –0.01 ± 0.19; n = 352 **12 Months:** ● logMAR, study eye: 0.003 ± 0.18; n = 311 ● logMAR, both eyes: –0.05 ± 0.11; n = 310 -	**Change in endothelial cell count, mean loss** **3 Months:** 242 ± 416; n = 345 **12 Months:** 228 ± 353; n = 304	-
			PCS	393	68 ± 10	● **Pre-operative corneal astigmatism, n (%)** ● < 0,75 dioptre: 177 (45) ● 0,75 to <2.0 dioptre: 184 (47) ● ≥ 2.0 dioptre: 29 (7.4) ● **Habitual UDVA logMAR**: 0.68 (0.50) ● **endothelial cell count:** 2604 ± 348	**3 Months post-op** ● logMAR (imputed): 0.14 (0.27); n = 393 ● logMAR (complete case): 0.14 (0.26); n = 317 ● logMAR (per protocol): 0.14 (0.26); n = 317 **12 Months post-op** ● logMAR (study eye): 0.17 (0.25); n = 291 ● logMAR (both eyes open): 0.07 (0.20); n = 292	**3 Months:** 0.01 ± 0.21; n = 317 **12 Months:** ● logMAR, study eye: 0.03 ± 0.23; n = 292 ● logMAR, both eyes: –0.03 ± 0.17; n = 291	**Change in endothelial cell count, mean loss** **3 Months:** 200 ± 369; n = 308 **12 Months:** 175 ± 312; n = 284	-
2.	Schweitzer, 2020 RCT France (18)	Postoperative, 4th day, 1st, 3rd, and 12th month	**FLACS**	440	72.4 ± 8.6	● **endothelial cell count:** 2569 ± 405 ● **Baseline UCVA:** 0.64 ± 0.44 ● **Baseline BCVA:** 0.24 ± 0.24	**3 Months:** 0.14 ± 0.19	**3 Months:** –0.21 ± 0.24 LogMAR	-	-

			PCS	430	72.1 ± 8.7	• **endothelial cell count:** 2526 ± 409 • **Baseline UCVA:** 0.69 ± 0.46 • **Baseline BCVA:** 0.25 ± 0.26	**3 Months:** 0.13 ± 0.18	**3 Months:** –0.23 ± 0.26 LogMAR	-	-
3.	Roberts, 2019 RCT UK (19)	Pre-operative, the day, 1st month	**FLACS**	200	69.9 ± 10.9	• **Preoperative ECD:** 2505 ± 313 cells/mm2 • **Intraocular pressure CDE**: 9.6 ± 7.0	**1 Month:** 0.15 ± 0.19	-	-	-
			CPS	200	70.5 ± 9.8	• **Preoperative ECD:** 2534 ± 327 cells/mm2 • **Intraocular pressure CDE**: 11.1 ± 9.8	**1 Month:** 0.15 ± 0.21	-	-	-
4.	Wang, 2020 Cohort Prospective China (15)	Pre-operative, post-operative, 1st week, and 1st month	**FLACS** + Tobramycin and dexamethasone eye drops (4 times daily until 14th day post surgery; once a day for 30 days post-surgery) + Pranofen eye drops (3 times daily for 30 days post surgery)	50	56.66 ± 5.68	• **Baseline UCVA:** 0.86 ± 0.44 • **Baseline BCVA:** 0.74 ± 0.49 • **Baseline DLI:** 2.65 ± 0.78	**1 Week:** 0.19 ± 0.24 **1 Month:** 0.21 ± 0.17	**1 Week:** 0.19 ± 0.39 **1 Month:** 0.19 ± 0.28 **6 Months:** 0.19 ± 0.28	-	-
			PCS + Tobramycin & dexamethasone eye drops (4 times daily until 14th day post surgery; once a day for 30 days post-surgery) + Pranofen eye drops (3 times daily for 30 days post surgery)	50	61.33 ± 7.52	• **Baseline UCVA:** 0.69 ± 0.32 • **Baseline BCVA:** 0.58 ± 0.34 • **Baseline DLI:** 3.14 ± 1.73	**1 Week:** 0.16 ± 0.23 **1 Month:** 0.19 ± 0.28	**1 Week:** 0.18 ± 0.14 **1 Month:** 0.12 ± 0.18 **6 Months:** 0.12 ± 0.18	-	-

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5.	Crozafon, 2021 Cohort Retrospective France (20)	1st week, 1st month, and 6th month	**FLACS**	496	71.7 ± 9.0	• **Endothelial cell count:** 2362 ± 381 • **Baseline BCVA:** 0.21 ± 0.19	-	**1 Week:** -0.14 logMAR **1 Month:** -0.17 logMAR **6 Months:** -0.17 logMAR	-	-
			PCS	811	72.2 ± 9.9	• **Endothelial cell count:** 2381 ± 424 • **Baseline BCVA:** 0.27 ± 0.23	-	**1 Week:** -0.12 logMAR **1 Month:** -0.15 logMAR **6 Months:** -0.16 logMAR	-	-
6.	Vasavada, 2019 RCT US (21)	Next day, 1st week, 1st month, 3rd month, and 6th month	**FLACS** + topical prednisolone, moxifloxacin, and cyclopentolateed post-operative	91	67.21 ± 11.11	• **Preoperative ECD:** 2351 ± 405 cells/mm2 • **Preoperative CoV**: 32.7 ± 6.7 • **Preoperative HEX (%)**: 53.4 ± 12.3	**1 Week:** 0.18 ± 0.31 **1 Month:** 0.14 ± 0.10 **3 Months:** 0.10 ± 0.09	**1 Week:** logMAR 0.089 **1 Month:** logMAR 0.14	**6 Months:** 2,157 ± 392.7	**3 Months:** 9.76 ± 1.6 **6 Months:** 7.55 ± 1.8
			CPS + topical prednisolone, moxifloxacin, and cyclopentolateed post-operative	91	63.70 ± 11.84	• **Preoperative ECD:** 2493 ± 394 cells/mm2 • **Preoperative CoV**: 30.7 ± 6.3 • **Preoperative HEX (%)**: 54.1 ± 10.4	**1 Week:** 0.27 ± 0.65 **1 Month:** 0.12 ± 0.09 **3 Months:** 0.09 ± 0.11	**1 Week:** logMAR 0.178 **1 Month:** logMAR 0.12	**6 Months:** 2,246 ± 570.3	**3 Months:** 9.85 ± 1.1 **6 Months:** 8.20 ± 0.87
7.	Dzhaber, 2020 RCT US (22)	Next day, 1st week, 1st month, and 3rd month	**FLACS** + antibiotic four times for a week + steroid + NSAID drops four times a day for a week and tapered over three weeks	67	68.3 ± 9.1	• **Intra-operative CDE**: 6.7 ± 4.5	-	-	**1 Month:** 2,370 ± 580 **3 Months:** 2,374 ± 527	**1 Month:** 10.7 ± 20.0 **3 Months:** 11.2 ± 17.9
			CPS + antibiotic four times for a week + steroid + NSAID drops four times a day for a week and tapered over three weeks	67	68.3 ± 9.1	• **Intra-operative CDE**: 6.9 ± 5.3	-	-	**1 Month:** 2,374 ± 527 **3 Months:** 2,433 ± 526	**1 Month:** 6.8 ± 18.0 **3 Months:** 8.0 ± 18.5

8.	Qu, 2024 Cohort Retrospective China (23)	1st and 6th month	**LAstig-FLACS** **HAstig-FLACS**	31 21	58.37 ± 10.74 55.48 ± 11.93	**LAstig-FLACS** • **Pre-operative ACD**: 3.25 ± 0.38 • **Pre-operative Corneal Astigmatism**: 0.54 ± 0.25 **HAstig-FLACS** • **Pre-operative ACD**: 3.31 ± 0.35 • **Pre-operative Corneal Astigmatism**: 1.40 ± 0.41	**L-FLACS** **1 Month:** 0.07 ± 0.09 **6 Months:** 0.03 ± 0.04 **H-FLACS** **1 Month:** 0.08 ± 0.12 **6 Months:** 0.01 ± 0.04	-	-	-
			PCS	21	57.94 ± 12.31	• **Pre-operative ACD**: 3.44 ± 0.33 • **Pre-operative Corneal Astigmatism**: 0.75 ± 0.53	**1 Month:** 0.06 ± 0.09 **6 Months:** 0.04 ± 0.05	-	-	-
9.	Chee, 2021 RCT Singapore (24)	Preoperative and 1st month	**FLACSg** (600 nm grid) **FLACS16** (16-segment fragmentation)	22 23	72.0 ± 9.0 73.5 ± 9.9	**FLACSg (600 nm grid)** • **Pre-operative ACD**: 3.44 ± 0.33 • **Endothelial cell count:** 2464 ± 536 • **Lens thickness**: 4.74 ± 0.45 **FLACS16** • **Pre-operative ACD**: 3.13±0.40 • **Endothelial cell count:** 2625 ± 274 • **Lens thickness**: 4.71±0.40	-	**1 Month:** **FLACSg:** 0.21 ± 0.16 **FLACS16:** 0.20 ± 0.16	**6 Months:** **FLACSg:** 2,232 ± 454 **FLACS16:** 2,513 ± 358	**1 Month:** 6.78 ± 3.62
			PCS	48	75.8 ± 8.0	• **Pre-operative ACD**: 3.02±0.39 • **Endothelial cell count:** 2551 ± 354 • **Lens thickness**: 4.79±0.36	-	**1 Month** 0.25 ± 0.24	**6 Months:** 2,247 ± 376	**1 Month:** 11.96 ± 4.1

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10.	Liang, 2024 Cohort Retrospective China (25)	preoperative, 1st week, and 6th month	**FLACS**	48	57.09 ± 13.18	• **Pre-operative BCVA**: 1.07 ± 0.52 • **CFT:** 223.17 ± 47.26 • **SCFT**: 82.64 ± 38.32	-	**1 Week:** 0.26 ± 0.36 **6 Months:** 0.25 ± 0.34	-	-
			PCS	54	60.57 ± 11.43	• **Pre-operative BCVA**: 1.21 ± 0.45 • **CFT:** 205.67 ± 72.29 • **SCFT**: 68.29 ± 43.64	-	**1 Week:** 0.48 ± 0.31 **6 Months:** 0.45 ± 0.28	-	-
11.	Conrad-Hengerer, 2015 RCT Germany (11)	preoperative, 1st week; 1st, 2nd, 3rd, and 6th month	**FLACS** + topical ofloxacin + dexamethasone ed 4x1 for 5 days post-operative (dexamethasone was gradually tapered over 6 weeks)	100	71.6	• **Pre-operative ACD**: 2.59 ± 0.40 • **Axial length**: 23.55 ± 1.06 • **Pre-operative CDVA**: 0.44 ± 0.14	**1 Week:** 0.86 **1 Month:** 0.88 **3 Months:** 0.91	**3 Months:** logMAR 0.10 **6 Months:** logMAR 0.10	-	**6 Months:** 7.5 ± 2.8
			PCS + topical ofloxacin + dexamethasone ed 4x1 for 5 days post-operative (dexamethasone was gradually tapered over 6 weeks)	100	71.6	• **Pre-operative ACD**: 2.57 ± 0.41 • **Axial length**: 23.55 ± 1.07 • **Pre-operative CDVA**: 0.43 ± 0.13	**1 Week:** 0.72 **1 Month:** 0.77 **3 Months:** 0.82	**3 Months:** logMAR 0.09 **6 Months:** logMAR 0.09	-	**6 Months:** 9.2 ± 3.1

DISCUSSION

The initial objective of this systematic review was to investigate and compare FLACS and conventional phacoemulsification procedure. A total of six RCTs and five observational studies with a total of 4,238 participants were included in the analysis. FLACS was introduced to the cataract surgery field in 2008 and has been shown to improve success rates, enhance precision, and minimize collateral effects on surrounding tissues (Sun et al., 2019). The findings of this review indicate that FLACS tends to outperform PCS in terms of uncorrected distance visual acuity (UDVA), best-corrected visual acuity (BCVA), endothelial cell count (ECC), endothelial cell loss (ECL), and intraoperative complications. FLACS demonstrates faster short-term postoperative improvements in UDVA and BCVA outcomes compared to conventional phacoemulsification. This finding aligns with Filkorn et al., (2012) who categorized the population based on axial length and found that FLACS exhibited a mean absolute error in equivalent spherical refraction, with significant differences in short and long eyes. The rapid visual acuity improvement can be attributed to the preservation of ocular structures, such as the capsular bag, during the FLACS procedure (Sun et al., 2019). Furthermore, FLACS can produce a stable incision tear with precise width and length in corneal incision procedures, facilitating more effective wound healing in the cornea (Ang et al., 2018; Filkorn et al., 2012). However, in the long term, FLACS and conventional phacoemulsification do not show significant differences. Although conventional phacoemulsification has been reported to have a 0.50 D error from the refractive target, after a six-month follow-up, both procedures yield comparable results with no clinical relevance (Conrad-Hengerer et al., 2015; Ewe et al., 2016). FLACS may offer a slight benefit in terms of early visual recovery, which can be advantageous for patients who prioritize rapid restoration of visual acuity after surgery. Nevertheless, the long-term outcomes indicate a small difference between FLACS and PCS.

Endothelial cell density serves as an indicator of corneal healing and long-term corneal damage. The findings of this review suggest that FLACS may be associated with slightly greater long-term endothelial cell loss. This contrasts with findings by Al-Mohtaseb et al. (2017) who reported that the mean percentage of endothelial cell loss at a one-month follow-up was lower in the FLACS group compared to conventional phacoemulsification, in both early and advanced cataract stages. Notably, the reduction in endothelial cell loss was more pronounced in patients with denser cataracts, indicating that FLACS may provide advantages in such cases (Al-Mohtaseb et al., 2017). Khan et al. (2017) compared changes in endothelial cell count between the two procedures and found that the mean change in endothelial cell count was higher in the FLACS group.

Intraoperative complications were rare in both procedures. However, Chen et al. (2015) reported a higher complication rate in PCS compared to FLACS, with overall complication rates of 5.8% for PCS and 1.8% for FLACS. Specifically, posterior capsule rupture was observed in two out of 38 FLACS surgeries, corneal abrasion occurred in two out of 130 FLACS cases. Furthermore, posterior capsule rupture, vitreous loss, and zonular dehiscence were more prevalent in conventional phacoemulsification (Chen et al., 2015). In contrast, Ibrahim et al. (2019) and Wang et al. (2019) found no significant difference between the two procedures regarding intraoperative complications. The lower complication rates in FLACS could be attributed to its ability to produce a precise and accurate incision within measured width and length, and capsulectomy, which helps preserve IOL and anatomical integrity, resulting in fewer intraoperative complications.

Limitations

This review includes multiple high-quality RCTs and observational studies, enhancing reliability. However, the limited follow-up periods and heterogeneity in outcome measures pose challenges in evaluating long-term differences between FLACS and PCS comprehensively.

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CONCLUSION

FLACS offers advantages in early postoperative visual recovery, which may benefit patients prioritizing quick vision restoration. However, PCS may provide slightly better long-term endothelial preservation. Both techniques ultimately result in similar visual outcomes in the long term, with FLACS presenting unique but manageable intraoperative risks.

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Conflict of Interest

None.

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Ethical Clearance

None.

Author Contribution

VSD and SD drafted the research, and manuscript. VSD and SD continued the searching strategy, data extraction, and analysis. VSD wrote the manuscript, and SD in charge of grammar reviewed. RDT critically reviewed the manuscript and data analysis. All authors read and approved the final manuscript.

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