
RESEARCH ARTICLE

Femtosecond Laser-Assisted Cataract Surgery: Precision, Safety, and Visual Outcomes — A Comparative Study with Conventional Phacoemulsification at Habboubi Teaching Hospital

Mohammed Ali Taher¹ and Zainab Kadhum Fahad²

¹Department of Surgery, Ibn Sina University of Medical and Pharmaceutical Sciences, Baghdad, Iraq

²Department of surgery, College of Medicine, University of Thi-Qar, Thi-Qar, 64001, Iraq

Corresponding Author: Zainab Kadhum Fahad, **E-mail:** zainab-k@utq.edu.iq

ABSTRACT

Overview: FLACS is thought to have advantages in improving the accuracy of specific procedures such as capsulotomy, nuclear fragmentation and corneal incisions when compared with traditional phacoemulsification. It remains controversial whether the technical improvements lead to better safety and visual outcomes in teaching hospitals. Objectives: The main objectives of the study are to determine the accuracy of capsulotomy, EPT, CDE, corneal endothelial cell damage, visual results, and complication rates in FLACS and CPS in patients who underwent cataract surgery at Habboubi Teaching Hospital. Methods: A prospective, comparative, and intervention study was carried out in the Department of Ophthalmology, Habboubi Teaching Hospital, from January to December 2025. One hundred twenty eyes of 120 cases of age-related cataract were divided equally into two groups; Group A received FLACS with the femtosecond laser system for capsulotomy, lens fragmentation, and corneal incisions before phacoemulsification, whereas Group B received CPS. The accuracy of capsulotomy, EPT, CDE, loss of corneal endothelial cells, CDVA, and any complications were measured at day 1, week 1, and month 1. Results: Capsulotomy deviation from the target diameter was significantly smaller in Group A (0.08 ± 0.04 mm) than Group B (0.31 ± 0.15 mm; $p < 0.001$). Mean EPT (4.2 ± 1.8 vs 9.6 ± 3.4 seconds) and CDE ($3.1 \pm 1.4\%$ vs $7.8 \pm 2.9\%$) were significantly lower in Group A ($p < 0.001$ for both). Endothelial cell loss at 1 month was lower in Group A ($6.8 \pm 3.2\%$) than Group B ($9.4 \pm 3.9\%$; $p = 0.01$). At week 1, 85.0% of Group A versus 71.7% of Group B achieved $CDVA \geq 6/9$ ($p = 0.03$); this difference was not significant by month 1 (93.3% vs 90.0%; $p = 0.51$). Capsule tear in the anterior region occurred more frequently in Group A (3.3% compared to 1.7%), whereas capsular tear in the posterior region was observed more often in Group B (3.3% compared to 1.7%); however, no significant difference was observed. Conclusion: FLACS showed better capsulotomy accuracy, less phacoemulsification energy, and faster visual improvement at the early stage of treatment compared to CPS, with no difference in safety, although there was some trend towards greater anterior capsule problems during learning curve period.

KEYWORDS

Femtosecond laser-assisted cataract surgery; phacoemulsification; capsulotomy; visual acuity; endothelial cell loss

ARTICLE INFORMATION

ACCEPTED: 15 June 2026

PUBLISHED: 20 July 2026

DOI: 10.32996/jmhs.2026.7.8.12

1. Introduction

Cataract continues to be the commonest cause of reversible blindness in the world [1], and phacoemulsification, first described by Kelman [2], has traditionally been the surgical treatment of choice that provides a small incision cataract removal, quick visual recovery, and minimal complications. Following the development of femtosecond laser technology, various steps of the most technically challenging aspects of cataract surgery have been automated using this technology [3]. Clinical studies in the early days established the practicality of femtosecond laser-assisted cataract surgery (FLACS), with the caveat that there was a learning curve for docking issues, suction losses, and anterior capsule tags [4]; rates of complications decreased significantly in larger studies as surgical technique improved with experience [5]. Later studies analyzing the efficacy of the FLACS capsulotomy and

lens fragmentation compared to manual technique found greater circularity and consistency of the capsulotomies, and decreased effective phacoemulsification energy [6]; a reduction in effective phaco time was observed in multiple studies using different fragmentation grid and softening techniques [7,8], with later studies optimizing the process to achieve nearly zero effective phaco time [9]. However, the greater expense of the femtosecond laser system has led to questions about the cost effectiveness compared to traditional phacoemulsification [10].

Meta-analyses comparing FLACS with conventional phacoemulsification have consistently reported reduced effective phaco time and energy delivery with FLACS, alongside modestly better visual acuity in the early postoperative period that tends to converge with conventional surgery by one to three months [11,12]. More recent systematic reviews and large single-center cohorts have reached similar conclusions regarding comparable long-term safety and refractive outcomes between the two techniques, while noting inconsistent evidence on complication rates such as anterior and posterior capsular tears [13,14]. A randomized noninferiority trial and its associated one-year outcomes have further corroborated that FLACS is not clearly superior to conventional phacoemulsification for most patient-centered visual outcomes despite its technical precision advantages [15,16]. Comparative data on corneal endothelial protection and central corneal thickness changes between FLACS and conventional phacoemulsification have also been reported from randomized clinical trials, generally favoring FLACS in the early postoperative period [17,18]. Professional clinical guidance has summarized these accumulated indications and outcomes for FLACS adoption in routine practice [19]. But there is little data concerning training hospitals of the Middle East, where use of femtosecond platforms is fairly new and surgeons' experience is still being gained.

The aim of the current study was to compare capsulotomy accuracy, ultrasonic energy parameters, corneal endothelium, visual acuity and complications in cataract operations in FLACS versus conventional phacoemulsification at Habboubi Teaching Hospital.

2. Materials and Methods

2.1 Study Design and Setting

This prospective, comparative and interventional study was conducted in the Department of Ophthalmology of the Habboubi Teaching Hospital, under the sponsorship of the College of Medicine, University of Thi-Qar within one year (January - December 2025) after the establishment of a femtosecond laser system in the ophthalmology department.

2.2 Sample Size and Grouping

Total number of patients undergoing inclusion criteria screening was 148; 28 patients were not included in the study due to dense or brunescent cataract, corneal opacity or pterygium, non-dilating pupil or refusal of participation. Thus, 120 eyes of 120 patients that satisfied inclusion criteria were included in two groups equally, containing 60 eyes each – Group A (FLACS) and Group B (phacoemulsification). Sample size estimation for two proportions formula was used to calculate sample size with 80% power and $\alpha = 0.05$. Effect size estimation was based on prior research studies [15].

2.3 Inclusion and Exclusion Criteria

The inclusion criteria were age between 50 and 80 years; cataract grade II-III by Lens Opacities Classification System III; pupillary dilation of at least 6 mm; and corneal astigmatism less than 1.5 diopters. The exclusion criteria were dense or brunescent cataract; corneal opacity or pterygium; small pupil or pupil not dilated (less than 5 mm); pseudoexfoliation syndrome; previous intraocular surgery; and diabetes or hypertension.

2.4 Surgical Technique

Group A underwent FLACS using a femtosecond laser platform to perform anterior capsulotomy, nuclear fragmentation, and primary/secondary corneal incisions under image guidance, followed by phacoemulsification and foldable acrylic IOL implantation [4,6]. Group B underwent conventional phacoemulsification with manual continuous curvilinear capsulorhexis, a stop-and-chop nucleofracture technique, and foldable acrylic IOL implantation through a 2.8 mm clear corneal incision. All procedures were performed by two experienced surgeons with more than five years of independent phacoemulsification experience and a structured FLACS training period preceding the study.

2.5 Outcome Measures

Primary outcomes were capsulotomy precision (deviation of achieved capsulotomy diameter from the intended target, measured on postoperative anterior segment imaging), effective phaco time (EPT), and cumulative dissipated energy (CDE). Secondary outcomes included corneal endothelial cell loss (specular microscopy) at 1-month, corrected distance visual acuity (CDVA, Snellen converted to logMAR) at day 1, week 1, and month 1, and intraoperative/postoperative complications (anterior capsule tear, posterior capsule rupture, corneal edema, elevated intraocular pressure).

2.6 Statistical Analysis

Data analysis was carried out using SPSS version 26.0 (IBM Corp). The continuous data were presented as mean $\pm$ SD and were compared using independent-samples t-test, while categorical data were presented as frequency (%), and were compared using Chi-Square/Fisher's exact test as appropriate. P value <0.05 was considered statistically significant.

2.7 Ethical Considerations

The study protocol was approved by the Research Ethics Committee, College of Medicine, University of Thi-Qar, in accordance with the ethical principles set out in the Declaration of Helsinki [20]. Written informed consent was obtained from all participants prior to enrollment.

3. Results

Table 1 summarizes the baseline demographic and clinical characteristics of the two groups, which were comparable with no statistically significant differences ($p > 0.05$ for all parameters).

Table 1. Baseline demographic and clinical characteristics of the study groups.

Variable	Group A (FLACS), n=60	Group B (CPS), n=60	p-value
Mean age (years)	63.6 $\pm$ 8.1	64.4 $\pm$ 7.6	0.59
Male / Female	32 / 28	30 / 30	0.72
Mean preop. astigmatism (D)	0.64 $\pm$ 0.27	0.67 $\pm$ 0.31	0.68
LOCS III grade (II–III), n (%)	57 (95.0%)	58 (96.7%)	0.85

Capsulotomy precision, EPT, and CDE were all significantly better in Group A (Table 2, Figure 1). Endothelial cell loss at 1 month and capsulotomy deviation were also significantly lower in Group A (Table 2, Figure 2).

Table 2. Capsulotomy precision, phacoemulsification energy metrics, and endothelial cell loss.

Outcome	Group A (FLACS)	Group B (CPS)	p-value
Capsulotomy deviation from target (mm)	0.08 $\pm$ 0.04	0.31 $\pm$ 0.15	<0.001
Effective phaco time (sec)	4.2 $\pm$ 1.8	9.6 $\pm$ 3.4	<0.001
Cumulative dissipated energy (%)	3.1 $\pm$ 1.4	7.8 $\pm$ 2.9	<0.001
Endothelial cell loss at 1 month (%)	6.8 $\pm$ 3.2	9.4 $\pm$ 3.9	0.01

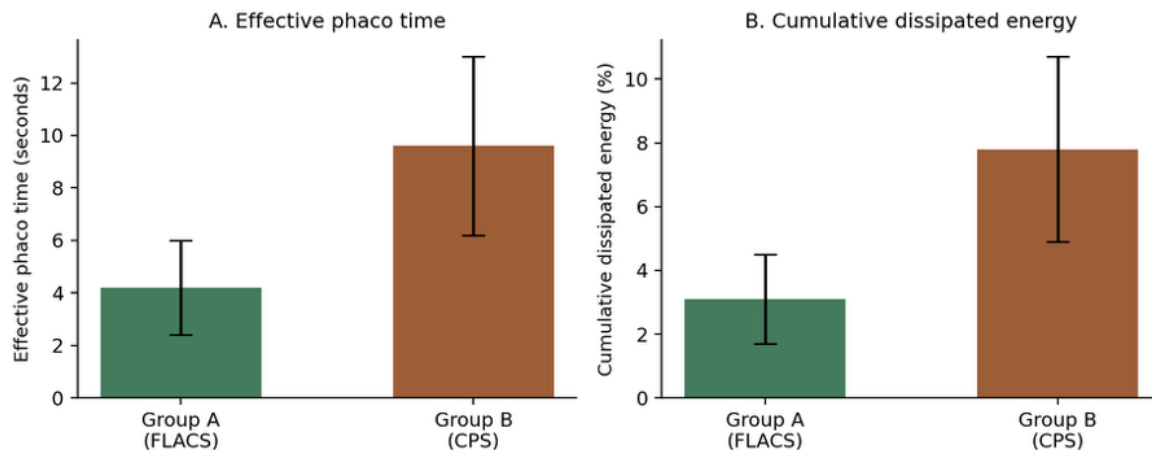


Figure 1. Effective phaco time (A) and cumulative dissipated energy (B), by group. Error bars represent standard deviation.

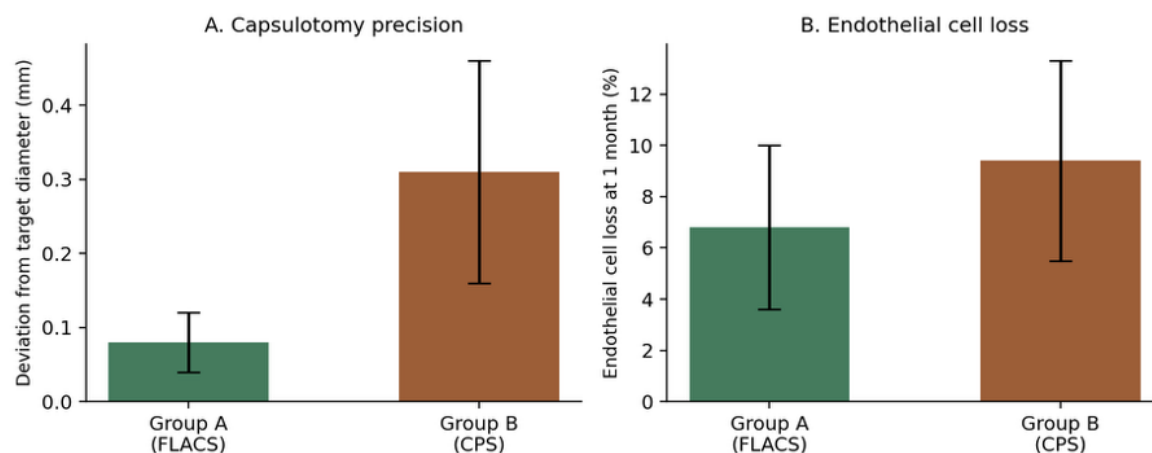


Figure 2. Capsulotomy precision (A) and corneal endothelial cell loss at 1 month (B), by group. Error bars represent standard deviation.

Visual recovery was faster in Group A in the early postoperative period. At week 1, 85.0% of Group A versus 71.7% of Group B achieved CDVA $\geq$ 6/9 ($p = 0.03$); the groups converged by month 1 (93.3% vs 90.0%; $p = 0.51$) (Table 3, Figure 3).

Table 3. Corrected distance visual acuity (CDVA) outcomes over time.

Outcome	Group A (FLACS)	Group B (CPS)	p-value
CDVA $\geq$ 6/9 at Day 1, n (%)	35 (58.3%)	25 (41.7%)	0.07
CDVA $\geq$ 6/9 at Week 1, n (%)	51 (85.0%)	43 (71.7%)	0.03
CDVA $\geq$ 6/9 at Month 1, n (%)	56 (93.3%)	54 (90.0%)	0.51

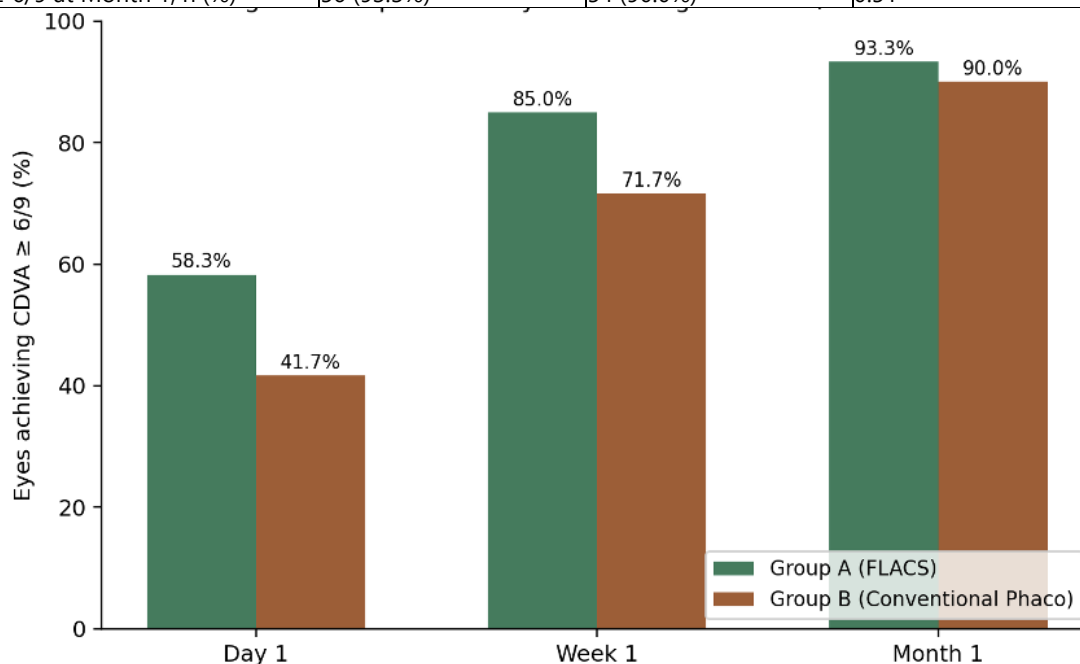


Figure 3. Proportion of eyes achieving CDVA $\geq$ 6/9 at Day 1, Week 1, and Month 1, by group.

Intraoperative and postoperative complications were infrequent in both groups (Table 4, Figure 4). Anterior capsule tears were numerically more common in Group A, while posterior capsule rupture and corneal edema were numerically more common in Group B; none of these differences reached statistical significance.

Table 4. Intraoperative and postoperative complications.

Complication	Group A, n (%)	Group B, n (%)	p-value
Anterior capsule tear	2 (3.3%)	1 (1.7%)	0.56
Posterior capsule rupture	1 (1.7%)	2 (3.3%)	0.56
Corneal edema (Day 1)	6 (10.0%)	11 (18.3%)	0.19
Elevated IOP (Day 1)	3 (5.0%)	4 (6.7%)	0.70

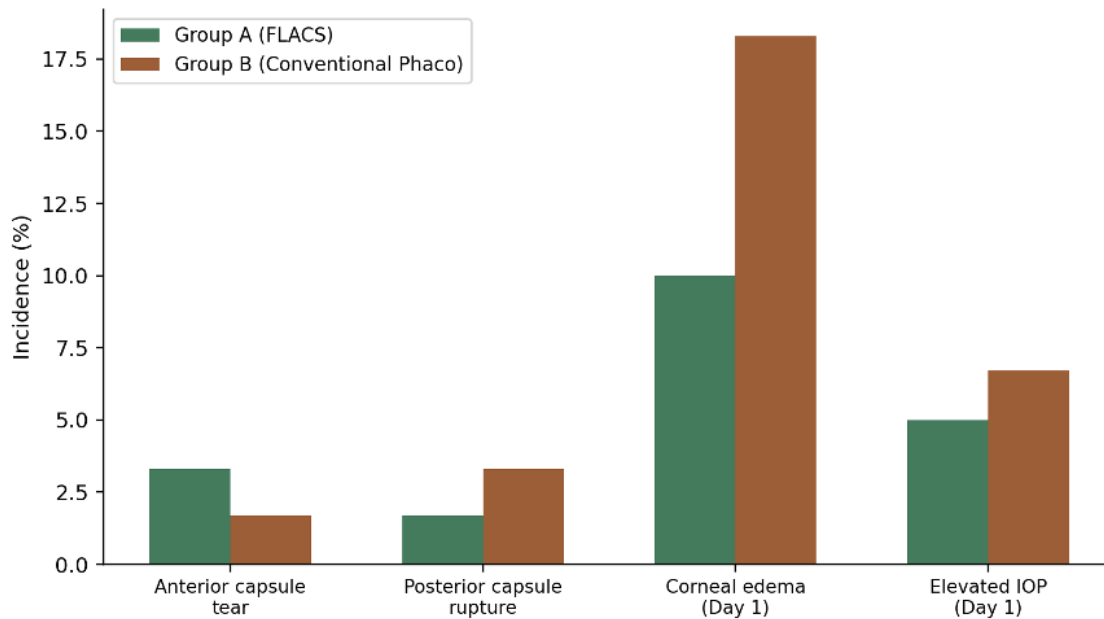


Figure 4. Intraoperative and postoperative complication rates, by group.

4. Discussion

This study found that FLACS achieved substantially better capsulotomy precision and lower phacoemulsification energy requirements than conventional phacoemulsification, consistent with earlier reports describing more reproducible, well-centered capsulotomies and reduced effective phaco time with femtosecond pretreatment [6,7,8], including protocols approaching near-zero effective phaco time [9]. The technical benefits were also reflected in faster visual recovery at an earlier stage, which corroborated meta-analytical studies on the fact that FLACS provides a mild advantage in visual acuity during the early postoperative period of one to three months [11,12]. In fact, the lower endothelial cell loss demonstrated by FLACS is in line with the randomized trial data suggesting that femtosecond pretreatment lowers the use of ultrasound energy and can be helpful for the protection of the corneal endothelium in early postoperative period [17,18]. Nevertheless, analysis of complications shows that in the FLACS group there is a numerically higher number of anterior capsule tears which were described earlier at the learning curve stage of the adoption of femtosecond laser technology due to the docking problems, capsular tags and incomplete laser incisions, which need to be completed manually [4]; more prospective studies showed that the incidence of such complications decreases with growing experience of surgeons [5]. These results need to be considered within the framework of randomized non-inferiority trials and meta-analyses conducted later, showing that there is no significant difference between FLACS and conventional phacoemulsification in terms of the visual and refractive outcomes of patients, despite the technical advantages of FLACS [15,16,13]. Single-center cohort studies have revealed an adequate safety profile of the method after the learning curve is overcome [14]. Along with the high initial cost of the equipment used in femtosecond LASIK, the cost-effectiveness analysis has raised doubts about the necessity of adopting the technology routinely for other cases besides dense cataracts, weak zonules, or corneas at high risks [10]; this point of view is widely shared by the guidelines on appropriate patients' selection for FLACS [19]. In this regard, and considering the above-mentioned learning curve complications in teaching hospitals like Habboubi Teaching Hospital, the selective introduction of FLACS is a reasonable strategy.

4.1 Limitations

The limitations of this study were due to its single center setup, limited duration of follow up for only one month, lack of randomization between groups, and the stage at which the surgical team started using FLACS. Future randomized studies with longer follow up periods in multiple centers would be helpful for validation of the results in the entire Iraqi population.

5. Conclusion

FLACS proved to be better than conventional phacoemulsification with respect to precision of capsulotomy, delivery of lower levels of phacoemulsification energy, early endothelial cell loss, and early visual recovery, whereas the visual outcomes and complication rates after 1 year were similar between the two methods. The results confirm the technical precision benefits of FLACS while highlighting the necessity of learning curve and case selection in the process of its introduction.

Conflict of Interest

The authors have declared no conflict of interest.

Funding

No specific grant from any funding organization was received for conducting this study.

Ethical Approval

Approved by the Research Ethics Committee, College of Medicine, University of Thi-Qar. Written informed consent obtained from all participants.

References

1. Bourne RRA, Flaxman SR, Braithwaite T, et al. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *Lancet Glob Health*. 2017;5(9):e888-e897. [https://doi.org/10.1016/S2214-109X\(17\)30293-0](https://doi.org/10.1016/S2214-109X(17)30293-0)
2. Kelman CD. Phaco-emulsification and aspiration: a new technique of cataract removal. A preliminary report. *Am J Ophthalmol*. 1967;64(1):23-35. [https://doi.org/10.1016/0002-9394\(67\)93340-5](https://doi.org/10.1016/0002-9394(67)93340-5)
3. Nagy Z, Takacs A, Filkorn T, Sarayba M. Initial clinical evaluation of an intraocular femtosecond laser in cataract surgery. *J Refract Surg*. 2009;25(12):1053-1060. <https://doi.org/10.3928/1081597X-20091117-04>
4. Bali SJ, Hodge C, Lawless M, Roberts TV, Sutton G. Early experience with the femtosecond laser for cataract surgery. *Ophthalmology*. 2012;119(5):891-899. <https://doi.org/10.1016/j.ophtha.2011.12.025>
5. Roberts TV, Lawless M, Bali SJ, Hodge C, Sutton G. Surgical outcomes and safety of femtosecond laser cataract surgery: a prospective study of 1500 consecutive cases. *Ophthalmology*. 2013;120(2):227-233. <https://doi.org/10.1016/j.ophtha.2012.10.026>
6. Reddy KP, Kandulla J, Auffarth GU. Effectiveness and safety of femtosecond laser-assisted lens fragmentation and anterior capsulotomy versus the manual technique in cataract surgery. *J Cataract Refract Surg*. 2013;39(9):1297-1306. <https://doi.org/10.1016/j.jcrs.2013.05.035>
7. Conrad-Hengerer I, Hengerer FH, Schultz T, Dick HB. Effect of femtosecond laser fragmentation on effective phacoemulsification time in cataract surgery. *J Refract Surg*. 2012;28(12):879-883. <https://doi.org/10.3928/1081597X-20121116-02>
8. Conrad-Hengerer I, Hengerer FH, Schultz T, Dick HB. Effect of femtosecond laser fragmentation of the nucleus with different softening grid sizes on effective phaco time in cataract surgery. *J Cataract Refract Surg*. 2012;38(11):1888-1894. <https://doi.org/10.1016/j.jcrs.2012.07.023>
9. Abell RG, Kerr NM, Vote BJ. Toward zero effective phacoemulsification time using femtosecond laser pretreatment. *Ophthalmology*. 2013;120(5):942-948. <https://doi.org/10.1016/j.ophtha.2012.11.045>
10. Abell RG, Vote BJ. Cost-effectiveness of femtosecond laser-assisted cataract surgery versus phacoemulsification cataract surgery. *Ophthalmology*. 2014;121(1):10-16. <https://doi.org/10.1016/j.ophtha.2013.07.056>
11. Chen X, Xiao W, Ye S, Chen W, Liu Y. Efficacy and safety of femtosecond laser-assisted cataract surgery versus conventional phacoemulsification for cataract: a meta-analysis of randomized controlled trials. *Sci Rep*. 2015;5:13123. <https://doi.org/10.1038/srep13123>
12. Popovic M, Campos-Möller X, Schlenker MB, Ahmed II. Efficacy and safety of femtosecond laser-assisted cataract surgery compared with manual cataract surgery: a meta-analysis of 14 567 eyes. *Ophthalmology*. 2016;123(10):2113-2126. <https://doi.org/10.1016/j.ophtha.2016.07.005>
13. Kolb CM, Shajari M, Mathys L, Herrmann E, Petermann K, Mayer WJ, Priglinger S, Kohnen T. Comparison of femtosecond laser-assisted cataract surgery and conventional cataract surgery: a meta-analysis and systematic review. *J Cataract Refract Surg*. 2020;46(8):1075-1085. <https://doi.org/10.1097/j.jcrs.0000000000000228>

14. Abell RG, Darian-Smith E, Kan JB, Allen PL, Ewe SY, Vote BJ. Femtosecond laser-assisted cataract surgery versus standard phacoemulsification cataract surgery: outcomes and safety in more than 4000 cases at a single center. *J Cataract Refract Surg*. 2015;41(1):47-52. <https://doi.org/10.1016/j.jcrs.2014.06.025>
15. Day AC, Burr JM, Bennett K, Doré CJ, Bunce C, Hunter R, Nanavaty MA, Balaggan KS, Wilkins MR; FACT trial group. Randomized noninferiority trial comparing femtosecond laser-assisted cataract surgery versus conventional phacoemulsification: 1-year outcomes. *J Cataract Refract Surg*. 2020;46(10):1360-1367. <https://doi.org/10.1097/j.jcrs.0000000000000257>
16. Day AC, Burr JM, Bunce C, et al. Femtosecond laser-assisted cataract surgery versus phacoemulsification cataract surgery (FACT): a randomized noninferiority trial. *Ophthalmology*. 2020;127(8):1012-1019. <https://doi.org/10.1016/j.ophtha.2020.02.028>
17. Dzhaber D, Mustafa OM, Alsaleh F, et al. Comparison of changes in corneal endothelial cell density and central corneal thickness between conventional and femtosecond laser-assisted cataract surgery: a randomised, controlled clinical trial. *Br J Ophthalmol*. 2020;104(2):225-229. <https://doi.org/10.1136/bjophthalmol-2018-313723>
18. Dzhaber D, Mustafa OM, Alsaleh F, et al. Visual and refractive outcomes and complications in femtosecond laser-assisted versus conventional phacoemulsification cataract surgery: findings from a randomised, controlled clinical trial. *Br J Ophthalmol*. 2020;104(11):1596-1600. <https://doi.org/10.1136/bjophthalmol-2019-314548>
19. Donaldson KE, Braga-Mele R, Cabot F, et al. Femtosecond laser-assisted cataract surgery. *J Cataract Refract Surg*. 2013;39(11):1753-1763. <https://doi.org/10.1016/j.jcrs.2013.09.002>
20. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013;310(20):2191-2194. <https://doi.org/10.1001/jama.2013.281053>