DOI: https://doi.org/10.53350/pjmhs221661097

ORIGINAL ARTICLE

Femtosecond Laser vs. Conventional Phacoemulsification: Long-Term Posterior Capsule Opacification

JAMAL HUSSAIN[1], NAWAB ALI KHAN[2], ABSHAR AHMAD[3]
[1]*Assistant Professor Ophthalmology Swat Medical College and Swat Medical Complex*
[2]*MBBS FCPS Consultant Ophthalmologist Department of Ophthalmology Timergara Teaching Hospital Dir Lower*
[3]*MBBS MCPS Consultant Ophthalmologist Department of Ophthalmology Timergara Teaching Hospital Dir Lower*
Correspondence to: Nawab Ali Khan, Email: drnawabali265@gmail.com

ABSTRACT

Background: Posterior capsule opacification (PCO) is the most common long-term complication after cataract surgery and may lead to decreased visual acuity requiring Nd:YAG laser capsulotomy. Advances in surgical techniques such as femtosecond laser–assisted cataract surgery aim to improve surgical precision and potentially reduce postoperative complications.

Objective: To compare the long-term incidence of posterior capsule opacification between femtosecond laser–assisted cataract surgery and conventional phacoemulsification.

Methodology: This was a hospital-based analytical cross-sectional study conducted at Swat Medical Complex Teaching Hospital from March 2021 to march 2022 including 235 patients undergoing cataract surgery.

Results: The mean age of patients was 63.8 ± 8.7 years with nearly equal gender distribution. Capsulotomy diameter was more consistent in the femtosecond group (5.01 ± 0.06 mm) compared with the conventional group (5.19 ± 0.21 mm). Ultrasound energy (5.9 ± 2.3% vs 9.8 ± 3.1%) and effective phaco time (27.4 ± 7.8 vs 39.6 ± 9.5 seconds) were significantly lower in the femtosecond group. Posterior capsule opacification occurred in 11.9% of patients in the femtosecond group compared with 23.9% in the conventional group. Nd:YAG capsulotomy was required in 7.6% of patients in the femtosecond group and 17.1% in the conventional group. Postoperative visual acuity was slightly better in the femtosecond group (0.07 ± 0.05 logMAR) compared with the conventional group (0.10 ± 0.07 logMAR).

Conclusion: Femtosecond laser–assisted cataract surgery demonstrated improved surgical precision, reduced ultrasound energy use, and lower incidence of posterior capsule opacification compared with conventional phacoemulsification.

Keywords: Cataract surgery, Femtosecond laser, Phacoemulsification, Posterior capsule opacification, Nd:YAG capsulotomy, Visual outcomes.

INTRODUCTION

One of the most widespread ophthalmic surgeries is the cataract surgery, which is still the ultimate treatment of the lens opacities of visual importance. Widespread issues with the surgical method may also occur, but the most common below-the-line complication specifically following cataract surgery is posterior capsule opacification (PCO), which may result in steady deterioration of the visual performance necessitating Nd:YAG laser capsulotomy[1]. PCO is caused by the increase in and migration of the residual lens epithelial cells onto the back capsule following surgery[2]. Traditional phacoemulsification was regarded as the gold standard of removing cataract. The process consists of the fragmentation of the crystalline lens by use of ultrasound and then aspiration and implantation of the intraocular lens into the capsular bag[3]. Despite its high effectiveness, an unfinished cortical cleanup, damaged capsulotomy, and leftover lens epithelial cells could also be some of the factors that can lead to the occurrence of posterior capsule opacification with time[4].

The latest technology is called Femtosecond laser-assisted cataract surgery (FLACS) uses Lasers to advance the precision and reproducibility of surgery. The femtosecond laser is capable of undertaking some of the vital surgery procedures such as corneal incisions, anterior capsulotomy and lens fragmentation with high precision[5]. This would lead to higher accuracy which could translate to a more stable capsulotomy size and an improved centration of the intraocular lens[6]. Posterior capsule opacification is a phenomenon caused by the growth and subsequent fibrotic or pearl-like metamorphosis of the remaining epithelial cells into opacities that pose a hindrance to light transmission to the retina[7]. Its development is affected by numerous factors that include the methodology of surgery, the type of intraocular lens, patient factors, and post-surgical inflammation[8]. The adequate interlocking of the anterior capsule and intraocular lens optic has been observed to lower the processes of epithelial cell migration and lower the PCO formation[9].

The use of femtosecond laser technology can help to reduce PCO rates to achieve a more circular and well-centeredoptic of the capsulotomy, which guarantees the uniformity of the overlap of the intraocular lens optic[10]. Moreover, laser-assisted lens fragmentation can decrease the ultrasound energy used in surgery and intraocular trauma[11]. Nevertheless, the long-term efficacy of the use of femtosecond laser in the cataract surgery in avoiding the occurrence of the posterior capsule opacification is controversial. It has been reported that 100 efficiency of femtosecond laser surgeries can be reduced as compared to the traditional phacoemulsification[12], and other studies indicate there is no significant difference between the two methods[13]. The design and material of intraocular lens implanted also is another significant determinant of the PCO development. Intraocular lenses of the modern square-edge type provide a mechanical hindrance that prevents the movement of lens epithelial cells across the posterior capsule[14]. This shape can be combined with a properly sized capsulotomy to minimize additional opacification of the capsule[15].

Objective: To compare the long-term incidence of posterior capsule opacification between femtosecond laser–assisted cataract surgery and conventional phacoemulsification.

METHODOLOGY

This was a hospital-based analytical cross-sectional study conducted at Swat Medical Complex Teaching Hospital from March 2021 to March 2022 including 235 patients undergoing cataract surgery.

Inclusion Criteria

- Patients aged ≥40 years diagnosed with age-related cataract and scheduled for cataract extraction with intraocular lens implantation.
- Patients undergoing either femtosecond laser–assisted cataract surgery or conventional phacoemulsification.
- Patients with clear visualization of the posterior capsule at the end of surgery.
- Patients willing to participate and able to attend long-term postoperative follow-up.

Exclusion Criteria

- Patients with previous ocular surgery or trauma.
- Patients with pre-existing posterior capsule rupture or zonular instability.
- Patients with advanced glaucoma, retinal disease, or corneal pathology affecting visual outcomes.
- Patients with systemic or ocular inflammatory conditions that could influence postoperative capsular changes.

Data Collection: After obtaining informed consent, demographic and clinical data were recorded using a structured proforma. All patients underwent a detailed ophthalmic evaluation including visual acuity assessment, slit-lamp examination, intraocular pressure measurement, and dilated fundus examination. Preoperative biometric measurements including axial length, keratometry readings, and intraocular lens power calculation were obtained using optical biometry. Patients were divided into two groups based on the surgical technique used: femtosecond laser–assisted cataract surgery group and conventional phacoemulsification group. In the femtosecond laser group, key surgical steps such as corneal incision, anterior capsulotomy, and lens fragmentation were performed using a femtosecond laser system before lens removal. In the conventional group, standard manual phacoemulsification was performed using ultrasound energy. In both groups, intraocular lens implantation was performed within the capsular bag. Patients were followed postoperatively at scheduled intervals to assess visual outcomes and the development of posterior capsule opacification. Slit-lamp examination was used to detect capsular opacification, and the need for Nd:YAG laser capsulotomy was recorded as an indicator of clinically significant PCO.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Comparisons between the femtosecond laser group and the conventional phacoemulsification group were performed using independent t-test for continuous variables and chi-square test for categorical variables. The association between surgical technique and posterior capsule opacification incidence was also evaluated. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 235 patients were included with a mean age of 63.8 ± 8.7 years. Most patients were older than 65 years (89; 37.9%), followed by 56–65 years (84; 35.7%) and 40–55 years (62; 26.4%). Males accounted for 121 (51.5%) and females 114 (48.5%). Diabetes mellitus was present in 78 (33.2%) patients and hypertension in 92 (39.1%). The mean preoperative visual acuity was 0.82 ± 0.25 logMAR. Mean axial length and keratometry were 23.46 ± 0.91 mm and 43.7 ± 1.8 D respectively.

Among the patients, 118 underwent femtosecond laser surgery and 117 conventional phacoemulsification. Capsulotomy diameter was more consistent in the femtosecond group (5.01 ± 0.06 mm) compared with conventional surgery (5.19 ± 0.21 mm, p <0.001). Ultrasound energy (5.9 ± 2.3% vs 9.8 ± 3.1%) and effective phaco time (27.4 ± 7.8 vs 39.6 ± 9.5 seconds) were significantly lower in the femtosecond group (p <0.001). Complete cortical cleanup occurred in 113 (95.8%) vs 103 (88.0%) cases (p = 0.03). Intraoperative complications occurred in 4 (3.4%) and 7 (6.0%) cases respectively.

Table 1: Demographic and Baseline Clinical Characteristics of Patients (n = 235)

Variable	Category	Total (n = 235)
Age (years)	Mean ± SD	63.8 ± 8.7
Age Group	40–55 years	62 (26.4%)
	56–65 years	84 (35.7%)
	>65 years	89 (37.9%)
Gender	Male	121 (51.5%)
	Female	114 (48.5%)
Diabetes Mellitus	Yes	78 (33.2%)
	No	157 (66.8%)
Hypertension	Yes	92 (39.1%)
	No	143 (60.9%)
Preoperative Visual Acuity (logMAR)	Mean ± SD	0.82 ± 0.25
Axial Length (mm)	Mean ± SD	23.46 ± 0.91
Keratometry (D)	Mean ± SD	43.7 ± 1.8

Posterior capsule opacification developed in 14 patients (11.9%) in the femtosecond group compared with 28 (23.9%) in the conventional group (p = 0.018). The mean time to PCO detection was 19.6 ± 6.2 months in the femtosecond group and 17.4 ± 5.9 months in the conventional group (p = 0.04). Fibrotic PCO occurred in 6 (5.1%) vs 13 (11.1%) patients, while pearl-type PCO occurred in 8 (6.8%) vs 15 (12.8%) patients respectively.

Nd:YAG capsulotomy was required in 9 patients (7.6%) in the femtosecond group compared with 20 (17.1%) in the conventional group (p = 0.027). Postoperative visual acuity was slightly better in the femtosecond group (0.07 ± 0.05 logMAR) compared with 0.10 ± 0.07 in the conventional group (p = 0.002). Residual refractive error was lower (0.38 ± 0.26 D vs 0.49 ± 0.31 D, p = 0.01) and patient satisfaction scores were higher (8.9 ± 0.9 vs 8.3 ± 1.2).

Table 2: Distribution of Surgical Techniques and Intraoperative Parameters

Variable	Femtosecond Laser (n = 118)	Conventional Phaco (n = 117)	p-value
Capsulotomy Diameter (mm)	5.01 ± 0.06	5.19 ± 0.21	<0.001
Ultrasound Energy Used (%)	5.9 ± 2.3	9.8 ± 3.1	<0.001
Effective Phaco Time (seconds)	27.4 ± 7.8	39.6 ± 9.5	<0.001
Complete Cortical Cleanup	113 (95.8%)	103 (88.0%)	0.03
Intraoperative Complications	4 (3.4%)	7 (6.0%)	0.34

Table 3: Incidence of Posterior Capsule Opacification During Follow-Up

Variable	Femtosecond Laser (n = 118)	Conventional Phaco (n = 117)	p-value
Posterior Capsule Opacification	14 (11.9%)	28 (23.9%)	0.018
	104 (88.1%)	89 (76.1%)	
Time to PCO Detection (months)	19.6 ± 6.2	17.4 ± 5.9	0.04
Fibrotic Type PCO	6 (5.1%)	13 (11.1%)	0.09
Pearl Type PCO	8 (6.8%)	15 (12.8%)	0.11

Table 4: Nd:YAG Laser Capsulotomy Requirement and Postoperative Visual Outcomes

Variable	Femtosecond Laser (n = 118)	Conventional Phaco (n = 117)	p-value
Nd:YAG Capsulotomy Required	9 (7.6%)	20 (17.1%)	0.027
	109 (92.4%)	97 (82.9%)	
Postoperative Visual Acuity (logMAR)	0.07 ± 0.05	0.10 ± 0.07	0.002
Residual Refractive Error (D)	0.38 ± 0.26	0.49 ± 0.31	0.01
Patient Satisfaction Score (0–10)	8.9 ± 0.9	8.3 ± 1.2	0.003

DISCUSSION

The most prevalent long-term result after a cataract surgery procedure is opacification of the posterior capsule which is also a significant determinant of visual outcome. The average age of patients in the current study was 63.8 + 8.7 years with almost an equal gender ratio, which aligns with the past study that cataract surgery is mainly used in older age groups with the same gender composition[16]. Our findings revealed that the femtosecond laser surgery that yielded a more consistent capsulotomy diameter (5.01 ± 0.06 mm) than phacoemulsification done conventionally (5.19 ± 0.21 mm). The ultrasound energy (5.9 +2.3 percent vs 9.8 +3.1 percent) and effective phaco time (27.4 +7.8 seconds vs 39.6 +9.5 seconds) were also significantly inferior in the group undergoing femtosecond. The same type of decreases in the ultrasound energy and enhanced surgical accuracy have been documented in the earlier studies that tested the femtosecond laser-assisted cataract surgery[17]. The postoperative rate of opacification of the anterior of the all-capsule was also less in the femtosecond group (11.9) than in the traditional phacoemulsification group (23.9), and the PCO detection time was a little longer (19.6 + 6.2 months vs. 17.4 + 5.9 months). Similar decline in PCO incidence related to more accurate

capsulotomy and better IOL overlap has also been reported in the past studies[18].

There was a morphological finding of fibrotic PCO in 5.1 vs 11.1 of the patients and pearl-type PCO in 6.8 vs 12.8 of the patients in the femtosecond and conventional groups respectively. In other studies, these same tendencies of decreased epithelial cell growth after laser-assisted surgery have been found[19]. The frequency of Nd:YAG capsulotomy was lower in the femtosecond group (7.6) than in the conventional group (17.1%). Other studies have also indicated a lower rate of capsule lowers of cases undergoing fatsosecond laser cataract surgery as a result of less opacification of the posterior capsule[20]. In the femtosecond group, the postoperative visual acuity was slightly improved (0.07 + 0.05 logMAR vs 0.10 + 0.07), and lower residual refractive error (0.38 + 0.26 D vs 0.49 + 0.31 D) and higher patient satisfaction (8.9 + 0.9 vs 8.3 + 1.2) were found. In the past studies, the same refractive results and patient satisfaction have also been observed to be improved[21]. All in all, the results indicate that the femtosecond laser-aided cataract surgery can offer more accurate surgery and reduce the posterior capsule opacification rates in the long-run than traditional phacoemulsification.

CONCLUSION

It is concluded that femtosecond laser–assisted cataract surgery demonstrated better surgical precision, lower ultrasound energy use, and reduced effective phaco time compared with conventional phacoemulsification. The incidence of posterior capsule opacification and the requirement for Nd:YAG capsulotomy were also lower in the femtosecond group. Additionally, slightly better postoperative visual acuity, lower residual refractive error, and higher patient satisfaction were observed, suggesting that femtosecond laser–assisted cataract surgery may provide improved long-term outcomes compared with conventional phacoemulsification.

REFERENCES

1. Shah R, Vlasak N, Evans BJW. High myopia: reviews of myopia control strategies and myopia complications. Ophthalmic Physiol Opt. 2024;44(6):1248–60. https://doi.org/10.1111/opo.13366. Epub 2024 Jul 31.
2. Soliman MK, Hardin JS, Jawed F, Uwaydat SH, Faramawi MF, Chu CJ, et al. A database study of visual outcomes and intraoperative complications of postvitrectomy cataract surgery. Ophthalmology. 2018;125(11):1683–91. https://doi.org/10.1016/j.ophtha.2018.05.027. Epub 2018 Jul 21.
3. Wu Z, Zhang J, Chen Y, Gao R, Lin Z. Efficacy of phacovitrectomy combined with internal limiting membrane peeling for macular diseases. Eye Sci. 2012;27(1):25–9. https://doi.org/10.3969/j.issn.1000-4432.2012.01.005.
4. Hernandez-Bogantes E, Abdala-Figuerola A, Olivo-Payne A, Quiros F, Wu L. Cataract following Pars plana vitrectomy: A review. Semin Ophthalmol. 2021;36(8):824–31. Epub 2021 Jun 6.
5. Zhao L, Tan M, Zhang J, Hao M, Liang S, Ji M, Guan H. Comparative study of FLACS vs conventional phacoemulsification for cataract patients with high myopia. J Cataract Refract Surg. 2024;50(6):624–30. https://doi.org/10.1097/j.jcrs.0000000000001425.
6. Xu J, Chen X, Wang H, Yao K. Safety of femtosecond laser-assisted cataract surgery versus conventional phacoemulsification for cataract: A meta-analysis and systematic review. Adv Ophthalmol Pract Res. 2022;2(1):100027. https://doi.org/10.1016/j.aopr.2022.100027.
7. Asif MI, Sinha R, Anjum S, Sahay P, Singh R, Agarwal T, et al. Comparison of clinical outcomes between femtosecond laser-assisted cataract surgery versus conventional phacoemulsification in vitrectomized eyes - A prospective interventional study. Indian J Ophthalmol. 2024;72(9):1285–90. 4103/IJO.IJO_1804_23. Epub 2024 May 20.
8. Cai L, Ma D, Xu X, Han X, Qiu X, Lu Y, Yang J. Comparative study of FLACS vs conventional phacoemulsification for complex cataracts in vitrectomized eyes. J Cataract Refract Surg. 2022;48(12):1381–7. https://doi.org/10.1097/j.jcrs.0000000000000998.
9. Wen L, Lian H, Liu Y, Wei B, Deng Y, Hu J, et al. Effect of femtosecond laser-assisted cataract surgery for cataracts after Pars plana vitrectomy: a prospective randomized controlled study. BMC Ophthalmol. 2025;25(1):79. https://doi.org/10.1186/s12886-025-03871-w.
10. Flitcroft DI, He M, Jonas JB, Jong M, Naidoo K, Ohno-Matsui K, et al. IMI - Defining and Classifying Myopia: a proposed set of standards for clinical and epidemiologic studies. Invest Ophthalmol Vis Sci. 2019;60(3):M20-M30. https://doi.org/10.1167/iovs.18-25957. Erratum in: Invest Ophthalmol Vis Sci. 2024;65(13):19. doi: 10.1167/iovs.65.13.19.
11. Praveen MR, Shah GD, Vasavada AR, Mehta PG, Gilbert C, Bhagat G. A study to explore the risk factors for the early onset of cataract in India. Eye (Lond). 2010;24(4):686–94. https://doi.org/10.1038/eye.2009.137. Epub 2009 Jun 12.
12. Schweitzer C, Brezin A, Cochener B, Monnet D, Germain C, Roseng S, et al. Femtosecond laser-assisted versus phacoemulsification cataract surgery (FEMCAT): a multicentre participant-masked randomised superiority and cost-effectiveness trial. Lancet. 2020;395(10219):212–24. https://doi.org/10.1016/S0140-6736(19)32481-X.
13. De Giacinto C, D'Aloisio R, Bova A, Candian T, Perrotta AA, Tognetto D. Intraocular pressure changes during femtosecond Laser-Assisted cataract surgery: A comparison between two different patient interfaces. J Ophthalmol. 2019;2019:5986895. https://doi.org/10.1155/2019/5986895.
14. Chung HS, Lee H, Park SY, Min CH, Kim M, Kim JY, Tchah H. Intraocular pressure changes before and after a femtosecond laser procedure for cataract surgery. Sci Rep. 2024;14(1):9020. https://doi.org/10.1038/s41598-024-55961-2.
15. Schultz T, Joachim SC, Szuler M, Stellbogen M, Dick HB. NSAID pretreatment inhibits prostaglandin release in femtosecond Laser-Assisted cataract surgery. J Refract Surg. 2015;31(12):791–4. https://doi.org/10.3928/1081597X-20151111-01.
16. Lv H, Yang J, Liu Y, Jiang X, Liu Y, Zhang M, et al. Changes of intraocular pressure after cataract surgery in myopic and emmetropic patients. Med (Baltim). 2018;97(38):e12023. https://doi.org/10.1097/MD.0000000000012023.
17. Qi J, He W, Lu Q, Zhang K, Lu Y, Zhu X. Schlemm Canal and trabecular meshwork features in highly myopic eyes with early intraocular pressure elevation after cataract surgery. Am J Ophthalmol. 2020;216:193–200. Epub 2020 Feb 14.
18. Choi W, Kim JD, Bae HW, Kim CY, Seong GJ, Kim M. Axial length as a risk factor for Steroid-Induced ocular hypertension. Yonsei Med J. 2022;63(9):850–5. https://doi.org/10.3349/ymj.2022.63.9.850.
19. Fenberg MJ, Hainsworth KJ, Rieger FG 3rd, Hainsworth DP. Vitrectomy as a risk factor for complicated cataract surgery. Mo Med. 2016 Jan-Feb;113(1):44–7.
20. Croft MA, Heatley G, McDonald JP, Katz A, Kaufman PL. Accommodative movements of the lens/capsule and the strand that extends between the posterior vitreous zonule insertion zone & the lens equator, in relation to the vitreous face and aging. Ophthalmic Physiol Opt. 2016;36(1):21–32. https://doi.org/10.1111/opo.12256.
21. Wang EF, Worsley A, Polkinghorne PJ. Comparative study of femtosecond laser-assisted cataract surgery and conventional phacoemulsification in vitrectomized eyes. Clin Exp Ophthalmol. 2018;46(6):624–629. Epub 2018 Jan 22. https://doi.org/10.1111/ceo.13133