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Letter to the Editor

The use of lens anterior capsule disc for corneal endothelium protection during femtosecond laser-assisted cataract surgery in eyes with low endothelial cell density

Dear Editor,

Cataract surgery affects the endothelial cells with a risk for corneal edema, decompensation, and a decrease in visual acuity.[1–3] Previous studies had reported endothelial cell loss rates in standard ultrasound phacoemulsification cataract surgery (PCS) ranged from 4.5% to 42.6%, where there is a strong association between total ultrasound energy, nuclear density, surgical technique, and surgeon's skill.[4–7] The reduction in corneal endothelial cell density (ECD) was even greater in eyes with FECD and primary corneal guttata that had cataract surgery and lens implantation, ranging from 17.3% to 24%.[8]

Surgeons have tried to reduce the loss of corneal endothelial cells (CEC) in cases with primary corneal guttata and Fuchs endothelial corneal dystrophy (FECD) to ensure a less traumatic surgical procedure and decrease complication rates.[9,10] Several approaches had been developed to minimize damage to the CEC.[11–13] In recent years, femtosecond laser-assisted cataract surgery (FLACS) has grown in popularity, and it is now employed in cataract surgery to conduct lens fragmentation, anterior capsulotomy, and corneal incisions.[14] FLACS resulted in less CEC loss compared to standard PCS. Because the decrease in CEC loss was more pronounced in the denser cataract, FLACS may be more effective in those instances.[15]

Recent studies discussed the use of isolated capsulorrhexis flap technique or lens anterior capsule disc (LACD) during FLACS which seemed to provide mechanical protection for CEC[16,17] We adapted and described the efficacy and safety of this technique in eyes with low corneal ECD.

1. Case presentation and methods description

LACD technique was proposed for patients with low ECD such as in Fuchs' endothelial dystrophy with ECD less than 1500 cells/mm2 in whom we would like to preserve the endothelial cells as much as possible. This technique could also potentially be performed in cases with rock hard cataract but normal ECD, where we would want to minimize injury to the corneal endothelial cells. In this study, we reported three patients with significant cataract and low ECD who underwent FLACS and LACD technique. At initial visit, the patients underwent a series of standardized ocular evaluations, which included visual acuity, intraocular pressure, and slit lamp examination, followed by ocular biometry and specular microscopy. All patients had low ECD (less than 1500 cells/mm2) but normal central corneal thickness (less than 600 μm) preoperatively.

The surgical techniques were as follows: The femtosecond laser (performed with Ziemer LDV Z8 platform) was docked on the patient's eye, and then 5.2 mm anterior capsulotomy, nuclear fragmentation, and 2.2 mm corneal incision were programmed to be performed sequentially. After opening the main incision, a small fraction of dispersive OVD (Viscoat, Alcon) was carefully injected into the anterior chamber immediately above the lens anterior capsule (Fig. 1A). Then, the dispersed OVD was injected again slowly just under the disc to lift it up carefully until it was adjacent to the posterior cornea with minimal contact with the endothelium (Fig. 1B). After achieving a good position of the disc, cohesive OVD (Provisc, Alcon) was injected to fill the anterior chamber, fixate the position of the disc, and minimize free movement during nuclear manipulation. This approach ensured minimal contact between the disc and the endothelium while stabilizing its position throughout the surgery. The nucleus was emulsified with the standard phacoemulsification procedure (Centurion, Alcon) while keeping the LACD at the center (Fig. 1C). Intraoperative anterior segment optical coherence tomography (OCT) captured the position of the LACD relative to posterior cornea with minimal endothelial touch (Fig. 2). The cortex was then removed using an aspirated handpiece while maintaining the position of the LACD. The disc could be removed either at the end of cortex removal or after IOL implantation together with OVD removal (Fig. 3). At the end of surgery, corneal incision was sealed by the stromal hydration. All the surgeries in this case series were performed by a single surgeon.

Case 1 was a 78-year-old female who was scheduled for cataract surgery in her left eye (LE). Her initial visual acuity was 20/40 with the presence of grade 4 lens nuclear sclerosis, and preoperative ECD was 924 cells/mm2. FLACS was chosen as her procedure of recommendation. The LACD technique was performed and the surgery was uneventful. One day after the surgery, slit lamp examination revealed moderate stromal edema with descemet folds. CEC counts was 687 cells/mm2 two weeks postoperatively. The rate of CEC loss was 25.64% and final best corrected visual acuity (BCVA) of her LE was 20/30.

Case 2 was a 54-year-old female who underwent FLACS for her right eye (RE). This patient had grade 3 nuclear sclerosis with preoperative BCVA of 20/30 and 939 cells/mm2 preoperative ECD. At postoperative day 1, the cornea was clear without other remarkable finding. Compared with preoperative CEC count, it was 817 at 2 months after the surgery with the rate of CEC loss of 12.99%. Final BCVA was 20/25.

Case 3 was a 67-year-old female with grade 3 nuclear density with initial visual acuity of 20/40, but accompanied with grade 4 corneal guttata and ECD 1362 cells/mm2. She underwent FLACS with the same LACD technique on her RE. One day after the surgery, no corneal edema was observed. The ECD was 1290 at one month postoperatively with 5.28% loss rate. Comparison of morphological findings in specular microscopy were documented without significant changes (Fig. 3). BCVA of the RE at final follow up was 20/25.

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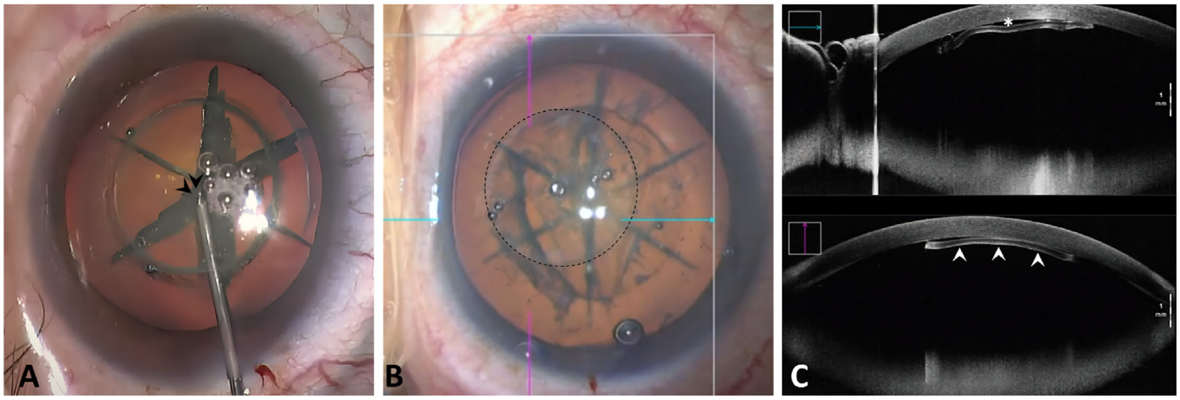

Fig. 1. Initial steps of lens anterior capsule disc (LACD) technique in FLACS. (A) OVD was injected (black arrows) into the anterior chamber and underneath the anterior capsule disc to bring it up towards the posterior cornea. (B) Intraoperative OCT was used to confirm the position of the LACD (dotted black circle) relative to posterior cornea. (C) OCT images confirmed the position of the disc (white arrows) and the presence of interface gap (asterix) between the disc and the corneal endothelium with minimal endothelial touch.

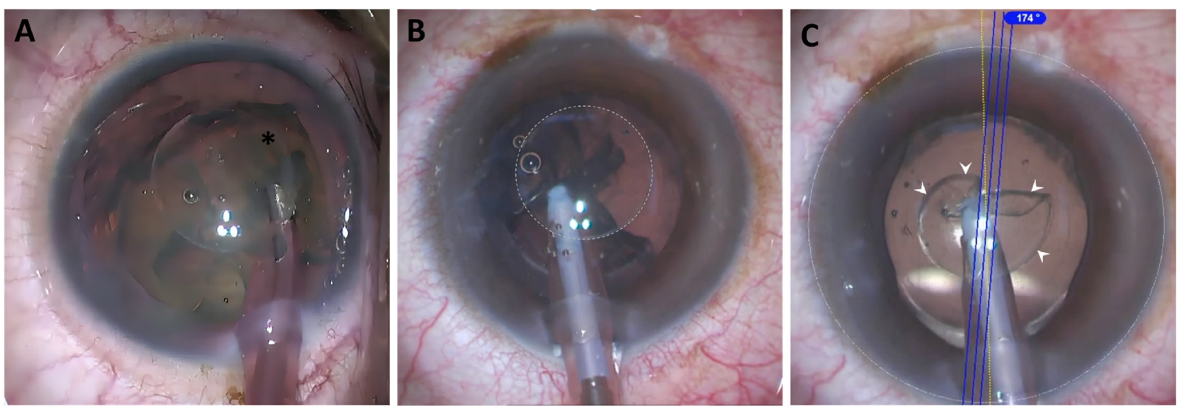

Fig. 2. Cataract extraction followed by removal of the LACD at the end of phacoemulsification procedure. (A) The disc (asterix) was always maintained at the center during the nuclear management in phacoemulsification procedure. (B) During aspiration of the cortex followed by IOL implantation, the disc (dotted white circle) was always maintained at the center. (C) During OVD removal at the end of the surgery, the disc was also aspirated and removed from the anterior chamber (white arrows).

2. Discussion

In cases with substantial cataract and low ECD, majority of patients may benefit from cataract surgery and may not require corneal transplantation.[18] Cataract surgery is an option to consider for people with visually significant cataracts and mild to moderate corneal damage. As a result, we thought it was clinically reasonable to begin with cataract surgery in these three patients of low ECD. Nevertheless, they still carried potential risk of postoperative corneal edema and decompensation, and might require corneal transplantation in the future, as we informed the patients prior to surgery.

Corneal endothelial decompensation is thought to be increased by mechanical trauma during PCS associated with ultrasonic power and total time.[19] When cataracts are extracted, for example, lens fragments can collide with the endothelium.[20] New approaches, such as using newer platforms to minimize power, changing energy mode, using the softshell technique to protect the CECs, and pre-chopping the nucleus with manual methods or the femtosecond laser, can reduce trauma to CEC.[21–23] Chen et al. found that a skilled cataract surgeon kept CEC loss at 19.96% 3 months postoperatively with PCS, while CEC loss with FLACS was 7.85% 3 months postoperatively.[24]

Mechanical protection for the CEC was initially developed using silicone hydrogel lenses to minimize damage caused by ultrasonic vibrations, turbulent currents, and lens fragments.[25] This procedure was modified by Li et al. who employed an isolated anterior capsule flap generated with a femtosecond laser during FLACS instead of a silicone hydrogel lens.[16] In cases with normal preoperative CEC count, they discovered that CEC loss could be as low as 6.40%–7.45%.

Despite this excellent outcome, our initial hypothesis was that the anterior capsule disc may either serve as a mechanical barrier or harm the CEC if it came into direct contact with it. Therefore, we decided to apply this technique to patients that already had a low ECD and significant cataracts. Our technique was also slightly different to what was published. While Li et al.[16] employed OVD under the LACD to elevate it until attached to the corneal endothelium, we injected a small fraction of dispersive OVD on top of the disc to provide a thin barrier between the disc and corneal endothelium and under the disc to help elevate it towads the posterior cornea. Dispersive OVD served two purposes during this procedure. First, to provide initial protection and coating to corneal endothelium, and second, to help the disc adhere to the endothelium due to the adhesive properties of dispersive OVD. We then change to cohesive OVD to fill the anterior chamber, provide additional protection using soft-shell technique, and maintain the disc in place throughout the procedure. At the end of the procedure, the LACD may be removed either prior to or subsequent to IOL implantation. Our rationale posits minimal consequential disparity, as IOL implantation is presumed to exhibit negligible detriment to the corneal endothelium. Thus, the extraction of the disc during either cortex or OVD aspiration is anticipated to yield similar outcomes.

FLACS results in a reduction of energy consumption with lower cumulative dispersed energy (CDE) comparing to PCS and has endothelial sparing effect especially in patients with harder cataracts.[26,27] When

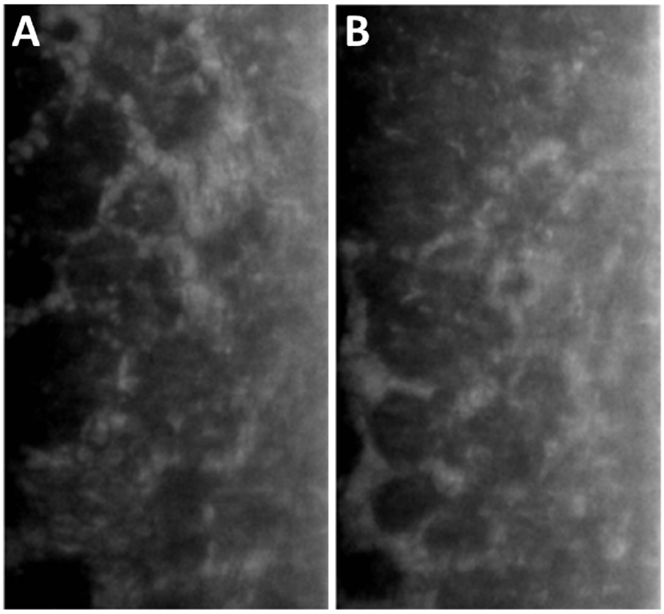

Fig. 3. Preoperative and postoperative specular microscopy comparison of case 3. There was no significant difference in terms of endothelial cell morphology between preoperative (A) and postoperative (B) which showed grade 4 corneal guttata at central cornea.

compared to conventional PCS, nuclear fragmentation with FLACS also lessens intraoperative ultrasound energy and intraocular manipulations.[28] We believed that the LACD technique offers extra protection in addition to FLACS, which already reduces the risk of damage to the CEC. By making this minor adjustment during cataract surgery, we might use the anterior capsule disc to give additional protection instead of discarding it, especially in eyes with low ECD to reduce CEC trauma as much as feasible.

Compared to published data by Krarup et al.[8] of 23.67% CEC loss rate in eyes with FECD that had undergone FLACS alone, our cases with FLACS and LACD technique showed similar, if not lower, percentage of CEC loss, ranging from 5.28% to 25.64%. LACD act as a mechanical barrier to protect the corneal endothelium. In an experimental study using rabbit models by Wu et al.[17] showed that despite direct contact between the disc and corneal endothelium, there was minimal endothelial cell loss rate. Nevertheless, we would like to employ this technique in patients with low ECD as these patients were already prepared for the need of corneal transplantation in the future since we could not assure the effect of LACD when in direct contact with the CEC.

Given its relative simplicity and short learning curve, LACD technique has a good feasibility of being used in clinical practice. It would not cause harm even if the disc could not be maintained in place or was unintentionally removed during quadrant removal; FLACS could be carried on normally. The benefit of this method is that the disc stayed in place thanks to the adhesive properties of the thin layer of dispersive OVD that was present between the disc and the endothelium. Nevertheless, this report is not without limitations. The major drawback is the small number of case studies which is limited to only three patients. Therefore, in order to demonstrate the protective effect of the LACD approach, further studies with larger sample sizes, better study designs, such as randomised controlled trials, and longer follow-up with serial assessments of specular microscopy, is required.

3. Conclusions

In summary, our study showed the possible role and benefit of using LACD to give additional protection for the CEC during cataract surgery especially in cases with low corneal ECD. However, larger prospective study is required to provide higher level of evidence in terms of efficacy and safety of this novel technique.

Study approval

This study was conducted in accordance with the principles of the Declaration of Helsinki, and the study protocol was reviewed by the institutional review board of JEC Eye Hospital. Informed consent to publish this case report was obtained from the patients in writing.

Author contributions

The authors confirm contribution to the paper as follows: Conception and design of study: JH, TDG; Data collection: JH, NAN; Drafting and writing the manuscript: JH, TDG, NAN. All authors reviewed the results and approved the final version of the manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Abbreviations

BCVA	Best corrected visual acuity
CEC	Corneal endothelial cells
ECD	Endothelial cells density
FECD	Fuchs endothelial corneal dystrophy
FLACS	Femtosecond laser-assisted cataract surgery
IOL	Intraocular lens
LACD	Lens anterior capsule disc
PCS	Phacoemulsification cataract surgery
OVD	Ophthalmic viscoelastic device

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.aopr.2024.02.002.

References

1. Miyata K, Maruoka S, Nakahara M, et al. Corneal endothelial cell protection during phacoemulsification: low- versus high-molecular-weight sodium hyaluronate. *J Cataract Refract Surg.* 2002;28(9):1557–1560. https://doi.org/10.1016/s0886-3350(02)01540-7. PMID: 12231310.
2. Lundberg B, Jonsson M, Behndig A. Postoperative corneal swelling correlates strongly to corneal endothelial cell loss after phacoemulsification cataract surgery. *Am J Ophthalmol.* 2005;139(6):1035–1041. https://doi.org/10.1016/j.ajo.2004.12.080. PMID: 15953433.
3. Hayashi K, Yoshida M, Manabe S, Hirata A. Cataract surgery in eyes with low corneal endothelial cell density. *J Cataract Refract Surg.* 2011;37(8):1419–1425. https://doi.org/10.1016/j.jcrs.2011.02.025. PMID: 21684110.
4. Reuschel A, Bogatsch H, Barth T, Wiedemann R. Comparison of endothelial changes and power settings between torsional and longitudinal phacoemulsification. *J Cataract Refract Surg.* 2010;36:1855–1861. https://doi.org/10.1016/j.jcrs.2010.06.060. PMID: 21029892.
5. Kosrirukvongs P, Slade SG, Berkeley RG. Corneal endothelial changes after divide and conquer versus chip and flip phacoemulsification. *J Cataract Refract Surg.* 1997;23:1006–1012. https://doi.org/10.1016/s0886-3350(97)80072-7. PMID: 9379369.

6. Milla E, Verges C, Cipres M. Corneal endothelium evaluation after phacoemulsification with continuous anterior chamber infusion. *Cornea*. 2005;24:278–282. https://doi.org/10.1097/01.ico.0000138851.49203.c4. PMID: 15778598.
7. Kim EC, Byun YS, Kim MS. Microincision versus small-incision coaxial cataract surgery using different power modes for hard nuclear cataract. *J Cataract Refract Surg*. 2011;37:1799–1805. https://doi.org/10.1016/j.jcrs.2011.04.024. PMID: 21839609.
8. Krarup T, Rose K, Mensah AMA, et al. Comparing corneal outcome between femtosecond laser-assisted cataract surgery and conventional phaco surgery in Fuchs' endothelial dystrophy patients: a randomized pilot study with 6mo follow up. *Int J Ophthalmol*. 2021;14(5):684–692. https://doi.org/10.18240/ijo.2021.05.07. PMID: 34012882 PMCID: PMC8077011.
9. Pacifico RL. Ultrasonic energy in phacoemulsification: mechanical cutting and cavitation. *J Cataract Refract Surg*. 1994;20:338–341. https://doi.org/10.1016/s0886-3350(13)80587-1. PMID: 8064612.
10. Hayashi K, Hayashi H, Nakao F, Hayashi F. Risk factors for corneal endothelial injury during phacoemulsification. *J Cataract Refract Surg*. 1996;22:1079–1084. https://doi.org/10.1016/s0886-3350(96)80121-0. PMID: 8915805.
11. Liu Y, Zeng M, Liu X, et al. Torsional mode versus conventional ultrasound mode phacoemulsification: randomized comparative clinical study. *J Cataract Refract Surg*. 2007;33:287–292. https://doi.org/10.1016/j.jcrs.2006.10.044. PMID: 17276271.
12. Can I, Takmaz T, Cakici F, Ozgul M. Comparison of Nagahara phaco-chop and stop-and-chop phacoemulsification nucleotomy techniques. *J Cataract Refract Surg*. 2004;30:663–668. https://doi.org/10.1016/j.jcrs.2003.06.006. PMID: 15050265.
13. Ravalico G, Tognetto D, Baccara F, Lovisato A. Corneal endothelial protection by different viscoelastics during phacoemulsification. *J Cataract Refract Surg*. 1997;23:433–439. https://doi.org/10.1016/s0886-3350(97)80190-3. PMID: 9159690.
14. Abouzeid H, Ferrini W. Femtosecond-laser assisted cataract surgery: a review. *Acta Ophthalmol*. 2014;92:597–603. https://doi.org/10.1111/aos.12416. PMID: 24835818.
15. Al-Mohtaseb Z, He X, Yesilirmak N, et al. Comparison of corneal endothelial cell loss between two femtosecond laser platforms and standard phacoemulsification. *J Refract Surg*. 2017;33(10):708–712. https://doi.org/10.3928/1081597X-20170731-01. PMID: 28991340.
16. Li S, Chen X, Zhao J, et al. Isolated capsulorhexis flap technique in femtosecond laser-assisted cataract surgery to protect the corneal endothelial cells. *J Invest Surg*. 2019;32(1):35–38. https://doi.org/10.1080/08941939.2017.1372537. PMID: 29252045.
17. Wu B, Ding X, Li S, et al. Mechanical protective effect of lens anterior capsule disc on corneal endothelial cells during femtosecond laser-assisted cataract surgery in a rabbit model. *BMC Ophthalmol*. 2023;23(1):166. https://doi.org/10.1186/s12886-023-02918-0. PMID: 37076866 PMCID: PMC10114485.
18. Viberg A, Liv P, Behndig A, et al. The impact of corneal guttata on the results of cataract surgery. *J Cataract Refract Surg*. 2019;45(6):803–809. https://doi.org/10.1016/j.jcrs.2018.12.023. PMID: 30967299.
19. Gupta SK, Singh R, Sharma AK, et al. Is manual small incision cataract surgery the preferred technique for hard cataract? *J Ophthalmol*. 2020;5:000201. https://doi.org/10.23880/oajo-16000201.
20. Ramirez-Garcia MA, Khalifa YM, Buckley MR. Vulnerability of corneal endothelial cells to mechanical trauma from indentation forces assessed using contact mechanics and fluorescence microscopy. *Exp Eye Res*. 2018;175:73–82. https://doi.org/10.1016/j.exer.2018.06.005. PMID: 29883637 PMCID: PMC6497073.
21. Abell RG, Kerr NM, Howie AR, et al. Effect of femtosecond laser-assisted cataract surgery on the corneal endothelium. *J Cataract Refract Surg*. 2014;40(11):1777–1783. https://doi.org/10.1016/j.jcrs.2014.05.031. PMID: 25217072.
22. Abell RG, Kerr NM, Vote BJ. Toward zero effective phacoemulsification time using femtosecond laser pretreatment. *Ophthalmology*. 2013;120:942–948. https://doi.org/10.1016/j.ophtha.2012.11.045. PMID: 23465860.
23. Takacs AI, Kovacs I, Mihaltz K, et al. Central corneal volume and endothelial cell count following femtosecond laser-assisted refractive cataract surgery compared to conventional phacoemulsification. *J Refract Surg*. 2012;28:387–391. https://doi.org/10.3928/1081597X-20120508-02. PMID: 22589291.
24. Chen X, Yu Y, Song X, et al. Clinical outcomes of femtosecond laser-assisted cataract surgery versus conventional phacoemulsification surgery for hard nuclear cataracts. *J Cataract Refract Surg*. 2017;43:486–491. https://doi.org/10.1016/j.jcrs.2017.01.010. PMID: 28532933.
25. Kim S, Cha D, Song YB, et al. Effects of senofilcon A mechanical protector on corneal endothelial cells during phacoemulsification in rabbit eyes: pilot study. *J Cataract Refract Surg*. 2017;43:394–399. https://doi.org/10.1016/j.jcrs.2017.01.006. PMID: 28410724.
26. Ou Y, Wang Y, Wu T. Comparison of ultrasound energy consumption between low-energy femtosecond laser-assisted cataract surgery and conventional phacoemulsification cataract surgery in patients with different cataract densities. *Eur J Ophthalmol*. 2023;33(3):1373–1379. https://doi.org/10.1177/11206721221147952. PMID: 36575599.
27. Lin HY, Kao ST, Chuang YJ, et al. Comparison of cumulative dispersed energy between conventional phacoemulsification and femtosecond laser-assisted cataract surgery with two different lens fragmentation patterns. *Lasers Med Sci*. 2022;37(2):843–848. https://doi.org/10.1007/s10103-021-03321-1. PMID: 33876322 PMCID: PMC8918128.
28. Whang WJ, Yang HJ, Lee SH, et al. Effect of pre-fragmentation on efficacy and safety for phacoemulsification in femtosecond laser-assisted cataract surgery: a non-randomized clinical trial. *Ann Transl Med*. 2023;11(1):5. https://doi.org/10.21037/atm-22-1279. PMID: 36760257 PMCID: PMC9906215.

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