Review

Not peer-reviewed version

The Eight-Chop Technique: Mechanistic Principles and Clinical Performance of a Segmentation-First Phacoemulsification Strategy

Tsuyoshi Sato *

Posted Date: 24 December 2025

doi: 10.20944/preprints202512.2212.v1

Keywords: cataract surgery; phacoemulsification; nuclear fragmentation; segmentation-first; fluidics; Eight-Chop technique

Review

The Eight-Chop Technique: Mechanistic Principles and Clinical Performance of a Segmentation-First Phacoemulsification Strategy

Tsuyoshi Sato

Sato Eye Clinic, Japan; perfect-eightchop@sato-ganka.com

Abstract

Purpose: To review the conceptual evolution, mechanical principles, and clinical outcomes of the Eight-chop nuclear fragmentation technique, and to clarify its position within modern cataract surgery. **Methods:** A narrative review was conducted focusing on the historical development of nuclear fragmentation strategies, including sculpting-based techniques, divide-and-conquer, chop-based methods, femtosecond laser–assisted cataract surgery, and prechop techniques. Particular attention was given to the wedge-induced fracture mechanism, geometric optimization through eightfold division, and integration with modern fluidics systems. Published clinical studies and the authors' clinical data were analyzed across a wide range of cataract subtypes. **Results:** Across standard cataracts and challenging conditions—including dense nuclear cataracts, white cataracts, small pupils, shallow anterior chamber, microcornea, diabetic eyes, and pseudoexfoliation syndrome—the Eight-chop technique consistently demonstrated reduced phaco time, cumulative dissipated energy, and irrigation volume compared with conventional techniques. Corneal endothelial cell density loss was generally limited to approximately 1–3%, even in high-risk subgroups. Postoperative intraocular pressure showed a sustained reduction over mid- to long-term follow-up. These subtype-specific outcomes are integrated in Table 1, highlighting the reproducibility and low invasiveness of the technique regardless of nuclear hardness or anterior segment anatomy. **Conclusions:** Eight-chop is a segmentation-first nuclear fragmentation strategy based on complete in-the-bag prefragmentation using a wedge-induced fracture mechanism. Its compatibility with modern fluidics systems, including AFS, enhances anterior chamber stability and reinforces its minimally invasive profile. By reducing energy use, fluid load, and zonular stress, Eight-chop represents a rational and versatile option for contemporary cataract surgery, particularly in high-risk eyes.

Keywords: cataract surgery; phacoemulsification; nuclear fragmentation; segmentation-first; fluidics; Eight-Chop technique

---

1. Introduction

Phacoemulsification has become the standard procedure for modern cataract surgery worldwide, and its safety and efficiency have largely depended on strategies for crystalline lens nuclear fragmentation [1,2]. Because the success or failure of nuclear fragmentation is directly linked to stabilization of intraoperative parameters, reduction of postoperative inflammation, preservation of corneal endothelial cell density (CECD), reduction of intraoperative complications, and earlier recovery of visual function [3–5], the evolution of nuclear fragmentation techniques has formed the foundation for improvements in the safety of cataract surgery.

Looking back at the history of nuclear fragmentation, early sculpting techniques required large amounts of ultrasound energy for nuclear removal and represented a major cause of corneal endothelial damage [6]. Subsequently, the introduction of divide-and-conquer by Gimbel established the concept of segmentation based on mechanical fracture [2]. Thereafter, techniques such as stop-

doi:10.20944/preprints202512.2212.v1

and-chop and phaco-chop were proposed and have become widely adopted in contemporary practice [7–10]. However, none of these techniques presuppose complete mechanical nuclear division before the initiation of phacoemulsification, and they commonly rely on incomplete fragmentation within the anterior chamber. As a result, issues remain, including increased ultrasound energy, reduced aspiration efficiency, and unnecessary mechanical stress on the posterior capsule and zonular apparatus [11–13]. These limitations may further increase the risk of intraoperative complications in challenging cases such as dense nuclear cataracts, white cataracts, poor pupillary dilation, shallow anterior chamber (SAC), microcornea, diabetic eyes, and pseudoexfoliation syndrome [14–18].

In contrast, recently introduced active fluidics systems (AFS) have enabled phacoemulsification under low intraocular pressure (IOP) conditions and have markedly improved anterior chamber stability [19,20]. However, under low IOP settings, fragment followability and occlusion stability become critical determinants of surgical outcomes, making it more important than ever that nuclear fragments possess appropriate size and geometry [21,22]. In other words, a conceptual reconstruction of nuclear segmentation that is compatible with modern fluidics technology is required.

Against this background, the Eight-chop technique developed by the author is not a mere accumulation of incremental technical modifications but a surgical procedure constructed on a clearly defined surgical philosophy. The philosophy of Eight-chop consists of four fundamental principles. First, the most hazardous maneuvers should be performed under conditions that ensure maximal visibility and anterior chamber stability. Second, ultrasound energy should be used not to divide the nucleus but to remove it. Third, mechanical stress on the posterior capsule and zonules should not be compensated for by surgical skill but should be minimized by design at a fundamental level. Fourth, maintaining an identical surgical sequence, even in anatomically or pathologically challenging cases, contributes to improved surgical safety.

Based on these principles, the Eight-chop technique was devised as a “segmentation-first” surgical concept in which complete intrabag nuclear division is achieved before phacoemulsification [23]. The fragmentation principle of this technique applies concepts from fracture mechanics based on the wedge-induced fracture mechanism [24], and further aims to maximize controllability and aspiration efficiency of nuclear fragments in the anterior chamber through geometric optimization into eight segments. For routine nuclei (Emery–Little Grade I–III), a one-handed technique without the use of a second instrument is adopted as the standard, and subsequent phacoemulsification is completed using the phaco tip alone [23]. Only in extremely hard nuclei (Emery–Little Grade IV or higher) may a lance chopper or sustainer be used during the fragmentation process [23]; however, this is strictly limited to assisting segmentation, and the fundamental philosophy of Eight-chop—namely, completing phacoemulsification without a second instrument after fragmentation—is consistently maintained.

In this review, we first provide an overview of the historical development of nuclear fragmentation techniques, and then clarify the essential principles required to achieve safe and efficient nuclear segmentation from the perspectives of the wedge-induced fracture mechanism and intraoperative fluidics. We further define the conceptual framework of the Eight-chop technique and discuss its clinical implementation and safety in various challenging cases, as well as its positioning in future cataract surgery. The aim of this review is to present Eight-chop not merely as a single technique but as a comprehensive approach that reconstructs the nuclear removal strategy itself in modern cataract surgery.

The author has performed more than 20,000 cataract surgeries over the past two decades, in the majority of which the Eight-chop technique has been used as the primary method of nuclear fragmentation. Other nuclear fragmentation techniques were rarely employed. This long-term and consistent clinical experience based on a single technique has made it possible to evaluate the Eight-chop technique from a unified perspective across patient populations with diverse nuclear hardness and ocular comorbidities.

2. Evolution of Nuclear Fragmentation Strategies

2.1. Sculpting-Based Techniques Before Segmentation

In the early era of phacoemulsification, sculpting techniques, in which the majority of the nucleus was removed by ultrasound energy, were the dominant approach [1,3]. This method required large amounts of energy for the management of dense nuclei and resulted in problems such as corneal endothelial damage, anterior chamber instability, and prolonged surgical time [4–6]. Continuously sculpting the nucleus without substantially altering its morphology had inherent technical limitations, and the need for more efficient and less invasive nuclear management gradually became recognized.

2.2. Divide-and-Conquer: Establishment of the Segmentation Concept

The divide-and-conquer technique introduced by Gimbel was groundbreaking in that it systematically introduced the concept of "segmentation" into cataract surgery through the creation of deep grooves and division of the nucleus into four quadrants [2]. However, groove formation still required a large amount of ultrasound energy, and the technique was fundamentally based on sculpting, which imposes stress on the posterior capsule and zonular apparatus [4–6]. In addition, nuclear division required simultaneous manipulation of a second instrument and the ultrasound tip, resulting in a learning curve for acquisition of the technique.

Because nuclear division in this method relies primarily on shear forces, its fracture efficiency is lower compared with fracture based on the wedge-induced fracture mechanism. Moreover, since the division procedure is performed within the irrigated anterior chamber, surgeons must avoid contact with the capsular bag, iris, and corneal endothelium in an inherently unstable surgical field, introducing intraoperative risks [11–13]. During manipulation, traction applied to the globe through the main incision and side ports, as well as fluid leakage from the wounds, further contributes to anterior chamber instability.

In addition, the shear force generated by the second instrument and ultrasound tip has mechanical limitations, and in hard nuclei, the posterior plate often remains incompletely fractured. Consequently, the amount of anterior chamber manipulation during emulsification increases, which tends to elevate the risk of complications [13].

2.3. Stop-and-Chop: A Hybrid Technique Combining Sculpting and Chopping

In 1994, Koch proposed the stop-and-chop technique as a modification of the chopping technique introduced by Nagahara [7]. This technique is characterized by a stepwise approach in which the nucleus is first divided into two halves by conventional groove creation and cracking, followed by further division of each hemi-nucleus using horizontal chopping [7–9].

Stop-and-chop achieved wide clinical acceptance because it did not require pure chopping skills from the outset. However, it is essentially a hybrid technique that presupposes the space created by central sculpting and fundamentally follows the workflow of divide-and-conquer. As a result, it is difficult to fully benefit from the reductions in ultrasound energy and improvements in fragmentation efficiency offered by pure horizontal or vertical chop techniques [9,10]. In particular, dense nuclei often require additional manipulations, making an increase in anterior chamber maneuvers unavoidable.

2.4. Phaco-Chop: Advancement of Mechanical Fragmentation

Phaco-chop, introduced by Nagahara, represents an important shift from sculpting-based nuclear processing to a technique that emphasizes mechanical separation along the natural fiber arrangement of the nucleus [9]. By approximating the tips of two instruments in a horizontal direction, the nucleus is divided mechanically, enabling a reduction in the ultrasound energy

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 December 2025 doi:10.20944/preprints202512.2212.v1

required for nuclear management [9,10]. This high energy efficiency is based on advancing natural cleavage planes that exploit the lamellar structural characteristics of lens nuclear fibers.

Nevertheless, this technique also has inherent limitations. Initial impalement of the ultrasound tip into the central nucleus requires a certain amount of ultrasound energy, and dependence on ultrasound increases as nuclear hardness rises [13]. In addition, fragmentation requires coordinated manipulation of the ultrasound tip and an auxiliary instrument, and acquisition of the technique necessitates stepwise experience. Furthermore, because the mechanism relies primarily on pushing forces, the posterior plate may remain intact in hard nuclei, resulting in insufficient mobilization of nuclear fragments [11–13]. Consequently, additional maneuvers or strong auxiliary instrument manipulation may be required, raising concerns regarding increased stress on the zonular apparatus.

2.5. Phaco Prechop: Presentation of a Pre-Phaco Segmentation Concept and Its Limitations

Phaco prechop, proposed by Akahoshi, was developed as a dedicated set of instruments and techniques to mechanically divide the lens nucleus before the use of the ultrasound tip [25]. These prechop techniques form an independent category in that they aim to complete nuclear segmentation in advance.

In cases with high nuclear hardness, equatorial support using a sustainer is often required to avoid direct transmission of force generated during division or impalement to the capsular bag and zonules. On the other hand, nuclear debris generated after the initial division may remain in the anterior chamber, potentially reducing visibility for subsequent steps, and the number of fragments is often limited to four. Furthermore, determination of instrument insertion depth depends heavily on surgeon experience, and both insufficient and excessive insertion can compromise safety. Workflow-related constraints, including increased procedural steps and instrument use, have also hindered widespread adoption.

Thus, while phaco prechop presented the important concept of completing intrabag nuclear segmentation prior to phacoemulsification, limitations related to visibility, restricted fragmentation number, difficulty in intraoperative judgment, and workflow complexity prevented broad generalization. Nevertheless, this concept shares conceptual commonality with the Eight-chop technique and can be regarded as a pioneering approach that demonstrated the independence of nuclear segmentation.

2.6. Positioning and Limitations of Nuclear Pretreatment in Femtosecond Laser–Assisted Cataract Surgery

Nuclear pretreatment in femtosecond laser–assisted cataract surger represents a strategy of dividing the nucleus prior to phacoemulsification, and reductions in effective phaco time (EPT) and cumulative dissipated energy (CDE) have been reported [18]. However, consistent superiority over conventional manual surgery has not been demonstrated for major outcomes such as postoperative visual acuity, refractive results, CECD, or complication rates [18]. This is likely because final nuclear removal still depends on phacoemulsification, and the essential nature of nuclear management remains unchanged.

In addition, laser-pretreated nuclear fragments do not always achieve complete occlusion of the phaco tip, and situations in which sufficient vacuum cannot be obtained—particularly with peristaltic systems—have been reported [26]. Taken together, while femtosecond laser–assisted cataract surger has certain rational advantages as a nuclear pretreatment strategy, there remains room for improvement in addressing the fundamental challenges of nuclear management.

2.7. Structural Limitations Common to Conventional Techniques

Conventional nuclear fragmentation techniques share structural limitations across different procedures. First, shear-force–dependent fragmentation tends to leave the posterior plate intact, resulting in incomplete segmentation and nonuniform fragment size and shape. Consequently, these fragments are poorly suited to modern fluidics, leading to reduced followability and occlusion stability [13,21]. Second, because fragmentation is performed in the irrigated anterior chamber, surgeons must avoid unnecessary contact with the capsule, iris, and corneal endothelium under conditions where anterior chamber stability is not fully secured. Traction associated with manipulation through the main incision and side ports, as well as fluid leakage, further destabilizes the anterior chamber and increases intraoperative risk [19,21]. Third, simultaneous manipulation of the ultrasound tip and a second instrument disperses attention and may reduce precision or transmit unnecessary force. In particular, manipulation by the second instrument increases traction stress on the zonules, and inappropriate ultrasound tip handling is directly associated with posterior capsule rupture [11,12]. These issues become more pronounced in high-risk eyes such as those with pseudoexfoliation, SAC, or microcornea, thereby increasing the risk of intraoperative complications [11,12,14–18]. Thus, while conventional techniques rely heavily on surgeon expertise, they also possess intrinsic procedural limitations.

2.8. Positioning of Eight-Chop: A Segmentation Strategy Overcoming Conventional Limitations

Eight-chop is a strategy designed to overcome the limitations inherent in conventional segmentation techniques. Its core elements include full-thickness fracture based on the wedge-induced fracture mechanism [24] and geometric optimization through division into eight segments to adapt fragment shape to modern fluidics. Complete prefragmentation allows early mobilization of nuclear fragments, and minimizing dependence on a second instrument enables both safety and efficiency. Eight-chop can therefore be positioned as a natural extension of the theoretical and practical evolution of segmentation strategies in modern cataract surgery [23].

3. Conceptual Framework of Eight-Chop

3.1. Fundamental Philosophy of Eight-Chop: Strategic Shift Through Complete Prefragmentation

The most fundamental characteristic of Eight-chop lies in its strategic concept of completely dividing the lens nucleus into eight independent small fragments prior to phacoemulsification. Through this complete prefragmentation, the workflow of nuclear management becomes essentially different from that of conventional techniques. Whereas traditional methods such as divide-and-conquer, stop-and-chop, and phaco-chop presuppose the simultaneous performance of nuclear fragmentation and phacoemulsification within the anterior chamber, Eight-chop completes segmentation before the phacoemulsification stage [2,7–10]. This transformation of workflow is the primary factor underlying the improvements in anterior chamber stability, reduction in manipulation, expansion of the safety margin, and enhanced efficiency of phacoemulsification achieved with Eight-chop [23].

3.2. Wedge-Induced Fracture Mechanism: The Mechanical Foundation of Eight-Chop

Nuclear fragmentation in Eight-chop is based on the wedge-induced fracture mechanism, which differs fundamentally from the shear-dominant separation used in conventional chop techniques. The essence of this fracture mechanism lies in advancing the instrument tip into the nucleus and then opening it to generate a wedge effect, thereby efficiently producing tensile components within the nucleus and propagating these forces through the full thickness of the nuclear structure [24].

This fracture mode is effective in cases with ordinary nuclear hardness (Emery–Little Grade I–III) and constitutes the basic mechanical principle of Eight-chop. In conventional divide-and-conquer, stop-and-chop, and phaco-chop techniques, successful nuclear division depends on shear or opposing forces generated by the second instrument and ultrasound tip, and these forces are inevitably transmitted to the posterior capsule and zonular apparatus [2,7–10]. In contrast, because Eight-chop completes nuclear segmentation prior to phacoemulsification through wedge-induced fracture, there is no need to spread or tear the nucleus during emulsification.

As a result, even in nuclei of ordinary hardness, Eight-chop fundamentally minimizes mechanical stress applied to the posterior capsule and zonules. This feature has particular safety significance in eyes with pseudoexfoliation syndrome, SAC, or microcornea, where supporting structures are fragile or the working space is restricted [11,12].

In cases with high nuclear hardness (Grade IV or higher), the presence of a posterior plate may impede fragmentation; however, even under such conditions, the wedge-induced fracture mechanism remains effective. With instruments such as the Eight-chopper II or lance chopper, improvements in tip design enhance nuclear penetration, and the wedge effect generated by opening the instrument is reliably transmitted to the posterior plate. Consequently, full-thickness fracture can be achieved safely and reproducibly even in dense nuclei, which are difficult to manage with conventional shear-based chop techniques [23,24].

Importantly, this mechanical advantage is not limited to hard nuclei but represents a principle that consistently applies across a spectrum from ordinary to highly dense nuclei. Eight-chop is not a technique that switches fracture modes according to nuclear hardness; rather, it is a segmentation strategy that applies a single mechanical principle—wedge-induced fracture—across a wide range of cases through appropriate instrument design and manipulation.

Through this mechanical foundation, Eight-chop reduces the amount of manipulation required during both nuclear fragmentation and phacoemulsification, thereby expanding intraoperative stability and the safety margin. In particular, the ability to minimize posterior capsule and zonular stress even in routine cataract surgery provides a strong rationale for positioning Eight-chop as a universal nuclear fragmentation strategy suitable for daily clinical practice [23].

3.3. Segmentation Strategy of Eightfold Division in the Eight-Chop Technique: Geometric Rationale

The “eightfold division” in the Eight-chop technique is not intended to subdivide the nucleus into the smallest possible fragments for its own sake. Rather, it represents a practical and highly reproducible segmentation strategy derived from a comprehensive consideration of crystalline lens nuclear structure, the operative space within the anterior chamber, and the fluidics characteristics of modern phacoemulsification systems.

Importantly, the number eight does not constitute a rigid requirement, but rather a realistic target that balances nuclear fragment size with intraoperative controllability [23]. In the Eight-chop technique, the resulting nuclear fragments do not need to be perfectly uniform, and minor variability according to intraoperative conditions does not compromise either safety or efficiency. The essential requirement of this technique is that each fragment be sufficiently small and easily controllable as an independent unit.

In eyes with normal nuclear density (Emery–Little Grade I–III), nuclei divided into eight fragments exhibit high mobility within the anterior chamber, allowing aspiration to proceed while maintaining an adequate safety margin from the corneal endothelium, iris, and posterior capsule. Reduction in fragment volume improves followability and enables stable occlusion at the phaco tip, thereby enhancing emulsification and aspiration efficiency [21,22]. As a result, the extent of instrument manipulation within the anterior chamber is reduced, leading to decreased intraoperative fluid fluctuation and a lower risk of unintended contact.

The small fragment size is also critically important for surgical stability under low IOP conditions. With the increasing adoption of AFS, anterior chamber stability is highly dependent on the behavior of nuclear fragments. The small fragments generated by eightfold division are more easily controlled from a fluid-dynamic perspective, which may suppress surge events while contributing to reductions in irrigation volume and cumulative ultrasound energy [19–22].

Even in cases with high nuclear hardness (Grade IV or higher), the eightfold division strategy does not lose its effectiveness. By limiting the volume and thickness of each fragment, nuclear pieces can be more readily mobilized out of the capsular bag, and graspability with the phaco tip is improved. Consequently, safe emulsification and aspiration can be achieved while minimizing contact with the corneal endothelium, even in hard nuclei [13,23].

From a practical standpoint, division of the nucleus into six fragments is structurally difficult to achieve, whereas subdivision into ten or more fragments leads to increased procedural complexity and reduced efficiency. When segmentation is initiated from the nuclear center, equal sixfold division is geometrically difficult to realize, and excessive fragmentation compromises fragment controllability. Taken together, eightfold division represents an optimal solution derived from considerations of divisibility, maneuverability, and efficiency, and there is no need to alter the number of divisions according to nuclear hardness [23].

In summary, the eightfold division employed in the Eight-chop technique is not an adaptation limited to specific cases or nuclear densities, but rather a geometrically rationalized segmentation strategy designed to provide the most stable operative environment and a high level of safety in routine cataract surgery.

3.4. Minimization of Dependence on a Second Instrument Through Complete Prefragmentation

One of the core elements supporting the clinical safety and reproducibility of the Eight-chop technique is the essential reduction in dependence on a second instrument achieved through complete prefragmentation. In conventional nuclear fragmentation techniques such as divide-and-conquer, stop-and-chop, and phaco-chop, simultaneous shearing maneuvers using an ultrasound tip and a chopper (or hook) are indispensable, inevitably imposing lateral and tractional stresses on the posterior capsule and the zonular apparatus during the procedure [2,7–12].

In contrast, in the Eight-chop technique, nuclear segmentation is completed prior to the initiation of phacoemulsification, eliminating the need for lateral separation or forceful auxiliary instrument manipulation during the emulsification phase. As a result, nuclear fragment removal can be accomplished essentially with the phaco tip alone, and inadvertent tractional or compressive forces transmitted to the lens-supporting structures by a second instrument are fundamentally avoided.

Importantly, this characteristic is effective regardless of nuclear hardness. Even in routine nuclei (Emery–Little Grade I–III), conventional techniques require repeated chopper manipulation for nuclear division and fragment control, whereas in Eight-chop, small and independent nuclear fragments become mobile at an early stage, allowing rotation, grasping, and aspiration to occur naturally. This leads to a reduction in the overall amount of intraoperative manipulation during phacoemulsification and contributes to improved stability of the surgical field.

Furthermore, reduced use of a second instrument contributes to stabilization of wound architecture and anterior chamber fluidics. When a side-port incision is unnecessary or minimized, wound deformation and irrigation leakage associated with instrument manipulation are reduced, thereby suppressing fluctuations in anterior chamber depth [19,21]. This factor is particularly important in surgery performed under low IOP conditions using an active fluidics system.

In high-risk eyes, such as those with pseudoexfoliation syndrome, SAC, or microcornea, manipulation with a second instrument itself is known to constitute a risk factor for intraoperative complications [11,12,14–18]. By adopting a workflow based on complete prefragmentation, the Eight-chop technique reduces this structural risk and provides a level of safety that is qualitatively distinct from that of conventional techniques.

Taken together, the minimization of dependence on a second instrument in the Eight-chop technique should be regarded not as a mere simplification of surgical maneuvers, but as an inevitable consequence of a design philosophy aimed at fundamentally reducing mechanical stress on the lens-supporting structures.

3.5. Integration with Fluidics, Particularly Low–Intraocular Pressure Active Fluidics Systems

In recent phacoemulsification systems, active fluidics has become the mainstream approach, and stability of the anterior chamber under low IOP conditions is strongly required [19,20]. The segmentation strategy of the Eight-chop technique is highly compatible with fluidics, as smaller nuclear fragments improve followability and provide more stable occlusion [21,22]. As a result, surge

 doi:10.20944/preprints202512.2212.v1

is less likely to occur, irrigation volume is reduced, and postoperative inflammation and corneal endothelial cell damage may be suppressed [4–6,20].

In the modern surgical environment, in which nuclear fragment behavior has become a critical determinant of surgical success under low IOP conditions, the Eight-chop technique can be positioned as a segmentation method with exceptionally high compatibility, particularly in terms of stabilizing nuclear fragment dynamics within low-pressure fluidics environments [27].

3.6. Eight-Chop as a Comprehensive Segmentation Strategy Integrating Mechanics, Geometry, and Fluidics

The theoretical foundation of the Eight-chop technique is characterized by the organic integration of three elements—fracture mechanics [24], geometric segmentation, and modern fluidics [19–22]—within the surgical workflow, rather than treating them as independent concepts. Reconstruction of the workflow through complete prefragmentation, safe and stable fragmentation based on the wedge-induced fracture mechanism, the rationality of the eight-segment structure, and high compatibility with low–IOP fluidics together achieve a level of comprehensive optimization that could not be realized with conventional nuclear fragmentation techniques.

Eight-chop should therefore be regarded not merely as a new nucleus fragmentation technique, but as a methodology that theoretically and practically redefines the evolution of segmentation science in cataract surgery [23].

4. Clinical Evidence

4.1. Clinical Performance in Standard Cataract Surgery

The Eight-chop technique has consistently demonstrated low invasiveness and high efficiency even in standard cataract surgery (normal cataracts), as confirmed by previously published studies and the authors' clinical data [23]. Existing studies have reported that the Eight-chop technique results in lower intraoperative ultrasound usage, CDE, shorter phaco time, and reduced irrigation volume, with operative times of approximately 3.7–5.4 minutes and CDE values around 5.0–9.2 [23]. These values are clearly lower than those reported for divide-and-conquer and phaco-chop techniques, suggesting that the segmentation characteristics of Eight-chop, which fragment the nucleus into small pieces, contribute substantially to intraoperative energy reduction [9,10,22,23].

Both previously published studies by the author show similar trends. In Eight-chop cases involving normal nuclei (Emery–Little Grade II–III), the mean operative time was 4.5–4.6 minutes, mean phaco time was 14.3–16.2 seconds, mean CDE was 5.8–7.0, and irrigation volume was approximately 25.5–28.9 mL [28,29]. Postoperative CECD loss was 1.2–2.7% at both 7 and 19 weeks, consistent with multiple previous reports demonstrating the low endothelial damage associated with Eight-chop [4–6,23].

These findings indicate that the segmentation strategy of Eight-chop—namely, completing nuclear fragmentation prior to phacoemulsification and minimizing nuclear manipulation during ultrasound emulsification—achieves high reproducibility and safety even in standard cataracts, regardless of nuclear hardness [23]. In particular, reductions in anterior chamber turbulence and excessive nuclear manipulation were consistently associated with suppression of postoperative inflammation and endothelial stress [4–6,19–22]. Collectively, evidence from multiple published studies and the authors' clinical data indicates that the Eight-chop technique is an efficient and minimally invasive fragmentation method even for normal cataracts, representing a viable option for standard cataract surgery in terms of anterior chamber stability, energy efficiency, and endothelial protection [23].

4.2. Hard Nuclear Cataracts

Hard nucleus cataracts corresponding to Emery–Little Grades IV–V have long been considered among the most technically challenging cases for lens nucleus fragmentation[11, 13]. Due to marked thickening and sclerosis of the posterior nuclear plate, achieving full-thickness fracture from the nuclear center to the posterior pole is often difficult using conventional techniques such as divide-and-conquer, stop-and-chop, and phaco-chop [9–11,13]. Consequently, repeated chopping maneuvers and lateral separation within the anterior chamber are frequently required, increasing mechanical stress on the posterior capsule and zonular apparatus [11,12]. In addition, prolonged ultrasound use and increased irrigation volume in hard nuclear cases are major contributors to postoperative corneal endothelial damage [4–6,13].

The Eight-chop technique was developed specifically to overcome these mechanical and geometric limitations [23]. In this method, a lance chopper is inserted obliquely into the central nucleus, and the tip is gradually opened to activate the wedge-induced fracture mechanism, thereby creating a continuous deep cleavage plane extending from the nuclear center toward the posterior nuclear plate [23,24]. This principle enables reproducible full-thickness nuclear fragmentation including the posterior plate, without applying excessive lateral traction forces, which are often required in conventional techniques [23].

The authors have evaluated the efficacy and safety of Eight-chop in clinical studies involving Emery–Little Grade IV–V nuclear cataracts, and the results have already been reported [23,30]. In these studies, octasection of the nucleus prior to phacoemulsification was achieved in the majority of cases, even in extremely hard nuclei, and intraoperative parameters were favorable. Specifically, the mean operative time was 10.5 minutes, mean phaco time was 38.9 seconds, mean aspiration time was 135.6 seconds, mean CDE was 19.2, and mean irrigation volume was 53.0 mL [30]. These values indicate low invasiveness when compared with previously reported outcomes of conventional techniques for hard nuclear cataracts [23,30].

Postoperative outcomes also demonstrated marked endothelial protection. At 19 weeks postoperatively, CECD loss was 0.2% in Grade IV, 6.8% in Grade IV plus, and 9.6% in Grade V cases, with an overall mean of 3.7% [30]. CECD loss showed significant correlations with phaco time, CDE, and irrigation volume, suggesting that complete prefragmentation by Eight-chop reduces intraoperative energy load and contributes to endothelial protection [23,30].

Because nuclear fragmentation is completed prior to phacoemulsification in Eight-chop, no additional fragmentation maneuvers are required within the anterior chamber. Ophthalmic viscosurgical device (OVD) injected before fragmentation not only protects the corneal endothelium but also forms a physical buffer between the nucleus and posterior capsule, preventing direct transmission of stress to the posterior capsule during deep fracture [4–6]. Even in Grade IV–V cases, the incidence of posterior capsule rupture was low, and nuclear drop or extensive zonular dehiscence was rare [23,30].

Taken together, Eight-chop is a nuclear fragmentation technique capable of overcoming the intrinsic difficulty of hard nuclear cataracts through both geometric fracture strategy and reduction of intraoperative energy load. It can therefore be positioned as a highly safe and reproducible segmentation strategy for dense nuclear cataracts [23,30].

4.3. White Cataract

White cataracts often present with high nuclear hardness and frequently lack epinucleus. As a result, the nucleus is prone to direct contact with the posterior capsule, forcing conventional techniques such as divide-and-conquer, stop-and-chop, and phaco-chop to perform deep nuclear fragmentation in an unstable irrigation environment with extremely hard nuclei and absent cortical support [26,31]. Consequently, the risks of posterior capsule rupture (PCR) and zonular apparatus damage are markedly increased26. Moreover, maintaining an adequate distance between the nucleus and posterior capsule is inherently difficult, fundamentally limiting the safety margin during deep manipulation [26,31].

Although white cataract remains a high-difficulty condition even with Eight-chop, the fundamental strategy of completing segmentation entirely prior to phacoemulsification remains consistent [23]. After achieving a stable capsulorhexis, a sufficient amount of OVD is injected into the

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 December 2025 doi:10.20944/preprints202512.2212.v1

anterior chamber and capsular bag to form a thick physical protective layer between the nucleus and posterior capsule [4–6]. The Eight-chopper is then inserted into the central nucleus, and continuous cracks are propagated toward the posterior plate using the wedge-induced fracture mechanism [23,24]. By standardizing the insertion angle and opening width of the Eight-chopper and ensuring posterior capsule protection with OVD, deep segmentation can be achieved safely [23].

The authors have already reported the efficacy and safety of Eight-chop in white cataract cases as a preprint [32]. In that study, octasection of the nucleus was achieved at a high rate prior to phacoemulsification, and intraoperative parameters were favorable. Specifically, the mean operative time was 11.4 minutes, mean phaco time was 31.4 seconds, mean aspiration time was 150.0 seconds, mean CDE was 12.1, and mean irrigation volume was 61.9 mL, indicating low invasiveness compared with previously reported white cataract outcomes [32–34].

Postoperative endothelial protection was also favorable, with CECD loss of 5.5% at 7 weeks and 3.7% at 19 weeks [32]. The incidence of posterior capsule rupture was approximately 1%, and severe zonular dialysis or nuclear drop was rarely observed [32]. These results suggest that complication risk in white cataracts is more strongly dependent on deep nuclear fragmentation performed under unstable conditions than on the anatomical condition itself.

After completion of octasection, each nuclear fragment is sequentially guided into the safety zone and emulsified while maintaining sufficient distance from the corneal endothelium, iris, and posterior capsule. At the start of phacoemulsification, liquefied cortical material has already been removed, and anterior chamber visibility is well maintained [26]. Because the fragments are small and mobile, and anterior chamber depth is stabilized by OVD and fluidics, phacoemulsification can be performed with maneuverability comparable to that in routine cases [19–22].

Thus, Eight-chop can be positioned as a technique that addresses the essential risk factors of white cataract—namely, deep nuclear fragmentation in an unstable irrigation environment and direct nucleus–posterior capsule contact—through dual safety mechanisms of complete prefragmentation and posterior capsule protection with OVD [23].

4.4. Small Pupil Eyes

Eyes with small pupils inherently carry an increased surgical risk because the operative space itself is physically restricted, bringing nuclear fragmentation and phacoemulsification maneuvers into close proximity with the iris, corneal endothelium, and posterior capsule [11,12,15]. In conventional techniques such as divide-and-conquer, phaco-chop, and stop-and-chop, nuclear fragmentation and emulsification proceed simultaneously, requiring complex instrument maneuvering within a limited visual field and working space. This increases the likelihood of iris injury, posterior capsule damage, and excessive zonular stress [7–10,15].

As with dense cataracts (Section 4.2) and white cataracts (Section 4.3), the fundamental strategy of the Eight-chop technique is to “completely complete nuclear segmentation within the capsular bag before initiating phacoemulsification” [23]. After stable completion of capsulorhexis, an adequate amount of OVD is injected into both the anterior chamber and the capsular bag to stabilize the anterior chamber and protect the posterior capsule. Under these conditions, a dedicated Eight-chopper is used to repeatedly create wedge-induced fractures from the central nucleus toward the posterior aspect, dividing the nucleus into eight fragments within the capsular bag [23,24]. Through this “complete pre-segmentation,” the most high-risk nuclear fragmentation steps are completed within the capsular bag rather than in the anterior chamber, ensuring reproducibility and an adequate safety margin even under the constraint of a small pupil.

In small pupil eyes, conventional techniques often require forceful nuclear manipulation and lateral separation using a second instrument [7–10,20]. In contrast, because the fragmentation process in Eight-chop is completed within the capsular bag, there is no need for additional deep nuclear fragmentation in the anterior chamber [23]. During the emulsification phase, the already miniaturized nuclear fragments can be sequentially guided to the center of the anterior chamber and aspirated using minimal tip manipulation under stable fluidics conditions [19–22]. As a result,

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 December 2025 doi:10.20944/preprints202512.2212.v1

mechanical contact with the iris and unnecessary traction maneuvers are markedly reduced, mitigating the structural risk of excessive instrument manipulation that is characteristic of small pupil eyes.

In previously reported data by the authors, Eight-chop performed in small pupil cases with the use of iris hooks demonstrated excellent intraoperative parameters: mean operative time of 10.6 minutes, mean phaco time of 20.7 seconds, mean aspiration time of 101.1 seconds, mean CDE of 7.8, and mean fluid usage of 38.0 mL [28]. The reduction in CECD was limited to 2.1% at 19 weeks postoperatively, which was remarkably mild compared with conventional reports [4–6,28]. Significant safety advantages were also confirmed in comparisons with control groups. Furthermore, IOP showed a significant decrease at 7 and 19 weeks postoperatively, suggesting that this technique may be minimally invasive to the intraocular environment even in small pupil eyes [4–6,28].

Thus, Eight-chop can be positioned as a technique capable of addressing the inherent challenges of small pupil eyes—namely, "restricted surgical space" and "excessive instrument maneuvering"—through a workflow that clearly separates segmentation and emulsification, combined with pre-fragmentation of the nucleus into smaller pieces as a dual safety mechanism [23]. As with dense and white cataracts, Eight-chop should be regarded not merely as a risk-avoidance technique but as a strategy that fundamentally transforms the risk structure itself in small pupil eyes, representing a genuine alternative to conventional approaches.

4.5. Shallow Anterior Chamber Eyes

Eyes with a SAC inherently present a high risk of corneal endothelial damage due to the physical restriction of the operative space, which brings the phaco tip into close proximity with the corneal endothelium, increasing susceptibility to mechanical contact as well as thermal and fluidic stress [4–6,18]. In conventional techniques such as divide-and-conquer and phaco-chop, nuclear fragmentation and emulsification are performed simultaneously within the anterior chamber, significantly limiting maneuverability in shallow chambers and increasing the risk of CECD loss [7–10,18].

The fundamental principle of Eight-chop, as in dense cataracts (4.2), white cataracts (4.3), and small pupil eyes (4.4), is to "completely complete nuclear segmentation within the capsular bag before initiating phacoemulsification" [23]. After stable completion of capsulorhexis, sufficient OVD is injected into both the anterior chamber and the capsular bag to mechanically secure anterior chamber depth and form a protective layer between the corneal endothelium and the nucleus [4–6]. Subsequently, the Eight-chopper is inserted vertically into the central nucleus, and wedge-induced fracture mechanisms are used to divide the nucleus into eight fragments within the capsular bag [23,24]. This approach allows the most potentially invasive deep nuclear fragmentation steps to be completed within the capsular bag rather than in the anterior chamber.

Clinical data also support the effectiveness and safety of Eight-chop in SAC eyes. In a study comparing 80 SAC eyes with anterior chamber depth <3.0 mm and 80 control eyes, the SAC group demonstrated a mean operative time of 4.7 ± 1.1 minutes, mean phaco time of 15.4 ± 6.1 seconds, mean aspiration time of 65.6 ± 17.3 seconds, mean CDE of 5.87 ± 2.01, and mean fluid usage of 26.6 ± 8.1 mL. Most of these parameters showed no significant differences compared with the control group with deeper anterior chambers [35].

From the perspective of corneal endothelial protection, the characteristics of this technique are also evident. In the SAC group, CECD loss was only 1.3% at 7 weeks, 1.1% at 19 weeks, and 0.9% at 1 year postoperatively, values that are markedly lower than the approximately 6–13% endothelial loss reported in conventional SAC cases [4–6,35]. Furthermore, no significant correlation was observed between anterior chamber depth and CECD loss, suggesting that shallow anatomy itself is not the primary determinant of endothelial damage [35].

In contrast, a significant correlation was observed between CDE and CECD loss, indicating that endothelial damage is driven more by energy load than by anatomical factors [4–6,24]. This finding is highly consistent with the Eight-chop concept, which minimizes ultrasound energy usage.

 doi:10.20944/preprints202512.2212.v1

Complete pre-segmentation of the nucleus reduces reliance on ultrasound energy, thereby maintaining a stable surgical environment even under anatomically unfavorable SAC conditions.

Accordingly, Eight-chop can be positioned as a technique capable of addressing the intrinsic constraints of SAC eyes—namely, endothelial proximity and restricted operative space—through a dual safety mechanism consisting of complete in-the-bag segmentation and spatial buffering with OVD [22]. As with dense cataracts, white cataracts, and small pupil eyes, Eight-chop in SAC cases represents not merely a strategy for avoiding risk, but a strategic platform that fundamentally redesigns the risk structure itself.

4.6. Microcornea Eyes

Eyes with microcornea are regarded as one of the most challenging groups in cataract surgery because the small corneal diameter restricts the entire anterior segment working space, bringing nuclear manipulation and phacoemulsification into extremely close proximity with the corneal endothelium, iris, and posterior capsule [3,16]. Even when axial length and anterior chamber depth are within normal ranges, the small corneal diameter alone can severely limit intraoperative maneuverability, rendering conventional divide-and-conquer and phaco-chop techniques prone to overcrowding within the anterior chamber and inherently increasing the risk of endothelial damage and intraoperative complications [3,7–10].

As with dense cataracts (4.2), white cataracts (4.3), small pupil eyes (4.4), and SAC eyes (4.4), the fundamental principle of Eight-chop is to “completely complete nuclear segmentation within the capsular bag before phacoemulsification” [23]. After stable completion of continuous curvilinear capsulorhexis, sufficient OVD is injected into the anterior chamber and capsular bag to physically secure a safe distance from the corneal endothelium [4–6]. The Eight-chopper is then inserted vertically into the central nucleus, and the nucleus is divided into eight fragments via the wedge-induced fracture mechanism, completing the most invasive deep nuclear fragmentation steps within the capsular bag rather than in the confined anterior chamber [23,24].

The effectiveness of Eight-chop in microcornea eyes is supported by clinical data. In a study of 52 microcornea eyes with corneal diameters ≤10 mm compared with 52 control eyes, the microcornea group showed a mean operative time of 5.9 ± 2.4 minutes, mean phaco time of 17.9 ± 8.9 seconds, mean aspiration time of 77.0 ± 27.2 seconds, mean CDE of 7.06 ± 3.97, and mean fluid usage of 31.1 ± 11.6 mL, indicating excellent intraoperative performance (available as preprint) [36]. Although operative time and fluid usage were significantly higher than in controls, there were no significant differences in phaco time, aspiration time, or CDE, demonstrating preserved surgical efficiency despite the unfavorable anatomical conditions [36].

From the standpoint of corneal endothelial protection, postoperative CECD loss in the microcornea group was mild, at 3.6% at 7 weeks and 1.5% at 19 weeks, with no significant differences compared to controls (2.3% and 1.4%, respectively) [34]. These values are markedly lower than the 4–30% CECD loss reported for conventional techniques in microcornea eyes [4–6,16], suggesting that the structural disadvantage of small corneal diameter is effectively neutralized by Eight-chop.

Moreover, despite significantly shallower anterior chamber depth and smaller pupil diameter in the microcornea group—both unfavorable anatomical factors—no serious intraoperative complications such as posterior capsule rupture, zonular dialysis, or dropped nucleus were observed [36]. These findings indicate that the segmentation-first concept of Eight-chop can be safely applied even in eyes with severely restricted anterior segment space.

In summary, in microcornea eyes, Eight-chop can be positioned as a nuclear fragmentation technique capable of addressing multiple structural constraints—including restricted anterior segment space, limited visualization and instrument mobility, and proximity to the corneal endothelium—by combining complete in-the-bag segmentation with spatial buffering using OVD [23]. The fundamental principles shared across Sections 4.1–4.4 remain consistently effective in microcornea eyes, supporting Eight-chop as a practical and versatile nuclear fragmentation strategy for safe and reproducible phacoemulsification in such challenging cases.

 doi:10.20944/preprints202512.2212.v1

4.7. Diabetic Eyes

Diabetic eyes are known to carry an increased risk of corneal endothelial damage during cataract surgery [17,37–39]. Under hyperglycemic conditions, the accumulation of transforming growth factor-β–induced proteins and advanced glycation end products leads to structural and functional impairment of corneal endothelial cells [17]. In addition, increased deposition of fibronectin and vitronectin at the Descemet membrane–stroma interface, together with reduced Na^{+}/K^{+}-ATPase activity, compromises endothelial pump function, resulting in reduced endothelial reserve even before surgery [4,5]. Consequently, diabetic patients are more vulnerable to mechanical stress caused by ultrasound energy and irrigation fluid, and they tend to exhibit a more pronounced postoperative decrease in CECD [37–39].

The Eight-chop technique is based on the fundamental principle of mechanically dividing the crystalline lens nucleus into eight fragments prior to phacoemulsification, thereby minimizing ultrasound energy exposure and irrigation volume [23]. In evaluations of this technique in diabetic eyes, intraoperative parameters demonstrated a highly minimally invasive profile, with surgical times of 4.6–4.9 minutes, phaco time of 14–16 seconds, CDE of approximately 6, and irrigation volume of approximately 27 mL [40]. The rate of CECD loss was approximately 5% at 7 weeks postoperatively, approximately 4% at 19 weeks, and remained as low as approximately 2% even at 1 year, representing favorable outcomes compared with previously reported CECD loss rates of 10–18% in diabetic eyes [37,38,40].

When compared with control eyes, diabetic eyes showed a slightly greater short-term reduction in CECD; however, no significant difference was observed in the long term. These findings suggest that the ultrasound energy–reducing effect of the Eight-chop technique may protect the vulnerable corneal endothelium in diabetic eyes [23].

Furthermore, diabetic patients have a higher prevalence of glaucoma, making postoperative IOP changes an important outcome measure [14,37,38]. With this technique, an approximately 8% reduction in IOP was observed at 1 year postoperatively even in diabetic eyes, yielding outcomes comparable to or better than those in non-diabetic eyes [40]. This IOP-lowering effect is thought to be partly attributable to the reduction in irrigation volume and ultrasound exposure achieved with the Eight-chop technique, which may lessen mechanical stress not only on the corneal endothelium but also on the trabecular meshwork and Schlemm's canal [14,19–21].

In summary, although diabetic eyes present an inherent disadvantage due to preexisting endothelial dysfunction, the Eight-chop technique, based on the core concept of reducing ultrasound energy through pre-fragmentation of the nucleus, represents a useful surgical option that can contribute to both corneal endothelial protection and postoperative IOP stabilization.

4.8. Pseudoexfoliation Syndrome

Pseudoexfoliation (PEX) syndrome is a systemic fibrotic disorder characterized by the deposition of fibrillar extracellular abnormal material in the anterior segment tissues and the lens-supporting structures, and it is regarded as one of the highest-risk conditions in cataract surgery[11, 12]. Eyes with PEX frequently present with concomitant reductions in CECD, small pupil size, anterior chamber instability, and weakening of the zonular apparatus [11,12]. As a result, serious intraoperative complications—such as poor nuclear rotation, capsular instability, posterior capsule rupture, vitreous prolapse, and intraocular lens (IOL) decentration—occur more readily, and previous reports have indicated that the risk of surgical complications in PEX eyes is approximately 2.7-fold higher than that in non-PEX eyes [11].

The Eight-chop technique was designed with the core principle of avoiding intraoperative amplification of zonular stress in such high-risk eyes [23]. In conventional divide-and-conquer and phaco-chop techniques, nuclear manipulation and rotation are required during the fragmentation process, resulting in cumulative increases in tensile stress applied to weakened zonules [23]. In contrast, with the Eight-chop technique, the nucleus is maintained in a stable position within the capsular bag, and deep nuclear fracture is induced from the nuclear center toward the posterior plate

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 December 2025 doi:10.20944/preprints202512.2212.v1

using a wedge-induced fracture mechanism, completing octasection prior to the initiation of phacoemulsification [23,24]. Consequently, nuclear rotation and excessive lateral manipulation are unnecessary, and the generation of zonular stress—problematic in PEX eyes—is minimized.

Clinical data on the use of the Eight-chop technique in PEX eyes demonstrate extremely low invasiveness, with intraoperative parameters including an operative time of 6.7 ± 3.4 minutes, phaco time of 17.4 ± 7.8 seconds, aspiration time of 85.2 ± 26.6 seconds, CDE of 6.91 ± 2.87, and irrigation fluid use of 33.4 ± 10.9 mL [29]. Although these values showed statistically significant differences compared with control groups, they were markedly lower than those reported for dense nuclear cases treated with conventional phaco-chop or stop-and-chop techniques, indicating that intraoperative stress can be minimized even in PEX eyes [29,41,42].

Notably, although intraoperative findings of zonular weakness were identified in 13 of 75 PEX eyes (17.3%), insertion of a capsular tension ring (CTR) was not required in any case [29]. This outcome is considered to result from minimizing the tension vectors applied to the capsule and zonules during nuclear fragmentation by avoiding ultrasound tip impalement or sculpting of the nuclear center and instead using the Eight-chopper in combination with a nucleus sustainer [23]. Postoperatively, no cases of IOL decentration, pseudophakodonesis, or clinically significant zonular dialysis were observed [29].

From the perspective of corneal endothelial protection, PEX eyes are known to exhibit higher postoperative CECD loss rates, reaching 9–11% within several months after surgery in previous reports [4,11]. In contrast, eyes treated with the Eight-chop technique demonstrated CECD loss rates of only 3.7% at 7 weeks and 2.7% at 19 weeks postoperatively [39]. This reduction is considered to be directly attributable to decreased ultrasound energy usage time and reduced irrigation volume within the anterior chamber [4–6,13].

In addition, postoperative IOP management is particularly important in PEX eyes. With this technique, significant IOP reductions of approximately 13% were observed at both 7 and 19 weeks postoperatively in both the PEX and control groups, with no significant intergroup differences [29]. This finding is thought to reflect the reduced surgical invasiveness associated with the low-CDE and low-irrigation characteristics of the Eight-chop technique, which may minimize mechanical damage and functional impairment of the trabecular meshwork and Schlemm's canal.

Based on these findings, the Eight-chop technique can be considered a surgical approach that enables stable execution of nuclear fragmentation and phacoemulsification in eyes with PEX syndrome without the routine use of a capsular tension ring (CTR), demonstrating excellent safety and high reproducibility.

Table 1. Surgical performance of the Eight-chop technique across cataract subtypes.

Subtype	Operative Time (min)	Phaco Time (s)	Aspiration Time (s)	CDE	Fluid Use (mL)	CECD Loss (%)
Normal cataract[23]	3.7–5.4	11.6–20.2	Not reported	5.0–9.2	22.9–33.3	0.9–1.0
Hard nuclear cataract[30]	10.5	38.9	135.6	19.2	53.0	3.7
White cataract[32]	11.4	31.4	150.0	12.1	61.9	3.7
Small pupil eyes[28]	10.6	20.7	101	7.8	38.0	2.1
Shallow anterior chamber eyes[35]	4.7	15.4	65.6	5.87	26.6	1.1
Microcornea eyes[36]	5.9	17.9	77.0	7.1	31.1	1.5
Diabetic eyes[40]	4.6	15.5	68.1	6.5	27.0	3.9
Pseudoexfoliation syndrome[29]	6.7	17.4	85.2	6.9	33.4	2.7

Table 1 summarizes key intraoperative and postoperative parameters of the Eight-chop technique across cataract subtypes analyzed in Sections 4.1–4.8, including operative time, phaco time, aspiration time, CDE, irrigation volume, and percentage change in CECD. CDE = cumulative dissipated energy; CECD = corneal endothelial cell density.

4.9. Glaucoma and Intraocular Pressure Changes

Changes in IOP after cataract surgery in glaucomatous eyes are known to be closely associated with the degree of mechanical and fluid-dynamic insult applied to the aqueous outflow pathways during surgery [43,44]. Conventional techniques such as divide-and-conquer, stop-and-chop, and phaco-chop often involve relatively long ultrasound exposure times and large volumes of anterior chamber irrigation, which may impose substantial fluid stress on the trabecular meshwork and the region surrounding Schlemm's canal.

The Eight-chop technique is characterized by its ability to markedly reduce both intraoperative ultrasound energy usage and irrigation volume, owing to its technical feature of completing nuclear fragmentation prior to phacoemulsification [23]. Indeed, clinical studies employing the Eight-chop technique have demonstrated CDE values generally in the range of 5–8 and irrigation volumes of approximately 25–35 mL, indicating clearly lower invasiveness compared with conventionally reported techniques [23].

In long-term clinical studies using the Eight-chop technique, analyses of eyes undergoing cataract surgery alone demonstrated a significant postoperative reduction in IOP compared with preoperative values, with this effect persisting for up to 5 years. Specifically, the IOP reduction rate at 1 year postoperatively ranged from 9.1% to 19.8%, and a reduction of 10.6–17.4% was maintained even at 5 years postoperatively [45].

Notably, even in the subgroup of eyes with preoperative IOP values below 15 mmHg, a significant IOP reduction was observed from the early postoperative period (7 weeks), and an average reduction of approximately 1.6 mmHg persisted at 5 years postoperatively [45]. This finding contrasts with previous reports on conventional cataract surgery, in which postoperative IOP reduction in eyes with low preoperative IOP has been described as minimal or transient [46,47].

Analyses including eyes with primary open-angle glaucoma (POAG) showed a similar trend, with the Eight-chop technique demonstrating significant IOP reduction from the early postoperative period [48]. These results suggest that the minimally invasive nuclear processing achieved with the Eight-chop technique may minimize intraoperative damage to trabecular meshwork cells and Schlemm's canal endothelium, thereby contributing to preservation of aqueous outflow function.

In summary, the Eight-chop technique possesses clear technical characteristics that suppress ultrasound energy usage and anterior chamber irrigation load, and it can be positioned as a surgical approach capable of stabilizing postoperative IOP changes in glaucomatous eyes. However, further investigations, including prospective comparative studies, are required to clarify the precise mechanisms underlying the IOP-lowering effect and to determine its relative advantages over other minimally invasive surgical techniques.

4.10. Integration with Modern Fluidics Systems (Active Fluidics System and Low-IOP Surgery)

In recent years, cataract surgical platforms have evolved from conventional gravity-based irrigation systems to AFS, which enable real-time control of IOP [19,21]. In traditional systems, irrigation pressure depends on bottle height, resulting in limited responsiveness to abrupt changes in aspiration flow rate or vacuum pressure. Consequently, intraoperative surge phenomena and transient anterior chamber collapse have been difficult to avoid [19,21]. These events have been regarded as major contributors to mechanical stress on the corneal endothelium, pressure loading on the anterior chamber angle, and increased traction forces on the zonular apparatus and posterior capsule, leading to intraoperative complications and postoperative inflammatory responses [20,21].

AFS is a closed-loop control system that dynamically adjusts irrigation pressure based on a preset target IOP, enabling stable maintenance of anterior chamber volume and IOP even under varying aspiration loads [19,21]. As a result, abrupt fluctuations in anterior chamber pressure—previously difficult to prevent—are effectively suppressed, markedly improving the intraoperative environment for nuclear fragment manipulation [19]. In particular, surgery under low irrigation pressure conditions (low-IOP surgery) has attracted attention for its potential benefits in corneal

 doi:10.20944/preprints202512.2212.v1

endothelial protection, reduction of pressure-related stress on posterior segment structures, and suppression of postoperative macular edema [20,41].

The Eight-chop technique exhibits extremely high compatibility with such modern fluidics environments. The fundamental principle of Eight-chop is mechanical octasection of the nucleus prior to the initiation of phacoemulsification, eliminating the need for ultrasound energy during the nuclear fragmentation phase [23]. Owing to this technical characteristic, the cumulative ultrasound energy (CDE), ultrasound time, and irrigation fluid usage required during surgery can be intrinsically reduced [23,30]. Under AFS conditions, enhanced anterior chamber stability allows precise intracapsular nuclear fragmentation to be performed with greater reproducibility, thereby maximizing the advantages of the Eight-chop technique.

In contralateral-eye comparative studies using AFS, surgical conditions with target IOPs set at 55 mmHg (standard setting group) and 28 mmHg (low-IOP setting group) demonstrated no significant differences in operative time, CDE, or irrigation fluid usage [27]. However, the low-IOP setting group showed significant prolongation of ultrasound time and aspiration time [27]. Similar trends have been suggested in other comparative studies utilizing AFS [19]. These findings indicate that excessive lowering of IOP may reduce followability of nuclear fragments and compromise vacuum maintenance efficiency, potentially impairing the efficiency of nuclear fragment processing [19,21].

Regarding postoperative inflammatory responses, no significant differences in anterior chamber flare values were observed between the low-IOP and standard setting groups using AFS [27]. In addition, the reduction rate of CECD was maintained at an extremely low level, and no significant differences were reported in morphological indices such as central corneal thickness (CCT), coefficient of variation of cell area (CV), or percentage of hexagonal cells (HEX) [27]. These findings are consistent with other reports of minimally invasive cataract surgery using AFS [19,20,41].

4.11. Surgical Controllability and Reproducibility of the Eight-Chop Technique

The final characteristic of the Eight-chop technique lies in its ability to provide a high level of consistency and predictability from the perspective of clinical workflow and surgeon controllability. Because segmentation and phacoemulsification–aspiration are clearly separated into two distinct phases, the overall surgical process can be logically organized into a "segmentation phase" and an "aspiration–removal phase," with well-defined objectives and precautions for each step.

During the segmentation phase, the primary goal is to achieve complete octasection using a wedge-induced fracture mechanism within the capsular bag. Throughout this phase, anterior chamber fluidics are mainly stabilized by the use of OVD. In the subsequent aspiration–removal phase, the main objective is the safe, sequential removal of pre-segmented nuclear fragments. In this stage, fluidics stability is maintained through a combination of device-side control, including AFS, and precise manipulation of the phaco tip by the surgeon. This two-phase structure allows surgeons to better recognize intraoperative conditions, particularly in complex cases, thereby facilitating early detection and avoidance of potential complications.

Furthermore, the one-handed approach without the use of a second instrument provides an operative environment in which the surgeon can continuously focus on the position, angle, and aspiration status of the ultrasound tip. This feature is especially advantageous in cases with limited working space, such as SAC, fragile zonules, microcornea, and small pupils, where it contributes significantly to improved procedural stability and safety. In addition, minimal wound distortion reduces irrigation fluid leakage, allowing a stable intraocular fluidic environment to be maintained throughout the procedure—another important workflow-related advantage of the Eight-chop technique.

In summary, the Eight-chop technique should be regarded not merely as a novel nuclear fragmentation method, but as a comprehensive segmentation strategy based on a two-phase workflow that completely separates segmentation from phacoemulsification–aspiration. This design enables high safety and consistent surgical outcomes across a wide spectrum of challenging cataract cases.

5. Conclusion

The Eight-chop technique was developed as a unique segmentation strategy aimed at completing nuclear division entirely within the capsular bag, thereby minimizing intraoperative energy use, irrigation volume, and instrument interference. Based on the accumulation of clinical data presented in this review, the Eight-chop technique has been shown to provide consistent advantages in both surgical efficiency and minimal invasiveness compared with conventional nuclear fragmentation techniques. These subtype-specific clinical outcomes are summarized in an integrated manner in Table 1.

First, the distinctive procedural feature of the Eight-chop technique—namely pre-phaco segmentation—creates a surgical environment in which nuclear processing can be safely performed within the anterior chamber even in a wide range of challenging cases, including hard nuclear cataracts, white cataracts, microcornea, SAC, zonular weakness, small pupils, pseudoexfoliation syndrome, and diabetic patients. As a result, phaco time, CDE, and irrigation volume are markedly reduced, demonstrating minimal invasiveness across multiple dimensions, including maintenance of anterior chamber depth, reduction of mechanical stress on the corneal endothelium, and decreased energy exposure to the trabecular meshwork.

With respect to postoperative CECD, the Eight-chop technique demonstrated relatively consistent and low levels of endothelial cell loss, with approximately 1–2% reduction at 1 year even in cases with hard nuclei and in diabetic patients, compared with previously reported loss rates of 5–18% following conventional techniques. Notably, despite the intrinsic vulnerability of the corneal endothelium in diabetic patients, the absence of a meaningful difference compared with non-diabetic eyes represents an important clinical implication supporting the low invasiveness of this technique.

Postoperative IOP changes further support the potential advantages of the Eight-chop technique. A sustained IOP reduction of approximately 8–12% was observed over the mid- to long-term postoperative period up to several years, which appears greater than the generally reported IOP reduction of 4–10% following standard phacoemulsification. This finding is consistent with the procedural characteristics of the Eight-chop technique, in which reduced energy use and irrigation volume may lessen intraoperative impact on aqueous outflow tissues such as the trabecular meshwork and Schlemm's canal, suggesting an intriguing relationship between segmentation strategy and postoperative IOP behavior. Importantly, the Eight-chop technique is highly compatible with modern fluidics systems, including AFS, which further contributes to anterior chamber stability and reinforces its minimally invasive nature.

In clinical scenarios that have traditionally required adjunctive devices—such as pseudoexfoliation syndrome, small pupils, white cataracts, and zonular weakness—the Eight-chop technique enables completion of nuclear segmentation entirely within the capsular bag, thereby potentially reducing the need for supplementary procedures or devices, including capsular tension rings, hooks, or pupil expansion rings. In particular, suppression of zonular stress may contribute to a lower risk of postoperative complications and may prompt reconsideration of the routine indications for capsular tension ring implantation.

Nevertheless, it must be acknowledged that the current evidence is derived from clinical data obtained at a limited number of institutions and by a limited number of surgeons. Further investigations are required to evaluate reproducibility, learnability, and international applicability. In addition, clarification of the range of nuclear hardness suitable for the Eight-chop technique, as well as direct comparative studies with other segmentation techniques—including phaco-chop, femtosecond laser–assisted cataract surgery, and phaco prechop—remain important future challenges. Despite these limitations, the available clinical data support the conclusion that the Eight-chop technique meets contemporary demands in cataract surgery for minimal invasiveness, efficiency, and minimization of energy and fluid usage.

 doi:10.20944/preprints202512.2212.v1

Although the Eight-chop technique requires an understanding of the mechanics of wedge-induced fracture and a certain level of technical familiarity, mastering its core concept may shorten the learning curve. The procedure is essentially completed using a single consistent method, with stable instrument handling and a workflow that facilitates focused manipulation, contributing to high reproducibility and precision. For surgeons already experienced in dual-instrument nuclear fragmentation techniques, transitioning to single-instrument manipulation may in fact be straightforward. Furthermore, because nuclear segmentation is performed within the capsular bag under protection by OVD rather than under irrigation, anterior chamber stability is enhanced, contributing to improved intraoperative safety and control.

In summary, the Eight-chop technique represents a potential new position in the evolution of nuclear fragmentation strategies and may serve as a viable option that balances safety and efficiency, particularly in hard nuclear cataracts and in patients with systemic comorbidities. With further validation through multicenter studies and independent surgeon evaluations, the Eight-chop segmentation science may be further refined and established as one of the standard nuclear processing strategies in modern cataract surgery.

Data availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy and ethical considerations.

Financial disclosure: The author has no financial or proprietary interest in any material or method mentioned.

References

1. Kelman CD. Phaco-emulsification and aspiration. A new technique of cataract removal. A preliminary report. Am J Ophthalmol 1967;64:23-35
2. Gimbel HV. Divide and conquer nucleofractis phacoemulsification: development and variations. J Cataract Refract Surg 1991;17:281–291
3. Linebarger EJ, Hardten DR, Shah GK, Lindstrom RL. Phacoemulsification and modern cataract surgery. Surv Ophthalmol 1999;44:123-147
4. Walkow T, Anders N, Klebe S. Endothelial cell loss after phacoemulsification: relation to preoperative and intraoperative parameters. J Cataract Refract Surg 2000;26:727-732
5. Hwang HB, Lyu B, Yim HB, Lee NY. Endothelial cell loss after phacoemulsification according to different anterior chamber depths. J Ophthalmol 2015;2015:210716
6. Pereira AC, Porfírio F, Jr., Freitas LL, Belfort R, Jr. Ultrasound energy and endothelial cell loss with stop-and-chop and nuclear preslice phacoemulsification. J Cataract Refract Surg 2006;32:1661-1666
7. Koch PS, Katzen LE. Stop and chop phacoemulsification. J Cataract Refract Surg 1994;20:566–570
8. Chang DF. Why learn chopping? In: Chang DF, eds. Phaco Chop and Advanced Phaco Techniques. SLACK Incorporated; 2013:3–9
9. Vajpayee RB, Kumar A, Dada T, Titiyal JS, Sharma N, Dada VK. Phaco-chop versus stop-and-chop nucleotomy for phacoemulsification. J Cataract Refract Surg 2000;26:1638-1641
10. Park J, Yum HR, Kim MS, Harrison AR, Kim EC. Comparison of phaco-chop, divide-and-conquer, and stop-and-chop phaco techniques in microincision coaxial cataract surgery. J Cataract Refract Surg 2013;39:1463–1469
11. Shingleton BJ, Neo YN, Cvintal V, Shaikh AM, Liberman P, O'Donoghue MW. Outcome of phacoemulsification and intraocular lens implantion in eyes with pseudoexfoliation and weak zonules. Acta Ophthalmol 2017;95:182–187
12. Hayashi K, Yoshida M, Manabe SI, Hirata A. High-risk factors for zonular complications during cataract surgery in eyes with pseudoexfoliation syndrome. Br J Ophthalmol 2024;108:1193–1199
13. Fernández-Muñoz E, Chávez-Romero Y, Rivero-Gómez R, Aridjis R, Gonzalez-Salinas R. Cumulative dissipated energy (CDE) in three phaco-fragmentation techniques for dense cataract removal. Clin Ophthalmol 2023;17:2405–2412

14. Moghimi S, Johari M, Mahmoudi A, Chen R, Mazloumi M, He M, Lin SC. Predictors of intraocular pressure change after phacoemulsification in patients with pseudoexfoliation syndrome. Br J Ophthalmol 2017;101:283–289
15. Kopsachilis N, Carifi G. Phacoemulsification using 8 flexible iris hooks in a patient with a short eye, small pupil, and phacodonesis. J Cataract Refract Surg 2014;40:1408–1411
16. Khokhar S, Gupta S, Tewari R, Agarwal R, Gogia V, Sinha G, Agarwal T. Scleral tunnel phacoemulsification: Approach for eyes with severe microcornea. Indian J Ophthalmol 2016;64:320-322
17. Zarei-Ghanavati S, Hadi Y, Habibi A, Ashraf Khorasani M, Yoo SH. Cataract and diabetes: review of the literature. J Cataract Refract Surg 2024;50:1275-1283
18. Mencucci R, De Vitto C, Cennamo M, Vignapiano R, Buzzi M, Favuzza E. Femtosecond laser-assisted cataract surgery in eyes with shallow anterior chamber depth: comparison with conventional phacoemulsification. J Cataract Refract Surg 2020;46:1604–1610
19. Rauen MP, Joiner H, Kohler RA, O'Connor S. Phacoemulsification using an active fluidics system at physiologic vs high intraocular pressure: impact on anterior and posterior segment physiology. J Cataract Refract Surg 2024;50:822-827
20. Liu Y, Hong J, Chen X. Comparisons of the clinical outcomes of Centurion(®) active fluidics system with a low IOP setting and gravity fluidics system with a normal IOP setting for cataract patients with low corneal endothelial cell density. Front Med (Lausanne) 2023;10:1294808
21. Vasavada V, Vasavada AR, Vasavada VA, Vasavada SA, Bhojwani D. Real-time dynamic changes in intraocular pressure after occlusion break: comparing 2 phacoemulsification systems. J Cataract Refract Surg 2021;47:1205-1209
22. Masuda Y, Iwaki H, Kato N, Takahashi G, Oki K, Tsuneoka H. Irrigation dynamic pressure-assisted hydrodissection during cataract surgery. Clin Ophthalmol 2017;11:323-328
23. Sato T. Efficacy and safety of the eight-chop technique in phacoemulsification for patients with cataract. J Cataract Refract Surg 2023;49:479–484
24. Jacobsson L, Sandström J, Brander L, Flansbjer M. Tensile fracture initiation and propagation of granite and gneiss at wedge splitting tests: Part 1—Effect of notch type on tensile crack initiation and fracture mechanics results. International Journal of Fracture 2025;249:45
25. Akahoshi T. Phaco prechop: Manual nucleofracure prior to phacoemulsification. Operative Tech Cataract Refract Surge 1998;1:69–91
26. Scott RA, Holtmeyer CJ, Parker TM, Willis JK, Scott WJ, Olson RJ. Efficiency of venturi vs peristaltic-based phacoemulsification in femtosecond laser cataract surgery. J Cataract Refract Surg 2025;51:382-387
27. Sato T. Does Lowering Intraoperative Intraocular Pressure Reduce Surgical Invasiveness in Active-Fluidics Eight-Chop Phacoemulsification? A Fellow-Eye Comparative Study. Preprints 2025;doi:10.20944/preprints202512.200678.v202511.
28. Sato T. Eight-chop technique in phacoemulsification using iris hooks for patients with cataracts and small pupils. J Clin Med 2024;13:7298
29. Sato T. Cataract Surgery in Pseudoexfoliation Syndrome Using the Eight-Chop Technique. J Pers Med 2025;15:396
30. Sato T. Minimizing Endothelial Cell Loss in Hard Nucleus Cataract Surgery: Efficacy of the Eight-Chop Technique. J Clin Med 2025;14:2576
31. Arshinoff SA. Ophthalmic viscosurgical devices for intumescent cataracts: pressure-equalized cataract surgery. J Cataract Refract Surg 2015;41:1549-1550
32. Sato T. Efficacy and Safety of the Eight-Chop Technique in Phacoemulsification for White Cataract. Preprints 2025;doi:10.20944/preprints202512.201415.v202511
33. Vasavada A, Singh R, Desai J. Phacoemulsification of white mature cataracts. J Cataract Refract Surg 1998;24:270-277
34. Vajpayee RB, Bansal A, Sharma N, Dada T, Dada VK. Phacoemulsification of white hypermature cataract. J Cataract Refract Surg 1999;25:1157-1160
35. Sato T. Corneal endothelial cell loss in shallow anterior chamber eyes after phacoemulsification using the eight-chop technique. J Clin Med 2025;14:3045

 doi:10.20944/preprints202512.2212.v1

36. Sato T. Cataract Surgery in Microcornea Eyes Using the Eight-Chop Technique. Preprints 2025;doi:10.20944/preprints202510.201082.v202511.
37. Salavat MC, Munteanu M, Chercotă V, Ardelean AI, Schuldez A, Dinu V, Borugă O. Corneal Endothelial Cell Loss Following Cataract Surgery in Patients with Type 2 Diabetes Mellitus: A Comprehensive Review. Biomedicines 2025;13:1726
38. Opala A, Kołodziejski Ł, Grabska-Liberek I. Impact of Well-Controlled Type 2 Diabetes on Corneal Endothelium Following Cataract Surgery: A Prospective Longitudinal Analysis. J Clin Med 2025;14:3603
39. Akansha, Yadav RS. Comparative assessment of the corneal endothelium following phacoemulsification surgery in patients with type II diabetes and nondiabetes. Saudi J Ophthalmol 2025;39:77-83
40. Sato T. Corneal Endothelial Changes After Phacoemulsification Using the Eight-Chop Technique in Diabetic Eyes. J Pers Med 2025;15:209
41. Wang S, Tao J, Yu X, Diao W, Bai H, Yao L. Safety and prognosis of phacoemulsification using active sentry and active fluidics with different IOP settings - a randomized, controlled study. BMC Ophthalmol 2024;24:350
42. Igarashi T, Ohsawa I, Kobayashi M, Umemoto Y, Arima T, Suzuki H, Igarashi T, Otsuka T, Takahashi H. Effects of hydrogen in prevention of corneal endothelial damage during phacoemulsification: A prospective randomized clinical trial. Am J Ophthalmol 2019;207:10–17
43. Gallardo MJ, Supnet RA, Ahmed IIK. Viscodilation of Schlemm's canal for the reduction of IOP via an ab-interno approach. Clin Ophthalmol 2018;12:2149-2155
44. Guan H, Mick A, Porco T, Dolan BJ. Preoperative factors associated with IOP reduction after cataract surgery. Optom Vis Sci 2013;90:179-184
45. Sato T. Long-Term Effects of the Eight-Chop Technique in Phacoemulsification on Intraocular Pressure for Cataract Patients. Preprints 2025;doi:10.20944/preprints202512.201454.v202511.
46. Poley BJ, Lindstrom RL, Samuelson TW, Schulze R, Jr. Intraocular pressure reduction after phacoemulsification with intraocular lens implantation in glaucomatous and nonglaucomatous eyes: Evaluation of a causal relationship between the natural lens and open-angle glaucoma. J Cataract Refract Surg 2009;35:1946–1955
47. Poley BJ, Lindstrom RL, Samuelson TW. Long-term effects of phacoemulsification with intraocular lens implantation in normotensive and ocular hypertensive eyes. J Cataract Refract Surg 2008;34:735–742
48. Sato T. Effects of the Eight-Chop Technique in Phacoemulsification on Intraocular Pressure in Patients with Primary Open-Angle Glaucoma and Controls. Preprints 2025;doi:10.20944/preprints202512.201427.v202511.