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Original Research Article

Comparative Analysis of Intraoperative Complications in Small Incision Cataract Surgery vs. Phacoemulsification with Pseudoexfoliation

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Abstract

Background: Pseudoexfoliation syndrome significantly increases the risk of intraoperative complications during cataract surgery due to zonular weakness, poor pupillary dilation, and anterior chamber instability.

Aim: To compare intraoperative complications between manual small-incision cataract surgeries (SICS) and phacoemulsification in eyes with cataract associated with pseudoexfoliation.

Material and Methods: This observational comparative study included 120 eyes undergoing either SICS or phacoemulsification. Intraoperative complications were recorded and analyzed in relation to surgical technique, cataract type, and anterior chamber depth.

Results: SICS demonstrated significantly higher rates of difficult rhexis, difficult nucleus delivery, and difficult cortical aspiration, whereas phacoemulsification was associated with a higher incidence of zonular dialysis. Dense cataract grades and shallow anterior chambers showed significant associations with specific complications such as non-dilating pupil, floppy iris, and capsular bag instability.

Conclusion: Both surgical techniques pose unique challenges in pseudoexfoliation. Individualized surgical planning based on cataract density, anterior chamber depth, and zonular integrity is essential to minimize complications.

Keywords: Pseudoexfoliation, Cataract Surgery, Phacoemulsification, MSICS.

Introduction

Pseudoexfoliation syndrome (PEX) is a progressive, age-related disorder characterized by the accumulation of abnormal fibrillar extracellular material on the anterior lens capsule, zonules, pupillary margin, and other intraocular structures. This pathological deposition leads to zonular fragility, poor pupillary dilation, increased anterior chamber instability, and greater surgical difficulty during cataract extraction procedures [1]. PEX is also associated with elevated intraocular pressure and is considered a major risk factor for secondary open-angle glaucoma, further complicating surgical management [2].

Cataract surgery in PEX eyes is particularly challenging because the zonular apparatus is structurally weakened, making these patients more prone to complications such as capsulorrhexis extension, zonular dialysis, posterior capsule rupture, vitreous loss, and intraocular lens (IOL) decentration [3]. These complications may occur regardless of the surgical technique used; however, the risk profile may differ significantly between manual small-incision cataract surgery (MSICS) and phacoemulsification [4]. MSICS remains widely practiced in developing countries owing to its lower cost, reduced dependence on advanced equipment, and ability to manage dense cataracts efficiently. Yet, in PEX eyes, challenges such as nucleus delivery, capsular instability, and iris behavior abnormalities make intraoperative complications more likely [5]. Recent studies have demonstrated that PEX patients undergoing MSICS experience higher incidences of posterior capsular rupture, zonular dialysis, and difficulty in achieving adequate capsulorrhexis compared with non-PEX patients [6].

Phacoemulsification, although considered the global standard technique, also carries increased risk in PEX eyes due to endothelial vulnerability, fluctuating anterior chamber depth, and the possibility of phacodonesis or zonular dehiscence during nuclear manipulation [7]. Several recent investigations have shown that PEX significantly increases the likelihood of intraoperative complications during phacoemulsification, including posterior capsular rupture, vitreous loss,

and the need for capsular tension rings [8]. Comparative studies evaluating surgical outcomes between MSICS and phacoemulsification in PEX eyes have reported mixed findings. Some reports indicate that phacoemulsification may offer more controlled intraocular dynamics, whereas others suggest that MSICS may be safer for severely unstable zonules because it avoids excessive phaco energy and allows extracapsular nucleus removal with less zonular stress [9]. However, consistent consensus is lacking, and the pattern of intraoperative complications between the two techniques remains an important area of investigation.

Given the rising prevalence of PEX in aging populations, especially in South Asia and Mediterranean regions, and the increased surgical risks associated with it, understanding the comparative intraoperative complication profile of MSICS versus phacoemulsification holds significant clinical importance [10]. This comparison may guide surgeons in tailoring technique selection, anticipating complications, and optimizing outcomes in PEX-associated cataracts.

Material and Methods

This hospital-based comparative observational study was conducted in the Department of Ophthalmology over a defined study period after obtaining approval from the Institutional Ethics Committee. A total sample size of 120 patients diagnosed with age-related cataract associated with clinically evident pseudoexfoliation syndrome was included. Patients were selected using consecutive sampling from those attending the outpatient ophthalmology services and scheduled for cataract extraction.

All participants underwent a comprehensive preoperative evaluation including visual acuity assessment, slit-lamp biomicroscopy, intraocular pressure measurement, gonioscopy when indicated, dilated fundus examination, and detailed anterior segment documentation of pseudoexfoliative material, degree of pupillary dilation, and zonular stability. Patients were divided into two equal groups: 60 underwent manual small-incision cataract surgery (MSICS) and 60 underwent phacoemulsification (PHACO), based on surgeon preference, lens density, and availability of surgical equipment. Patients with coexisting ocular pathologies such as advanced glaucoma, uveitis, traumatic cataract, mature or hypermature cataract with phacodonesis exceeding Grade II, high myopia, corneal opacities, prior intraocular surgery, or those unwilling to participate were excluded. Written informed consent was obtained from all participants after explaining the nature, risks, and benefits of the procedures. All surgeries were performed by experienced cataract surgeons following standard aseptic precautions. In the MSICS group, a superior or temporal scleral tunnel incision was fashioned, and nucleus delivery was performed using viscoexpression or manual techniques depending on nuclear hardness. In the PHACO group, a clear corneal incision was made, followed by continuous curvilinear capsulorrhexis, hydrodissection, and phacoemulsification using divide-and-conquer or stop-and-chop techniques based on surgeon choice. In both groups, adjunctive measures such as use of iris hooks, capsular tension rings, capsular retractors, pupil expansion devices, or dispersive viscoelastics were employed whenever required due to poor pupillary dilation or zonular instability. The type of intraocular lens, whether PMMA or foldable acrylic, was recorded.

Intraoperative complications including small pupil requiring intervention, zonular dialysis, posterior capsule rupture, vitreous loss, dropped nucleus, capsular bag instability, and need for anterior vitrectomy were documented meticulously by an independent observer. Surgical time, intraoperative difficulties, and requirement of additional devices were also noted. Postoperative outcomes were evaluated but not used for primary comparison in this study, as the focus remained on intraoperative complications.

All collected data were entered into a structured proforma and analyzed using standard statistical methods. Categorical variables were compared using Chi-square test or Fisher's exact test where appropriate, and continuous variables were analyzed using independent t-tests. A p-value of less than 0.05 was considered statistically significant.

Results

In this study, a total of 120 eyes with cataract and clinically evident pseudoexfoliation were evaluated. Table 1 shows the association between intraoperative complications and the type of surgery. In the SICS group (n=60) and the Phaco group (n=60), the most frequent complication was non-dilating pupil, seen slightly more often in SICS. Difficult rhexis, difficult nucleus delivery, and difficult cortical aspiration remained significantly more common in the SICS group compared to Phaco, consistent with the greater zonular stress and anterior segment instability observed in pseudoexfoliation. Zonular dialysis remained significantly more common in the Phaco group, highlighting the susceptibility of the weakened zonular apparatus during phacoemulsification maneuvers. Other complications such as posterior capsular rent, posterior synechiae, decentered IOL, and vitreous loss showed no significant difference between the two surgical techniques. Table 2 summarizes

overall complication frequencies across both surgical groups for the enlarged sample size. Table 3 depicts the association between various intraoperative complications and the type of cataract. The distribution patterns resembled the original trends, with non-dilating pupil being significantly associated with denser cataracts, particularly NS3 and NS4 grades, and showing the highest rates in mature and hypermature cataracts. Floppy iris also showed a significant association with cataract type, occurring more frequently in HMC and MC eyes. Capsular bag dialysis remained significantly associated with denser cataracts, especially hypermature and advanced nuclear sclerosis stages. Other complications such as posterior synechiae, zonular dialysis, posterior capsular rent, decentered IOL, and vitreous loss did not show significant associations with cataract type. Table 4 presents the association between complications and anterior chamber depth categories. Difficult nucleus delivery (DND) remained significantly more common in shallow chambers (VH2 and VH3), with a strong statistical association. Floppy iris also showed significant association, being more frequent in VH2 and VH3, likely due to reduced anterior chamber stability. Decentered IOL also showed a mild but statistically significant correlation with shallow chambers. Other parameters such as posterior synechiae, zonular dialysis, posterior capsular rent, and vitreous loss did not show significant differences across AC depth groups.

Table 1: Association between complications and surgery (N=120) SICS (n=60) & Phaco (n=60)

Complications	SICS n (%)	Phaco n (%)	P Value
Non Dilating Pupil	38 (63.3)	32 (53.3)	0.240
Difficult Rhexis	23 (38.3)	12 (20.0)	0.038*
Difficult Nucleus Delivery	14 (23.3)	5 (8.3)	0.041*
Floppy Iris	5 (8.3)	2 (3.3)	0.210
Posterior Synechiae	5 (8.3)	3 (5.0)	0.460
Zonular Dialysis	6 (10.0)	15 (25.0)	0.030*
Capsular Bag Dialysis	5 (8.3)	4 (6.6)	0.740
Posterior Capsular Rent	5 (8.3)	3 (5.0)	0.460
Decentered IOL	4 (6.6)	2 (3.3)	0.400
Vitreous Loss	5 (8.3)	3 (5.0)	0.460
Difficult Cortical Aspiration	23 (38.3)	12 (20.0)	0.038*

Table 2: Complications and Surgery (Overall Frequencies for N=120)

Complications	Total n (%)
Non Dilating Pupil	70 (58.3)
Difficult Rhexis	35 (29.1)
Difficult Nucleus Delivery	19 (15.8)
Floppy Iris	7 (5.8)
Posterior Synechiae	8 (6.6)
Zonular Dialysis	21 (17.5)
Capsular Bag Dialysis	9 (7.5)
Posterior Capsular Rent	8 (6.6)
Decentered IOL	6 (5.0)
Vitreous Loss	8 (6.6)
Difficult Cortical Aspiration	35 (29.1)

Table 3: Association between complications and type of cataract (N=120)

Complications	HMC (n=6)	MC (n=8)	NS1 (n=31)	NS2 (n=47)	NS3 (n=21)	NS4 (n=7)	P Value
Non Dilating Pupil	4 (66.6)	8 (100.0)	13 (41.9)	24 (51.0)	16 (76.1)	6 (85.7)	0.020*
Difficult Rhexis	0	3 (37.5)	5 (16.1)	11 (23.4)	9 (42.8)	2 (28.6)	0.340
Difficult Nucleus Delivery	2 (33.3)	3 (37.5)	3 (9.6)	4 (8.5)	3 (14.2)	1 (14.3)	0.190
Floppy Iris	1 (16.6)	2 (25.0)	1 (3.2)	1 (2.1)	0	0	0.011*
Posterior Synechiae	1 (16.6)	1 (12.5)	0	1 (2.1)	2 (9.5)	1 (14.3)	0.210
Zonular Dialysis	1 (16.6)	1 (12.5)	3 (9.6)	4 (8.5)	5 (23.8)	0	0.410
Capsular Bag Dialysis	2 (33.3)	1 (12.5)	1 (3.2)	2 (4.2)	3 (14.2)	0	0.031*
Posterior Capsular Rent	1 (16.6)	1 (12.5)	1 (3.2)	1 (2.1)	2 (9.5)	0	0.360
Decentered IOL	1 (16.6)	0	1 (3.2)	3 (6.3)	0	0	0.550
Vitreous Loss	1 (16.6)	1 (12.5)	1 (3.2)	1 (2.1)	2 (9.5)	0	0.360
Difficult Cortical Aspiration	2 (33.3)	3 (37.5)	4 (12.9)	11 (23.4)	7 (33.3)	1 (14.3)	0.560

Table 4: Association between complications and anterior chamber (AC) depth (N=120) ND (n=110), VH2 (n=6), VH3 (n=4)

Complications	ND n (%)	VH2 n (%)	VH3 n (%)	P Value
Non Dilating Pupil	64	3	3	0.720
Difficult Rhexis	28	0	0	0.290
Difficult Nucleus Delivery	10	4	2	<0.001*
Floppy Iris	3	2	2	0.008*
Posterior Synechiae	6	1	0	0.240
Zonular Dialysis	11	0	1	0.350
Capsular Bag Dialysis	6	1	1	0.058
Posterior Capsular Rent	6	1	0	0.240
Decentered IOL	3	1	1	0.027*
Vitreous Loss	6	1	0	0.240
Difficult Cortical Aspiration	23	3	1	0.330

Discussion

The present study evaluated intraoperative complications associated with manual small-incision cataract surgery (SICS) and phacoemulsification in eyes with pseudoexfoliation (PEX), a clinical condition well known for zonular instability, poor pupillary dilation, anterior chamber fluctuations, and increased intraoperative risks. The findings of our study showed that SICS was associated with significantly higher rates of difficult rhexis, difficult nucleus delivery, and difficult cortical aspiration, while phacoemulsification demonstrated a greater frequency of zonular dialysis. These results are consistent with emerging contemporary evidence describing the behavior of PEX eyes during cataract extraction. Recent investigations have emphasized that PEX-related stromal weakness predisposes patients to greater capsulorrhexis challenges and increases intraoperative manipulation time, particularly in extracapsular techniques such as SICS, which rely on nucleus delivery maneuvers that exert tractional forces on the capsular bag [11]. Furthermore, reduced pupillary dilation—a prominent feature in PEX due to atrophic and rigid iris sphincter tissue—contributes to greater anterior segment instability, thereby increasing the likelihood of rhexis-related complications and difficulty in nuclear manipulation in SICS procedures [12].

On the other hand, phacoemulsification, despite being less dependent on nucleus delivery, has its own set of risks in PEX eyes. The significantly higher incidence of zonular dialysis observed in the phaco group aligns with recent multicentric reports demonstrating that phacoemulsification may exacerbate zonular stress through hydrodissection waves, phaco tip vacuum forces, and rotational movements during nuclear fragmentation [13]. The weakened or fragmented zonular fibers in PEX eyes are unable to fully counteract these stresses, resulting in increased dialysis and the occasional need for capsular tension devices. Additionally, newer studies have highlighted that subtle zonular fragility in PEX often remains undetected preoperatively and may only manifest once phacoemulsification begins, further increasing the risk of intraoperative zonular complications [14].

The association between cataract type and complications, particularly the significantly higher rates of non-dilating pupil and capsular bag dialysis in denser cataracts such as NS3, NS4, mature, and hypermature cataracts, is also supported by recent evidence. Dense cataracts require greater mechanical manipulation and generate more ultrasonic energy during phacoemulsification, increasing the stress on the already compromised zonules in PEX eyes [15]. Similarly, deeper nuclear sclerosis contributes to exaggerated lens mobility, which further predisposes the zonular apparatus to tractional damage. The significant association between shallow anterior chamber depth and complications such as difficult nucleus delivery, floppy iris, and decentered IOL also reflects the mechanical interplay between diminished intraoperative working space, iris billowing, and compromised stability of the capsular bag.

Overall, the trends demonstrated in this study reinforce the notion that both SICS and phacoemulsification pose unique intraoperative challenges in PEX eyes. SICS may be preferred when the nucleus is very hard and equipment limitations exist, but careful preoperative assessment of pupil behavior and zonular integrity is essential. Phacoemulsification may provide better control in early-to-moderate cataracts but requires additional caution regarding zonular stress. Tailoring surgical technique, using adjunctive devices such as iris hooks or capsular tension rings, and anticipating complications based on anterior chamber depth and cataract grade are crucial to achieving optimal outcomes.

Conclusion

In conclusion, pseudoexfoliation significantly increases the complexity of cataract surgery,

regardless of the chosen surgical technique. SICS demonstrated higher rates of rhexis-related and nucleus-related challenges, whereas phacoemulsification showed a greater incidence of zonular dialysis. Denser cataract grades and shallow anterior chambers were strongly associated with specific complications such as poor pupillary dilation, capsular bag instability, and floppy iris. These findings highlight the importance of thorough preoperative evaluation, individualized surgical planning, and the use of appropriate intraoperative support devices in PEX eyes. A tailored surgical approach based on cataract type, anterior chamber depth, and zonular integrity can help minimize complications and improve intraoperative safety in this high-risk group.

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