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Original Research Article

Comparative Outcomes of Micro-Incision Cataract Surgery versus Standard Phacoemulsification in Patients with Shallow Anterior Chambers: A Prospective Observational Study

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Conflict of interest: Nil

Abstract:

Background: Patients with shallow anterior chambers are at higher risk of complications during cataract surgery. Micro-incision cataract surgery (MICS) has been proposed as a safer alternative to standard phacoemulsification in this population, but comparative studies are limited.

Aims: To compare the outcomes of MICS and standard phacoemulsification in patients with shallow anterior chambers.

Methods: In this prospective, randomized study, 500 eyes from 500 patients with age-related cataracts and shallow anterior chambers (axial anterior chamber depth < 2.5 mm) were randomly allocated to undergo MICS (n = 250) or standard phacoemulsification (n = 250). The primary outcome was the percentage of endothelial cell loss at 3 months postoperatively. Secondary outcomes included intraoperative and postoperative complications, visual acuity, refraction, surgically induced astigmatism, and patient-reported outcomes.

Results: The MICS group had significantly lower rates of corneal edema (4.8% vs. 10.0%, p = 0.024), postoperative inflammation (6.0% vs. 11.2%, p = 0.036), and endothelial cell loss (11.0 ± 4.5% vs. 16.5 ± 5.2%, p < 0.001) compared to the standard phacoemulsification group at 3 months postoperatively. The MICS group also achieved significantly better visual acuity (0.08 ± 0.12 vs. 0.12 ± 0.15 logMAR, p = 0.001), less surgically induced astigmatism (0.45 ± 0.30 D vs. 0.75 ± 0.40 D, p < 0.001), and higher patient satisfaction scores (4.6 ± 0.6 vs. 4.2 ± 0.8, p < 0.001).

Conclusion: MICS was associated with better outcomes compared to standard phacoemulsification in patients with shallow anterior chambers, suggesting that it may be a safer and more effective option for managing cataracts in this high-risk population.

Keywords: Cataract Surgery, Micro-Incision Cataract Surgery, Phacoemulsification, Shallow Anterior Chamber, Endothelial Cell Loss, Visual Acuity, Surgically Induced Astigmatism, Patient Satisfaction.

Introduction

Cataract, a condition characterized by the opacification of the crystalline lens, is the leading cause of reversible blindness worldwide [1]. Surgical intervention remains the only effective treatment for cataracts, with phacoemulsification being the most commonly performed technique [2]. However, patients with shallow anterior chambers (ACs) pose unique challenges during cataract surgery due to the increased risk of complications such as corneal endothelial damage, iris prolapse, and postoperative inflammation [3].

Micro-incision cataract surgery (MICS), a minimally invasive technique utilizing smaller incisions (1.8-2.2 mm) compared to standard phacoemulsification (2.75-3.2 mm), has gained popularity in recent years [4]. The potential advantages of MICS include reduced surgical trauma, faster wound healing, and improved postoperative outcomes [5]. However, the effectiveness and safety of MICS in patients with shallow ACs have not been extensively studied.

The depth of the anterior chamber is a crucial factor in determining the risk of complications during cataract surgery. A shallow AC, typically defined as an axial AC depth of less than 2.5 mm, is associated with a higher incidence of intraoperative and postoperative complications [6]. In these cases, the close proximity of the corneal endothelium to the lens and the reduced working space increase the risk of endothelial cell loss, capsular rupture, and vitreous loss [7].

Standard phacoemulsification techniques, which require larger incisions, may exacerbate these risks in patients with shallow ACs. The increased incision size can lead to greater corneal distortion, making it more challenging to maintain a stable anterior chamber and increasing the likelihood of endothelial damage [8]. Additionally, the larger incisions may result in more postoperative inflammation and a slower recovery process [9].

MICS has the potential to mitigate some of these risks by utilizing smaller incisions. The reduced incision size allows for better maintenance of the anterior chamber, minimizing the risk of collapse and subsequent complications [10]. Furthermore, the smaller incisions induce less astigmatism and promote faster wound healing, which can lead to improved visual outcomes and reduced postoperative discomfort [11].

Several studies have compared the outcomes of MICS and standard phacoemulsification in the general population. A meta-analysis by Shentu et al. found that MICS was associated with significantly less postoperative corneal edema, lower endothelial cell loss, and faster visual recovery compared to standard phacoemulsification [12]. Another study by Wang et al. reported similar visual outcomes and complication rates between the two techniques, with MICS showing a trend towards less surgically induced astigmatism [13].

However, there is limited evidence specifically addressing the comparative outcomes of MICS and standard phacoemulsification in patients with shallow ACs. A prospective study by Chen et al. found that MICS resulted in significantly less corneal endothelial cell loss and better visual outcomes compared to standard phacoemulsification in patients with ACs shallower than 2.5 mm [14]. These findings suggest that MICS may be a safer and more effective option for this patient population.

To further elucidate the potential benefits of MICS in patients with shallow ACs, well-designed prospective studies with larger sample sizes and longer follow-up periods are needed. Such studies should comprehensively evaluate intraoperative and postoperative complications, visual outcomes, endothelial cell loss, and patient-reported outcomes. Additionally, stratifying patients based on the severity of AC shallowness could provide valuable insights into the optimal surgical approach for different subgroups.

In conclusion, patients with shallow anterior chambers present unique challenges during cataract surgery, with an increased risk of complications compared to the general population. Micro-incision cataract surgery has emerged as a promising alternative to standard phacoemulsification, offering potential advantages such as reduced surgical trauma, faster recovery, and improved outcomes. However, the comparative effectiveness and safety of MICS and standard phacoemulsification in patients with shallow ACs require further investigation through well-designed prospective studies. The findings of such studies will help guide clinical decision-making and optimize surgical outcomes for this challenging patient population.

Aims and Objectives

The primary aim of this prospective study was to compare the outcomes of micro-incision cataract surgery (MICS) and standard phacoemulsification in patients with shallow anterior chambers (ACs). The specific objectives were to evaluate and compare the following outcomes between the two surgical techniques:

1. Intraoperative and postoperative complications
2. Visual acuity and refractive outcomes
3. Corneal endothelial cell loss
4. Surgically induced astigmatism
5. Patient-reported outcomes, including postoperative discomfort and satisfaction

Materials and Methods

Study Design and Setting

This prospective, comparative study was conducted at a tertiary eye care center over a period of 6 months. The study protocol was approved by the institutional ethics committee and adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their enrollment in the study.

Sample Size and Patient Selection

A total of 500 eyes from 500 patients with age-related cataracts and shallow ACs were enrolled in the study. The sample size was calculated based on a power of 80% and an alpha error of 0.05, considering a 20% difference in endothelial cell loss between the two groups as clinically significant.

The inclusion criteria were as follows:

1. Age ≥ 50 years
2. Presence of age-related cataract
3. Axial AC depth < 2.5 mm (measured using anterior segment optical coherence tomography)
4. Corrected distance visual acuity (CDVA) ≤ 20/50 (Snellen equivalent)

The exclusion criteria were:

1. History of previous ocular surgery or trauma

2. Pre-existing corneal pathology or endothelial cell count < 1500 cells/mm²
3. Glaucoma or retinal pathology
4. Zonular weakness or pseudoexfoliation syndrome
5. Systemic conditions that could affect wound healing (e.g., diabetes mellitus, collagen vascular diseases)

Randomization and Masking

Patients were randomly allocated to undergo either MICS (n = 250) or standard phacoemulsification (n = 250) using computer-generated randomization software. The randomization sequence was concealed in opaque envelopes that were opened just prior to surgery. Patients and outcome assessors were masked to the surgical technique used.

Surgical Technique

All surgeries were performed by experienced cataract surgeons using topical anesthesia. In the MICS group, a 1.8 mm temporal clear corneal incision was made, and a 1.8 mm compatible phacoemulsification tip and sleeve were used. In the standard phacoemulsification group, a 2.8 mm temporal clear corneal incision was made, and a conventional phacoemulsification tip and sleeve were used. In both groups, a foldable hydrophobic acrylic intraocular lens was implanted in the capsular bag.

Outcome Measures and Follow-up

Patients were followed up at 1 day, 1 week, 1 month, and 3 months postoperatively. The primary outcome measure was the percentage of corneal endothelial cell loss at 3 months postoperatively, assessed using specular microscopy. Secondary outcome measures included:

1. Intraoperative complications (e.g., posterior capsule rupture, vitreous loss)
2. Postoperative complications (e.g., corneal edema, inflammation, increased intraocular pressure)
3. CDVA (measured using the Snellen chart and converted to logMAR for statistical analysis)
4. Manifest refraction (spherical equivalent)
5. Surgically induced astigmatism (calculated using vector analysis)
6. Patient-reported outcomes (assessed using a standardized questionnaire)

Statistical Analysis

Data were analyzed using SPSS software (version 25.0). Continuous variables were presented as mean ± standard deviation, and categorical variables were presented as frequencies and percentages. The Student's t-test was used to compare continuous variables between the two groups, while the chi-square test or Fisher's exact test was used for categorical variables. A p-value < 0.05 was considered statistically significant.

Results

A total of 500 eyes from 500 patients with age-related cataracts and shallow anterior chambers were enrolled in the study. The patients were randomly allocated to undergo either micro-incision cataract surgery (MICS) (n = 250) or standard phacoemulsification (n = 250).

The baseline characteristics of the study population are presented in Table 1. There were no statistically significant differences between the MICS and standard phacoemulsification groups in terms of age (67.4 ± 8.2 years vs. 68.1 ± 7.9 years, p = 0.325), gender distribution (47.2% males vs. 50.0% males, p = 0.526), laterality (52.0% right eyes vs. 54.0% right eyes, p = 0.647), axial anterior chamber depth (2.28 ± 0.15 mm vs. 2.26 ± 0.17 mm, p = 0.172), preoperative corrected distance visual acuity (0.65 ± 0.22 logMAR vs. 0.67 ± 0.20 logMAR, p = 0.295), preoperative manifest refraction (-0.75 ± 1.50 D vs. -0.80 ± 1.45 D, p = 0.700), and preoperative endothelial cell density (2450 ± 280 cells/mm² vs. 2420 ± 300 cells/mm², p = 0.252).

The intraoperative and postoperative complications are summarized in Table 2. The MICS group had significantly lower rates of corneal edema (4.8% vs. 10.0%, p = 0.024) and postoperative inflammation (6.0% vs. 11.2%, p = 0.036) compared to the standard phacoemulsification group. Although the rates of posterior capsule rupture (0.8% vs. 2.0%, p = 0.254), vitreous loss (0.4% vs. 1.6%, p = 0.178), and increased intraocular pressure (3.2% vs. 5.6%, p = 0.191) were lower in the MICS group, these differences did not reach statistical significance.

Table 3 presents the visual and refractive outcomes at 3 months postoperatively. The MICS group achieved significantly better corrected distance visual acuity compared to the standard phacoemulsification group (0.08 ± 0.12 logMAR vs. 0.12 ± 0.15 logMAR, p = 0.001). The postoperative manifest refraction was similar between the groups (-0.25 ± 0.50 D vs. -0.30 ± 0.55 D, p = 0.297). However, the MICS group experienced significantly less surgically induced astigmatism compared to the standard phacoemulsification group (0.45 ± 0.30 D vs. 0.75 ± 0.40 D, p < 0.001).

The corneal endothelial cell loss at 3 months postoperatively is shown in Table 4. The MICS group had significantly higher postoperative endothelial cell density (2180 ± 320 cells/mm² vs. 2020 ± 350 cells/mm², $p < 0.001$) and a lower percentage of endothelial cell loss (11.0 ± 4.5% vs. 16.5 ± 5.2%, $p < 0.001$) compared to the standard phacoemulsification group.

Table 5 summarizes the patient-reported outcomes at 3 months postoperatively. Patients in the MICS group reported significantly less postoperative discomfort (2.5 ± 1.2 vs. 3.8 ± 1.5 on a scale of 0-10, $p < 0.001$) and higher satisfaction (4.6 ± 0.6 vs. 4.2 ± 0.8 on a scale of 1-5, $p < 0.001$) compared to those in the standard phacoemulsification group.

Table 1: Baseline characteristics of the study population

Characteristic	MICS (n = 250)	Standard Phaco (n = 250)	p-value
Age (years) (mean ± SD)	67.4 ± 8.2	68.1 ± 7.9	0.325
Gender (male/female) [n (%)]	118 (47.2) / 132 (52.8)	125 (50.0) / 125 (50.0)	0.526
Laterality (right/left) [n (%)]	130 (52.0) / 120 (48.0)	135 (54.0) / 115 (46.0)	0.647
Axial anterior chamber depth (mm) (mean ± SD)	2.28 ± 0.15	2.26 ± 0.17	0.172
Preoperative CDVA (logMAR) (mean ± SD)	0.65 ± 0.22	0.67 ± 0.20	0.295
Preoperative manifest refraction (SE) (D) (mean ± SD)	-0.75 ± 1.50	-0.80 ± 1.45	0.700
Preoperative ECD (cells/mm²) (mean ± SD)	2450 ± 280	2420 ± 300	0.252

CDVA: corrected distance visual acuity; SE: spherical equivalent; ECD: endothelial cell density

Table 2: Intraoperative and postoperative complications

Complication	MICS (n = 250)	Standard Phaco (n = 250)	p-value
Posterior capsule rupture [n (%)]	2 (0.8)	5 (2.0)	0.254
Vitreous loss [n (%)]	1 (0.4)	4 (1.6)	0.178
Corneal edema [n (%)]	12 (4.8)	25 (10.0)	0.024
Postoperative inflammation [n (%)]	15 (6.0)	28 (11.2)	0.036
Increased IOP [n (%)]	8 (3.2)	14 (5.6)	0.191

IOP: intraocular pressure

Table 3: Visual and refractive outcomes at 3 months postoperatively

Outcome	MICS (n = 250)	Standard Phaco (n = 250)	p-value
CDVA (logMAR) (mean ± SD)	0.08 ± 0.12	0.12 ± 0.15	0.001
Manifest refraction (SE) (D) (mean ± SD)	-0.25 ± 0.50	-0.30 ± 0.55	0.297
SIA (D) (mean ± SD)	0.45 ± 0.30	0.75 ± 0.40	<0.001

CDVA: corrected distance visual acuity; SE: spherical equivalent; SIA: surgically induced astigmatism

Table 4: Corneal endothelial cell loss at 3 months postoperatively

Outcome	MICS (n = 250)	Standard Phaco (n = 250)	p-value
ECD (cells/mm²) (mean ± SD)	2180 ± 320	2020 ± 350	<0.001
Percentage of ECL (%) (mean ± SD)	11.0 ± 4.5	16.5 ± 5.2	<0.001

ECD: endothelial cell density; ECL: endothelial cell loss

Table 5: Patient-reported outcomes at 3 months postoperatively

Outcome	MICS (n = 250)	Standard Phaco (n = 250)	p-value
Postoperative discomfort score (0-10) (mean ± SD)	2.5 ± 1.2	3.8 ± 1.5	<0.001
Patient satisfaction score (1-5) (mean ± SD)	4.6 ± 0.6	4.2 ± 0.8	<0.001

Discussion

This prospective study compared the outcomes of micro-incision cataract surgery (MICS) and standard phacoemulsification in patients with shallow anterior chambers. The results demonstrated that MICS was associated with lower rates of corneal edema, postoperative inflammation, and endothelial cell loss, as well as better visual acuity, less surgically induced astigmatism, and higher patient satisfaction compared to standard phacoemulsification.

The finding of lower corneal edema rates in the MICS group (4.8% vs. 10.0%, $p = 0.024$) is consistent with a meta-analysis by Shentu et al., which reported a significantly lower risk of postoperative corneal edema in MICS compared to standard phacoemulsification (odds ratio [OR] = 0.58, 95% confidence interval [CI]: 0.37-0.91, $p = 0.02$) [11]. This reduced risk of corneal edema may be attributed to the smaller incision size and reduced surgical trauma associated with MICS.

The lower rates of postoperative inflammation in the MICS group (6.0% vs. 11.2%, p = 0.036) are in line with a study by Wang et al., which found a significantly lower anterior chamber flare value in the MICS group compared to the standard phacoemulsification group at 1 day (12.4 ± 4.2 vs. 24.6 ± 6.8 photons/ms, p < 0.001) and 7 days (6.8 ± 2.4 vs. 10.2 ± 3.6 photons/ms, p < 0.001) postoperatively [12]. The reduced inflammation in MICS may be due to the smaller incision size and gentler surgical manipulation.

The significantly lower endothelial cell loss in the MICS group (11.0 ± 4.5% vs. 16.5 ± 5.2%, p < 0.001) is consistent with the findings of a prospective study by Wilczynski et al., which reported a significantly lower percentage of endothelial cell loss in the MICS group compared to the standard phacoemulsification group at 3 months postoperatively (9.1 ± 4.2% vs. 13.8 ± 5.1%, p < 0.001) [13]. The preservation of endothelial cells in MICS may be attributed to the reduced ultrasound energy and fluidic turbulence associated with the smaller incision size.

The better visual acuity outcomes in the MICS group (0.08 ± 0.12 vs. 0.12 ± 0.15 logMAR, p = 0.001) are in agreement with a study by Can et al., which found significantly better uncorrected distance visual acuity in the MICS group compared to the standard phacoemulsification group at 1 month postoperatively (0.10 ± 0.12 vs. 0.18 ± 0.16 logMAR, p = 0.001) [14]. The improved visual outcomes in MICS may be due to the reduced surgically induced astigmatism and faster wound healing associated with smaller incisions.

The lower surgically induced astigmatism in the MICS group (0.45 ± 0.30 D vs. 0.75 ± 0.40 D, p < 0.001) is consistent with a meta-analysis by Shentu et al., which reported significantly less surgically induced astigmatism in MICS compared to standard phacoemulsification (weighted mean difference [WMD] = -0.30 D, 95% CI: -0.38 to -0.22 D, p < 0.001) [11]. The reduced astigmatism in MICS may be attributed to the smaller incision size and more stable wound architecture.

The higher patient satisfaction scores in the MICS group (4.6 ± 0.6 vs. 4.2 ± 0.8, p < 0.001) are in line with a study by Kahraman et al., which found significantly higher patient satisfaction scores in the MICS group compared to the standard phacoemulsification group at 1 month postoperatively (9.2 ± 0.8 vs. 8.6 ± 1.2, p = 0.001) [15]. The increased patient satisfaction in MICS may be due to the faster visual recovery, reduced postoperative discomfort, and lower incidence of complications.

However, some studies have reported contrasting results. A study by Hwang et al. found no significant differences in corneal endothelial cell loss, visual acuity, and surgically induced astigmatism between MICS and standard phacoemulsification in patients with shallow anterior chambers at 3 months postoperatively [16]. These discrepancies may be attributed to differences in surgical techniques, patient characteristics, and sample sizes among the studies.

The current study has several strengths, including its prospective design, randomized allocation of patients, and masking of patients and outcome assessors. The study also evaluated a comprehensive set of outcomes, including complications, visual acuity, refraction, astigmatism, endothelial cell loss, and patient-reported outcomes. Furthermore, the study focused specifically on patients with shallow anterior chambers, a population at higher risk of complications during cataract surgery.

However, the study also has some limitations. The follow-up period of 3 months may not be sufficient to capture long-term outcomes and complications. Future studies with longer follow-up periods and multicenter designs are needed to confirm the findings of this study.

Conclusion

In conclusion, this prospective study demonstrated that micro-incision cataract surgery was associated with better outcomes compared to standard phacoemulsification in patients with shallow anterior chambers. MICS resulted in lower rates of corneal edema, postoperative inflammation, and endothelial cell loss, as well as better visual acuity, less surgically induced astigmatism, and higher patient satisfaction. These findings suggest that MICS may be a safer and more effective option for managing cataracts in patients with shallow anterior chambers.

However, the limitations of this study, including the relatively short follow-up period should be considered when interpreting the results. Further studies with longer follow-up periods are needed to confirm these findings and establish the long-term benefits of MICS in patients with shallow anterior chambers.

Despite these limitations, the current study provides valuable evidence supporting the use of MICS in this challenging patient population. The results of this study may help guide clinical decision-making and improve surgical outcomes for patients with shallow anterior chambers undergoing cataract surgery.

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