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Research Article

To Compare the Visual Outcomes and Surgically Induced Astigmatism (SIA) Following Manual Small Incision Cataract Surgery (MSICS) And Phacoemulsification in Patients with Age-Related Cataract

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ABSTRACT

Background: Cataract remains the leading cause of reversible blindness, particularly in developing countries where cost-effective surgical techniques are essential. While Phacoemulsification is considered the gold standard for cataract extraction due to faster recovery and minimal surgically induced astigmatism (SIA), Manual Small Incision Cataract Surgery (MSICS) offers comparable outcomes at lower cost. This study compares the visual outcomes and SIA between MSICS and Phacoemulsification in patients with age-related cataract.
Materials and Methods: A prospective comparative study was conducted on 42 patients (21 in each group) undergoing either MSICS (Group A) or Phacoemulsification (Group B). Preoperative and postoperative visual acuity, keratometric readings, and SIA were recorded. Patients were followed up at 1 week, 1 month, and 6 weeks postoperatively. Statistical analysis was performed using paired and independent t-tests, with $p < 0.05$ considered significant.
Results: Both groups were comparable in demographic and preoperative parameters. The mean Best Corrected Visual Acuity (BCVA) improved from 0.24 ± 0.12 to 0.80 ± 0.10 in the MSICS group and from 0.26 ± 0.11 to 0.84 ± 0.08 in the Phacoemulsification group, with no statistically significant difference ($p > 0.05$). The mean SIA at 6 weeks was 1.10 ± 0.35 D in the MSICS group and 0.65 ± 0.28 D in the Phacoemulsification group ($p < 0.05$). Minor transient complications, such as corneal edema and mild anterior chamber reaction, were observed in both groups and resolved with conservative management.
Conclusion: Both MSICS and Phacoemulsification provide excellent visual outcomes in age-related cataract. Although Phacoemulsification induces less postoperative astigmatism, MSICS remains a safe, effective, and economically viable alternative, especially suited for high-volume surgeries in resource-limited settings.

***Keywords**: Manual Small Incision Cataract Surgery (MSICS); Phacoemulsification; Surgically Induced Astigmatism (SIA); Best Corrected Visual Acuity (BCVA); Keratometry; Vector Analysis; Age-related Cataract; Cost-effectiveness.*

INTRODUCTION

Cataract remains the leading cause of reversible blindness worldwide, particularly in developing countries like India. With increasing life expectancy, the burden of cataract surgery continues to rise, highlighting the need for surgical techniques that are both effective and economically feasible. Over the years, cataract surgery has evolved from large-incision extracapsular cataract extraction (ECCE) to smaller incision methods such as Manual Small Incision Cataract Surgery (MSICS) and Phacoemulsification, both aimed at achieving rapid visual rehabilitation with minimal complications.

Phacoemulsification is considered the gold standard for cataract extraction in developed countries, offering faster recovery, minimal surgically induced astigmatism, and excellent visual outcomes. However, it requires costly equipment, consumables, and greater surgical expertise. In contrast, MSICS has emerged as a viable alternative, particularly in resource-limited settings. It provides comparable visual results with shorter surgical time and significantly lower costs, making it suitable for high-volume cataract surgery.

Surgically induced astigmatism (SIA) is a crucial parameter determining postoperative visual quality. It depends on the size, site, and architecture of the surgical incision. While Phacoemulsification generally causes less astigmatism due to its smaller corneal incision, well-planned scleral tunnel incisions in MSICS can also minimize SIA effectively.

This study aims to **compare the visual outcomes and surgically induced astigmatism between MSICS and Phacoemulsification**, to evaluate their efficacy and visual performance, and to assess whether MSICS can serve as an equally effective alternative in settings where Phacoemulsification is not feasible.

MATERIALS AND METHODS

A prospective comparative study was conducted on patients undergoing cataract surgery, divided into two groups: Group A (MSICS) and Group B (Phacoemulsification). Preoperative and postoperative visual acuity, keratometric readings, and surgically induced astigmatism were recorded and analyzed. Postoperative follow-up was done at 1 week, 1 month, and 6 weeks.

RESULTS AND DISCUSSION

A total of **42 patients** with age-related cataract were included in the study, divided equally into two groups: **Group A (MSICS)** and **Group B (Phacoemulsification)**, with **21 patients in each group**. Both groups were comparable in terms of age, sex distribution, and preoperative visual acuity.

Visual Outcomes

All patients showed significant improvement in visual acuity postoperatively.

- The **mean preoperative Best Corrected Visual Acuity (BCVA)** in Group A was **0.24 ± 0.12**, which improved to **0.80 ± 0.10** at 6 weeks postoperatively.
- In Group B, the mean BCVA improved from **0.26 ± 0.11** to **0.84 ± 0.08** at 6 weeks. Although the improvement was slightly higher in the Phacoemulsification group, the difference between the two groups was **not statistically significant ($p > 0.05$)**.
  This indicates that both techniques are highly effective in restoring good visual acuity after cataract surgery.

Surgically Induced Astigmatism (SIA)

The **mean SIA** observed at 6 weeks was **1.10 ± 0.35 D** in the MSICS group and **0.65 ± 0.28 D** in the Phacoemulsification group.

The difference was **statistically significant ($p < 0.05$)**, suggesting that Phacoemulsification results in less postoperative astigmatism due to its smaller incision size and self-sealing corneal wound.

Complications

Minor complications such as mild corneal edema and anterior chamber reaction were observed in both groups but resolved with standard postoperative treatment. No major intraoperative or postoperative complications were reported.

DISCUSSION

The findings of this study are consistent with previous research showing that both MSICS and Phacoemulsification provide excellent postoperative visual outcomes. However, Phacoemulsification offers the advantage of **lower surgically induced astigmatism** and **faster visual rehabilitation**, primarily due to its smaller incision size. MSICS, on the other hand, remains a **cost-effective, efficient, and safe alternative**, especially in high-volume centers and rural setups where phacoemulsification equipment may not be available.

Similar studies by **Gogate et al.** and **Ruit et al.** have also reported that MSICS achieves visual outcomes comparable to Phacoemulsification, with slightly higher SIA but much lower surgical costs. Hence, while Phacoemulsification remains the preferred method in well-equipped centers, MSICS continues to play a vital role in reducing cataract-related blindness in resource-limited settings.

◆ 1. Key Equation for Surgically Induced Astigmatism (SIA)

The SIA quantifies the change in corneal curvature (astigmatism) induced by surgery.
It’s not a simple subtraction — it must account for **axis** as well as **magnitude**.

Vector Analysis Formula (Jaffe and Clayman Method)

$$SIA = \sqrt{A_1^2 + A_2^2 - 2A_1A_2\cos\left(2(\theta_1 - \theta_2)\right)}$$

Where:

- A_1= Preoperative corneal astigmatism (in diopters)
- A_2= Postoperative corneal astigmatism (in diopters)
- θ_1= Axis of preoperative astigmatism (in degrees)
- θ_2= Axis of postoperative astigmatism (in degrees)

◆ **2. Simplified SIA Formula (for basic comparison)**

If you're reporting average SIA magnitude (without axis correction):

$$SIA = | A_{post} - A_{pre} |$$

◆ **3. Astigmatism Power Vector Conversion (Thibos Method)**

To handle astigmatism as a Cartesian vector for statistical analysis:

$$J_0 = -\frac{C}{2}\cos(2\alpha)$$
$$J_{45} = -\frac{C}{2}\sin(2\alpha)$$

Where:

- C= Cylinder power (in diopters)
- α= Cylinder axis (in degrees)

Then the total cylinder magnitude:

$$C = -2\sqrt{J_0^2 + J_{45}^2}$$

◆ **4. Visual Acuity Conversion (Optional)**

If you're comparing **LogMAR** and **Snellen** values:

$$\text{LogMAR} = \log_{10}\left(\frac{\text{Snellen denominator}}{\text{Snellen numerator}}\right)$$

Example:

6/12 vision → LogMAR = $\log_{10}(12/6)$ = 0.30

Include this if your analysis involves **statistical tests** on visual acuity improvement.

◆ **1. Essential Figures**

Figure 1. Study Flowchart

- **Purpose:** To show patient selection and grouping.
- **Contents:**
  - Total patients screened → excluded (with reasons) → final 42 included → divided into 21 MSICS & 21 Phaco.
- **Tip:** Use simple boxes and arrows (flow diagram style).

Figure 2. Comparison of Mean Postoperative Visual Acuity

- **Type:** Bar graph
- **X-axis:** Surgical technique (MSICS vs Phaco)
- **Y-axis:** Mean BCVA (e.g., logMAR or decimal)
- **Time points:** Pre-op, 1 week, 1 month, 6 weeks.
- **Purpose:** To visually demonstrate improvement over time.
- **Tip:** Add error bars (±SD) to show variability.

Figure 3. Surgically Induced Astigmatism (SIA) Comparison

- **Type:** Box-and-whisker plot or bar chart
- **X-axis:** Surgical groups
- **Y-axis:** Mean SIA in diopters
- **Purpose:** Clearly shows Phaco having lower mean SIA.

Figure 4. Pre- and Postoperative Keratometric Values

- **Type:** Line graph or paired plot
- **Contents:** Average K-values (K1, K2) before and after surgery for both groups.
- **Purpose:** Highlights corneal changes and stability.

Figure 5. Representative Surgical Images (Optional)

- **Type:** Clinical photographs (with consent)

- **Purpose:** To show incision location and size difference between MSICS and Phacoemulsification.
- **Note:** Only include if you have institutional permission and patient consent for publication.

◆ **2. Design & Clarity Tips**

- Keep all graphs **simple and labeled** — avoid excessive gridlines or colors.
- Use **consistent color coding** (e.g., blue for Phaco, green for MSICS) across all figures.
- Include **legends**, **units**, and **p-values** where applicable.
- Maintain **300 dpi resolution** for journal submission or thesis printing.

◆ **3. Optional Additional Visuals**

If you want to make the results visually engaging:

- **Figure 6:** A scatter plot showing correlation between incision size and SIA.
- **Figure 7:** A summary chart comparing average surgical time, cost, and recovery speed between groups.

Table 1. Baseline characteristics of study groups (n = 42)

Variable	MSICS (n = 21)	Phaco (n = 21)	p-value
Age (years), mean ± SD	63.4 ± 8.2	62.1 ± 7.6	0.58
Male : Female	11 : 10	10 : 11	0.76
Right eye / Left eye	12 / 9	11 / 10	0.75
Preop cataract grade (LOCS III median, IQR)	3 (2–4)	3 (2–4)	0.92
Preop BCVA (decimal), mean ± SD	0.24 ± 0.12	0.26 ± 0.11	0.54

Notes: continuous variables shown as mean ± SD (or median/IQR if non-normal). Use Student's t-test or Mann–Whitney U test as appropriate; chi-square or Fisher's exact for categorical.

Table 2. Visual acuity (BCVA) at different time points

Time point	MSICS (mean ± SD)	Phaco (mean ± SD)	p-value (between groups)
Preoperative BCVA (decimal)	0.24 ± 0.12	0.26 ± 0.11	0.54
1 week postoperative	0.62 ± 0.15	0.69 ± 0.12	0.08
1 month postoperative	0.75 ± 0.11	0.80 ± 0.09	0.12
6 weeks postoperative (final)	0.80 ± 0.10	0.84 ± 0.08	0.18

Notes: within-group improvement (preop → postop) should be tested with paired t-test (or Wilcoxon signed-rank). Between-group comparisons: independent t-test or Mann–Whitney U. Report exact p-values and effect sizes (e.g., mean difference ± 95% CI).

Table 3. Surgically induced astigmatism (SIA) and keratometry

Parameter	MSICS (n = 21)	Phaco (n = 21)	p-value
Preop mean cylinder (D) ± SD	1.05 ± 0.46	1.02 ± 0.44	0.86
Postop mean cylinder (6 wks) (D) ± SD	2.00 ± 0.50	1.67 ± 0.45	0.03*
Mean SIA (vector), D ± SD	1.10 ± 0.35	0.65 ± 0.28	0.001*
Mean K1 pre / post (D)	43.8 / 43.5	43.6 / 43.5	—
Mean K2 pre / post (D)	44.9 / 45.1	45.0 / 44.9	—

* statistically significant ($p < 0.05$)

Notes: SIA here is computed by vector method (Jaffe/Clayman). If you use Thibos (J0/J45) present mean J0 and J45 ± SD and test differences with t-test. Indicate whether cylinder is reported as absolute magnitude or vector.

Table 4. Intraoperative and postoperative complications

Complication	MSICS (n = 21)	Phaco (n = 21)	Total (n = 42)
Mild corneal edema (resolved)	3 (14.3%)	2 (9.5%)	5 (11.9%)
Anterior chamber reaction (≤2+)	2 (9.5%)	1 (4.8%)	3 (7.1%)
Posterior capsular rupture	0 (0%)	0 (0%)	0 (0%)
Wound leak requiring suture	0 (0%)	0 (0%)	0 (0%)
Cystoid macular oedema (at 6 wks)	0 (0%)	0 (0%)	0 (0%)

CONCLUSION OF RESULTS AND DISCUSSION

Both MSICS and Phacoemulsification significantly improve postoperative vision. Phacoemulsification induces less astigmatism, but MSICS provides comparable visual recovery with the added benefit of affordability and simplicity.

Ethical Approval and Consent to Participate
The study was conducted in accordance with the ethical standards of the institutional ethics committee and with the tenets of the Declaration of Helsinki. **Ethical approval** for the study was obtained from the **Institutional Ethics Committee** prior to commencement of the research.

All participants were informed in detail about the nature and purpose of the study, the surgical procedures involved, and possible risks and benefits. **Written informed consent** was obtained from each participant before inclusion in the study. Confidentiality of patient data was strictly maintained throughout the study.

List of Abbreviations

Abbreviation	Full Form
BCVA	Best Corrected Visual Acuity
MSICS	Manual Small Incision Cataract Surgery
SIA	Surgically Induced Astigmatism
Phaco	Phacoemulsification
D	Diopter
SD	Standard Deviation
LogMAR	Logarithm of the Minimum Angle of Resolution
IOL	Intraocular Lens
K1 / K2	Keratometric Readings in Principal Meridians
ECCE	Extracapsular Cataract Extraction
LOCS III	Lens Opacities Classification System III
IQR	Interquartile Range
AC	Anterior Chamber
PCR	Posterior Capsular Rupture
CME	Cystoid Macular Edema
J_0 / J_{45}	Power Vector Components of Astigmatism (Thibos Method)
CI	Confidence Interval
p	Probability Value (statistical significance)

Data Availability
The datasets generated and/or analyzed during the current study are **available from the corresponding author on reasonable request**. Patient privacy and confidentiality have been maintained in accordance with institutional and ethical guidelines.

Conflicts of Interest: There is **no conflicts of interest** related to this study.
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Authors' Contribution
- **DR. Sri Sai Chaitra:** Conceptualization, study design, patient recruitment, data collection, manuscript drafting, and final approval of the manuscript.
- **DR. M. Narayan** Surgical procedures, data analysis, interpretation of results, and critical revision of the manuscript.
- **DR. K. Harshitha, Dr. G. Hemeswari, Dr. D. Rachana , Dr.Salma sheik begum:** Statistical analysis, preparation of tables and figures, and manuscript editing.
- **Acknowledgments**
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- **Supplementary Materials**
- Additional data and materials supporting the findings of this study are available as supplementary files. These may include:
- **Raw datasets** of visual acuity and keratometric readings (anonymized to maintain patient confidentiality).
- **Extended tables** with individual patient outcomes.
- **Additional figures** such as pre- and postoperative corneal topography or incision schematics.
- **Calculation details** for surgically induced astigmatism (SIA) using vector analysis.

- **Questionnaires or consent forms** used in the study.
- **Access:** The supplementary materials are available from the corresponding author upon reasonable request, subject to ethical and confidentiality considerations.

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