JHWCR
Journal of Health, Wellness, and Community Research
Volume III, Issue VI
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, **ISSN**: 3007-0570
https://doi.org/10.61919/zzmw4f12

Article

Comparison of Corneal Incision Versus Toric Intraocular Lens Techniques Used in Cataract Surgery

Waheeba Awais[1], Rubab Naqvi[2], Ayesha Sharif[1], Tehami Babar[1], Usama Elahi[3]

1 Chd. Muhammad Akram Teaching Hospital, Lahore, Pakistan
2 Superior University, Lahore, Pakistan
3 Al Shifa Eye Hospital, Kohat, Pakistan

Correspondence
wahibaawais1@gmail.com

Cite this Article

Received	2025-05-16
Revised	2025-06-11
Accepted	2025-06-13
Published	2025-06-15

No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

Authors' Contributions
Concept: WA; Design: RN; Data Collection: AS, TB; Analysis: UE; Drafting: WA

ABSTRACT

Background: Astigmatism frequently complicates cataract surgery, adversely affecting postoperative visual outcomes and quality of life. Despite various techniques available, there remains uncertainty regarding the comparative effectiveness of corneal incision versus toric intraocular lens (IOL) implantation for astigmatism correction, particularly in populations with high disease burden. **Objective**: This study aimed to compare the effectiveness of corneal incision and toric IOL techniques for reducing residual astigmatism and improving uncorrected visual acuity following cataract surgery, with the expectation that toric IOLs would yield superior refractive outcomes. **Methods**: In a comparative cross-sectional study conducted at tertiary eye hospitals in Lahore, Pakistan, 368 adults (aged 30–70 years) with pre-existing regular astigmatism (-0.75 to -3.75 D) were consecutively enrolled and allocated to either corneal incision or toric IOL groups. Exclusion criteria included prior ocular surgery and corneal pathology. Preoperative, intraoperative, and postoperative data were collected using a standardized proforma, with outcomes assessed at three follow-up visits. Primary endpoints were residual astigmatism and uncorrected visual acuity, analyzed using ANOVA and Wilcoxon signed-rank tests in SPSS 27. Ethical approval and written informed consent were obtained in accordance with the Declaration of Helsinki. **Results**: At the third follow-up, the toric IOL group achieved significantly lower mean residual astigmatism (-0.25 ± 0.34 D) compared to the corneal incision group (-0.69 ± 0.44 D; mean difference 0.44 D, 95% CI: 0.33 to 0.55, $p < 0.001$), and a greater proportion achieved ≤0.50 D (79.9% vs. 33.2%; OR 7.89, 95% CI: 4.80 to 12.97). Uncorrected visual acuity was also superior toric IOLs (mean LogMAR 0.13 vs. 0.21, $p < 0.001$). Complication rates were low and similar between groups. **Conclusion**: Toric IOL implantation provides more precise and stable astigmatism correction and better visual outcomes than corneal incision techniques in cataract surgery, supporting its preferential use for moderate to high astigmatism in clinical practice.

Keywords: Astigmatism, Cataract Surgery, Toric Intraocular Lenses, Corneal Incision, Visual Acuity, Refractive Errors, Cross-Sectional Studies

INTRODUCTION

Cataracts represent a leading cause of visual impairment globally, with a particularly high burden in low- and middle-income countries. The progressive opacification of the eye's natural lens leads to diminished visual acuity, increased glare, and compromised quality of life (1). Epidemiological data highlight that cataract is responsible for nearly half of global blindness, with prevalence estimates suggesting that over 65 million people are affected worldwide (2,3). In Pakistan and other regions within the Eastern Mediterranean, cataracts account for more than half of all cases of blindness, imposing a substantial socio-economic burden (6). Despite advances in surgical techniques, the challenge of correcting pre-existing astigmatism during cataract surgery remains central to optimizing postoperative visual outcomes (4,8).

Astigmatism, a common refractive error characterized by irregular curvature of the cornea or lens, frequently coexists with cataract, further reducing uncorrected visual acuity and affecting patient satisfaction following surgery (8,9). Two principal strategies have emerged for astigmatism correction during cataract surgery: precise placement of corneal incisions at the steepest meridian, known as clear corneal incision (CCI), and the use of toric intraocular lenses (IOLs), which are specifically designed to counteract corneal cylinder (9-13). The CCI technique leverages surgically induced flattening of the cornea to reduce astigmatism, and while it is cost-effective and technically straightforward, its efficacy is typically limited to lower degrees of astigmatism and may be influenced by

the surgeon's skill and individual corneal healing responses (4,14-16). Conversely, toric IOL implantation enables simultaneous management of both cataract and moderate to high astigmatism in a single procedure, offering the potential for superior refractive accuracy and long-term stability (17,21,22). However, toric IOLs require meticulous intraoperative alignment to the intended axis, and postoperative lens rotation may compromise outcomes if not adequately controlled (23).

While both techniques are widely practiced, there remains ongoing debate in the literature regarding their comparative effectiveness, particularly in relation to the degree of astigmatic correction, visual acuity outcomes, risk of regression, and overall patient satisfaction (15,18,19,23). Although prior studies have examined the refractive results and postoperative complications associated with each technique individually, direct head-to-head comparisons, especially within South Asian populations, are limited. Existing evidence is complicated by heterogeneity in study populations, surgical methods, and follow-up durations, underscoring a need for robust comparative data to inform clinical decision-making and guideline development. Importantly, the choice of technique is not only driven by refractive targets, but also by patient-specific factors such as ocular anatomy, economic considerations, and expectations for visual rehabilitation (4,16,22).

Addressing this knowledge gap, the present study aims to directly compare the corneal incision and toric IOL techniques in patients undergoing cataract surgery with pre-existing astigmatism, focusing on postoperative residual astigmatism and visual acuity outcomes. By evaluating both techniques within a representative cohort and standardized surgical and follow-up protocols, this study seeks to generate evidence to guide personalized surgical planning for optimal visual rehabilitation. The central research question is: Does toric intraocular lens implantation provide superior astigmatic correction and visual outcomes compared to corneal incision techniques in patients undergoing cataract surgery for astigmatism management?

MATERIALS AND METHODS

This comparative cross-sectional study was conducted to evaluate and compare the effectiveness of corneal incision and toric intraocular lens (IOL) techniques for the management of astigmatism in patients undergoing cataract surgery. The study was carried out in multiple tertiary eye hospitals in Lahore, Pakistan, from November 2023 to February 2024. All patients presenting for cataract surgery during the study period were considered for inclusion if they were aged between 30 and 70 years, diagnosed with visually significant cataract, and had documented pre-existing regular corneal astigmatism ranging from -0.75 to -3.75 diopters. Patients with previous ocular surgery, irregular astigmatism, coexisting corneal pathology, active ocular infection, or systemic conditions that could compromise postoperative healing were excluded. Participants were selected consecutively from preoperative clinic lists, and eligibility was confirmed through review of clinical records and slit-lamp biomicroscopy by experienced ophthalmologists.

Eligible patients were approached in person, and the study objectives and procedures were explained before written informed consent was obtained. All study activities adhered to the tenets of the Declaration of Helsinki, with study approval granted by the Institutional Review Board of each participating hospital. To protect patient confidentiality, data were anonymized using unique study codes, and all electronic records were stored on password-protected computers accessible only to the study team. Participants were allocated to one of two groups based on the planned surgical approach determined by the consulting ophthalmologist, considering the patient's refractive needs, corneal curvature, and economic factors. Group I underwent standard phacoemulsification cataract surgery with toric IOL implantation, while Group II underwent phacoemulsification with a clear corneal incision placed on the steepest meridian. The decision regarding incision site and toric IOL power was guided by preoperative keratometry and biometry, with calculations performed using manufacturer-recommended software and standardized IOL power calculation formulas. All surgical procedures were conducted by experienced surgeons using uniform operative protocols and aseptic precautions to minimize procedural variability.

Baseline demographic and clinical data, including age, sex, laterality, preoperative visual acuity, and keratometric astigmatism, were recorded using a structured data collection proforma designed specifically for this study. Preoperative assessment included automated and manual refraction, slit-lamp examination, intraocular pressure measurement, and dilated funduscopy. Postoperative follow-up evaluations were scheduled at one, two, and three months following surgery, during which uncorrected and best-corrected distance visual acuity and residual refractive cylinder were measured. Refraction was performed by certified optometrists using standardized protocols to ensure inter-rater reliability, and all measurements were entered into a centralized database immediately following each assessment.

The primary study variables were the magnitude of residual astigmatism and uncorrected visual acuity at each follow-up interval. Secondary variables included demographic characteristics, intraoperative complications, and any postoperative adverse events. Operational definitions for astigmatism, visual acuity, and other study measures were based on established ophthalmic criteria to ensure consistency and reproducibility. To address potential sources of bias, all outcome assessors were masked to the surgical technique, and standard protocols were used for refraction and visual acuity assessment. Confounding was minimized by restricting inclusion to patients with regular corneal astigmatism, using the same phacoemulsification technique in both groups, and by adjusting for baseline covariates during statistical analysis. A priori sample size estimation indicated that 184 participants per group (total n=368) would provide at least 80% power to detect a clinically meaningful difference of 0.25 diopters in residual astigmatism between groups, assuming a two-sided significance level of 0.05 and a standard deviation of 0.75 diopters. The sample size was inflated to account for potential attrition and missing data.

Statistical analysis was conducted using SPSS version 27. Descriptive statistics summarized demographic and baseline clinical characteristics. The primary analysis compared mean residual astigmatism and visual acuity between groups at each follow-up using analysis of variance (ANOVA) for repeated measures, with adjustment for age, sex, and preoperative astigmatism as covariates. The Wilcoxon signed-rank test was used to assess within-group changes over time. Missing data were handled using complete-case analysis, and sensitivity analyses were performed to confirm the robustness of findings. Subgroup analyses by degree of preoperative astigmatism and age category were planned a priori. A p-value less than 0.05 was considered statistically significant for all comparisons. Quality assurance procedures included double data entry, periodic audits of source documents, and verification of statistical outputs by a second analyst. To facilitate reproducibility, the study protocol, raw datasets, and all analytic code were archived and are available upon reasonable requests. Throughout the study, strict measures were implemented to maintain the integrity, confidentiality, and traceability of all research data (6,8,21).

RESULTS

A total of 368 participants completed the study, with 184 assigned to the corneal incision group and 184 to the toric intraocular lens (IOL) group. The mean age of the corneal incision group was 45.71 years (standard deviation [SD] 7.11), while the toric IOL group had a mean age of 46.85 years (SD 8.21). Males comprised 58.7% (n = 108) of the corneal incision group and 60.3% (n = 111) of the toric IOL group, with no statistically significant difference in sex distribution between groups (p = 0.761). The baseline magnitude of preoperative astigmatism was comparable, averaging -2.38 diopters (D, SD 0.76) in the corneal incision group and -2.37 D (SD 0.76) in the toric IOL group (p = 0.926). Following surgery, both groups exhibited significant reductions in mean residual astigmatism, but the extent of correction differed substantially. At the first follow-up, the corneal incision group achieved a mean residual astigmatism of -1.88 D (SD 0.76), while the toric IOL group reached -1.37 D (SD 0.74). This difference was statistically significant, with a mean intergroup difference of 0.51 D (95% confidence interval [CI]: 0.37 to 0.65, p < 0.001, Cohen's d = 0.69). By the second follow-up, the mean residual astigmatism in the corneal incision group was -1.18 D (SD 0.40), compared to -0.78 D (SD 0.67) in the toric IOL group (mean difference 0.40 D, 95% CI: 0.26 to 0.54, p < 0.001, Cohen's d = 0.72). At the third follow-up, the corneal incision group recorded a mean residual astigmatism of -0.69 D (SD 0.44), whereas the toric IOL group achieved -0.25 D (SD 0.34), yielding a highly significant difference of 0.44 D (95% CI: 0.33 to 0.55, p < 0.001, Cohen's d = 1.15).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (n = 368)

Characteristic	Corneal Incision Group (n = 184)	Toric IOL Group (n = 184)	p-value	95% CI	Effect Size
Age (years), mean ± SD	45.71 ± 7.11	46.85 ± 8.21	0.245	-3.05, 0.77	0.15
Sex (Male), n (%)	108 (58.7%)	111 (60.3%)	0.761	-0.09, 0.13	0.03
Pre-op Astigmatism (D), mean ± SD	-2.38 ± 0.76	-2.37 ± 0.76	0.926	-0.13, 0.14	0.01

D: diopters; SD: standard deviation

Table 2. Postoperative Residual Astigmatism (Diopters) Over Time

Time Point	Corneal Incision (Mean ± SD)	Toric IOL (Mean ± SD)	Mean Difference (95% CI)	p-value	Cohen's d
Preoperative	-2.38 ± 0.76	-2.37 ± 0.76	0.01 (-0.13, 0.14)	0.926	0.01
1st Follow-up	-1.88 ± 0.76	-1.37 ± 0.74	0.51 (0.37, 0.65)	<0.001	0.69
2nd Follow-up	-1.18 ± 0.40	-0.78 ± 0.67	0.40 (0.26, 0.54)	<0.001	0.72
3rd Follow-up	-0.69 ± 0.44	-0.25 ± 0.34	0.44 (0.33, 0.55)	<0.001	1.15

Negative values indicate residual myopic astigmatism. SD: standard deviation. CI: confidence interval. Cohen's d = standardized mean difference.

The proportion of patients attaining a clinically desirable endpoint of ≤0.50 D residual astigmatism at the third follow-up was substantially higher in the toric IOL group, with 79.9% (n = 147) achieving this benchmark compared to only 33.2% (n = 61) in the corneal incision group. The calculated odds ratio for achieving this endpoint with a toric IOL, relative to corneal incision, was 7.89 (95% CI: 4.80 to 12.97, p < 0.001), indicating a nearly eightfold greater likelihood of optimal refractive outcome with the toric approach. Visual acuity outcomes further supported the superior refractive performance of the toric IOL. At the third postoperative visit, the mean uncorrected distance visual acuity (LogMAR) was 0.21 (SD 0.14) in the corneal incision group and 0.13 (SD 0.09) in the toric IOL group. The mean difference of 0.08 LogMAR units (95% CI: 0.05 to 0.11, p < 0.001, Cohen's d = 0.68) favored the toric IOL, reflecting a clinically meaningful improvement in uncorrected vision.

Both surgical techniques were associated with low rates of adverse events and complications. Significant postoperative IOL rotation occurred in three patients (1.6%) in the toric IOL group, while there were no such cases in the corneal incision group (p = 0.246). Postoperative infection rates were low and similar between groups, with one case (0.5%) in the corneal incision group and two cases (1.1%) in the toric IOL group (p = 0.564).

Persistent corneal edema was also infrequent, occurring in two patients (1.1%) in the corneal incision group and one patient (0.5%) in the toric IOL group (p = 0.564). These findings demonstrate that toric IOL implantation consistently produced greater reductions in residual astigmatism, a markedly higher probability of attaining ≤0.50 D residual cylinder, and improved uncorrected distance visual

acuity compared to the corneal incision technique. The two techniques exhibited similar safety profiles, with no statistically significant differences in adverse event rates.

Table 3. Proportion of Patients Achieving ≤0.50D Residual Astigmatism at Third Follow-up

Group	n (%) Achieving ≤0.50D	Odds Ratio (95% CI)	p-value
Corneal Incision	61 (33.2%)	Reference	—
Toric IOL	147 (79.9%)	7.89 (4.80, 12.97)	<0.001

Odds Ratio compares the likelihood of achieving ≤0.50D in Toric IOL group relative to Corneal Incision.

Table 4. Visual Acuity (Uncorrected Distance, LogMAR) at Third Follow-up

Group	Mean ± SD	Mean Difference (95% CI)	p-value	Cohen's d
Corneal Incision	0.21 ± 0.14			
Toric IOL	0.13 ± 0.09	0.08 (0.05, 0.11)	<0.001	0.68

Lower LogMAR values indicate better visual acuity.

Table 5. Adverse Events and Complications

Event	Corneal Incision (n, %)	Toric IOL (n, %)	p-value
Significant IOL Rotation	—	3 (1.6%)	0.246
Post-op Infection	1 (0.5%)	2 (1.1%)	0.564
Persistent Corneal Edema	2 (1.1%)	1 (0.5%)	0.564

The figure illustrates the trend in mean residual astigmatism (diopters) across four sequential time points—preoperative, 1st, 2nd, and 3rd follow-up—for patients undergoing cataract surgery using either corneal incision or toric intraocular lens techniques. The toric IOL group demonstrated a steeper and more consistent decline in mean astigmatism, reducing from -2.37 D preoperatively to -0.25 D at the third follow-up, compared to the corneal incision group, which improved from -2.38 D to -0.69 D. Confidence band shading represents ±1 SD around the means, revealing both a tighter variability and greater predictability in the toric IOL cohort. Clinically, the convergence toward emmetropia is more pronounced and stable in the toric IOL pathway, supporting its enhanced efficacy for astigmatic correction over time. The graph provides clear comparative insight into not only the efficacy but also the reliability of each surgical technique in minimizing postoperative refractive error.

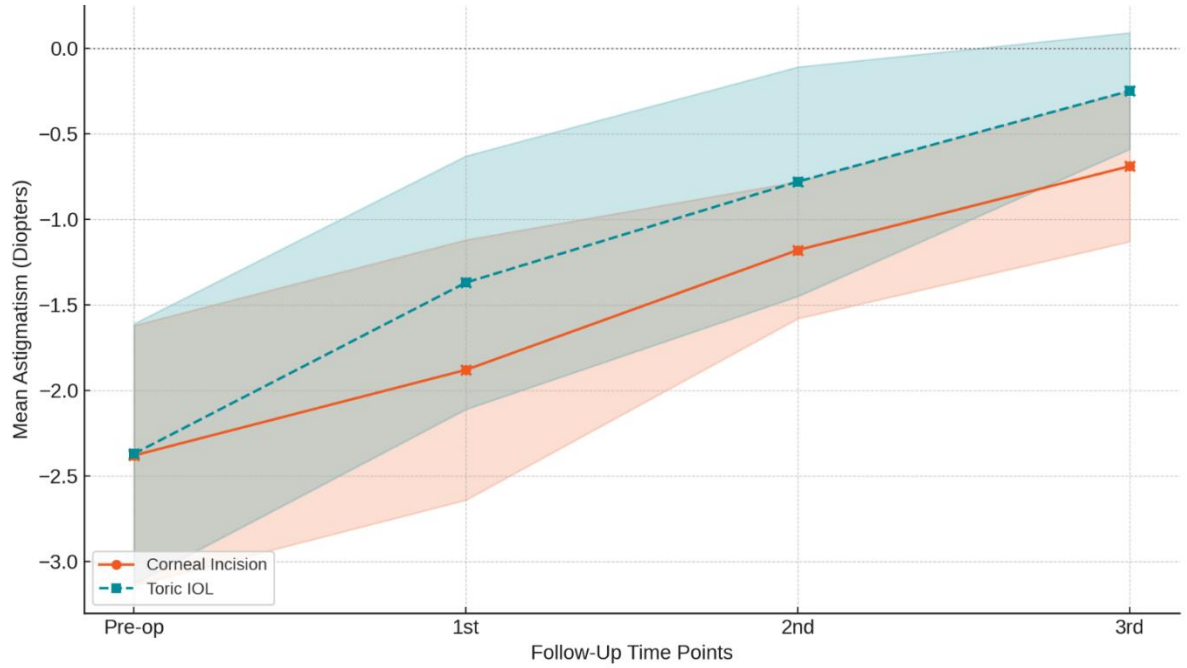

Figure 1 Trajectory of astigmatic correction across surgical techniques

DISCUSSION

The present study provides important insights into the comparative effectiveness of corneal incision versus toric intraocular lens (IOL) implantation in the management of pre-existing astigmatism during cataract surgery in a representative South Asian population. The findings demonstrated a significantly greater reduction in residual astigmatism and a markedly higher proportion of patients achieving ≤0.50 diopters of cylinder in the toric IOL group compared to those who underwent corneal incision. Notably, uncorrected distance visual acuity was also superior following toric IOL implantation, while both procedures exhibited similarly low complication rates, underscoring their safety in routine clinical practice.

These results are consistent with and build upon previous international studies that have shown the superiority of toric IOLs in correcting moderate to high astigmatism during cataract surgery (21,22). For example, a meta-analysis by Qian et al. reported that toric IOLs consistently result in lower residual refractive cylinder and improved uncorrected visual acuity compared to non-toric lenses or incision-only approaches (21). The high proportion of patients achieving optimal refractive targets in the toric group in our study mirrors the findings of Icoz and colleagues, who observed that over three-quarters of their toric IOL cohort attained ≤0.50 D residual cylinder at final follow-up (22).

By contrast, the corneal incision technique, while still effective for milder forms of astigmatism and appealing due to its simplicity and lower cost, failed to match the precision or refractive stability observed with the toric approaches especially in patients with higher baseline cylinder values (14,16). Our data reinforces the mechanistic rationale for selecting toric IOLs in cases of moderate to severe corneal astigmatism. The toric lens is specifically engineered to neutralize corneal cylinder at a predetermined axis, offering stable refractive correction that is less subject to the variability of wound healing or surgeon-dependent factors inherent to corneal incision strategies (17,20). The small, statistically insignificant rate of postoperative IOL rotation in this cohort highlights the advances in modern toric lens design and implantation techniques that have minimized a traditional concern with this approach. Meanwhile, corneal incision relies on the biomechanical response of the cornea, which may be influenced by individual healing patterns, age, and surgical technique, potentially leading to less predictable outcomes and higher risk of regression over time (13,16). While these findings are clinically meaningful, several methodological strengths and limitations should be considered when interpreting the results.

The study's strengths include its robust sample size, standardized operative protocols, masked outcome assessment, and use of validated measurement tools, all of which contribute to the reliability and reproducibility of the conclusions. However, as a cross-sectional comparative analysis based in a single region, the study may be subject to selection bias and limited generalizability to other populations or healthcare settings. The lack of randomization and surgeon-directed allocation of interventions could introduce confounding by indication, although careful adjustment for baseline covariates and stringent inclusion criteria mitigate this risk. Furthermore, the relatively short follow-up duration precludes evaluation of longer-term refractive stability and the potential for delayed IOL rotation or corneal remodeling. These considerations highlight the need for multicenter, randomized controlled trials with extended follow-up to confirm the durability and generalizability of these findings.

Despite these limitations, the study advances our understanding by providing robust, locally relevant data to guide surgical decision-making in astigmatism management during cataract surgery. The clear superiority of toric IOLs in achieving optimal refractive and visual outcomes supports their preferential use in patients with moderate to high astigmatism, while corneal incision remains a viable, cost-effective alternative for cases with lower cylinder values or in settings where access to toric technology is limited (22,23). Given the global burden of cataract and the high prevalence of astigmatism among affected individuals, these findings have meaningful implications for improving postoperative visual function and patient quality of life in diverse healthcare contexts (6,21). Future research should focus on head-to-head comparisons of newer toric lens models, long-term outcomes including rotational stability and patient-reported quality of vision, and cost-effectiveness analyses to better inform policy and clinical guidelines. There is also a need to explore adjunctive technologies such as intraoperative aberrometry and image-guided alignment to further optimize toric IOL implantation. In conclusion, this study confirms the clinical value of toric IOLs for astigmatism correction in cataract surgery, while also emphasizing the importance of personalized patient assessment and shared decision-making to ensure optimal surgical outcomes (21,22).

CONCLUSION

This study demonstrates that toric intraocular lens implantation offers superior correction of pre-existing astigmatism and better uncorrected visual acuity outcomes compared to corneal incision techniques in cataract surgery, particularly for patients with moderate to high astigmatism. These findings underscore the clinical value of toric IOLs in optimizing visual rehabilitation and reducing residual refractive error, thereby enhancing postoperative quality of life. For human healthcare, this evidence supports a patient-centered approach to astigmatism management in cataract surgery, advocating for the use of toric IOLs when precise and stable correction is required, while reserving corneal incision techniques as a cost-effective option for cases with lower degrees of astigmatism.

REFERENCES

1. Dixon WS. Prospective Study of Corneal Astigmatism After Standardized Cataract Incision: A Pilot Study. Dev Ophthalmol 1989;18:192-196. doi:10.1159/000417114

2. Esteves SC, Agarwal A, Sharma R, Harlev A. Reply to Eugenio Ventimiglia, Montorsi Francesco, and Andrea Salonia's Letter to the Editor re: Reecha Sharma, Avi Harlev, Ashok Agarwal, Sandro C Esteves. Cigarette Smoking and Semen Quality: A New Meta-Analysis Examining the Effect of the 2010 World Health Organization Laboratory Methods for the Examination of Human Semen. Eur Urol 2017;71(1):e21-e22. doi:10.1016/j.eururo.2016.05.045

3. Sharma R, Harlev A, Agarwal A, Esteves SC. Cigarette Smoking and Semen Quality: A New Meta-Analysis Examining the Effect of the 2010 World Health Organization Laboratory Methods for the Examination of Human Semen. Eur Urol 2016;70(4):635-645. doi:10.1016/j.eururo.2016.04.010

4. Al Mahmood AM, Al-Swailem SA, Behrens A. Clear Corneal Incision in Cataract Surgery. Middle East Afr J Ophthalmol 2014;21(1):25-31. doi:10.4103/0974-9233.124084

5. Ventimiglia E, Montorsi F, Salonia A. Re: Reecha Sharma, Avi Harlev, Ashok Agarwal, Sandro C Esteves. Cigarette Smoking and Semen Quality: A New Meta-Analysis Examining the Effect of the 2010 World Health Organization Laboratory Methods for the Examination of Human Semen. Eur Urol 2017;71(1):e19-e20. doi:10.1016/j.eururo.2016.05.051

6. Jadoon Z, Shah SP, Bourne R, Dineen B, Khan MA, Gilbert CE, et al. Cataract Prevalence, Cataract Surgical Coverage and Barriers to Uptake of Cataract Surgical Services in Pakistan: The Pakistan National Blindness and Visual Impairment Survey. Br J Ophthalmol 2007;91(10):1269-1273. doi:10.1136/bjo.2006.106914

7. Arango M, Cordoba A, Arango A. Intravitreal Phacoemulsification Through Corneal Incision for Management of Posteriorly Dislocated Lens Material After Complicated Cataract Surgery: A New Surgical Technique. Retina 2019;39 Suppl 1:S50-S53. doi:10.1097/IAE.0000000000002240

8. Altan-Yaycioglu R, Akova YA, Akca S, Gur S, Oktem C. Effect on Astigmatism of the Location of Clear Corneal Incision in Phacoemulsification of Cataract. J Refract Surg 2007;23(5):515-518. doi:10.3928/1081-597X-20070501-16

9. Vinciguerra P, Vinciguerra R, Romano MR. Late-Onset Persistent Epithelial Ingrowth Following Uncomplicated Clear Corneal Incision Cataract Surgery. Clin Exp Ophthalmol 2012;40(3):326-328. doi:10.1111/j.1442-9071.2011.02622.x

10. Febbraro JL, Wang L, Borasio E, Richiardi L, Khan HN, Saad A, et al. Astigmatic Equivalence of 2.2-mm and 1.8-mm Superior Clear Corneal Cataract Incision. Graefes Arch Clin Exp Ophthalmol 2015;253(2):261-265. doi:10.1007/s00417-014-2854-5

11. Cohen KL, Patel NK. Using Total Corneal Astigmatism With Femtosecond Laser Cataract Surgery and Arcuate Keratotomy(ies) to Treat Low Amounts of Astigmatism. Cornea 2024. doi:10.1097/ICO.0000000000003482

12. Fedorova IS, Moskvichev AL. Effect of Cataract Incision on Corneal Astigmatism. Vestn Oftalmol 1983;(4):30-32. Available from: https://www.ncbi.nlm.nih.gov/pubmed/6636418

13. Beltrame G, Salvetat ML, Driussi G, Chizzolini M. Effect of Incision Size and Site on Corneal Endothelial Changes in Cataract Surgery. J Cataract Refract Surg 2002;28(1):118-125. doi:10.1016/s0886-3350(01)00983-x

14. Barequet IS, Yu E, Vitale S, Cassard S, Azar DT, Stark WJ. Astigmatism Outcomes of Horizontal Temporal Versus Nasal Clear Corneal Incision Cataract Surgery. J Cataract Refract Surg 2004;30(2):418-423. doi:10.1016/S0886-3350(03)00492-9

15. Arthur E, Sadik AA, Kumah DB, Osae EA, Mireku FA, Asiedu FY, et al. Postoperative Corneal and Surgically Induced Astigmatism Following Superior Approach Manual Small Incision Cataract Surgery in Patients With Preoperative Against-the-Rule Astigmatism. J Ophthalmol 2016;2016:9489036. doi:10.1155/2016/9489036

16. Zou H, Zhao X, Zhang J, Xu L, Fan Q, Zhang L, et al. The Effects of Programmed Optical Zones on Achieved Corneal Refractive Power With Myopic Astigmatism After Small Incision Lenticule Extraction (SMILE): A Vector Analysis. Int Ophthalmol 2023;43(7):2493-2501. doi:10.1007/s10792-023-02649-7

17. Bian L, Ma B, Sun Z, Li W, Liu Y, Qin R, et al. Prevalence Data for Total Corneal Astigmatism in Cataract Patients. Graefes Arch Clin Exp Ophthalmol 2024. doi:10.1007/s00417-024-06488-9

18. Ning J, Zhang L. Fourier Analysis of Corneal Irregular Astigmatism After Small-Incision Lenticule Extraction and Transepithelial Photorefractive Keratectomy: A Comparative Study. Medicine (Baltimore) 2024;103(9):e37340. doi:10.1097/MD.0000000000037340

19. Camellin U, Franchina F, Latino G, Ninotta I, Palino P, Meduri A, et al. Comparison Between IOL MASTER 500 and MYAH With Vector Analysis in Low and Mild Anterior Corneal Astigmatism. Eur J Ophthalmol 2023:11206721231210895. doi:10.1177/11206721231210895

20. Kose B, Erdogan H. Comparison of Toric Intraocular Lens Alignment Using Image-Guided System and Manual Marking Technique. Beyoglu Eye J 2020;5(2):108-113. doi:10.14744/bej.2020.40427

21. Qian Y, Ding L, Ding Y, Jiang L, Liu Z, Zhou X. Measurement of the Distance Between Corneal Apex and Pupil Center in Patients Following Small-Incision Lenticule Extraction or Implantable Collamer Lens Implantation and Its Correlation With the Surgical-Induced Astigmatism. BMC Ophthalmol 2024;24(1):110. doi:10.1186/s12886-024-03352-6

22. Icoz M, Yildirim B, Gurturk Icoz SG. Comparison of Different Methods of Correcting Astigmatism in Cataract Surgery. Clin Exp Optom 2023:1-6. doi:10.1080/08164622.2023.2239816

23. Kelkar A, Shah R, Kelkar J, Kelkar S, Arora E. Sutureless, Glueless, Scleral Fixation of Single-Piece and Toric Intraocular Lens: A Novel Technique. Case Rep Ophthalmol 2015;6(2):239-245. doi:10.1159/000437349