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Toric Intraocular Lenses in the Correction of Astigmatism During Cataract Surgery

A Systematic Review and Meta-analysis

Line Kessel, MD, PhD,[1,2] *Jens Andresen, MD, PhD,*[3] *Britta Tendal, PhD,*[2,4] *Ditte Erngaard, MD,*[5] *Per Flesner, MD, PhD,*[6] *Jesper Hjortdal, PhD, DMSci*[7]

Topic: We performed a systematic review and meta-analysis to evaluate the benefit and harms associated with implantation of toric intraocular lenses (IOLs) during cataract surgery. Outcomes were postoperative uncorrected distance visual acuity (UCDVA) and distance spectacle independence. Harms were evaluated as surgical complications and residual astigmatism.

Clinical Relevance: Postoperative astigmatism is an important cause of suboptimal UCDVA and need for distance spectacles. Toric IOLs may correct for preexisting corneal astigmatism at the time of surgery.

Methods: We performed a systematic literature search in the Embase, PubMed, and CENTRAL databases within the Cochrane Library. We included randomized clinical trials (RCTs) if they compared toric with non-toric IOL implantation (± relaxing incision) in patients with regular corneal astigmatism and age-related cataracts. We assessed the risk of bias using the Cochrane Risk of Bias tool. We assessed the quality of evidence across studies using the GRADE profiler software (available at: www.gradeworkinggroup.org).

Results: We included 13 RCTs with 707 eyes randomized to toric IOLs and 706 eyes randomized to non-toric IOLs; 225 eyes had a relaxing incision. We found high-quality evidence that UCDVA was better in the toric IOL group (logarithm of the minimum angle of resolution [logMAR] mean difference, −0.07; 95% confidence interval [CI], −0.10 to −0.04) and provided greater spectacle independence (risk ratio [RR], 0.51; 95% CI, 0.36−0.71) and moderate quality evidence that toric IOL implantation was not associated with an increased risk of complications (RR, 1.73; 95% CI, 0.60−5.04). Residual astigmatism was lower in the toric IOL group than in the non-toric IOL plus relaxing incision group (mean difference, 0.37 diopter [D]; 95% CI, −0.55 to −0.19).

Conclusions: We found that toric IOLs provided better UCDVA, greater spectacle independence, and lower amounts of residual astigmatism than non-toric IOLs even when relaxing incisions were used. *Ophthalmology 2016;123:275-286 © 2016 by the American Academy of Ophthalmology. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).*

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During cataract surgery, the refractive status of the patient is changed. Some intraocular lenses (IOLs) correct spherical refractive errors, whereas others correct both spherical and astigmatic errors. Preoperative astigmatism 1.5 diopters (D) or greater is present in 20% of patients undergoing operation for age-related cataracts.[1] Residual postoperative astigmatism is an important cause for not obtaining planned emmetropia after cataract surgery.[2] Patients are 34 times more likely to use spectacles per diopter of astigmatic error in the better eye,[3] and residual postoperative astigmatism is an important reason for spectacle use even in patients with a spherical equivalent refraction ±0.5 D. Correcting residual astigmatism results in significantly improved visual acuity at all contrast levels at both distance and near.[4]

Astigmatism can be corrected by implanting a toric IOL or by changing the corneal curvature by LASIK or similar procedures, or by placing relaxing incisions at the steepest meridian to flatten the corneal curvature.[5] Relaxing incisions may correct up to 3 D of astigmatism, whereas toric IOLs can correct up to 8 D of astigmatism.[6] There are benefits and harms associated with toric IOLs and relaxing incisions. Toric IOLs can rotate. Small rotations do not affect the astigmatic power, but larger rotations will reduce the power of the IOL, for example, the correcting effect is eliminated if the IOL is rotated 30 degrees.[7] Thus, larger rotations, generally 10 degrees is used as a limit,[8] require surgical interventions to reposition the IOL. Relaxing incisions may be a site of infectious keratitis, and the refractive result may change over time as the cornea heals. Long-term stability studies of corneal-relaxing incisions are scarce, but it has been reported that the surgically induced astigmatism changes most in the first 10 weeks after surgery, with little change from 10 weeks up to 3 years after surgery.[9] Toric IOLs show the greatest rotation in the early postoperative period with little rotation after 1 week.[10]

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We conducted the present systematic review and meta-analysis to evaluate the benefits and potential harms of toric implantation to correct preexisting corneal astigmatism in patients undergoing phacoemulsification for age-related cataracts. Toric IOLs were compared with (1) non-toric IOLs without further attempts to surgically correct astigmatism and (2) non-toric IOLs combined with a relaxing incision to correct astigmatism. The study was initiated by an initiative of the Danish Health and Medicines Authorities as part of providing evidence-based national guidelines on the treatment of age-related cataracts.

Methods

We performed this systematic review and meta-analysis based on the principles described in the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) approach.[11] We chose to examine the effect of toric IOL implantation (I) versus non-toric IOL implantation (C) in patients with age-related cataracts and preoperative corneal astigmatism undergoing phacoemulsification (P) (PICO[12]). The effect (O) was evaluated as (1) number (in percentage) of patients who obtained postoperative spectacle independence at distance at all times, (2) uncorrected distance visual acuity (UCDVA) (in logarithm of the minimum angle of resolution [logMAR] or as a Snellen fraction as measured by included studies), (3) residual astigmatism (in diopters), and (4) number of operative and postoperative complications including reoperations for rotated IOL. The non-toric IOL could be combined with a relaxing incision. If included studies reported outcomes at more than 1 time point, the last reported time point was used in the analyses. The result of both toric IOLs and relaxing incision should be stable at 3 months, and none of the studies had a last reported time point earlier than 3 months postoperatively. We did not publish a protocol for the present review.

We conducted a systematic literature search on August 26, 2015, in the Embase, PubMed.gov, and Cochrane Central Library databases using the search term: (((((cataract) AND surgery) AND toric iol)) OR (((cataract) AND surgery) AND toric intraocular lens)) OR (((cataract) AND surgery) AND toric intraocular lens). Two authors (L.K. and J.H.) evaluated the title and abstract of all search hits for eligibility. If there was any doubt as to the eligibility of a study, it was obtained and read in full by 2 authors (L.K. and J.H.). Eligibility criteria were randomized controlled clinical trials comparing the result after toric versus non-toric IOL implantation in patients with preoperative regular corneal astigmatism and cataract. References that reported only on outcome after toric IOL implantation in patients with corneal ectasia, such as keratoconus, or marginal pellucid degenerations were excluded. The implantation of non-toric IOLs could be combined with limbal or corneal-relaxing incisions.

We assessed all included studies for risk of bias using the Cochrane Risk of Bias tool.[13] The Cochrane Risk of Bias tool evaluates a study for risk of bias associated with patient selection (randomization procedure and allocation of patients), study performance (blinding of patients and personnel), outcome detection (blinding of outcome assessors), data attrition (e.g., patients lost to follow-up or otherwise not accounted for), and bias associated with the reporting of study findings or other types of bias. Two reviewers independently assessed risk of bias and extracted data from the included studies (L.K. and J.H.). Discrepancies were solved by discussion and consensus. We extracted data concerning prespecified outcomes (spectacle independence, UCDVA $\geq$20/25, and rate of complications) from the included studies and entered them into a meta-analysis using the Review Manager Software.[14]

We evaluated the quality of the evidence for each prespecified outcome across included studies using the GRADE system. We evaluated each outcome for factors that could affect the reliability of the outcome by looking at study limitations (risk of bias, e.g., lack of allocation concealment or lack of blinding of patients or outcome assessors, incomplete accounting of patients, selective outcome reporting, or other limitations),[15] inconsistency (different results between studies),[16] indirectness (was the study population and intervention comparable to the patient population and intervention that is relevant to the readers of the present meta-analysis, use of surrogate measures),[17] imprecision (large confidence intervals [CIs] or the lack of statistical strength by included studies to answer the posed question),[18] and risk of publication bias (small number of studies or small number of included patients, lack of reporting of negative findings).[19] We prepared a summary of findings and evidence tables using the GRADE profiler software.[20]

We analyzed dichotomous outcome data by calculating risk ratios (RRs) and continuous outcome data by using mean differences. We used the Review Manager 5 Software[14] for estimation of overall treatment effects. We calculated pooled estimates of effects by using random-effects models. When possible, we performed subgroup analyses of outcomes. A priori, we analyzed toric versus non-toric IOL and toric versus non-toric IOL in combination with relaxing incisions and multifocal toric versus multifocal non-toric IOL. According to Danish law, no institutional board review was required for this systematic review.

Results

We identified 626 references after a systematic literature review. All references were screened for eligibility. After checking for duplicates and eliminating references that were deemed "not relevant" by title and abstract, we identified 25 potentially interesting references that were obtained in full and read thoroughly. We found 13 randomized clinical trials (RCTs) that fitted our inclusion criteria. These 13 RCTs compared the outcome after implantation of toric IOLs with non-toric IOL implantation in patients undergoing phacoemulsification for age-related cataract and with preexisting, regular corneal astigmatism.[21–33] An overview of included studies and interventions is provided in Table 1. Risk of bias assessment of included studies is provided in Table S1 (available at www.aaojournal.org). Furthermore, 12 nonrandomized studies reporting the effect of toric IOL implantation were identified.[34–45] All nonrandomized studies and studies not comparing toric with non-toric IOLs were excluded from the analyses. A list of excluded studies with reasons for exclusion is provided in Table S2 (available at www.aaojournal.org). A diagram of the literature search is shown in Table S3 (available at www.aaojournal.org).

The included studies differed with respect to length of follow-up and types of IOLs used. Four studies compared toric IOL with non-toric IOL,[24,29–31] and 9 studies compared toric IOL with non-toric IOL plus relaxing incisions (limbal or corneal).[21–23,25–28,32,33] All relaxing incisions were performed manually. In one study, both the toric and non-toric IOLs were multifocal.[22] In total, 707 eyes were randomized to toric IOL implantation and 706 eyes were randomized to non-toric IOL implantation. Of those implanted with a non-toric IOL, 225 eyes received a relaxing incision and 481 eyes received a non-toric IOL only without surgical attempts to correct astigmatism. The included studies differed with respect to the type of toric IOLs used and nomograms used for planning the location, size, and depth of