Comparison of Nd:YAG Laser Capsulotomy Rates Between Refractive Segmented Multifocal and Multifocal Toric Intraocular Lenses

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• PURPOSE: To investigate the early incidence of neodymium-doped yttrium aluminum garnet (Nd:YAG) laser capsulotomy according to intraocular lens (IOL) type (nontoric vs toric) and surgical techniques (femtosecond laser–assisted cataract surgery vs conventional phacoemulsification) in eyes with refractive multifocal IOLs.

• DESIGN: Retrospective case-control study.

• METHODS: Nine hundred thirteen eyes from 483 patients implanted with Lentis Mplus LS-313 MF20 (767 eyes) or Lentis Mplus Toric LU-313 MF20T (146 eyes) IOLs (Oculentis GmbH, Berlin, Germany) were enrolled. We compared the incidence of Nd:YAG laser capsulotomy between the nontoric and toric groups. In addition, the incidence of Nd:YAG laser capsulotomy was also evaluated according to the surgical technique used.

• RESULTS: The overall incidence of Nd:YAG laser capsulotomy was 10.2% (93/913 eyes). The Nd:YAG laser capsulotomy rate was significantly higher in the toric group (24/146; 16.4%) than in the nontoric group (69/767; 9.0%; $P = .007$). Of the 913 enrolled eyes, 448 eyes (49.1%) underwent femtosecond laser–assisted cataract surgery and 465 eyes (50.9%) underwent conventional phacoemulsification cataract surgery. There was no significant difference in the incidence of Nd:YAG laser capsulotomy between eyes with femtosecond laser–assisted cataract surgery and eyes with conventional phacoemulsification cataract surgery.

• CONCLUSION: Patients with refractive multifocal toric IOLs had higher early incidence rates of Nd:YAG laser capsulotomy when compared to those with refractive multifocal nontoric IOLs. Furthermore, femtosecond laser–assisted cataract surgery could not reduce the early incidence of Nd:YAG laser capsulotomy in this study. **(Am J Ophthalmol 2021;222:359–367.**

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POSTERIOR CAPSULE OPACIFICATION (PCO) IS ONE OF the most common causes of decreased visual acuity and blurry vision after cataract surgery and is the result of the migration of remaining equatorial lens epithelial cells.[1] Although visual acuity deterioration due to PCO after cataract surgery can be treated effectively with neodymium-doped yttrium aluminum garnet (Nd:YAG) laser capsulotomy, this procedure may lead to complications such as macular edema, increased intraocular pressure, and intraocular lens (IOL) dislocation and damage in rare cases.[2–4] In particular, it is difficult to complete an IOL exchange after Nd:YAG laser capsulotomy.[5] Therefore, if there is a possibility of future IOL exchange, it is necessary to carefully decide whether to perform Nd:YAG laser capsulotomy.[6] Patients receiving multifocal IOLs have high expectations for their postoperative vision and might require IOL exchange due to various causes.[7] Therefore, surgeons should make an effort to reduce PCO after cataract surgery.

Previous studies have reported that the occurrence of PCO differs depending on the material and design of the IOL used.[8,9] Patients receiving hydrophobic IOLs demonstrated lower PCO incidence and Nd:YAG laser capsulotomy rates when compared with those given hydrophilic IOLs.[9] It is well known that IOLs with a sharp optic edge design have less PCO than IOLs with a round optic edge design.[10] In addition, it is found that the PCO incidence varies depending on the surgical method. The PCO incidence and Nd:YAG laser capsulotomy rates in patients who underwent femtosecond laser–assisted cataract surgery were significantly lower than those among patients who underwent conventional cataract surgery.[11,12] On the other hand, other studies have found that there was no difference in the incidence of PCO and Nd:YAG laser capsulotomy between femtosecond laser–assisted cataract surgery and conventional cataract surgery, or the opposite result was reported.[13–16]

Unlike nontoric IOLs, toric IOLs with toricity on the posterior surface have different optics shapes depending on the orientation of the meridian. This change in optical surface according to the meridian may affect the maximal

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TABLE 1. Characteristics of the Intraocular Lenses Used in This Study

	Lentis Mplus LS-313 MF20	Lentis Mplus Toric LU-313 MF20T
Optic size, mm	6.0	6.0
Overall length, mm	11.0	11.0
Haptic angulation, °	0	0
Optic design	Biconvex	Biconvex
Anterior	Sector-shaped near vision segment	Sector-shaped near vision segment
Posterior	Aspheric surface	Aspherical and toric surface
IOL Design	Optic and haptics with square edges	Optic and haptics with square edges
Haptic	Plate haptic	Plate haptic
Material	Hydrophilic acrylates with hydrophobic surface	Hydrophilic acrylates with hydrophobic surface
Refractive index	1.46	1.46

IOL = intraocular lens.

optic–posterior capsule contact, especially in the early postoperative period. The authors hypothesized that the occurrence of PCO may differ between nontoric and toric IOLs because of this difference in posterior capsule and posterior optic adhesion patterns between nontoric and toric IOLs. Therefore, the present study sought to investigate whether there was a difference in the early incidence of Nd:YAG laser capsulotomy after cataract surgery between Lentis Mplus LS-313 MF20 and Lentis Mplus Toric LU-313 MF20T IOLs (Oculentis GmbH, Berlin, Germany), which have the same material and platform from the same company and differ only in the presence of toricity (Table 1).

MATERIALS AND METHODS

• **STUDY POPULATION:** This retrospective case-control study was conducted after approvals from the Research Ethics Committee of the Public Institutional Bioethics Committee (no. P01-202005-21-016) and from the Institutional Review Board of the Korea University Ansan Hospital (IRB no. 2020AS0064) were obtained. The medical records of cataract patients who underwent phacoemulsification with Lentis Mplus LS-313 MF20 or Lentis Mplus Toric LU-313 MF20T IOL implantation at the BGN Jamsil Lotte Tower Eye Clinic between January 1 and November 30, 2019, were retrospectively analyzed. Patients with a best-corrected visual acuity of 20/25 or greater in the operated eye after cataract surgery and who had undergone 3 or more months of postoperative follow-up were included. Patients with amblyopia; a history of corneal refractive surgery such as LASIK and LASEK; abnormal findings on anterior segment examination (except cataract), funduscopic examination, or Spectralis HRA-OCT (Heidelberg Engineering, Heidelberg, Germany) examination that may affect vision; traumatic cataract; complicated surgery (eg, anterior or posterior capsular); sulcus fixated lenses; postoperative complications; and additional corneal refractive surgeries to correct residual refractive errors following cataract surgery were excluded.

• **PATIENT EXAMINATION:** All patients underwent preoperative comprehensive ocular examinations with slit-lamp biomicroscopy, autorefractor/keratometer (Canon RK-F2 Full Auto Ref-Keratometer; Canon, Tokyo, Japan), funduscopy, and noncontact specular microscopy (Perseus; CSO, Firenze, Italy).

Preoperative keratometry (K), anterior chamber depth (ACD), and axial length (AL) were measured using an IOLMaster 700 (Carl Zeiss Meditec, Jena, Germany). The IOL power was calculated based on the predicted refraction by the SRK/T and Barrett Universal II formulas of the IOLMaster 700. The A-constant of the IOL was 118.5 for the Lentis Mplus LS-313 MF20 and 118.2 for the Lentis Mplus Toric LU-313 MF20T. For eyes with total corneal astigmatism of greater than 1.00 diopters (D) for with-the-rule astigmatism, 0.75 D for against-the-rule astigmatism, and 1.00 D for oblique astigmatism, the Lentis Mplus toric IOL was selected. Toric IOL cylinder power and axis for this IOL were calculated using an online Oculentis Toric IOL calculator with an expected incision-induced astigmatism value of 0.25 D.[17]

• **SURGICAL TECHNIQUE:** All phacoemulsifications and IOL implantations were performed by one experienced surgeon (JWK). In the case of toric IOL implantation, VERION image-guided system (Alcon Laboratories, Inc, Fort Worth, Texas, USA), which consists of a measurement unit and digital marker, was used. Before the surgery, using the VERION reference unit, a high-resolution reference image was captured. All patients who planned to receive the Lentis Mplus toric IOL underwent femtosecond laser–assisted cataract surgery using a LenSx (Alcon Laboratories, Inc) with a 5.5-mm continuous curvilinear capsulorrhexis (CCC) to promote rotational stability. With the Lentis Mplus IOL, some patients underwent femtosecond laser–assisted cataract surgery and others underwent conventional phacoemulsification with a 2.8-mm clear corneal incision and a manual 5.5-mm CCC with 6.0-mm corneal marker guidance (Shepard-Hoffer O/Z Marker with Cross Hair, 6.0 mm; Stephens Instruments, Lexington, Kentucky, USA). The surgical technique was selected according to the patient's consent and the surgeon's judgment. All of the surgeries were performed using a standard technique with the Ozil torsional handpiece and the Centurion phacoemulsification system (Alcon Laboratories, Inc). To sufficiently remove cortex and anterior subcapsular lens epithelial cells, hydrodissection and sufficient anterior capsule polishing were performed in all cataract surgeries. The capsular tension ring (Ringject; Ophtec, Groningen, Netherlands) was inserted into the capsular bag in all patients. After that, the IOL was inserted into the capsular bag using an injector system. When implanting the Lentis Mplus toric IOL, the VERION digital marker showed the exact axis of the toric IOL through a digital overlay of the live-surgery image during the surgery, and the toric IOL was rotated to the final position after ophthalmic viscosurgical device removal.

• **PREOPERATIVE AND POSTOPERATIVE MEDICATION:** All patients were instructed to instill 1.5% levofloxacin hydrate (Cravit; Santen, Osaka, Japan) and 1% prednisolone acetate (Prednilone; Daewoo Pharmaceutical Co, Seoul, Korea) every 6 hours and 0.1% bromfenac sodium hydrate (Bronuck; Taejoon Pharm, Seoul, Korea) every 12 hours from 3 days before the surgery to 1 month after surgery.[18]

• **PATIENT EVALUATION:** Postoperative examinations were performed at 1, 3, and 6 weeks and 3, 6, and 12 months. Autorefraction using an autorefractor/keratometer, uncorrected distance visual acuity (UDVA) and corrected distance visual acuity (CDVA) by manifest refraction (MR) at 5 m, uncorrected near visual acuity (UNVA) at 40 cm using a near vision chart, and slit-lamp examination were assessed at each visit. Nd:YAG laser capsulotomy was performed when eyes lost 2 or more Snellen lines of CDVA due to PCO or the patient-reported visual discomfort such as diplopia in near vision related to PCO.

• **SIMULATION TO CALCULATE THE GEOMETRICAL DIFFERENCE IN CONTACT AREA:** To compare the geometrical difference in IOL optic-posterior capsule contact area between nontoric and toric IOLs, modeling and a linear static analysis of simulation for finite element analysis was conducted using SolidWorks software (SolidWorks Premium, Waltham, Massachusetts, USA). Twenty-diopter nontoric IOLs, 20 D toric IOLs having a cylinder power of +1.50 D on the posterior surface, and a posterior lens capsule were designed. Because of the unavailability of accurate information on the anterior and posterior curvature of Lentis MPlus and Lentis Mplus toric IOL optics, radii of the anterior and posterior curvature were modified from nominal values used in a previous study to have biconvex optic design and a refractive index of 1.46.[19]

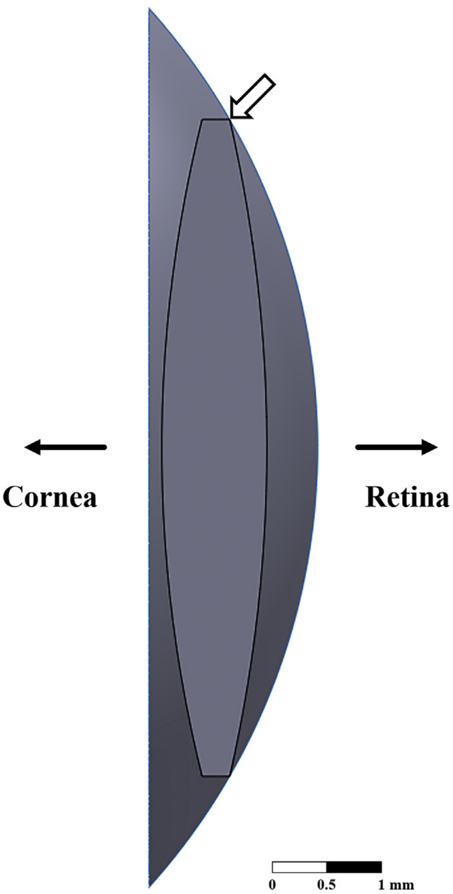

FIGURE 1. Intraocular lens and posterior lens capsule modeled in SolidWorks. The posterior lens capsule contacts the posterior optic edge of the intraocular lens (open arrow).

The radius of anterior curvature was set to 12.400 mm, the central optic thickness was 0.960 mm, and optic diameter was 6.000 mm in both the nontoric and toric IOL. The radius of posterior curvature was −12.400 mm in the nontoric IOL. The toric IOL was designed to have toricity on the posterior surface with steep radius of curvature of −13.405 mm and flat radius of curvature of −11.535 mm (Figure 1). The IOL material selected was acrylic. Posterior lens capsule diameter was set to 8.000 mm, the radius of curvature was −6.000 mm, and thickness was 0.007 mm.[20,21] The elastic properties of the lens capsule were set as follows: the modulus of elasticity was 1 N/mm^2, ultimate elastic modulus was 15 N/mm^2, Poisson ratio was 0.47, and mass density was 0.00105 g/mm^3.[22–24]

The boundary condition was assumed as fixed at the haptic direction of IOLs and fixed at the zonule direction of the lens capsule.[25] A total uniform force of 0.001 N was applied from posterior to anterior in the vertical direction of the posterior lens capsule surface. In a linear static analysis of simulation, 119,757 element mesh points of

TABLE 2. Comparison of Patient Characteristics and Eyes Between the Lentis Mplus and Lentis Mplus Toric Intraocular Lens Groups

	Lentis Mplus	Lentis Mplus Toric	*P* Value[a]
Total patients, n (eyes)	407 (767)	76 (146)	
Age, y, mean ± SD	57.8 ± 5.9	55.8 ± 7.1	.025
Sex, n (%)			
Male-female	90 (22.1): 317 (77.9)	16 (21.1): 60 (78.9)	.486[b]
Laterality, n (%)			
Right eye–left eye	382 (49.8): 385 (50.2)	73 (50.0): 73 (50.0)	.519[b]
Corneal power, D[c], mean ± SD	44.11 ± 1.41	44.51 ± 1.49	.002
Anterior chamber depth, mm[c], mean ± SD	3.14 ± 0.33	3.20 ± 0.35	.044
Axial length, mm[c], mean ± SD	23.63 ± 1.14	24.08 ±1.51	.001
IOL power, D, mean ± SD	20.0 ± 3.1	17.9 ± 4.6	<.001
IOL cylinder power, CD, mean ± SD	—	1.75 ± 0.45	—
Femtosecond CCC, n/total (%)	302/767 (39.4)	146/146 (100.0)	<.001[b]
Nd:YAG, n/total (%)	69/767 (9.0)	24/146 (16.4)	.007[b]
CDVA before Nd:YAG, logMAR, mean ± SD	0.10 ± 0.11	0.08 ± 0.06	.222
UNVA before Nd:YAG, logMAR, mean ± SD	0.16 ± 0.12	0.16 ± 0.11	.844
Follow-up period, mo, mean ± SD (range)	7.0 ± 2.4 (3.0-13.0)	6.6 ± 2.0 (3.0-11.0)	.022

CCC = continuous curvilinear capsulorrhexis, CD = cylindrical diopters, CDVA = corrected distance visual acuity, D = diopters, IOL = intraocular lens, logMAR = logarithm of minimum angle of resolution, UNVA = uncorrected near visual acuity.
[a]Student *t* test.
[b]χ^2 test.
[c]Corneal power, anterior chamber depth, and axial length measured by the IOLMaster 700.

Jacobian 4 points, comprised of equally spaced tetrahedra, were used. The result of this simulation was displayed using the resultant displacement of the posterior lens capsule, URES (mm). The contact angle of the IOL optic–posterior lens capsule contact area was measured using ImageJ (1.52a; http://rsb.info.nih.gov/ij/; provided in the public domain by the National Institutes of Health, Bethesda, MD, USA).

• **STATISTICAL ANALYSIS:** Data from all patients were statistically analyzed using the Statistical Package for Social Sciences Statistics Standard 20 (IBM Corp, Armonk, NY, USA). Student *t* tests and χ^2 tests were performed to compare patient characteristics and eyes between the Lentis Mplus and Lentis Mplus toric IOL groups and between eyes with and without Nd:YAG laser capsulotomy. Multivariate binary logistic regression analysis was performed for the odds ratio of factors associated with the incidence of Nd:YAG laser capsulotomy. The χ^2 linear trend test was performed to compare the incidence of Nd:YAG laser capsulotomy as toric IOL cylinder power increases. *P* values of less than .05 were considered to be statistically significant.

RESULTS

THIS STUDY INCLUDED 913 EYES FROM 483 PATIENTS WHO underwent uncomplicated phacoemulsification with Lentis Mplus LS-313 MF20 (767 eyes) or Lentis Mplus Toric LU-313 MF20T (146 eyes) IOL implantation. The mean age of the 483 enrolled patients was 57.5 ± 6.1 years (range: 42-78 years). In the whole study population, there were a total of 377 women (78.1%). Of 913 enrolled eyes, 465 eyes (50.9%) were subjected to the conventional phacoemulsification cataract surgery and 448 eyes (49.1%) underwent femtosecond laser–assisted cataract surgery. Nd:YAG laser capsulotomy was performed in 93 of 913 eyes (10.2%). Among the 93 eyes treated with Nd:YAG laser capsulotomy, 41 patients were treated unilaterally and 26 patients were treated bilaterally.

The Nd:YAG laser capsulotomy rate (16.4%) was significantly higher in the Lentis Mplus toric IOL group than in the Lentis Mplus IOL group (9.0%; *P* = .007), even though the postoperative follow-up period was shorter in the Lentis Mplus toric IOL group (6.6 ± 2.0 months) than in the Lent Mplus IOL group (7.0 ± 2.4; *P* = .022). There were no significant differences in CDVA (0.10 ± 0.11 and 0.08 ± 0.06 logMAR, respectively) and UNVA (0.16 ± 0.12 and 0.16 ± 0.11 logMAR, respectively) before Nd:YAG laser capsulotomy between the Lentis Mplus and Lentis MPlus toric IOL groups. The clinical characteristics of patients and their eyes including K, ACD, AL, IOL power, and IOL cylinder power are summarized in Table 2.

In the comparison of parameters of Nd:YAG laser capsulotomy, laterality and IOL type were related to Nd:YAG laser capsulotomy (Table 3). The incidence of Nd:YAG laser capsulotomy was significantly higher in the left eye

TABLE 3. Comparison of Patient Characteristics and Eyes Between Eyes With and Without Nd:YAG Laser Capsulotomy

	No Nd:YAG Laser Capsulotomy (n = 820)	Nd:YAG Laser Capsulotomy (n = 93)	*P* Value[a]
Age, y, mean ± SD	57.5 ± 6.0	56.6 ± 5.9	.857
Sex, n (%)			
Male-female	181 (22.1): 639 (77.9)	15 (16.1): 78 (83.9)	.115[b]
Laterality, n (%)			
Right eye–left eye	417 (50.9): 403 (49.1)	38 (40.9): 55 (59.1)	.043[b]
Corneal power, D[c], mean ± SD	44.16 ± 1.39	44.30 ± 1.74	.455
Anterior chamber depth, mm[c], mean ± SD	3.15 ± 0.33	3.16 ± 0.36	.806
Axial length, mm[c], mean ± SD	23.71 ± 1.22	23.64 ±1.24	.610
IOL power, D, mean ± SD	19.7 ± 3.5	19.8 ± 3.1	.756
IOL type, n (%)			
Mplus–Mplus toric	697 (85.1): 122 (14.9)	69 (74.2): 24 (25.8)	.007[b]
CCC type, n (%)			
Manual-femtosecond	419 (51.1): 401 (48.9)	46 (49.5): 47 (50.5)	.425[b]
Follow-up period, mo, mean ± SD	7.0 ± 2.4	6.8 ± 2.1	.639

CCC = continuous curvilinear capsulorrhexis, D = diopters, IOL = intraocular lens.
[a]Student *t* test.
[b]χ^2 test.
[c]Corneal power, anterior chamber depth, and axial length measured by the IOLMaster 700.

and Lentis Mplus Toric IOL group than in right eye and Lentis Mplus IOL group, respectively. When only patients who underwent femtosecond laser–assisted cataract surgery were compared to exclude the influence of the surgical method, the incidence of Nd:YAG laser capsulotomy in the Lentis Mplus toric IOL subgroup (16.4%) was still significantly higher than that in the Lentis Mplus IOL subgroup (7.6%). On the other hand, there was no significant difference in age, sex, preoperative biometrics (ie, K, ACD, and AL), IOL power, CCC type, and follow-up period between eyes with and without Nd:YAG laser capsulotomy.

A multivariate binary logistic regression analysis was performed using variables related to conducting Nd:YAG laser capsulotomy obtained by univariate analysis. The Lentis Mplus toric IOL showed a 2-fold higher incidence of Nd:YAG laser capsulotomy than the Lentis Mplus IOL in the binary logistic regression analysis (odds ratio [OR], 1.998; 95% confidence interval [CI], 1.207-3.307; P = .007; Table 4).

In the Lentis Mplus toric IOL group, the implanted toric IOL cylinder power was 1.50 D in the majority (71.2%), followed by 2.25 D (24.7%). The χ^2 linear trend test showed that the incidence of Nd:YAG laser capsulotomy had a tendency to decrease as the toric IOL cylinder power increased (P = .009; Figure 2).

• **SIMULATION TO CALCULATE THE GEOMETRICAL DIFFERENCE IN CONTACT AREA:** In the case of nontoric IOLs, the posterior lens capsule was in contact with the optic edge over 360° (blue circle), when a force of 0.001 N was applied to the posterior lens capsule. On the other hand, the posterior lens capsule made contact with the optic edge at 102° in the flattest meridians of the IOL toricity (blue arc), for a total of 204° (Figure 3).

TABLE 4. Multivariate Binary Logistic Regression Analysis of Factors Associated With Nd:YAG Laser Capsulotomy

	Odds Ratio	95% Confidence Interval	*P* Value
Laterality	1.504	0.971-2.329	.067
IOL type[a]	1.998	1.207-3.307	.007

IOL = intraocular lens.
[a]Lentis Mplus vs Lentis Mplus toric intraocular lenses.

DISCUSSION

THIS STUDY SOUGHT TO COMPARE THE EARLY INCIDENCE of Nd:YAG laser capsulotomy among patients with refractive multifocal IOL and those with a refractive multifocal toric IOL of the same material and design. The results of this study showed that the early incidence of Nd:YAG laser capsulotomy was significantly higher in relation to refractive multifocal toric IOLs than refractive multifocal IOLs. The hypothesis of why Nd:YAG laser capsulotomy was more frequently performed in eyes with refractive multifocal toric IOLs than in eyes with refractive multifocal IOLs is the asymmetric contact between the posterior toric surface of the lens and posterior capsules. It is well

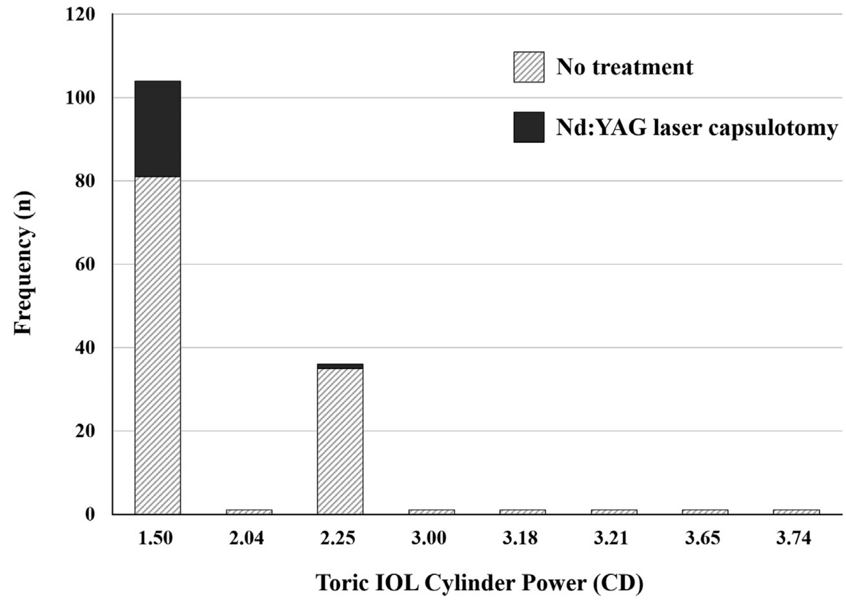

FIGURE 2. Frequency distribution of eyes with and without Nd:YAG laser capsulotomy according to the Lentis Mplus toric intraocular lens cylinder power.

known that maximal IOL optic–posterior capsule contact could reduce or prevent PCO.[26] Early postoperative capsular bend formation around the edge of an IOL optic could prevent PCO formation.[27] Although the posterior optic edge of the toric IOL is continued for the entire 360° of circumference, the posterior toric surface might block maximal contact from being achieved between the posterior surface of the IOLs and the posterior capsules because of the different curvature of optics according to the meridian. The Lentis Mplus toric IOL used in this study is a biconvex 1-piece lens with a posterior toric aspheric surface,[28] and its posterior toric surface might induce asymmetric contact between the optic surface and the posterior capsule and incomplete types of capsular bend formation,[29] facilitating migration of the remaining equatorial lens epithelial cells posterior to the lens. In a linear static analysis of the simulation to calculate the geometrical difference in contact area, nontoric IOLs made contact with the optic edge at 360° but the toric IOLs did not when the same force was applied to the posterior lens capsule. This difference in contact area might cause delayed formation of a 360° complete capsular band in toric IOLs compared with nontoric IOLs in the early postoperative period.

Factors related to PCO after cataract surgery can be divided into 2 types: surgical factors and IOL-related factors.[26] Surgical factors include sufficient cortex removal through hydrodissection and polishing, in-the-bag IOL implantation, and CCC covering all 360° of the optic margin. IOL-related factors include square-edge optic design, IOL material, and maximal IOL optic–posterior capsule contact.[26] In this study, among the 6 factors associated with PCO occurrence, sufficient cortex removal through hydrodissection and polishing and in-the-bag IOL implantation were not significantly different between the 2 groups, possibly because all hydrodissection, polishing, and IOL implantation processes were performed with the same surgical method by 1 experienced surgeon. To allow CCC to cover the 360° of IOL optics, a 5.5-mm CCC was created in cases of both femtosecond laser–assisted CCC and manual CCC, although this study could not confirm whether the anterior capsule overlapped the IOL optic 360° in all cases. In addition, eyes with anterior capsule-related problems were excluded from this study. There is a lower A-constant for the Lentis Mplus toric IOL (118.2) than the Lentis Mplus IOL (118.5). It is known that the central thickness of the Lentis Mplus toric IOL optic is greater than that of the Lentis Mplus IOL optic because of the additional posterior toricity. This difference might cause minor anterior displacement of the Lentis Mplus toric IOL, resulting in a lower A-constant and difference in the IOL optic–posterior capsule contact feature. Because IOLs of the same material and design made by the same company were used, the main difference between the nontoric and toric IOL groups in this study was the IOL optic–posterior capsule contact feature, as mentioned above.

Previous real-world evidence studies have reported that the 5-year cumulative incidence of Nd:YAG laser capsulotomy ranged 5.8%-19.3% in eyes with single-piece acrylic monofocal IOLs.[30,31] In a randomized controlled study, the 3-year incidence of Nd:YAG laser capsulotomy ranged 11.4%-18.6% in eyes with hydrophobic acrylic IOLs.[32] In this study, the early postoperative incidence of Nd:YAG

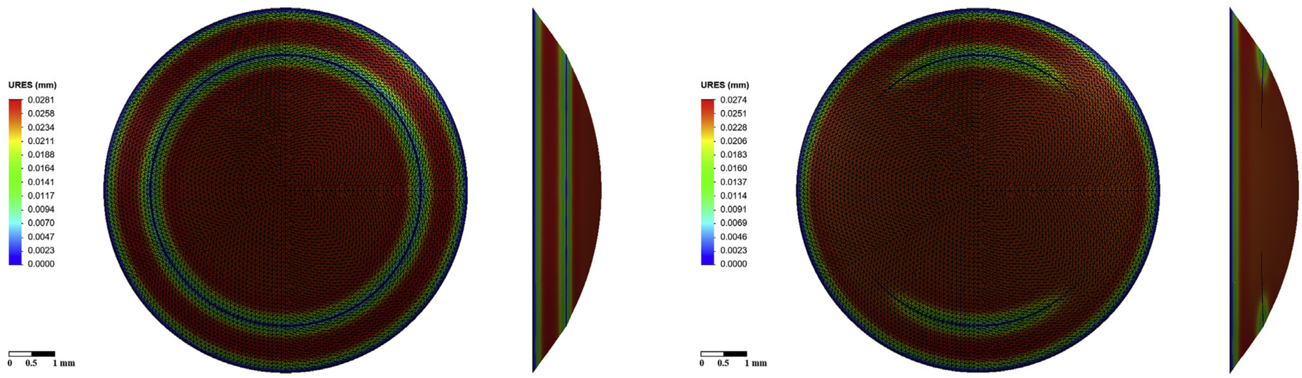

FIGURE 3. A linear static analysis of simulation for finite element analysis to calculate the geometrical difference in contact area between nontoric (Left) and toric intraocular lenses (Right). The area where the intraocular optic edge and posterior lens capsule are in contact is indicated in blue.

laser capsulotomy was 10.2%, which was faster and higher compared with the 5-year incidence of real-world evidence studies and the 3-year incidence in a randomized controlled study. It seems that patients with multifocal IOLs are more sensitive to PCO when compared to patients with monofocal IOLs, because patient expectations for multifocal IOLs are higher.[7] In a previous study comparing the 2-year incidence of Nd:YAG laser capsulotomy between hydrophobic and hydrophilic multifocal IOLs, the incidence of Nd:YAG laser capsulotomy was 4.5-fold higher in eyes with hydrophilic multifocal IOLs than eyes with hydrophobic multifocal IOLs.[33] In addition, one of the risk factors for the increased incidence of Nd:YAG laser capsulotomy is being younger than 60 or 63.5 years of age.[31,33] The materials used in Lentis Mplus and Lentis Mplus Toric IOLs assessed in this study are hydrophilic acrylates with a hydrophobic surface, and the mean age of patients enrolled in this study was 57.5 years.

Because of the retrospective nature of the investigation, this study was unable to randomly assign patients to the same distribution of parameters in the 2 groups. In the comparison of baseline parameters between the nontoric and toric groups, the Lentis Mplus toric IOL group had more younger patients, lower IOL power, and longer AL than the Lentis Mplus IOL group. Younger age and lower-diopter IOLs in longer eyes with larger capsular bags are associated with PCO formation and Nd:YAG laser capsulotomy.[27,31] However, there was no significant difference in age, AL, or IOL power between eyes with and without Nd:YAG laser capsulotomy in this study.[27,31] Multivariate binary logistic regression analysis showed that only IOL type was significantly related with Nd:YAG laser capsulotomy, although eyes undergoing Nd:YAG laser capsulotomy were more likely to be left eyes and in the toric IOL group in univariate analysis. It seems that incomplete capsular bend formation by the posterior toric surface might have a greater effect on PCO occurrence in the early postoperative period than do age, AL, or IOL power.

In this study, there was a difference in the frequency of femtosecond-laser CCC between the nontoric and toric groups. In patients receiving the toric IOL, femtosecond laser CCC was performed in all cases for postoperative rotational stability.[34] Thus, the frequency of femtosecond laser CCC was significantly higher in the toric group than in the nontoric group. Although a previous study reported that femtosecond laser CCCs reduced the incidence of PCO relative to conventional CCCs,[11,12] no other study has shown such benefit.[13–16] This study noted that the Lentis Mplus toric IOL was associated with Nd:YAG laser capsulotomy but femtosecond laser CCC was not. Although femtosecond laser CCC was performed more frequently in the toric group than in the nontoric group, the frequency of Nd:YAG laser capsulotomy was significantly higher in the former. Thus, it seems that PCO occurrence is likely to be more affected by placement of the toric IOL itself compared with femtosecond laser CCC application.

When a PCO occurs, a careful resolution is required using Nd:YAG laser capsulotomy without damaging the multifocal IOL.[35] In addition, a previous study suggested that Nd:YAG laser capsulotomy may cause IOL rotation, so Nd:YAG laser capsulotomy should be performed at least 3 months after cataract surgery in the case of toric IOL involvement.[36] In this study, all patients underwent Nd:YAG laser capsulotomy at least 3 months after cataract surgery, and vision improvement was observed in all cases, without any complications.

This study has some limitations that should be considered. First, although the study sample was large, the study was conducted retrospectively. Second, we did not identify the grade of PCO because of the nature of a retrospective study design but did compare the incidence of Nd:YAG laser capsulotomy. However, Nd:YAG laser capsulotomy was performed when slit-lamp testing confirmed PCO after pupil dilation in patients with decreased visual acuity or blurry vision. Identification of Nd:YAG laser capsulotomy may be a good indicator of visual loss due to early PCO after surgery. Third, radii of posterior curvature of nontoric and toric IOLs used in the finite element analysis are different from those of the Lentis Mplus and Lentis Mplus toric IOL optics. Differences in radii of curvature may cause differences in contact angle in the toric IOL case but may have no significant effect on the difference in contact area between 2 IOLs. Fourth, the incidence of Nd:YAG laser capsulotomy was higher in the Lentis Mplus toric IOL than the Lentis Mplus IOL but decreased with increasing toric IOL cylinder power in the Lentis Mplus toric IOL group. Low-toricity IOLs might develop low contact pressure compared with high-toricity IOLs,[27] as lower-diopter IOLs could cause weak posterior capsule adhesion and lower incidence of PCO.[27,37] Thus, a large-scale study is needed to confirm that the incidence of PCO confirmed through serial retroillumination anterior segment photos under mydriasis varies depending on toric IOL cylinder power. In addition, it would be helpful to repeat the investigation of PCO occurrence in IOLs with an anterior toric surface.

In conclusion, patients with refractive multifocal toric IOLs presented a higher incidence of Nd:YAG laser capsulotomy when compared with those with refractive multifocal nontoric IOLs. On the other hand, femtosecond laser CCC could not reduce the incidence of Nd:YAG laser capsulotomy when compared with outcomes of conventional CCC in this study. These results suggest that the implantation of a toric IOL has more influence on PCO occurrence than femtosecond laser CCC.

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