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Changes in Anterior Segment Morphology and Predictors of Angle Widening after Laser Iridotomy in South Indian Eyes

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Purpose: To compare anterior segment optical coherence tomography (ASOCT) angle morphology before and after laser peripheral iridotomy (LPI) in a cohort of South Indian subjects with primary angle-closure suspect (PACS) or primary angle-closure/primary angle-closure glaucoma (PAC/PACG) and to examine baseline parameters associated with angle widening.

Design: Prospective observational study.

Participants: A total of 244 subjects aged ≥30 years with PACS or PAC/PACG in at least 1 eye.

Methods: The ASOCT images and angle gonioscopic grades were analyzed for all subjects at baseline and 2 weeks after LPI. Multivariable linear and logistic regression models were used to determine predictors of angle widening (change in mean angle opening distance [AOD750]) and angle opening (all 4 quadrants with trabecular meshwork [TM] visible on gonioscopy after LPI).

Main Outcome Measures: Change in ASOCT parameters with LPI and baseline predictors of angle widening.

Results: Laser peripheral iridotomy resulted in angle widening on ASOCT with significant increases in AOD750, angle recess area, and trabecular iris surface area ($P < 0.05$ for all). Gonioscopically, 44.7% of all subjects had open angles in all 4 quadrants after LPI, with a greater percentage of angles open in the PACS group compared with the PAC/PACG group (52.4% vs. 36.4%; $P = 0.01$). In multivariable regression analyses, greater postoperative angle widening as defined by change in AOD750 was associated with shorter baseline AOD750 and axial length, and greater baseline anterior chamber depth, iris curvature, and lens vault ($P \leq 0.002$ for all). Gonioscopic angle opening after LPI was more common with wider baseline angle width (modified Shaffer grade) and lower cup-to-disc ratio ($P < 0.001$ for both).

Conclusions: In a South Indian population with PACS or PAC/PACG, LPI results in significant anterior chamber angle widening seen on both ASOCT and gonioscopy, although some degree of persistent iridotrabecular contact was present in approximately half of PACS eyes and approximately two thirds of PAC/PACG eyes on gonioscopy. The greatest widening by ASOCT was observed in eyes with features most consistent with greater baseline pupillary block. *Ophthalmology 2016;■:1–8 © 2016 by the American Academy of Ophthalmology*

Population-based studies have demonstrated a prevalence of angle-closure glaucoma in South India ranging from 0.5% to 2.75%,[1–5] with studies consistently noting a significantly higher prevalence of primary angle-closure suspect (PACS) compared with primary angle-closure (PAC) or primary angle-closure glaucoma (PACG).[2,4,5]

Laser peripheral iridotomy (LPI) is the primary treatment for angle closure based on its ability to relieve pupillary block.[6,7] After LPI in eyes with narrow angles, progression to angle-closure glaucoma is uncommon,[8] even in high-risk eyes such as the fellow eyes of patients with a unilateral acute angle-closure attack.[9] These observations suggest that LPI produces a favorable anatomic state, likely through anterior chamber angle widening.[10] However, LPI is not sufficient to prevent angle-closure progression in all eyes, and some eyes that undergo LPI subsequently develop elevated intraocular pressure (IOP),[9,11,12] peripheral anterior synechiae (PAS),[13] or glaucomatous optic neuropathy.[8,12,14] Persistent iridotrabecular contact, observed in approximately 20% of eyes after LPI,[15,16] may in part explain angle-closure progression in these eyes.[17] Understanding the anatomic changes that accompany LPI is important both for defining the favorable physiologic state typically produced by LPI and for identifying factors that predispose to possible progression after LPI (i.e., continued iridotrabecular contact).

Gonioscopy is limited in its ability to accurately characterize LPI-induced changes in anterior chamber morphology. Anterior segment optical coherence tomography (ASOCT), however, has emerged as a method for obtaining objective, reproducible high-resolution images that allow for quantification of anterior chamber parameters.

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Using ASOCT, studies of high-risk populations including Chinese[18–21] and Korean[16,22] eyes have shown LPI-induced changes in a number of anterior chamber– and iris-related parameters, including anterior chamber area (ACA),[18] anterior chamber volume (ACV),[18] angle width,[19] iris thickness (IT),[18,20,22] iris curvature (IC),[22] and lens vault (LV).[18,22] However, no previous study has investigated LPI-induced morphologic changes in Indian eyes using ASOCT. Given that India has the second highest burden of PACG in the world[1] and recent evidence suggesting ethnic variations in angle-closure parameters,[23–25] understanding LPI-induced anatomic changes in the Indian eye is a high priority.

The purpose of this study was to compare ASOCT angle morphology before and after LPI in a South Indian population with PACS or PAC/PACG and to examine baseline parameters associated with angle widening. To our knowledge, this is the largest study of LPI-induced changes in ASOCT parameters in South Indian eyes.

Methods

The study protocol was approved by the institutional review boards of the Aravind Eye Hospital and Johns Hopkins University, and written informed consent was obtained from all study participants. The study was conducted in adherence with the tenets of the Declaration of Helsinki.

Subjects

Subjects were recruited consecutively from patients visiting the Aravind Eye Hospital Glaucoma clinic in Pondicherry, located in South India. Individuals were eligible for inclusion if they were aged 30 years or older with a diagnosis of PACS or PAC/PACG in at least 1 eye. Subjects were excluded if they (1) were bilaterally pseudophakic; (2) had prior iridotomy, iridoplasty, or incisional glaucoma surgery in either eye; or (3) had signs or symptoms consistent with acute angle closure.

Stages of angle closure were defined for each individual on the basis of findings of the ophthalmic examination in the more severely affected eye according to the International Society of Geographical and Epidemiological Ophthalmology classification guidelines.[26] Guidelines were modified to collapse PAC and PACG into a single category (PAC/PACG), as previously described, because reliable visual fields were not consistently available.[27] Primary angle-closure suspect was defined as having 1 or both eyes with at least 2 quadrants of iridotrabecular contact without visible pigmented trabecular meshwork (TM). Subjects were classified as PAC/PACG if in addition to 2 full quadrants of appositional angle closure, they also had any 1 of the following: IOP >21 mmHg, PAS, abnormal trabecular pigmentation consistent with PAC/PACG, or a vertical cup-to-disc ratio (CDR) ≥0.7.

Clinical Assessment

All subjects underwent a standardized ophthalmic examination at baseline. Trained technicians collected ocular history, measured best-corrected Snellen visual acuity, and performed subjective refraction. Ultrasound pachymetry (PACSCAN 300P, Sonomed; Escalon Medical Corp., Wayne, PA) was used to measure central corneal thickness. A-scan ultrasonography (Sonomed A-scan; Escalon Medical Corp.) was used to obtain measurements of axial length, anterior chamber depth, and lens thickness. One of 3 masked glaucoma-trained ophthalmologists (S.K., P.K., or R.V.) completed slit-lamp examination of the anterior segment and posterior pole (optic disc and macula) and Goldmann applanation tonometry to measure IOP and gonioscopy.[27]

Gonioscopy was performed in a dimly illuminated room using a 1×1-mm slit beam. The most posterior structure in each quadrant was initially identified using a 2-mirror Goldmann-type gonioscopy lens (Volk Optical, Inc., Mentor, OH) in primary gaze. Modified Shaffer (mShaffer) grade was assigned for each quadrant on the basis of the most posterior structure seen: 0 = no structures, 1 = Schwalbe's line, 2 = pigmented TM, 3 = scleral spur (SS), and 4 = ciliary body. Indentation gonioscopy was performed with a Zeiss-style 4-mirror gonioscopy lens when necessary to distinguish uncomplicated iridotrabecular contact from iridotrabecular contact complicated by PAS.

Laser peripheral iridotomy was performed in affected eyes using a neodymium:yttrium-aluminum-garnet laser after pretreatment with 2% pilocarpine. The LPIs were positioned nasally or temporally between the 2 and 4 o'clock or 8 and 10 o'clock positions. Preference was given to iris crypts and avoiding iris vessels when possible. Subjects were reexamined 2 weeks after LPI, and gonioscopy and ASOCT were repeated at that time.

Anterior Segment Optical Coherence Tomography

A single trained technician obtained 2 ASOCT (Visante 3.0; Carl Zeiss, Meditec, Dublin, CA) images of the anterior segment of nasal and temporal quadrants (3- and 9-o'clock meridians) under dark conditions (<20 lux). The same technician obtained images after LPI under the same conditions. One image per eye was selected for analysis on the basis of the quality and clarity of the SS and angle structures. The images were then analyzed using the Anterior Segment Analysis Program (National University Health System, Singapore[28]) plug-in for ImageJ software (National Institutes of Health, Bethesda, MD[29]) after the 2 SSs were marked by a single trained masked technician (who was not involved in obtaining the images) according to the protocol described previously by Seager et al.[30] Angle measurements obtained from Anterior Segment Analysis Program–analyzed images were angle opening distance (AOD), angle recess area (ARA), and trabecular iris surface area (TISA) at 750 μm from the SS. Parameters describing the anterior chamber included anterior chamber width (ACW), central anterior chamber depth (cACD), ACA, and ACV. Finally, parameters were gathered to define the iris, including IT at 750 μm, iris area (IA), iris volume (IV), IC (defined as the longest perpendicular distance between the iris chord and the posterior iris surface), and pupillary diameter (PD). Lens vault, defined as the perpendicular distance between the horizontal line joining the 2 SSs and the anterior pole of the lens,[31] also was determined.

Statistical Analysis

Images from the eye with more advanced disease were analyzed for each subject. When both eyes had the same diagnosis (indicating a similar level of severity), the right eye was selected. The mean of the temporal and nasal angle measurements was used in all analyses. Group differences in baseline variables between PACS and PAC/PACG eyes were evaluated using the Student *t* test or Mann–Whitney test (for continuous variables) and chi-square test for categoric variables. Changes in categoric gonioscopic parameters were compared between groups before and after LPI using the chi-square test for independence, and within-group changes were compared using the McNemar test for correlated proportions.

Mean values for anterior segment parameters before and after LPI were compared using a paired *t* test. To determine predictors of