Comparison of iridocorneal angle in infants with retinopathy of prematurity and healthy infants using spectral domain optical coherence tomography

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PURPOSE To compare measurements and morphologic characteristics of the iridocorneal angle in preterm infants with retinopathy of prematurity (ROP) and healthy infants using spectral domain optical coherence tomography (SD-OCT).

METHODS In this observational, case–control study, the eyes of children with ROP and healthy controls under 1 year old were imaged using SD-OCT without sedation to capture the iridocorneal angle. The ROP staging was made by a pediatric retinal specialist. The following measurements were analyzed with custom software: angle opening distance (AOD_{500}) at 500 μm; angle opening in degrees (AOG); and angle recess area (ARA_{750}).

RESULTS A total of 27 eyes of 14 children with ROP and 21 of 13 children without ROP were included. The mean gestational age of children in the ROP group was 30 weeks; of the controls, 35 weeks. The mean birth weight in the ROP group was 1,545 g; in the non-ROP group 2,100 g. Mean age at the time of the study was 18.1 (ROP group) vs 25.7 weeks (non-ROP). In the ROP group AOD_{500} was 477 μm (95% CI, 358–597 μm), AOG was 37.3° (95% CI, 30.4°-44.3°), and ARA_{750} was 231 mm^2 (CI 95%, 171–291 mm^2). The same parameters on the non-ROP group were 400 μm (CI 95% 333–468 μm), 34.7° (CI 95% 30.4°-39°), and 203 mm^2 (95% CI, 171–236 mm^2). The iris showed a more convex pattern on eyes with ROP (56% vs 23%).

CONCLUSIONS In this study cohort, children with ROP showed higher AOD_{500}, AOG, and ARA_{750}, perhaps because of different patterns of physiological development in children with ROP. (J AAPOS 2014;18:344-346)

The iridocorneal angle and its disposition are affected during development (eg, shallowing of the anterior chamber, pigmentation of the trabecular meshwork) and influenced by such factors as race, age, iris color, eye dominance, corneal curvature, refractive state, and light conditions.[1,2] These variables and growth patterns have not been well described in the literature. The purpose of this study was to measure iridocorneal angle characteristics using spectral domain optical coherence tomography (SD-OCT) in children with retinopathy of prematurity (ROP) and compare the results to those obtained from healthy, non-ROP controls.[3,4]

Methods

In this observational, case–control study, the eyes of consecutive patients with ROP and healthy controls under 1 year of age seen at the Asociación para Evitar la Ceguera en México (APEC) from January 2012 to October 2012 were imaged using SD-OCT without sedation. Inclusion criteria were age less than 1 year and diagnosis of retinopathy of prematurity in the ROP group and any gestational age with healthy eyes in the non-ROP group and completion of imaging without sedation. Most of them were asleep when imaged. The study adhered to the tenets of the Declaration of Helsinki and was approved by the APEC Ethics Committee. The caregivers of study participants provided informed written consent. Only images that afforded visualization of the scleral spur were included; if the scleral spur was only partial, the image had to at least permit placement of measurement lines.

SD-OCT images were obtained using the iVue (Optovue Co, Fremont, CA), a noncontact portable tomograph with an axial resolution of 5 microns that performs 26,000 scans per second

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with a 840 nm LASER of supraluminiscent diodium.[5] Images were obtained under standard light conditions using simple scan of the anterior chamber and iridocorneal angle. The study was perfomed by two randomly assigned retina specialists, with the same level of training on SD-OCT imaging of the retina and the iridocorneal angle. Images of the temporal or nasal meridian (0° or 180° as possible) were obtained. Images were measured and analyzed by custom software. Images of pathologic and healthy eyes were assessed by a glaucoma specialist familiarized with iridocorneal angle imaging with this technique (MGH).

The main outcome measurements were angle opening distance (AOD_{500}), angle opening expressed in degrees (AOG), and angle recess area (ARA_{750}). AOD_{500} is the distance from the corneal endothelium at 500 μm anterior to the scleral spur to the anterior surface of the iris perpendicular to the trabecular meshwork. AOG is obtained measuring the angle at the scleral spur formed from two lines, one at the iris surface and the other along the corneal endothelium. ARA_{750} is the area bounded by the corneal endothelium, trabecular meshwork, and anterior iris surface out to a distance of 750 μm from the scleral spur[6,7] (Figure 1).

ROP was graded before angle measurements by a pediatric retina specialist according to the actual ROP staging.[8]

Continuous variabiles are reported as standard deviations of the mean. Statistical analysis was performed using the statistic package GraphPad Prism 2 version 4.03 (GraphPad Software Inc, San Diego, CA). No matching was performed; therefore, the Mann-Whitney test was used to compare results. A P value of < 0.05 was considered statistically significant.

Results

A total of 48 eyes of 27 children were included: 27 eyes (14 children [6 females]) in the ROP group and 21 eyes (13 children [7 females]) in the non-ROP group. The mean gestational age of children in the ROP group was 30 ± 2.5 weeks (range, 27-34 weeks); the mean birth weight, 1545 ± 395 g (range, 1070–2500 g); and the mean corrected age at the time of imaging, 18.1 ± 14 weeks (range, 4-51 weeks). The mean gestational age of the non-ROP controls was 35 ± 5.4 weeks (range, 26-40 weeks); the mean birth weight, 2100 ± 872 g (range, 780–3200 g); and the mean corrected age at imaging, 25.7 ± 21 weeks (range, 1-52 weeks).

Cross sectional SD-OCT allowed complete visualization of the scleral spur in 13 of 21 eyes in the non-ROP group and in 20 of 27 eyes in the ROP group (62% vs 74%).

AOD_{500}, AOG, and ARA_{750} values in ROP and non-ROP are given in Table 1. The main descriptive difference observed was the configuration of the iris (Figure 2). There was a higher percentage of eyes in the ROP group with a more convex pattern than was observed in the non-ROP group (56% vs 23%). It was possible to identify the trabecular meshwork in 25 eyes (93%) and the Schwalbe line in 23 of 27 eyes (85%) in the ROP group; in the control group the trabecular meshwork was identified in 16 eyes (76%), and the Schwalbe line was observed in 15 eyes (71%).

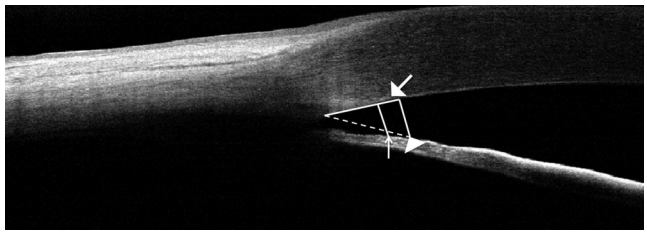

FIG 1. Spectral domain optical coherence tomograph (SD-OCT) of a patient in the non-ROP group with indications of iridocorneal angle measurements. The continuous line delineates the corneal endothelium; the dashed line, the iris surface. Angle opening distance (AOD_{500}) at 500 μm from the scleral spur is indicated by the thin arrow. The angle recess area (mm^2) is the area delimited by the corneal endothelium *(thick arrow)*, iris surface, and a line at 750 μm from to the scleral spur *(arrowhead)*. The angle opening in degrees is the angle in degrees formed at the scleral spur by the endothelium and iris surface lines.

Discussion

SD-OCT allows the imaging of eye structures with good resolution and does not require contact or sedation of patients. This is particularly useful in children. To our knowledge, this is the first report of iridicorneal angle characteristics in children using SD-OCT.

Perera and colleauges[9] have reported obtaining a clear and reliable identification of the scleral spur in 29.9% of images obtained with the RT VUE (Optovue Co, Fremont, CA) in adults: they identified the scleral spur more easily in the horizontal meridians than in the vertical meridians (44% vs 21%-30%). Wong and colleagues[10] reported a positive visualization of the scleral spur in 78.9% of the images obtained in an adult population using HD-OCT (Carl Zeiss, Cirrus HD-OCT). It is noteworthy that identification of the scleral spur was the limiting factor in both studies to obtaining reliable data of the angle structures.

In our study, the AOD_{500}, AOG, and ARA_{750} values were higher in eyes of children with ROP than in children with no ROP ($P > 0.05$). Eyes with ROP showed more convex iris than eyes without ROP (56% vs 23%). We did not analyze prevalence of glaucoma or intraocular pressure because we intended only to describe angle morphology. We observed that in the ROP group convex iris preserved angle opening (Figure 2). To evaluate its relation with angle width, a larger sample must be studied. Nevertheless, because the angle in the ROP group is wider, yet younger, it demonstrates a tendency of pathological angles to differ from normal ones during growth. The authors are currently conducting a study to measure the same variables by gestational age groups to elucidate the development of the iridocorneal angle

Table 1. Angle opening distance, angle opening, and angle recess area in the ROP and non-ROP groups

	ROP	non-ROP	*P* value[a]
AOD, μm	477 (95% CI, 358-597)	400 (95% CI , 333-468)	0.87
AOG, degrees	37 (95% CI, 30.4-44.3)	35 (95% CI, 30.4-39)	0.72
ARA, mm^2	231 (95% CI, 171-291)	203 (95% CI, 171-236)	0.98

AOD, angle opening distance; *AOG*, angle opening; *ARA*, angel recess area; *ROP*, retinopathy of prematurity.
[a]Mann-Whitney test.

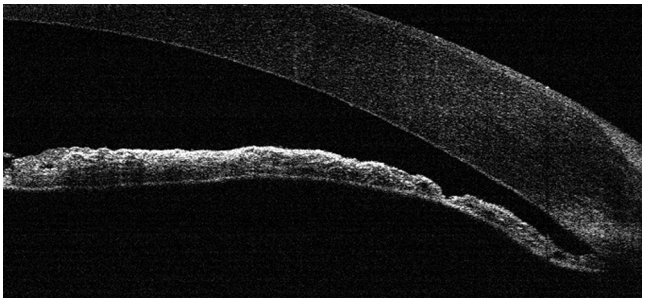

FIG 2. SD-OCT of the iris of a patient with ROP showing a convex configuration but a normal angle width.

structures on normal and pathologic eyes based on our current results.

Our study results are limited by several aspects of our study. First, our measurements may have been affected by not having controlled patients' fixation because of the implicit technical difficulties of imaging unsedated patients. Second, changes of the angle disposition under different light conditions were not studied.[11,12] Third, only one quadrant per eye (temporal or nasal) was studied because it proved challenging for even the experienced retinal specialists to perform the imaging without patients being sedated. It might prove fruitful to compare the data obtained by OCT imaging with the actual gold standard, that is, gonioscopy performed under anesthesia.

Literature Search

PubMed and the Cochrane Library databases were searched without date restrictions using the following medical subject headings and terms: *anterior chamber*, *iridocorneal angle*, *optical coherence tomography*, *children*, *retinopathy of prematurity*, *meta-analysis*, *review*, *clinical trial*, and *case report*.

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