Visual, refractive and structural long-term results in premature infants treated for retinopathy of prematurity

Priscila M. Viotto[a], Erna G. Knoll[a-b], Evangelina Espósito[a], Alejandro González-Castellanos[a], Agustina Ibáñez[a], Julio A. Urrets-Zavalía[a]

[a] *Departamento de Oftalmología, Clínica Universitaria Reina Fabiola, Universidad Católica de Córdoba, Argentina.*

[b] *Departamento de Oftalmología, Hospital Maternal y Neonatal Ramón Carrillo, Córdoba, Argentina.*

Received: June 10th, 2024.
Approved: July 15th, 2024.

Corresponsal author
Evangelina Esposito, M.D.
Department of Ophthalmology
University Clinic Reina Fabiola
Universidad Católica de Córdoba, Argentina
gely_e@hotmail.com

Oftalmol Clin Exp (ISSNe 1851-2658)
2024; 17(3): e359-e368.

Abstract

Purpose: To analyze the best-corrected visual acuity, refractive state and anatomical long-term results in premature infants consecutively treated for ROP by laser photocoagulation and/or intravitreal injections of anti-angiogenic agents.

Methods: Retrospective analytical study. Those children treated for ROP since 1998 by laser photocoagulation, intravitreal injections of antiangiogenic agents, or both, and who had a minimum ophthalmological follow-up of three years post-treatment were included. Descriptive and frequency statistics were used, and the Chi-square test and Spearman's correlation test were used for statistical association.

Results: 123 eyes of 62 patients were studied. The age at the last control was on average 9.66± 5.61 years. 116 eyes (94%) were treated by laser photocoagulation, 5 (4%) eyes required combined treatment, and 2 (2%) eyes with intravitreal injection of antiangiogenics. The mean spherical equivalent was -2.68±4.87 diopters, being significantly more negative in those with combined treatment (-11.54±2.36 D) and re-treatment (-12.46±3.26 D) and in those with posterior area disease (-7.50±5.49 vs +0.52±0.54 D) ($p<0.01$). Sixteen (15%) eyes were emmetropic, 32 (29%) eyes were hyperopic, and 62 (57%) eyes were myopic. 82 (74%) eyes had astigmatism and 20 (37%) patients

had anisometropia. Sixty (60%) eyes had good visual acuity, 26 (25%) eyes had regular visual acuity and 16 (15%) had poor visual acuity. In 97 (80%) eyes the fundus did not present sequelae of the disease or other pathologies.
Conclusions: Most treated children retain good visual acuity, despite significant refractive errors, mainly myopia. The more posterior the disease, the higher the prevalence of high myopia.
Keywords: Retinopathy of prematurity, laser photocoagulation, antiangiogenic intravitreal injection, myopia.

Resultados visuales, refractivos y estructurales a largo plazo en bebés prematuros tratados por retinopatía del prematuro

Resumen

Objetivo: Analizar la agudeza visual mejor corregida, el estado refractivo y los resultados anatómicos a largo plazo en bebés prematuros tratados consecutivamente por ROP mediante fotocoagulación con láser y/o inyecciones intravítreas de agentes antiangiogénicos.
Métodos: Estudio analítico retrospectivo. Se incluyeron aquellos niños tratados por ROP desde 1998 mediante fotocoagulación con láser, inyecciones intravítreas de agentes antiangiogénicos, o ambos, y que tuvieron un seguimiento oftalmológico mínimo de tres años postratamiento. Se utilizó estadística descriptiva y de frecuencia, y para asociación estadística se utilizó la prueba de Chi-cuadrado y la prueba de correlación de Spearman.
Resultados: Se estudiaron 123 ojos de 62 pacientes. La edad en el último control fue en promedio 9,66 ± 5,61 años. 116 ojos (94%) fueron tratados mediante fotocoagulación con láser, 5 (4%) ojos requirieron tratamiento combinado y 2 (2%) ojos con inyección intravítrea de antiangiogénicos. El equivalente esférico medio fue de -2,68±4,87 dioptrías, siendo significativamente más negativo en aquellos con tratamiento combinado (-11,54±2,36 D) y retratamiento (-12,46±3,26 D) y en aquellos con enfermedad de la zona posterior (-7,50±5,49 frente a +0,52±0,54 D) (p<0,01). Dieciséis (15%) ojos eran emétropes, 32 (29%) ojos eran hipermétropes y 62 (57%) ojos eran miopes. 82 (74%) ojos tenían astigmatismo y 20 (37%) pacientes tenían anisometropía. Sesenta (60%) ojos tenían buena agudeza visual, 26 (25%) ojos tenían agudeza visual regular y 16 (15%) tenían agudeza visual mala. En 97 (80%) ojos el fondo de ojo no presentó secuelas de la enfermedad ni de otras patologías.
Conclusiones: La mayoría de los niños tratados conservan una buena agudeza visual, a pesar de importantes errores refractivos, principalmente miopía. Cuanto más posterior es la enfermedad, mayor es la prevalencia de miopía alta.
Palabras clave: Retinopatía del prematuro, fotocoagulación con láser, inyección intravítrea antiangiogénica, miopía.

Resultados visuais, refrativos e estruturais em longo prazo em bebês prematuros tratados para retinopatia da prematuridade

Resumo

Objetivo: Analisar a acuidade visual melhor corrigida, o estado refrativo e os resultados anatômicos em longo prazo em bebês prematuros tratados consecutivamente com ROP por fotocoagulação a laser e/ou injeções intravítreas de agentes antiangiogênicos.
Métodos: Estudo analítico retrospectivo. Foram incluídas crianças tratadas com ROP desde 1998 por fotocoagulação a laser, injeções intravítreas de agentes antiangiogênicos, ou ambos, e que tiveram acompanhamento oftalmológico mínimo de três anos pós-tratamento. Foram utilizadas estatísticas descritivas e de frequência, e para associação estatística foram utilizados o teste Qui-quadrado e o teste de correlação de Spearman.
Resultados: Foram estudados 123 olhos de 62 pacientes. A idade no último controle foi em média 9,66 ± 5,61 anos. 116 olhos (94%) foram tratados com fotocoagulação a laser, 5 (4%) olhos necessitaram de tratamento combinado e 2 (2%) olhos com injeção intravítrea de antiangiogênicos. O equivalente esférico médio foi de -2,68±4,87 dioptrias, sendo significativamente mais negativo naqueles com tratamento combinado (-11,54±2,36 D) e retratamento (-12,46±3,26 D) e naqueles com doen-

ça da zona posterior (-7,50±5,49 vs + 0,52±0,54 D) (p<0,01). Dezesseis (15%) olhos eram emétropes, 32 (29%) olhos eram hipermétropes e 62 (57%) olhos eram míopes. 82 (74%) olhos apresentavam astigmatismo e 20 (37%) pacientes apresentavam anisometropia. Sessenta (60%) olhos tinham boa acuidade visual, 26 (25%) olhos tinham acuidade visual razoável e 16 (15%) tinham baixa acuidade visual. Em 97 (80%) olhos o fundo não apresentava sequelas da doença ou de outras patologias.

Conclusões: A maioria das crianças tratadas mantém boa acuidade visual, apesar de erros refrativos significativos, principalmente miopia. Quanto mais tardia for a doença, maior será a prevalência de alta miopia.

Palavras-chave: Retinopatia da prematuridade, fotocoagulação a laser, injeção intravítrea antiangiogênica, miopia.

Introduction

Retinopathy of prematurity (ROP) is an acquired impairment of normal retinal vascular development that may affect premature infants, and is one of the principal causes of visual handicap and preventable childhood blindness from retinal detachment and fibrotic scarring throughout the world, mainly in low and middle-income countries[1-5].

Timely and adequate treatment for ROP is highly effective in preventing blindness from retinal detachment. However, despite its efficacy some complications may occur, with high myopia being the more prevalent[5-8]. Although its occurrence with antiangiogenic intravitreal injections appears to be lower than with laser photocoagulation, it continues to be high[6-7].

The prevalence of myopia varies according to ROP severity. It has been observed that the more posterior and severe the disease is, the more severe the myopia that may result[7-8]. Besides, the high prevalence ROP-associated ametropias are up to 6 times higher than those observed among the general population[7-8].

The purpose of our study was to analyze best-corrected visual acuity, refractive state, and anatomical long-term results in premature infants consecutively treated for ROP by laser photocoagulation or intravitreal injections of anti-angiogenic agents, or both, and to correlate those results with characteristics of patients and disease.

Patients and methods

Infants with ROP treated consecutively from 1998 through 2018 in two third level neonatal units (Materno-Neonatal "Ramon Carrillo" Hospital, Ministry of Health of the Province of Cordoba, and the University Clinic Reina Fabiola, Catholic University of Cordoba) from Cordoba, Argentina.

Best-corrected visual acuity (BCVA) was assessed by a Snellen chart and converted into LogMAR units. BCVA was considered good when it was 0 to 0.3 LogMAR, regular 0.4 to 0.7 LogMAR, and poor 0.8 to 1 LogMAR. In illiterate children visual acuity was evaluated by means of the "E" Snellen chart. In non-collaborative children, visual behavior was evaluated by fixation and objects tracking, considering good BCVA in those who maintained fixation and correct object tracking, regular BCVA in those that could not maintain neither fixation nor tracking of object, and poor BCVA in those that could not achieve neither fixation nor tracking. Eye alignment was evaluated using Krimsky and cover tests.

Refraction was evaluated under cycloplegia with cyclopentolate 1% with an autorefractor (Shin-Nippon Accuref K-900, Takamatsu, Kagawa, Japan) or a streak retinoscope (Keeler Professional Streak 1302-P-1011, Britain, UK). A high myopic status was considered when refraction was of -6 or more negative diopters (D).

Anterior segment was evaluated with slit-lamp biomicroscopy, and ocular fundus with binocular indirect ophthalmoscopy and a +20D lens.

Data was obtained from patient files. Variables studied included gestational age (GA), birth weight (BW), gender, staging and localization of ROP, presence of plus disease, type of ocular treatment, best-corrected visual acuity in the last control, refractive spherical equivalent, power of cylinder, ocular alignment, and anatomical sta-

tus of the ocular fundus. Degree of prematurity was classified according to GA: Extreme prematurity (<27 weeks GA), high prematurity (28-31 weeks GA), early prematurity (32-33 weeks GA), late prematurity (34-37 weeks GA). Birth weight was classified into: Extremely low BW (<1000g), very low BW (1000-1499g) and low BW (1500-2500g).

Inclusion criteria: all infants treated by laser photocoagulation and/or with intravitreal injections of antiangiogenic drugs with a minimum follow-up of three years.

Exclusion criteria: infants with other ophthalmic or systemic diseases that could alter visual acuity and/or preclude its evaluation, and those infants that required ocular surgical interventions other than laser photocoagulation.

Statistical analysis: quantitative variables were evaluated by means of descriptive statistical analysis (mean, range and standard deviation), and qualitative variables with relative and absolute frequency distribution. To determine statistical association between variables, Chi square test was used for qualitative variables and Spearman correlation test for quantitative variables. Significance level was established at 5%. The R-medic software was used[9].

Ethical issues: Informed consent was obtained from parents of all treated infants in the study, which was approved by the institutional review board of each institution, and conducted in accordance with the tenets of the Declaration of Helsinki and the Good Clinical Practices of National Administration of Drugs, Food and Medical Technology (ANMAT) from the Ministry of Health of Argentina.

Results

One hundred and twenty-three eyes of 62 patients were included in the study. Mean age at last control was 9.66±5.61 years [range 3-23]. Thirty-three (53%) infants were female and 29 (47%) males. Mean gestational age at birth was 29.86±2.77 weeks. Eighteen (29%) patients were extreme premature, 21 (34%) high premature, 16 (27%) early premature, and 7 (11%) late premature. Mean birth weight was 1323±491g. Eighteen (29%) patients had extreme low BW, 23 (37%) had very low BW, and 21 (34%) had low BW.

Disease features

Data from 115 eyes were analyzed. Fifteen (13%) eyes presented stage II and 100 (87%) eyes stage III disease. Seventeen (15%) eyes developed the disease in zone I, 16 (14%) eyes in posterior zone II; 77 (67%) eyes in zone II, and 5 (5%) eyes in zone III. Plus disease was observed in 107 (93%) eyes.

Treatment

One hundred and sixteen (94%) eyes received laser photocoagulation, 113 eyes in one session and 3 eyes required retreatment. Five (4%) eyes were treated with a combination of photocoagulation and intravitreal injection of bevacizumab; 3 eyes required intravitreal injection of bevacizumab after the laser treatment because incomplete regression of the disease, and in 2 eyes intravitreal injection preceded the laser treatment. Two eyes (2%) were treated only by an intravitreal injection of bevacizumab. No immediate complications from either modality of treatment were observed.

In laser treated patients with zone I ROP mean number of spots was 1180±298, in those with posterior zone II ROP 973±578, in those with zone II ROP 725±368, and in those with zone III ROP 426±308. Laser treatment was delivered between 36 and 41 weeks of corrected GA in 75% of patients, and the remaining between weeks 42 and 49. Only one patient was treated at age 68 weeks of corrected GA.

Refractive results

Data from 110 eyes were analyzed in their last control. Sixteen (15%) eyes were emmetropes, 32 (29%) eyes hyperopes, and 62 (56%) eyes myopes, of whom 27 (25%) eyes had high myopia. In this latter group a combined treatment had been performed. Post treatment refractive status was highly correlated with zone of the dis-

Table 1. Refractive results according to localization of the disease.

Zone	Emmetropia	Hyperopia	Myopia	High Myopia
I	0%	2%	2%	7%
II Post	0%	1%	12%	2%
II	12%	24%	19%	15%
III	2%	3%	0%	0%

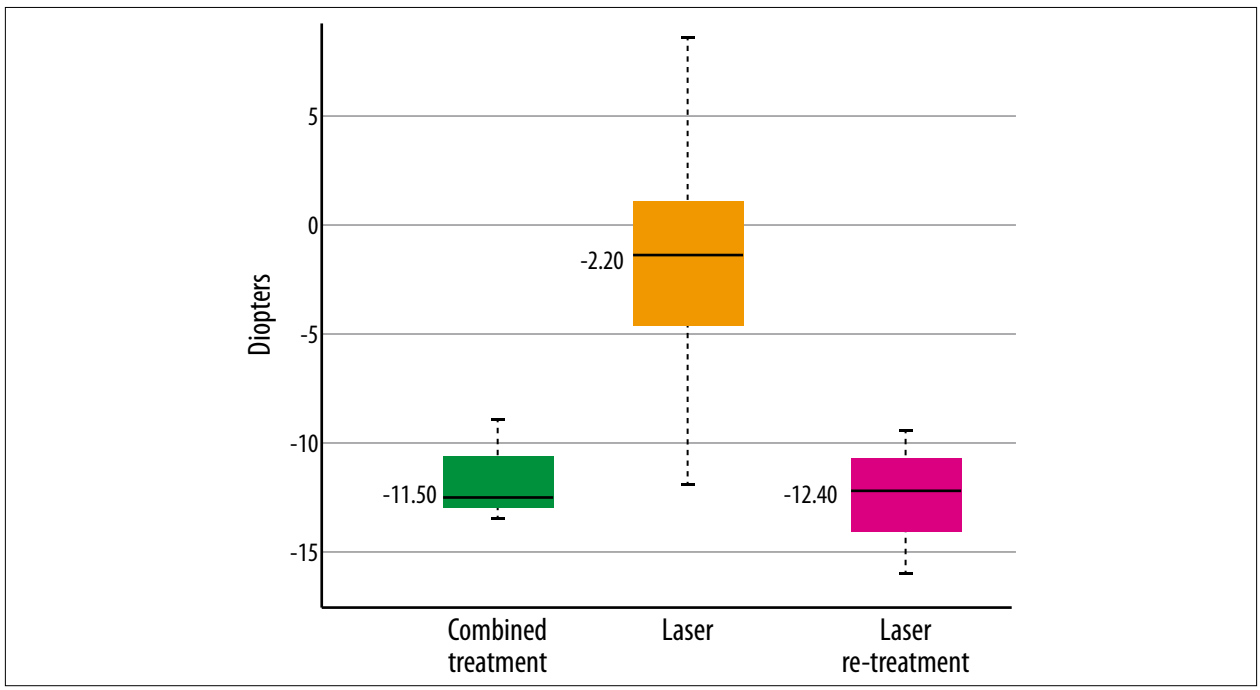

Figure 1. Spherical equivalent according to type of treatment.

ease (p<0.01). High myopia correlated with more posterior disease, and hyperopia and emmetropia with less posterior disease (Table 1).

Mean spherical equivalent was -2.68±4.87D. In those eyes requiring a combined treatment or a laser retreatment the spherical equivalent was significantly more negative (p<0.01), as shown in figure 1. In patients with posterior disease (zone I and posterior zone II) the spherical equivalent was significantly more negative when compared with those patients with zone II and zone III disease (p<0.01) as shown in table 2.

Anisometropia was present in 20 (37%) patients, with no differences found between different modalities of treatment and localization of the disease. Astigmatism greater than 1D was observed in 82 (74%) eyes, of whom 22 (20%) had a high astigmatism (greater than 3D). Sixty-four percent had a myopic astigmatism, 25% hyperopic astigmatism, and 11 % mixed astigmatism. Mean cylinder power was 1.77±1.25 D. No differences were found between different modalities of treatment and disease features. Seventy percent of astigmatisms were with the rule, 7% against the rule, and 23% oblique.

Table 2. Spherical equivalent (expressed in diopters) according to localization of the disease.

Zone	n	Median	Mean	Standard deviation	Statistical group
I	11	-9.38	-7.50	5.49	c
II Post	15	-3.25	-3.09	2.52	bc
II	73	-0.50	-1.99	4.71	ab
III	5	0.62	0.52	0.54	a

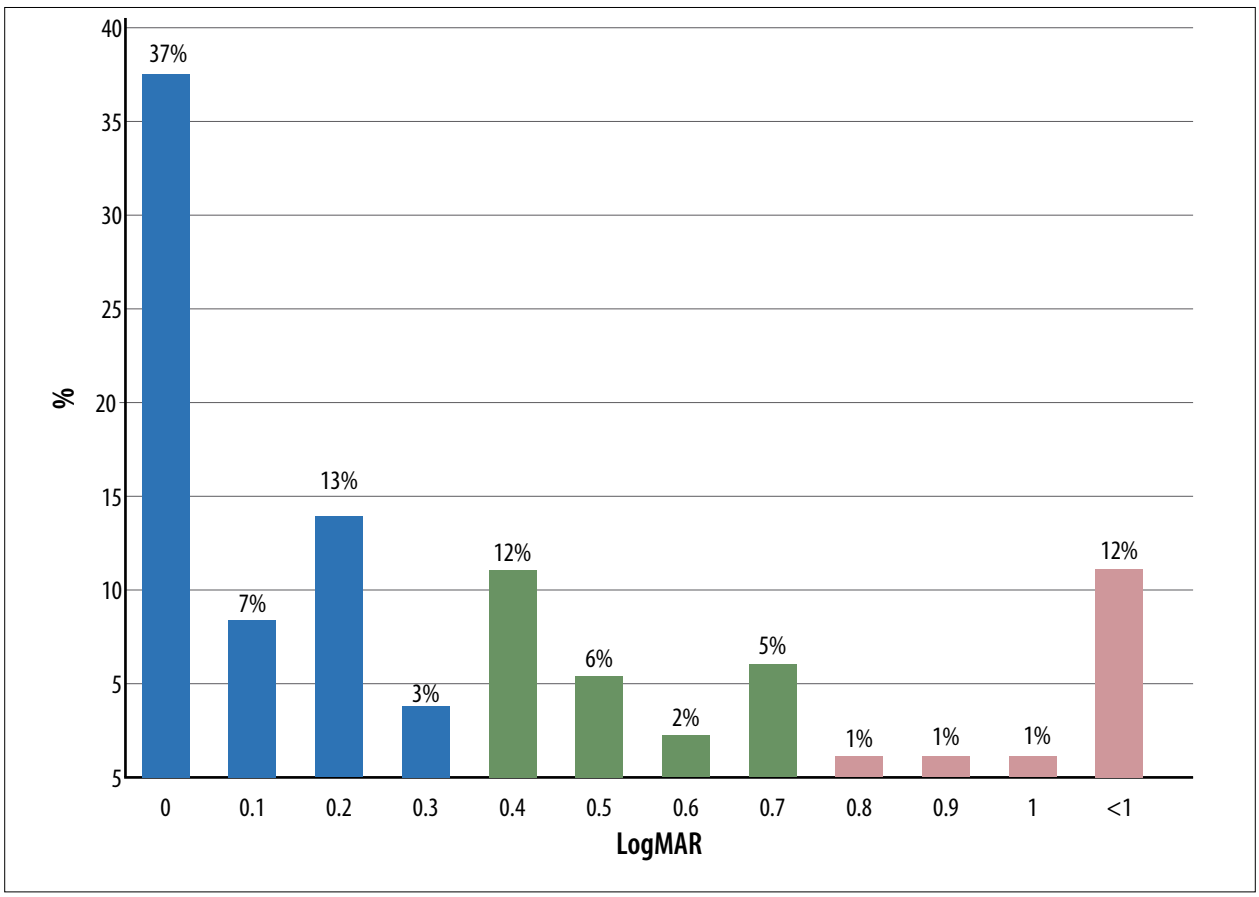

Figure 2. Best corrected visual acuity expressed in LogMAR units. Good visual acuity (blue bars), regular visual acuity (green bars), and bad visual acuity (pink bars).

Visual results

Visual acuity could be evaluated with a Snellen chart in 104 eyes. Sixty-two (60%) eyes presented a good final BCVA, 26 (25%) eyes a regular BCVA, and 16 (15%) a poor BCVA (Fig. 2).

Among infants that did not cooperate with visual acuity measurement, a good visual behavior was found in 18 eyes, and a regular behavior in 1 eye. A positive correlation was observed between BCVA and localization of the disease ($p<0.01$), with better BCVA among those infants that had zone II and zone III disease in comparison with those with zone I and posterior zone II disease (Table 3). Also, infants with worse BCVA had received more laser spots (1146±489) than

Table 3. Best corrected visual acuity frequency (n: 104) according to localization of the disease.

Zone	Best corrected visual acuity		
	Good	Regular	Bad
I	2	11	4
II Post	9	4	3
II	46	11	9
III	5	0	0

those with regular BCVA (737±291 spots) and good BCVA (680±376 spots) (p<0,01).

Anatomic results

Ninety-seven (79%) eyes did not present ROP or treatment sequels either in the anterior or the posterior segment. Three (2%) treated eyes were complicated by a retinal detachment, 11 (9%) eyes developed pre-macular fibrosis, 8 (7%) eyes presented different vascular anomalies such as vascular tortuosity, thin vessels or V-shaped temporal vascular arcades, 4 (3%) eyes a macular ectopia, 3 (2%) eyes absence of macular reflex, 5 (4%) eyes a tilted optic disk, and 2 (1%) eyes peripheral white without pressure.

Ocular motility

Data was obtained from 60 patients. Fifty-two (87%) of them were orthotropic at their last control, 6 (10%) presented esotropia, 2 (3%) exotropia. Four esotropic patients were hyperopic with a mean spherical equivalent of +4.5D, and both exotropic patients were myopic, one of them with high myopia.

Four children were found to have nystagmus, all of them having presented zone I disease with structural retinal sequels.

Discussion

High myopia is recognized as one of the most significant sequels in infants treated for ROP[5-8]. In our series we found a predominant myopic spherical equivalent (-2.68±4.87D). Other studies have found more a pronounced myopic shift, ranging between -5.11D and -8.44D, but some of them including only eyes with zone I disease[10-11], and in another one that a mean spherical equivalent of -6.35D was found, the patients had been treated at threshold disease stage according to the CRYO-ROP Study. On the other hand, we have found studies communicating spherical equivalents less negative, between -1.53D and 1.82D, but in two of them the mean age at the last control was 3 years in one study and only 10 months in the other one, ages considerably younger than in our series[12-14].

In patients treated with intravitreal antiangiogenics the spherical equivalent has been found to be less myopic (between -2.4 and +0.75)[6-7, 10, 12, 15-17]. Some studies have found a significant myopic refractive shift with laser photocoagulation when compared with antiangiogenic therapy[7, 16], but others did not[6, 13]. In our study we could not evaluate differences with both treatment modalities as we had very few cases treated by antiangiogenics. One study reported an association of mean spherical equivalent and gestational age[18], but we did not find such an association in our cohort. High myopia resulted in 25% of our treated patients, in accordance with other studies that have found high myopia in 22% to 55% of treated patients[10, 14, 19]. One study that evaluated 304 non-treatment-requiring premature infants found a significant less (9.9%) prevalence of myopia than the figures (56%) we found in our series[20].

A high prevalence of astigmatism was found in our series (74% of eyes), with a mean cylinder power of 1.77±1.25D, as observed by others that have found a mean cylinder power of 1,6 ± 1,5D[6], and an astigmatic prevalence of 54%[15]. In one study that only ROP in zone I treated eyes were included, the astigmatism prevalence was much higher (89.6%)[11], in contrast to other authors that found a median cylinder power of 0.00 (range=-4.5D to +1.5D)[14].

Although anisometropia is rare among the general population, being observed in 1%[21], in our study its prevalence was high (37% of treated eyes), higher than 16% reported in one study[15], but lower than 46% found in another study[11]. We did not find any correlation of anisometropia with localization of the disease, but it could be explained by its possible asymmetry.

The prevalence of strabismus was relatively low in our series (13%), and none of the strabismic children had presented zone III disease. As those esotropic patients had an elevated mean hyperopic spherical equivalent, one may speculate that their strabismus was more related to their refractive error and/or prematurity than to their ROP outcomes. In one study that evaluated 59 preterm infants without treated ROP a similar prevalence (12%) was found, that could explain that strabismus is more related to prematurity than with ROP treatment[22], but another study that included a higher number of non-treated premature infants showed a smaller prevalence (4.9%) of strabismus[20]. However, other studies that included ROP treated patients found a 33% prevalence of strabismus[15], and in another 28.8%[19], but both studies included a low number of treated patients.

In our series 60% of eyes obtained a good BCVA. In one study that BCVA was evaluated among laser-treated patients for ROP in zone I, a good visual result of ≥6/12 obtained with a Snellen chart (Logmar 0.3) was found in 81% of patients[11]. Similar results were also observed in another study that found a Snellen visual acuity of 6/12 or more in 17 of 24 patients treated with laser photocoagulation[19]. In a comparative study with laser photocoagulation versus antiangiogenic intravitreal injections in ROP, it was found that those eyes treated by antiangiogenic agents had a better final uncorrected visual acuity, although no significant difference was found when comparing with BCVA[16]. Post treatment visual acuity may be reduced because of the disease severity and/or the treatment itself, but also prematurity could contribute to infant's low vision, as reported in several studies that observed that premature babies had lower visual acuity than full-term babies[23-26]. However, another study that compared infants with treated versus spontaneously regressed ROP found a worse BCVA in treated infants[27].

Post treatment anatomic or structural results, determined by biomicroscopy and binocular indirect ophthalmoscopy, was found normal in the majority of our patients, with only a few cases presenting discrete vascular anomalies, in agreement with other study that obtained a favorable anatomic outcome in 96% of their cases[17]. Some studies have evaluated post treatment structural outcomes by means of optical coherence tomography (OCT), finding significantly reduced foveal, parafoveal, and perifoveal thicknesses in patients treated with antiangiogenic intravitreal injections compared with laser treated infants[16]. In another study evaluating treated babies with fluorescein angiography they observed vascular anomalies such as leakage, shunts, and ramifications in infants that had received intravitreal antiangiogenics, but none of those vascular anomalies in infants treated with laser photocoagulation[28].

Our study presents some weaknesses, among them its retrospective nature, the small sample size, especially in the antiangiogenic treated group, that precludes generalizing our findings.

However, the long-term follow-up (up to 20 years) and that all the patients have been diagnosed, treated and followed by the same experts and with the same protocol, constitutes an important strength.

Conclusions

In their last control, the majority of ROP treated infants had a good BCVA despite significant refractive errors, mainly myopia. Localization of the disease was observed as an important risk

factor related to the final refractive error, and posterior disease was associated with a higher prevalence of high myopia.

References

1. Fierson WM, American Academy of Pediatrics Section on Ophthalmology, American Academy of Ophthalmology, American Association for Pediatric Ophthalmology and Strabismus, American Association of Certified Orthoptists. Screening examination of premature infants for retinopathy of prematurity. *Pediatrics* 2018; 142: e20183061.
2. Arnesen L, Durán P, Silva J, Brumana L. A multi-country, cross-sectional observational study of retinopathy of prematurity in Latin America and the Caribbean. *Rev Panam Salud Publica* 2016; 39: 322-329.
3. Hariharan L, Gilbert CE, Quinn GE *et al*. Reducing blindness from retinopathy of prematurity (ROP) in Argentina through collaboration, advocacy and policy implementation. *Health Policy Plan* 2018; 33: 654-665.
4. Hansen ED, Hartnett ME. A review of treatment for retinopathy of prematurity. *Expert Rev Ophthalmol* 2019; 14: 73-87.
5. Chan-Ling T, Gole GA, Quinn GE *et al*. Pathophysiology, screening and treatment of ROP: A multi-disciplinary perspective. *Prog Ret Eye Res* 2018; 62: 77-119.
6. Hwang CK, Hubbard GB, Hutchinson AK, Lambert SR. Outcomes after intravitreal Bevacizumab versus laser photocoagulation for retinopathy of prematurity: a 5-Year retrospective analysis. *Ophthalmology* 2015; 122: 1008-1015.
7. Tan QQ, Christiansen SP, Wang J. Development of refractive error in children treated for retinopathy of prematurity with anti-vascular endothelial growth factor (anti-VEGF) agents: a meta-analysis and systematic review. *PLoS One* 2019; 14: e0225643.
8. Wang J, Ren X, Shen L *et al*. Development of refractive error in individual children with regressed retinopathy of prematurity. *Invest Ophthalmol Vis Sci* 2013; 54: 6018-6024.
9. Mangeaud A, Elías Panigo DH. R-medic: a simple and intuitive statistical analysis software. *Methodo* 2018; 3: 18-22. Available at: https://methodo.ucc.edu.ar/index.php/methodo/article/view/64
10. Geloneck MM, Chuang AZ, BEAT-ROP Cooperative Group *et al*. Refractive outcomes following bevacizumab monotherapy compared with conventional laser treatment: a randomized clinical trial. *JAMA Ophthalmol* 2014; 132: 1327-1333.
11. Shah PK, Ramakrishnan M, Sadat B *et al*. Long term refractive and structural outcome following laser treatment for zone 1 aggressive posterior retinopathy of prematurity. *Oman J Ophthalmol* 2014; 7: 116-119.
12. Chou YB, Wang AG, Yang HY *et al*. Refractive status, biometric components, and functional outcomes of patients with threshold retinopathy of prematurity: systemic review and a 17-year longitudinal study. *Graefes Arch Clin Exp Ophthalmol* 2022; 260: 3809-3816.
13. Kuo HK, Sun IT, Chung MY, Chen YH. Refractive error in patients with retinopathy of prematurity after laser photocoagulation or bevacizumab monotherapy. *Ophthalmologica* 2015; 234: 211-217.
14. Lolas M, Tuma A, Zanolli M *et al*. Anatomical and refractive outcomes in patients with treated retinopathy of prematurity. *Arch Soc Esp Oftalmol* 2017; 92: 472-476.
15. Veleva N, Chernodrinska V. Refractive status in children with laser-treated retinopathy of prematurity: our experience in Bulgaria. *Open Access Maced J Med Sci* 2019; 7: 1320-1323.
16. Lee YS, See LC, Chang SH *et al*. Macular structures, optical components, and visual acuity in preschool children after intravitreal bevacizumab or laser treatment. *Am J Ophthalmol* 2018; 192: 20-30.
17. Salman AG, Said AM. Structural, visual and refractive outcomes of intravitreal aflibercept injection in high-risk prethreshold type 1 retinopathy of prematurity. *Ophthalmic Res* 2015; 53: 15-20.
18. Kang HG, Kim TY, Han J, Han SH. Refractive outcomes of 4-year-old children after intra-

vitreal anti-vascular endothelial growth factor versus laser photocoagulation for retinopathy of prematurity. *Korean J Ophthalmol* 2019; 33: 272-278.
19. Axer-Siegel R, Maharshak I, Snir M *et al*. Diode laser treatment of retinopathy of prematurity: anatomical and refractive outcomes. *Retina* 2008; 28: 839-846.
20. Nickell M, Recko M, Young L *et al*. Outcomes for non-treatment-requiring infants evaluated for retinopathy of prematurity. *J AAPOS* 2023; 27: 269.e1-269.e4.
21. Mayer DL, Hansen RM, Moore BD *et al*. Cycloplegic refractions in healthy children aged 1 through 48 months. *Arch Ophthalmol* 2001; 119: 1625-1628.
22. Pétursdóttir D, Holmström G, Larsson E. Strabismus, stereoacuity, accommodation and convergence in young adults born premature and screened for retinopathy of prematurity. *Acta Ophthalmol* 2022; 100: e791-e797.
23. Larsson EK, Rydberg AC, Holmström GE. A population-based study on the visual outcome in 10-year-old preterm and full-term children. *Arch Ophthalmol* 2005; 123: 825-832.
24. Pétursdóttir D, Holmström G, Larsson E. Visual function is reduced in young adults formerly born prematurely: a population-based study. *Br J Ophthalmol* 2020; 104: 541-546.
25. Fieß A, Schuster AK, Nickels S *et al*. Association of low birth weight with myopic refractive error and lower visual acuity in adulthood: results from the population-based Gutenberg Health Study (GHS). *Br J Ophthalmol* 2019; 103: 99-105.
26. O'Connor AR, Fielder AR. Visual outcomes and perinatal adversity. *Semin Fetal Neonatal Med* 2007; 12: 408-414.
27. Park SH, Ma DJ, Choi DG. Long-term visual outcomes in children with regressed retinopathy of prematurity. *Sci Rep* 2023; 13: 4066.
28. Lepore D, Quinn GE, Molle F *et al*. Follow-up to age 4 years of treatment of type 1 retinopathy of prematurity intravitreal bevacizumab injection versus laser: fluorescein angiographic findings. *Ophthalmology* 2018; 125: 218-226.