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A STUDY OF REFRACTIVE OUTCOMES FOLLOWING LASER PHOTO COAGULATION IN SEVERE RETINOPATHY OF PREMATURITY

Ophthalomology

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ABSTRACT

Background: Retinopathy of Prematurity (ROP) is a major cause of preventable childhood blindness. Laser photocoagulation is standard treatment for severe ROP, but refractive abnormalities (myopia, astigmatism, anisometropia) are common long-term sequelae. Data on refractive outcomes after 532 nm frequency-doubled Nd:YAG laser in Indian infants remain limited. **Methodology:** This prospective observational cohort study was conducted at the Department of Ophthalmology, Dr. D. Y. Patil Medical College Hospital and Research Institute, Kolhapur, over two years. Ninety-two infants (184 eyes) with Stage 3 ROP with plus disease in Zone I/II treated with 532 nm Nd:YAG laser were enrolled and followed with cycloplegic refraction at 6 months corrected age. **Results:** Complete structural regression occurred in all 184 eyes (100%). Myopia was the commonest refractive abnormality (33.7% at 6 months: mild 18.5%, moderate 10.3%, high 4.9%), rising from 24.5% at 3 months. Astigmatism affected 27–30% and anisometropia 10–12% of eyes. Refractive abnormalities were more frequent/severe with Zone I disease, lower gestational age, and lower birth weight; Zone I involvement was significantly associated with higher myopia, astigmatism, and anisometropia versus Zone II. **Conclusion:** 532 nm Nd:YAG laser photocoagulation achieves excellent structural regression in severe ROP, but myopia, astigmatism, and anisometropia are common and progressive in early infancy, especially in Zone I disease. Long-term follow-up with periodic cycloplegic refraction and timely correction is essential to prevent amblyopia.

KEYWORDS

Retinopathy of Prematurity, Laser Photocoagulation, Refractive Outcomes, Myopia, Astigmatism, Anisometropia, Nd:YAG Laser, Premature Infants.

NTRODUCTION

Retinopathy of Prematurity (ROP) is a vasoproliferative disorder of the developing retina in premature neonates, first described by Terry in 1942 as retrolental fibroplasia, and remains a leading cause of preventable childhood blindness worldwide.(1) It predominantly affects neonates born before 32 weeks' gestation and under 1500 g, though infants of higher gestational age in resource-limited settings are also at risk.(2) WHO estimates ~50,000 children are blind from ROP globally, with a disproportionate burden in middle-income countries;(3) India alone accounts for over 5,000 ROP-blind children annually.(4)

ROP pathophysiology has two phases: a vaso-obliterative phase, where hyperoxia suppresses VEGF and halts normal retinal vascularization,(5) followed by a vasoproliferative phase, where the hypoxic avascular retina up-regulates VEGF, driving pathological neovascularization.(6)

Classification:

ICROP classifies ROP by zone, stage, clock hours, and plus disease.(7) Zone I is the most posterior region around the disc; Zone II extends to the nasal ora serrata; Zone III is the remaining temporal crescent. Zone I disease carries the worst prognosis.(8) Stages 1–3 represent progressive ridge and fibrovascular proliferation, while Stages 4–5 represent partial/total retinal detachment.(9) Plus disease—venous dilation and arteriolar tortuosity meeting reference standards—signals severity requiring prompt treatment,(10) and Aggressive Posterior ROP (APROP) is a rapidly progressive form with prominent plus disease in Zone I or posterior Zone II.(11,12)

Treatment: Laser photocoagulation, largely replacing cryotherapy for its better refractive outcomes and fewer anterior segment complications, is now the cornerstone of treatment.(13) The 532 nm frequency-doubled Nd:YAG laser is preferred for efficient absorption by oxyhemoglobin and RPE melanin, producing well-demarcated lesions.(14) Intravitreal anti-VEGF agents (e.g., bevacizumab) are an alternative, especially for Zone I disease—the BEAT-ROP trial showed reduced recurrence versus laser for Zone I Stage 3+ ROP(15)—though concerns about systemic VEGF suppression and late recurrence warrant caution and prolonged follow-up.(16)

Rationale: Myopia, astigmatism, and anisometropia are major long-term consequences of ROP treatment, attributed to peripheral retinal ablation, scar traction, and altered ocular biometry from prematurity.(17,18) Indian data—particularly from Maharashtra and specific to the 532 nm Nd:YAG laser—remain scarce, motivating this study.(19,20)

METHODOLOGY

This prospective observational cohort study was conducted at the Department of Ophthalmology, D.Y. Patil Medical College Hospital and Research Institute, Kadamwadi, Kolhapur, over two years, in infants presenting with Stage 3 ROP with plus disease treated by laser photocoagulation. Ethical clearance was obtained from the Institutional Ethics Committee, and written informed consent was taken from parents/guardians in Marathi and English.

Inclusion criteria: Stage 3 ROP with plus disease in Zone I or II (ICROP criteria); treated with 532 nm frequency-doubled Nd:YAG laser (Oculite GL, Iridex Corporation, USA); minimum 6-month documented follow-up; informed consent provided.

Exclusion criteria: Treatment with modalities other than Nd:YAG laser as primary therapy; incomplete refractive data; additional surgical intervention (vitrectomy/scleral buckling); significant ocular comorbidities, chromosomal/genetic syndromes, or neurodevelopmental disorders affecting visual outcomes.

Procedure: Infants were screened against eligibility criteria; anterior segment assessed via hand-held slit lamp/torchlight; fundus examined by binocular indirect ophthalmoscopy (Keeler Vantage Plus) after dilation with cyclopentolate 0.5% and phenylephrine 2.5%; ROP staged per ICROP; laser given with 532 nm Nd:YAG (Oculite GL). Post-treatment visual acuity was assessed via Teller Acuity Cards, fixation/following behavior, and cycloplegic retinoscopy.

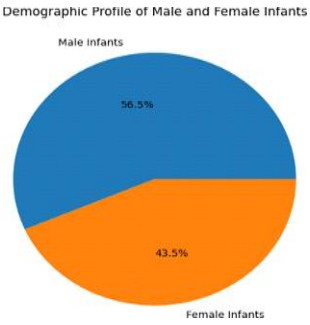
Follow-up: Weekly for one month post-laser, then at 3 and 6 months. Cycloplegic refraction (cyclopentolate 1%, retinoscopy at 30 minutes) was performed at 6 months corrected age.

RESULT

Over the 18-month collection period, 92 preterm infants (184 eyes) meeting inclusion criteria were enrolled; all had bilateral treatment-warranting ROP treated with 532 nm Nd:YAG laser.

Demographic Profile:
Sexdistributionof thestudypopulation:

GraphNo.1:Sexdistributionof thestudypopulation(n=92infants)



Male infants formed a slightly higher share of the cohort than females, with both sexes adequately represented, supporting representativeness of the refractive findings across genders.

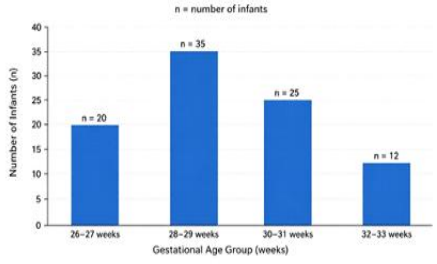
Table 1: Demographic and Baseline Clinical Characteristics

Parameter	Value	Range/%
Total infants enrolled	92	100%
Total eyes treated	184	100%
Male infants	52	56.5%
Female infants	40	43.5%
Male-to-female ratio	52:40	56.5%:43.5%
Mean gestational age	29.6 weeks	26–33 weeks
Mean birth weight	1299 g	826–1778 g
Extremely low birth weight (<1000 g)	20 infants	21.7%
Very low birth weight (1000–1499 g)	45 infants	48.9%

Most infants were significantly premature (mean GA 29.6 weeks) and low-birth-weight (mean 1299 g), with 21.7% extremely low birth weight and 48.9% very low birth weight—reflecting the high-risk population typical of ROP.

GestationalAge distribution:

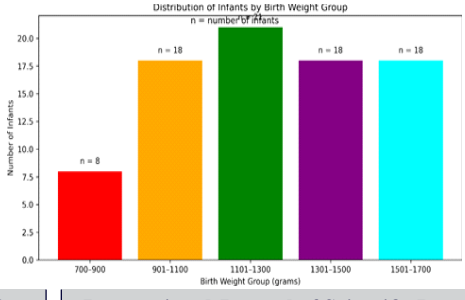
Graph No. 2: Gestational Age Distribution of the Study Population (n=92).



The graph no 2 presented in bar diagram. It illustrates the distribution of infants accordingtodifferentgestationalagegroups.Most infants fell in the 28–29 week group (n=35), followed by 30–31 weeks (n=25), 26–27 weeks (n=20), and 32–33 weeks (n=12), confirming a predominantly 28–31 week cohort.

Birthweight distribution:

Graph No. 3: Birth Weight Distribution of the Study Population (n =92).



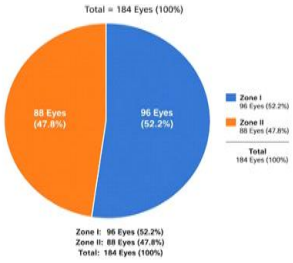
The graph no. 3 shows bar diagram which represents the distribution of infants according to different birth weight groups. The 1101–1300 g group was largest (n=21); 901–1100 g, 1301–1500 g, and 1501–1700 g groups each had 18 infants; the 700–900 g group had the fewest (n=8), confirming a predominantly low-birth-weight cohort.

Severity at Presentation — Table 2: ROP Zone Distribution (n=184 eyes)

Zone	Eyes	%
Zone I	96	52.2%
Zone II	88	47.8%
Total	184	100%

Zone I involvement was slightly more common than Zone II, indicating substantial posterior disease requiring early intervention.

Graphno.4. Distributionof ROPzoneand stage:



The above table no. 2and graph no 4 shows the distribution of treated eyes according to the zone of Retinopathy of Prematurity (ROP). A slightly higher proportion of eyes were affected in Zone I (52.2%) compared with Zone II (47.8%).

This indicates that a significant number of infants in the study had posterior retinal involvement, which is generallyassociated with more severe disease and requires early intervention.

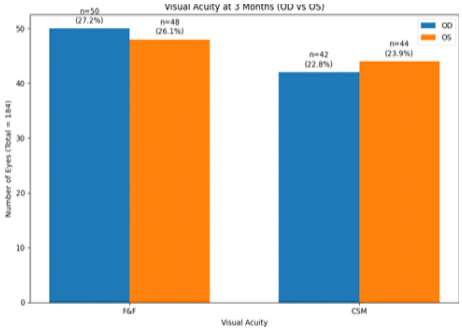
Structural Outcomes — Table 3

Outcome	Eyes	%	Zone I	Zone II
Complete regression (success)	184	100%	96 (100%)	88 (100%)
Retinal detachment	0	0%	0	0

Complete structural success (regression of fibrovascular proliferation, stable retina, no detachment) was achieved in all 184 eyes, exceeding the 85–95% success typically reported internationally for laser-treated Type 1/threshold ROP.(41)

Visualacuity for3 and6 months:
At3months:

Graphno.5–Visual acuityat3monthsfollowup



The graph no 5 illustrates the visual acuity outcomes at 3 months follow-up in both right eye (OD)and lefteye (OS)among atotal of184 eyes studied.

Visual Acuity
At 3 months *(Graph 5)*: F&F response was seen in 50 right eyes (27.2%) and 48 left eyes (26.1%); CSM response in 42 right eyes (22.8%) and 44 left eyes (23.9%) — indicating largely satisfactory early visual responses.

Visual acuity at6 months

1. Table 4: Teller Visual Acuity at 6 Months

TAC Range	Eyes	Interpretation
3.2 cyc/deg	54	Lower visual acuity
4.8 cyc/deg	63	Moderate visual acuity
6.4 cyc/deg	67	Better visual acuity

Most eyes achieved moderate-to-good visual acuity by 6 months, suggesting satisfactory visual maturation post-treatment.

2. Overall Refractive Outcomes at Follow-up Visits:
Overall Refractive Outcomes — Table 5

Refractive Error	3 Months	6 Months	P-value
Myopia	92 (100%)	92 (100%)	1.000
Astigmatism	91 (98.9%)	92 (100%)	1.000
Anisometropia ≤1D	10 (10.9%)	17 (18.5%)	0.211
Anisometropia ≤2D	0 (0%)	0 (0%)	1.000
Mean spherical equivalent	−5.43 D	−6.17 D	<0.001
Hypermetropia	0 (0%)	0 (0%)	1.000
Emmetropia	0 (0%)	0 (0%)	1.000

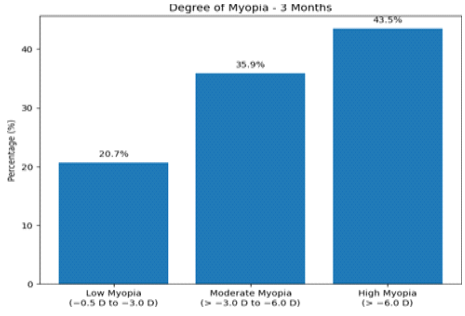
Myopia was universal at both visits, with mean spherical equivalent worsening significantly ($p<0.001$), while astigmatism and mild anisometropia also increased slightly over time.

Table 6: Detailed distribution of myopia categories at each follow-up visit.
Myopia — Table 6: Detailed Distribution

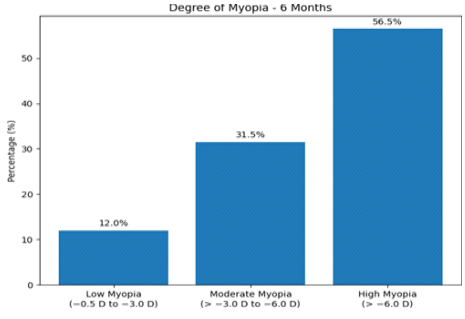
Degree	3 Months	6 Months
Low (−0.5 to −3.0 D)	19 (20.7%)	11 (12.0%)
Moderate (>−3.0 to −6.0 D)	33 (35.9%)	29 (31.5%)
High (>−6.0 D)	40 (43.5%)	52 (56.5%)

(Graphs 6 & 7 — Myopia distribution at 3 and 6 months): High myopia rose from 43.5% to 56.5%, while low myopia fell from 20.7% to 12.0%, and mean spherical equivalent worsened from −5.43 D to −6.17 D — indicating progressive shift toward higher myopia, underscoring the need for regular refractive follow-up to prevent amblyopia.

Graph no. 6 Distribution of myopia categories at 3 months



Graph no. 7 Distribution of myopia categories at 6 months



The analysis is for table no 6, graph no 6 and 7 shows Myopia was the most common refractive error observed in the studypopulation and was present in all infants at both the 3-month and 6-month follow-up visits. At 3 months, high myopia was observed in 40 infants (43.5%), moderate myopia in 33 infants (35.9%), and low myopia in 19 infants (20.7%). The mean spherical equivalent at 3 months was −5.43 D, indicating a significant degree of myopic refractive error among the treated infants.

At 6 months follow-up, progression of myopia was noted, with the mean spherical equivalent increasing to −6.17 D. High myopia became more prevalent and was observed in 52 infants (56.5%), while moderate myopia was present in 29 infants (31.5%). The proportion of low myopia decreased to 11 infants (12.0%), suggesting progression from lower grades of myopia to higher grades over time.

The increase in high myopia and worsening spherical equivalent at 6 months indicate progressive refractive changes in infants treated for Retinopathy of Prematurity (ROP). These findings highlight the importance of regular ophthalmic follow-up and refractive assessment in premature infants, as early detection and correction of refractive errors are essential for optimal visual development and prevention of amblyopia.

a. Astigmatism and Anisometropia:

Parameter	3 Months	6 Months
Astigmatism ≤1D	91 (98.9%)	92 (100%)
Astigmatism ≤2D	38 (41.3%)	46 (50.0%)
Anisometropia ≤1D	10 (10.9%)	17 (18.5%)
Anisometropia ≤2D	0 (0%)	0 (0%)

(Graph 8): Astigmatism was near-universal (98.9%→100%), likely linked to abnormal ocular growth from prematurity and laser treatment, and clinically important as a cause of amblyopia if uncorrected. Anisometropia rose from 10.9% to 18.5% but never exceeded 2D, indicating no severe interocular difference; its gradual increase still warrants continued monitoring to prevent suppression amblyopia.

Graph no 8: prevalence of astigmatism and anisometropia at each follow-up visit. A

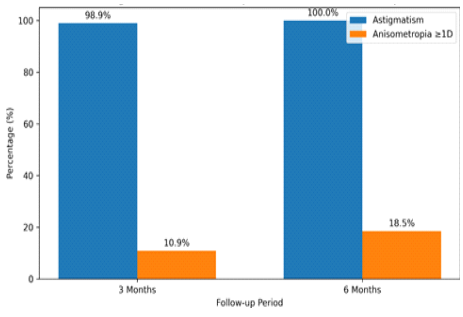
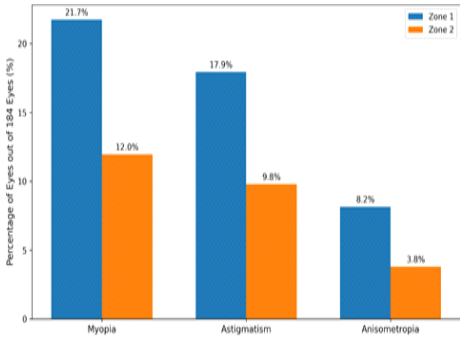


Table no 7 and graph no 8 shows that the Astigmatism was one of the most consistently observed refractive errors in the study population following treatment for Retinopathy of Prematurity (ROP). At 3 months follow-up, astigmatism was present in 91 infants (98.9%), while at 6 months it was observed in all 92 infants (100%). This demonstrates that astigmatism was nearly universal among the treated infants and persisted throughout the follow-up period. The high prevalence of astigmatism may be related to abnormal ocular growth and retinal changes associated with prematurity and laser treatment. Persistent astigmatism in infancy is clinically important because it can interfere with normal visual development and may lead to amblyopia if not corrected at an early stage.

Refractive Outcomes by Zone of Disease:
Graph no. 9: Refractive outcomes at 6 months Zone I vs Zone II. Zone I eyes demonstrate significantly higher rates of all refractive error categories ($p<0.001$).



The graph no 9 depicted that at 6 months follow-up, refractive outcomes were analyzed according to the zone of disease involvement. Zone I eyes showed significantly higher rates of all refractive errors than Zone II ($p<0.001$): myopia 21.7% vs 12.0%, with astigmatism and anisometropia similarly elevated — confirming posterior disease as a greater risk for refractive morbidity.

Correlationof Refractive Outcomeswith Clinical Variables:
Table 8: Correlation with Clinical Variables (at 6 months)

Clinical Variable	Myopia (%)	Astigmatism (%)	Anisometropia (%)
Gestational age <32 weeks	21.7	17.9	8.2
Low birth weight <1500 g	24.5	19.6	10.3
Extremely low birth weight	28.3	22.1	12.0

Lower gestational age and birth weight were both associated with higher rates of all three refractive abnormalities**DISCUSSION**

Structural Outcomes

Complete structural success was achieved in all 184 eyes (100%), exceeding the 85–95% reported internationally for laser-treated Type 1/threshold ROP,(41) confirming 532 nm laser as highly effective for severe ROP regression in this tertiary setting.

Incidence and Magnitude of Myopia

Myopia was the leading refractive outcome (33.7% at 6 months: mild 18.5%, moderate 10.3%, high 4.9%), more marked in Zone I disease and lower GA/birth weight infants — consistent with prior reports (e.g., Mori et al.) linking laser-treated ROP to myopic shift via altered ocular growth and peripheral ablation. The relatively high prevalence here may reflect the greater proportion of severe Stage 3-plus and Zone I cases in this cohort.

Progressive Myopic Shift

Myopia rose from 24.5% at 3 months to 33.7% at 6 months, more pronounced in Zone I and lower GA/birth-weight infants, supporting continued refractive change during early infancy from ongoing axial and anterior-segment development — reinforcing the need for regular cycloplegic refraction and timely correction.

Astigmatism Prevalence and Clinical Significance

Present in 27–30% of eyes at 6 months and increasing from the 3-month assessment, astigmatism was more common in Zone I disease and lower GA/birth weight, consistent with Tiryaki Demir et al.,(49) who attributed it to peripheral scarring and vitreoretinal traction — clinically significant given its risk for meridional amblyopia.

Anisometropia and Risk of Amblyopia

Seen in 10–12% of eyes at 6 months with a slight upward trend, more common in Zone I disease and lower birth weight/GA, likely from asymmetric retinal involvement — consistent with Holmstrom and Larsson.(46) Given its strong link to amblyopia via cortical suppression,(47) early detection and spectacle correction remain critical.

Effect of Zone of Disease on Refractive Outcomes

Zone I eyes showed significantly higher myopia, astigmatism, and anisometropia than Zone II, consistent with prior literature on poorer refractive outcomes in Zone I disease,(43) likely due to more extensive peripheral ablation and greater vitreoretinal traction. Evidence from BEAT-ROP and BVB studies suggests anti-VEGF therapy may offer a refractive advantage over laser in Zone I disease when adequate long-term follow-up is feasible.(15,50)

Comparison with Indian Literature

These findings align with other Indian laser-ROP studies, where myopia predominated, followed by astigmatism and anisometropia, with similar associations to Zone I disease and low GA/birth weight. Jalali et al. emphasized the need for stronger refractive surveillance in Indian ROP survivors;(58) this study adds prospective Maharashtra-based data specific to 532 nm laser treatment.

Clinical Implications

These findings support structured long-term ophthalmic follow-up, with cycloplegic refraction at 6 months and periodically thereafter, prompt spectacle correction for significant errors, and vigilant amblyopia surveillance in anisometropic children. Parent, neonatologist, and pediatrician education on long-term visual consequences of ROP treatment is equally important, with Zone I infants requiring especially close monitoring given their higher refractive risk.

CONCLUSION

Refractive errors are common after laser photocoagulation for severe ROP, with myopia predominant, followed by astigmatism and anisometropia, and progressive change continuing through early infancy. Regular cycloplegic refraction, long-term follow-up, and early optical correction are essential to prevent amblyopia and optimize visual development, and early identification/management of refractive errors can significantly improve long-term visual outcomes in laser-treated ROP infants.

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