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Review

INTRAOCULAR PRESSURE OF PREMATURE NEWBORNS – A SYSTEMATIC REVIEW WITH META-ANALYSIS

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SUMMARY – The intraocular pressure (IOP) ranges of premature newborns are not the same as those in full-term newborns and adult population. The exact ranges and causes, however, differ depending on the measurement techniques used and analysis. Our study aimed to summarize and analyze available information in the up-to-date literature concerning IOP values in premature newborns. We performed a systematic literature review with meta-analysis. Our research showed the mean IOP in premature newborns to range from 10 to 29 mmHg according to different authors, and its mean values were higher in premature compared to full-term newborns. The most commonly analyzed factor that probably affected IOP measurement was central corneal thickness. Longitudinal studies showed that IOP and central corneal thickness declined with maturation of the newborn and both factors were probably correlated. Additional studies with larger sample sizes and better differentiated sample groups need to be performed.

Key words: *Preterm infants; Infants; Central corneal thickness; Intraocular pressure*

Introduction

Premature infants have serious health issues from the day they are born. It is important to know their anatomical and physiological differences from full-term newborns so that we do not misdiagnose, overtreat or underestimate an existing problem. The visual system can suffer serious consequences from prematurity, as most widely discussed matter in the literature is the threat of developing retinopathy of prematurity. However, other problems often occur such as strabismus[1], refractive errors, particularly myopia[2], and cerebral vision impairment[3]. Thiagarajah *et al*. found in a retrospective study that included 247 premature patients that 2% had congenital glaucoma, which is significantly higher than the general population[4]. The authors think that the premature birth led to termination of the development of the trabecular meshwork or angle. Other authors[5,6] did not find a connection between primary congenital glaucoma and prematurity. However, those two conditions can coexist[5], and both are potentially blinding and need to be diagnosed and treated on time. Nakakura *et al*. presented a clinical case in 2021 that posed a difficulty in differentiating primary congenital glaucoma and large disks cupping which can be common in premature infants[7]. Ricci speculated that even the slightly increased intraocular pressure

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(IOP) in premature newborns could facilitate the development of retinopathy of prematurity because it can lead to significant reduction in the ocular perfusion pressure[8]. Everything mentioned so far makes it even more important to know the normal IOP ranges in premature infants. Our study aimed to summarize and analyze the available information in the up-to-date literature.

Material and Methods

We performed a systematic literature review using the key words "intraocular pressure", "preterm", "premature", "infants", "newborns", "neonates" in Pubmed, Google Scholar, and free search. It included 20 articles with information on IOP measurement in premature newborns, 10 of which were cross-sectional, 4 of them case-control studies comparing IOP between prematurely born and full-term infants, and 6 longitudinal studies. A meta-analysis of the four case-control studies was performed using Review Manager 5.4.

Results

Many teams have tried to estimate the mean IOP in premature newborns throughout the years. However, there have been great variations among the results of different studies. The first group of studies that we included in our review were cross-sectional studies[9-18] (Table 1), in which the authors had measured IOP in premature newborns at a certain point after birth (usually trying to do the measurement within the first week after birth and/or when the newborn is sufficiently stable) without following its changes with the growth of the infant. Their results showed serious variance, from 10 mmHg to 29 mmHg. All those studies were insufficient in count (from 21 to 70 patients) and were performed on premature newborns with different gestational age and birth weight. Even though some of the studies were done with the same type of devices[3,6,7,9] (Tono-pen, Reichart technologies, United States), their results still showed significant variation (from 10.3 mmHg to 24 mmHg). When using Tono-pen, local anesthesia and lid speculum were also used and the authors claimed that the infants were calm during the

Table 1. Cross-sectional studies of IOP in premature infants

Author/Year	Device	Subjects, n	GA	Mean IOP
1 Blockhurst[9], 1955	McLean tonometer	59	Premature	24.5 mmHg
2 Musarella and Morin[10], 1985	Perkins applanation tonometer	37	Premature	18.04 mmHg OD 18.62 mmHg OS
3 Tucker[11], 1992	Hand-held Tonopen II	70	<37 weeks	10.3 mmHg
4 Spierer[12], 1994	Noncontact Pulsair tonometer	53	32.7±2.9 weeks	10.11±2.21 mmHg
5 McKibbin[13], 1999	Ocular blood flow Tonograph	13	34 weeks	15.4 mmHg
6 Haus[14], 2008	Tono-Pen XL ICare rebound tonometer	69	28.4 weeks	16 mmHg 9 mmHg
7 Jeon[15], 2009	Tono-pen	58	<37 weeks	15.14±4.64 mmHg OD 15.29±3.70 mmHg OS
8 Zengin[16], 2014	—	—	Premature	17.2 mmHg
9 Khaja[17], 2014	Tono-pen XL	24	34.3 weeks	24.28 mmHg
10 Grover[18], 2016	—	45	28.2+/-2.3 weeks	29.0±9.0 mmHg

IOP = intraocular pressure; GA = gestational age

measurement. The oldest study that we found in the literature was published by Blockhurst[9] *et al.* in 1955. The measurements were performed with McLean tonometer (E. B. Meyrowitz, United States) and showed a medium value of 24.5 mmHg. Musarella and Morin[10] measured IOP with Perkins applanation tonometer (Haag-Streit UK, United Kingdom**)** and showed a value of 18 mmHg. Tucker *et al.*[11] and Spierer *et al.*[12] showed IOP of 10 mmHg and did not find correlation with gestational age and birth weight of the infants. The other two recent studies[17,18] showed much higher IOP values, i.e., 24 mmHg and 29±9 mmHg, respectively, which correlated with gestational age and birth weight of the newborns. The more so, Khaja *et al.*[17] found a weak but positive correlation with the central corneal thickness (CCT) but Grover *et al.*[18] did not. McKibben *et al.*[13] were the first to measure IOP with an ocular blood flow tonograph. In their study, the newborns were sedated and eye speculum was not used. The mean IOP that they found was 15.4 mmHg. Haus *et al.*[14] were the first to compare the mean IOP measured with ICare (Icare Finland Oy) rebound tonometer and Tono-pen XL tonometer in premature newborns. They found a significant difference between the results achieved with those two devices, i.e., 9 mmHg for ICare rebound tonometer (SD 2.2 mmHg) and 16 mmHg for Tono-pen (SD 4.4 mmHg). IOP values were significantly lower when evaluated by ICare rebound tonometer than by Tono-pen. According to these authors, ICare rebound tonometer reflected IOP better. They thought that Tono-pen measurements were probably falsely elevated due to defense and discomfort reactions to the anesthetic eye drops and bigger size of eyelid opening.

Another group of studies that we analyzed were four case-control cross-sectional studies[19-22] (Table 2) performed in a prospective manner, which compared CCT and IOP values between premature and full-term newborns. All infants were examined only once during the study period, not multiple times on different dates. All the studies from this group showed that IOP and CCT were higher in premature newborns compared to full-term newborns. Only the results of Muslubas *et al.*[20] showed no difference between IOP in premature and full-term infants, probably because of the higher gestational age (36.3±0.9 gestational

Table 2. Cross-sectional prospective case-control studies of IOP and CCT in premature and full-term newborns

Author	Country	Type of study device	Premature, n	GA (weeks)	Measurement age (weeks)	IOP premature (mmHg)	CCT (µm)	Full term, n	IOP full-term (mmHg)	CCT
1 Uva[19], 2011	Italy	Tono-pen XL; portable pachymeter (Pachmate DGH-55)	33	31±3	34±3	18.9±3.7	599±36	33	17±2.6	576±26
2 Muslubas[20], 2014	Turkey	Tono-pen Avia; portable pachymeter	45	31.5±2.7	36.3±0.9	16.2±2.7	600 ± 50	45	16.6±2.3	586±48
3 Karahan[21], 2015	Turkey	Tonopen XLTM; portable pachymeter, AccupachVI	63	28.5±2.1	32.7±1.7	17.5±2.1	576.5±16.4	55	16.3±1.9	562.7±18.4
4 Acar[22], 2015	Turkey	Tono-Pen XL ultrasonic pachymetry (Compact Touch 3-in-1 Ultrasound system)	89	29.24±2.25	32	19.39 ± 2.22	653.99 ±42.02	49	16.86±2.93	590.67±58.26

IOP = intraocular pressure; CCT = central corneal thickness; GA = gestational age

age) of the premature infants included in the study. All studies showed that CCT was higher in premature infants compared to full-term newborns. Uva *et al.*[19] and Acar *et al.*[22] showed that there was a correlation between CCT and IOP, which both declined with maturation of the infant. However, Muslubas *et al.*[20] and Karahan *et al.*[21] found no such correlation. All the mentioned studies had several limitations, i.e., small sample size; different characteristics of examined infants (postconceptual age, birth weight, age after birth, etc.); and cross-sectional design.

To analyze and combine data from the four case-control studies, we performed a meta-analysis using Rev Man 5.4. We used two variables, IOP and CCT, and compared the mean difference between their mean values in premature and full-term newborn babies. We used a random effect model due to the small size of the studies included. The mean difference in IOP (Fig. 1) between premature and full-term newborns was 1.83 mmHg (CI 0.91-2.74), which was slightly but significantly higher in preterm newborns. The mean difference of CCT according to our meta-analysis (Fig. 2) was 17.57 μm (CI 7.93-27.22), significantly higher in premature newborns. The test for the overall effect showed statistical significance for the two forest plots. To avoid heterogeneity, we excluded the study by Muslubas *et al.*[20] in the first forest plot (Fig. 1) and the study by Acar *et al.*[22] in the second forest plot (Fig. 2).

We also included six longitudinal studies[8,23-27] in our systematic review (Table 3) following the measurement of IOP in premature newborns. In each of them, the measurements were performed in the same infant on different dates at different time intervals. This type of studies gave the most accurate information considering

Study of Subgroup	Premature Mean [mmHg]	Premature SD [mmHg]	Premature Total	Full term Mean [mmHg]	Full term SD [mmHg]	Full term Total	Weight	Mean Difference IV, Random, 95% CI	Year
UVA, 2011	18.9	3.7	33	17	2.6	33	21.8%	1.90 [0.36, 3.44]	2011
Muslaubas 2014	16.2	2.7	45	16.6	2.3	45	0.0%	-0.40 [-1.44, 0.64]	2014
Acar, 2015	19.39	2.22	89	16.86	2.93	49	35.8%	2.53 [1.59, 3.47]	2015
Karahan 2015	17.5	2.1	63	16.3	1.9	55	12.4%	1.20 [0.48, 1.92]	2015
Total (95% CI)			**185**			**137**	**100.00%**	**1.83 [0.91, 2.74]**	

Heterogeneity Tau² = 0.00; Ch² = 0.83, df = 2 (P = 0.66); P = 0%
Test for overall effect Z = 3.57 (P = 0.0004)

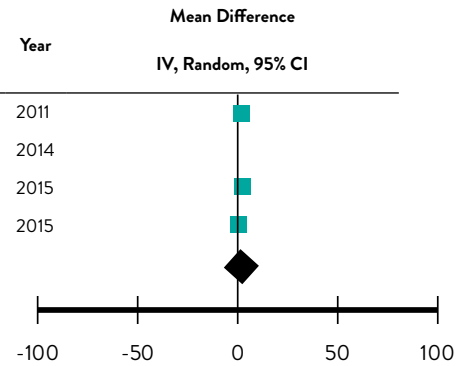

Fig.1. Meta-analysis of difference in intraocular pressure between premature and full-term infants.

Study of Subgroup	Premature Mean [mmHg]	Premature SD [mmHg]	Premature Total	Full term Mean [mmHg]	Full term SD [mmHg]	Full term Total	Weight	Mean Difference IV, Random, 95% CI	Year
UVA, 2011	599	36	33	576	26	33	40.5%	23.00 [7.85, 38.15]	2011
Muslaubas 2014	600	50	45	586	48	45	22.7%	14.00 [-6.25, 34.25]	2014
Acar, 2015	653.99	42.02	89	590.67	18.4	49	0.0%	63.32 [53.18, 73.46]	2015
Karahan 2015	576.5	16.4	63	562.7	58.2	55	36.8%	13.80 [-2.11, 29.71]	2015
Total (95% CI)			**141**			**133**	**100.0%**	**17.57 [7.93, 27.22]**	

Heterogeneity Tau² = 0.00; Ch² = 0.83, df = 2 (P = 0.66); P = 0%
Test for overall effect Z = 3.57 (P = 0.0004)

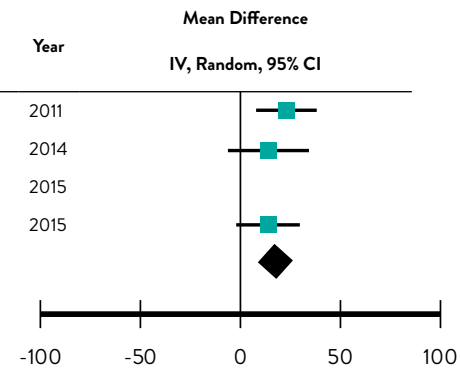

Fig. 2 Meta-analysis of difference in central corneal thickness between premature and full-term infants.

Table 3. Longitudinal studies of IOP measurement in premature newborns

Author/Device	Subjects, n	GA at birth	Measurements of IOP						
			After birth	Week 1	Week 2	Week 3	Week 4	Week 6	Week 8
1 Ricci[8], 1999 Proton, Tomey	20	26-32 weeks	13.23±2.86 mmHg	12.17±2.39 mmHg	12.51±1.3 mmHg	11.75±1.84 mmHg	10.96±1.84 mmHg	—	—
2 Ng[23], 2008 Tono-Pen	104	29.8 weeks	16.57 mmHg	—	—	—	16.13 mmHg	—	15.91 mmHg
3 Lindemeyer[24], 2012 Tono-Pen XL	41	29.7±1.6 weeks	—	14.9±4.5 mmHg	14.6 mmHg	14.32 mmHg	14.03 mmHg	13.74 mmHg	13.45 mmHg
4 Sekeroglu1[25], 2015 Tono-Pen	170	31.9 ±2.6 weeks	—	—	—	—	14.1±1.9 mmHg	—	13.7±1.7 mmHg
5 Acar[26], 2016 Tono-pen	110	28 weeks	—	—	—	—	18.28±2.78 mmHg	16.13±2.20 mmHg	14.67±2.04 mmHg
6 Balci[27], 2018 Tono-pen	40	26 weeks	----	---	18.7 ± 1.1 mmHg	---	15.3±0.9 mmHg	---	13.7±1.3 mmHg

GA = gestational age; IOP= intraocular pressure

IOP changes after birth. All authors used Tono-pen for measuring IOP, except for Ricci[8] who used ProTon (Tomey, Japan). Balci *et al.*[27] and Acar *et al.*[26] included a very homogeneous group of newborns, 26 weeks and 28 weeks of gestational age at birth, respectively. All studies[8,23-27] showed a statistically significant ($p<0.01$) decline of IOP values with negative correlation to the post conceptual age and birth weight of infants. All these studies[8,23-27] used local anesthesia and all of them except for Balci *et al.*[27] used eyelid speculum. Balci *et al.*[27] gently separated the eyelids manually without applying pressure to the globe. The results reported by Ng *et al.*[23] show that IOP was also negatively associated with the mean blood pressure, Apgar score at 1 minute, and use of inhaled corticosteroids, but correlated positively with high-frequency oscillatory ventilation. They also failed to show correlation between IOP and stage of retinopathy of prematurity[23]. Sekeroglu *et al.*[25] examined not only IOP but also CCT in premature newborns. This was the first longitudinal study to follow both values in different post conceptual ages in the same infant. The CCT and IOP were positively correlated with each other, and both were negatively correlated with gestational age, chronological age, and birth weight during first and second visits. Acar *et al.*[26] have also reported similar results later.

Discussion

Measuring IOP is a primary diagnostic method in assessing pediatric glaucoma patients and following the effects of their treatment. However, in pediatric patients measuring IOP with Goldman tonometry, which is the gold standard, is not possible, so other methods have been introduced. Studies[28,29] have shown that Tono-Pen and ICare are suitable devices in measuring IOP in newborns because they are better in measuring IOP in edematous corneas. Gandhi *et al.*[30] showed slightly higher measurement of IOP with Tono-Pen than with Goldman applanation tonometer. However, Iester *et al.*[31] did not find significant difference between the two devices and showed enough precision for accurate screening. ICare rebound tonometer does not require topical anesthetic and is well tolerated by children. However, in the study performed by McKee *et al.*[32], ICare showed results by 2 mmHg lower than with Tono-pen and this difference was greater in corneas with edema. The study by Haus *et al.*[14] also showed significantly lower measurement of IOP in premature newborns with ICare compared to Tono-pen. Since CCT (Table 2) is significantly thicker in premature compared to full-term newborns, Tono-pen might still be a better device to measure IOP in this age group.

Shiotz tonometry is rarely used in modern ophthalmic practice because it is less accurate in children due to decreased scleral rigidity. It is no longer considered acceptable method for measuring IOP in children except if no other devices are available[33].

Artificial IOP increase may develop due to increased venous pressure caused by Valsalva maneuver produced by resisting examination, forced closure of the eyelids, or use of eyelid speculum. Epley *et al.*[34] showed that using eyelid speculum in measuring IOP in children elevated it by an average of 4 mmHg. They performed the measurement under general anesthesia in order to exclude other factors such as vigorous resistance and forced eyelid closure. In 2022, Çiçek *et al.*[35] also showed average IOP rise by 2.6 mmHg caused by the use of eyelid speculum. They used ICare rebound tonometer under topical anesthesia. That is why the effects of using eyelid speculum need to be considered when measuring IOP in children. The use of general anesthesia, however, also has effects on IOP, mostly by decreasing it. According to Mikhail *et al.*[33], midazolam needs to be used for sedation if necessary because most of the studies do not show effect on IOP. If intubation is performed, then 3-5 minutes need to pass before measuring IOP.

The meta-analysis that we performed showed a 1.27 mmHg IOP difference between premature and full-term infants, and all the longitudinal studies also showed negative correlation of IOP measurement with postconceptual age of the infant. There are different theories trying to explain this phenomenon. According to Ricci[8] as one of the first authors to analyze this problem, it might be a result of the maturation of the aqueous drainage system induced by transition from the intrauterine to extrauterine environment. Karahan *et al.*[21] discussed whether this phenomenon represented a programmed maturation process related to an increase in dimensions of ocular structures under the influence of complex neuroendocrine control. Most recent studies have shown that the decrease in IOP with growth of the newborn is possibly due to a decrease in CCT. The gradual decrease in CCT after birth is due to better control of corneal hydration[36], corneal remodeling, and stretching of collagen fibers[3].

Other factors also need to be considered when measuring IOP in a newborn, such as mode of delivery, especially when measured in the first 24 hours after birth. Some authors[38,39] found a significant decrease in IOP in the first 12-24 hours after birth. They also found higher IOP in vaginally delivered newborns than those born with cesarean section. This difference might be caused by blood hormonal changes and physical stress[40].

Conclusion

The exact reference ranges of IOP in premature newborns have not been established so far. Our meta-analysis showed that IOP was significantly higher in premature infants compared to full-term newborns with a mean difference of 1.27 mmHg. All longitudinal studies showed significant negative correlation between the postconceptual age of infants and IOP. According to most authors, the method of choice for measuring IOP has been Tono-pen but the use of eyelid speculum needs to be avoided to prevent artificial increase. The exact causes of IOP decrease are not completely clear up to this point. Most probably, it is related to gradual CCT decrease with maturation of the newborn. Additional studies performed in a longitudinal pattern of larger sample sizes and better differentiated sample groups need to be performed and to follow changes in both IOP and CCT. Other factors such as mode of delivery, Apgar score, blood pressure, and medications need to be included in further analysis as well.

References

1. Gulati S, Andrews C, Apkarian A, *et al.* Effect of gestational age and birth weight on the risk of strabismus among premature infants. JAMA Pediatr. 2014;168(9):850-6. doi: 10.1001/jamapediatrics.2014.946
2. Larsson E, Rydberg A, Holmstrom G. A population-based study of the refractive outcome in 10-year-old preterm and full-term children. Arch Ophthalmol. 2005;123:825-32. doi: 10.1001/archopht.121.10.1430
3. O'Connor A, Wilson C, Fielder A. Ophthalmological problems associated with preterm birth. Eye. 2007;21(10):1254-60. doi: 10.1038/sj.eye.6702838
4. Thiagarajah C, Kern M, Jones LS. Case series of neonates with concomitant retinopathy of prematurity and congenital glaucoma. Invest Ophthalmol Vis Sci. 2006 May;47:720.

5. Senthil S, Balijepalli P, Garudadri C, Jalali S. Clinical presentation and management outcomes of coexistent congenital glaucoma and retinopathy of prematurity. J Glaucoma. 2019;28(1):20-6. doi:10.1097/ijg.0000000000001124
6. Dragosloveanu CD, Potop V, Coviltir V, *et al*. Prematurity – risk factor or coincidence in congenital glaucoma? Medicina. 2022;58(3):334. doi: 10.3390/medicina58030334
7. Nakakura S, Terao E, Kuroda N, Fujio S, Hirose Y, Tabuchi A, Kiuchi Y. A case report on premature twins: primary congenital glaucoma or large cupping disks mimicking primary congenital glaucoma? Cereus. 2021;13(8):e17108. doi: 10.7759/cureus.17108
8. Ricci B. Intraocular pressure in premature babies in the first month of life. J AAPOS. 1999;3:125-7. doi: 10.1016/s1091-8531(99)70083-2
9. Brockhurst RJ. The intraocular pressure of premature infants. Am J Ophthalmol. 1955;39(6):808-11. doi: 10.1016/0002-9394(55)90168-9
10. Musarella MA, Morin JD. Anterior segment and intraocular pressure measurements of the unanesthetized premature infants. Metab Pediatr Syst Ophthalmol. 1985;8:53-60. PMID: 3916748
11. Tucker SM, Enzenauer RW, Levin AV, Morin JD, Hellmann J. Corneal diameter, axial length, and intraocular pressure in premature infants. Ophthalmology. 1992;99(8):1296-300. doi: 10.1016/s0161-6420(92)31812-3
12. Spierer A, Huna R, Hirsh A, Chetrit A. Normal intraocular pressure in premature infants. Am J Ophthalmol. 1994; 117:801-3. doi: 10.1016/s0002-9394(14)70326-5
13. McKibbin M, Cassidy L, Dabbs TR, Verma D, McKibbin M. Intraocular pressure, pulse amplitude and pulsatile ocular blood flow measurement in premature infants screened for retinopathy of prematurity. Eye (Lond). 1999;13(Pt 2):266-7. doi: 10.1038/eye.1999.68
14. Haus AH, Jonescu-Cuypers C, Seitz B, Kaesmann-Kellner B. Comparison between intraocular pressure measurements with ICare rebound tonometry and Tonopen XL tonometry in premature infants. Invest Ophthalmol Vis Sci. 2008;49(13):712-712.
15. Jeon GS, Yi K. Intraocular pressure and central corneal thickness in premature infants. J Korean Ophthalmol Soc. 2009;50(8):1237-41. doi: https://doi.org/10.3341/jkos.2009.50.8.1237
16. Zengin N, Zengin MÖ, Karahan E, Tuncer I. Alterations in intraocular pressure and central corneal thickness in premature newborns. İzmir Dr. Behçet Uz Çocuk Hastanesi Dergisi. 201 4;4(1):20-4.
17. Khaja W, Chalam KV, Grover S. Normative data for intraocular pressure and central corneal thickness in preterm infants. Invest Ophthalmol Vis Sci. 2014;55(13):5913-5913.
18. Grover S, Zhou Z, Haji S, *et al*. Intraocular pressure in premature low birth weight infants. J Pediatr Ophthalmol Strabismus. 2016;53(5):300-4. doi: 10.3928/01913913-20160629-03
19. Uva MG, Reibaldi M, Longo A, *et al*. Intraocular pressure and central corneal thickness in premature and full-term newborns. J AAPOS. 2011;15(4):367-9. doi: 10.1016/j.jaapos.2011.04.004
20. Muslubas IB, Oral AY, Cabi C, Caliskan S. Assessment of the central corneal thickness and intraocular pressure in premature and full-term newborns. Indian J Ophthalmol. 2014;62(5):561-4. doi: 10.4103/0301-4738.133486
21. Karahan E, Zengin MO, Tuncer I, Zengin N. Correlation of intraocular pressure with central corneal thickness in premature and full-term newborns. Eur J Ophthalmol. 2015;25(1):14-7. doi: 10.5301/ejo.5000494
22. Acar DE, Acar U, Tunay ZO, *et al*. The intraocular pressure and central corneal thickness in healthy premature infants. J AAPOS. 2015 Apr;19(2):108-11. doi: 10.1016/j.jaapos.2014.10.027
23. Ng P, Tam B, Lee C, *et al*. A longitudinal study to establish the normative value and to evaluate perinatal factors affecting intraocular pressure in preterm infants. Invest Ophthalmol Vis Sci. 2008;49(1):87-92. doi: 10.1167/iovs.07-0954
24. Lindenmeyer RL, Farias L, Mendonça T, Fortes Filho JB, Procianoy RS, Silveira RC. Intraocular pressure in very low birth weight preterm infants and its association with postconceptional age. Clinics. 2012;67:1241-5. doi:10.6061/clinics/2012(11)03
25. Sekeroglu MA, Hekimoglu E, Petricli İS, *et al*. Central corneal thickness and intraocular pressure in premature infants. Int Ophthalmol. 2015;35(6):847-51. doi: 10.1007/s10792-015-0062-x
26. Acar DE, Acar U, Ozdemir O, Tunay ZO. Determination of normal values of intraocular pressure and central corneal thickness in healthy premature infants – a prospective longitudinal study. J AAPOS. 2016;20(3):239-42. doi: 10.1016/j.jaapos.2016.02.012
27. Balci O, Tanriverdi C, Gulkilik G, Aras C, Tastekin A. Longitudinal assessment of intraocular pressure in premature infants. Eur J Ophthalmol. 2018;28(1):108-11. https://dx.doi.org/10.5301/ejo.5000992
28. Yıldırım N, Sahin A, Basmak H, Bal C. Effect of central corneal thickness and radius of the corneal curvature

on intraocular pressure measured with the tonopen and noncontact tonometer in healthy schoolchildren. J Pediatr Ophthalmol Strabismus. 2007;44:216-22. doi: 10.3928/01913913-20070701-02

29. Neuburger M, Maier P, Böhringer D, Reinhard T, F Jordan J. The impact of corneal edema on intraocular pressure measurements using Goldmann applanation tonometry, Tono-Pen XL, iCare, and ORA: an *in vitro* model. J Glaucoma. 2013;22:584-90. doi: 10.1097/IJG.0b013e31824cef11
30. Gandhi PD, Gurses-Ozden R, Liebmann JM, Ritch R. Attempted eyelid closure affects intraocular pressure measurement. Am J Ophthalmol. 2001;131:417-20. doi: 10.1016/s0002-9394(00)00802-3
31. Iester M, Mermoud A, Acheche F, Roy S. New tonopen XL: comparison with the Goldmann tonometer. Eye (Lond). 2001;15(Pt 1):52-8. doi: 10.1038/eye.2001.13
32. McKee E, Ely A, Duncan J, Dosunmu E, Freedman S. A comparison of Icare PRO and Tono-Pen XL tonometers in anesthetized children. J AAPOS. 2015;19(4):332-7. doi: 10.1016/j.jaapos.2015.04.004
33. Mikhail M, Sabri K, Levin A. Effect of anesthesia on intraocular pressure measurement in children. Surv Ophthalmol. 2017:62(5):648-58. doi: 10.1016/j.survophthal.2017.04.003
34. Epley K, Tychsen L, Lueder G. The effect of an eyelid speculum on intraocular pressure measurement in children. Am J Ophthalmol. 2002 Dec;134(6):926-7. doi: 10.1016/s0002-9394(02)01793-2
35. Çiçek A, Bayram N, Alabay B, Vural E. The effect of an eyelid speculum on intraocular pressure measurement in newborns. J Pediatr Ophthalmol Strabismus. 2022;59(1):13-6. doi: 10.3928/01913913-20210518-01
36. Al-Umran KU, Pandolfi MF. Corneal diameter in premature infants. Br J Ophthalmol. 1992;76:292-3. doi: 10.1136/bjo.76.5.292
37. Kirwan C, O'Keefe M, Fitzsimon S. Central corneal thickness and corneal diameter in premature infants. Acta Ophthalmol Scand. 2005;83:751-3. doi: 10.1111/j.1600-0420.2005.00559.x
38. Yaprak DÇ, Karagöz IK, Elbay A, Bayraktar BT, Kılıç G. The changes in intraocular pressure and central corneal thickness in the first 24 hours of life in full-term newborns. South Clin Ist Euras. 2018;29(4):254-7. doi: 10.14744/scie.2018.69885
39. Ozkurt ZG, Balsak S, Balsak B, *et al*. The effects of delivery type and gender on intraocular pressure and central corneal thickness in newborns. Arq Bras Oftalmol. 2016;79:92-5. doi: 10.5935/0004-2749.20160028
40. Elbay A, Celik U, Celik B, *et al*. Intraocular pressure in infants and its association with hormonal changes with vaginal birth *versus* cesarean section. Int Ophthalmol. 2016;36(6):855-60. doi: 10.1007/s10792-016-0215-6

Sažetak

INTRAOKULARNI TLAK NEDONOŠČADI – SUSTAVNI PREGLED S METAANALIZOM

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Rasponi intraokularnog tlaka nedonoščadi nisu isti kao kod donošene novorođenčadi i odrasle populacije. Točni rasponi i uzroci, međutim, razlikuju se ovisno o primijenjenim tehnikama mjerenja i analize. Cilj našega istraživanja bio je sažeti i analizirati dostupne informacije u suvremenoj literaturi o vrijednostima očnog tlaka u nedonoščadi. Izveli smo sustavni pregled literature s metaanalizom. Naše je istraživanje pokazalo da se prosječni očni tlak u nedonoščadi kretao od 10-29 mmHg prema različitim autorima, a njegove srednje vrijednosti bile su veće u nedonoščadi u odnosu na novorođenčad u terminu. Najčešće analizirani čimbenik koji je vjerojatno utjecao na mjerenje očnog tlaka bila je debljina središnje rožnice. Studije su pokazale da su intraokularni tlak i debljina središnje rožnice opadali sa sazrijevanjem novorođenčeta i da su oba čimbenika vjerojatno povezana. Potrebno je provesti dodatne studije s većim uzorcima i bolje diferenciranim skupinama uzoraka.

Ključne riječi: *Nedonoščad; Dojenčad; Središnja debljina rožnice; Intraokularni tlak*