



Assessing Perioperative and Long-Term Outcomes of Delayed Cranial Vault Reconstruction in Nonsyndromic Single-Suture Craniosynostosis Patients



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Introduction

Craniosynostosis is a congenital condition characterized by premature fusion of one or more cranial sutures, affecting approximately 5.9 per 10,000 live births worldwide and presenting as either syndromic or nonsyndromic.¹⁻³ Premature suture fusion restricts normal skull growth and may result in elevated intracranial pressure, disrupted brain development, and progressive orbital abnormalities.⁴ Surgical correction is the mainstay of management, with intervention commonly performed between 4–8 months of age.^{5, 8-10} However, national data demonstrate that many children undergo surgery beyond this window.¹¹ Delayed surgery may increase complications and adverse outcomes, but its long-term effects remain unclear.^{6,12-13}

Purpose

To evaluate the impact of delayed cranial vault reconstruction (≥13 months) on perioperative, neurodevelopmental, and ophthalmologic outcomes in patients with nonsyndromic single-suture craniosynostosis.

Methods

Design:

- Retrospective cohort study (2014–2021) at a single tertiary craniofacial center

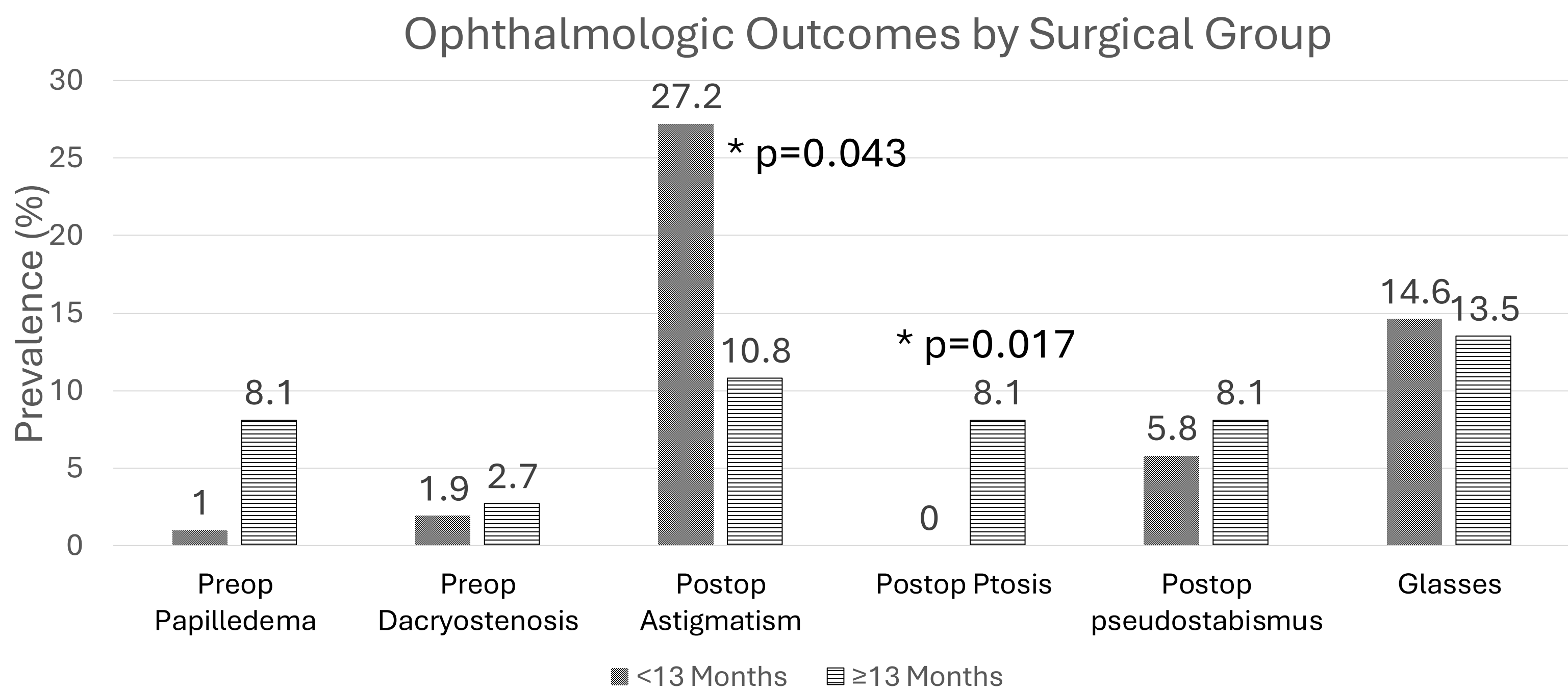
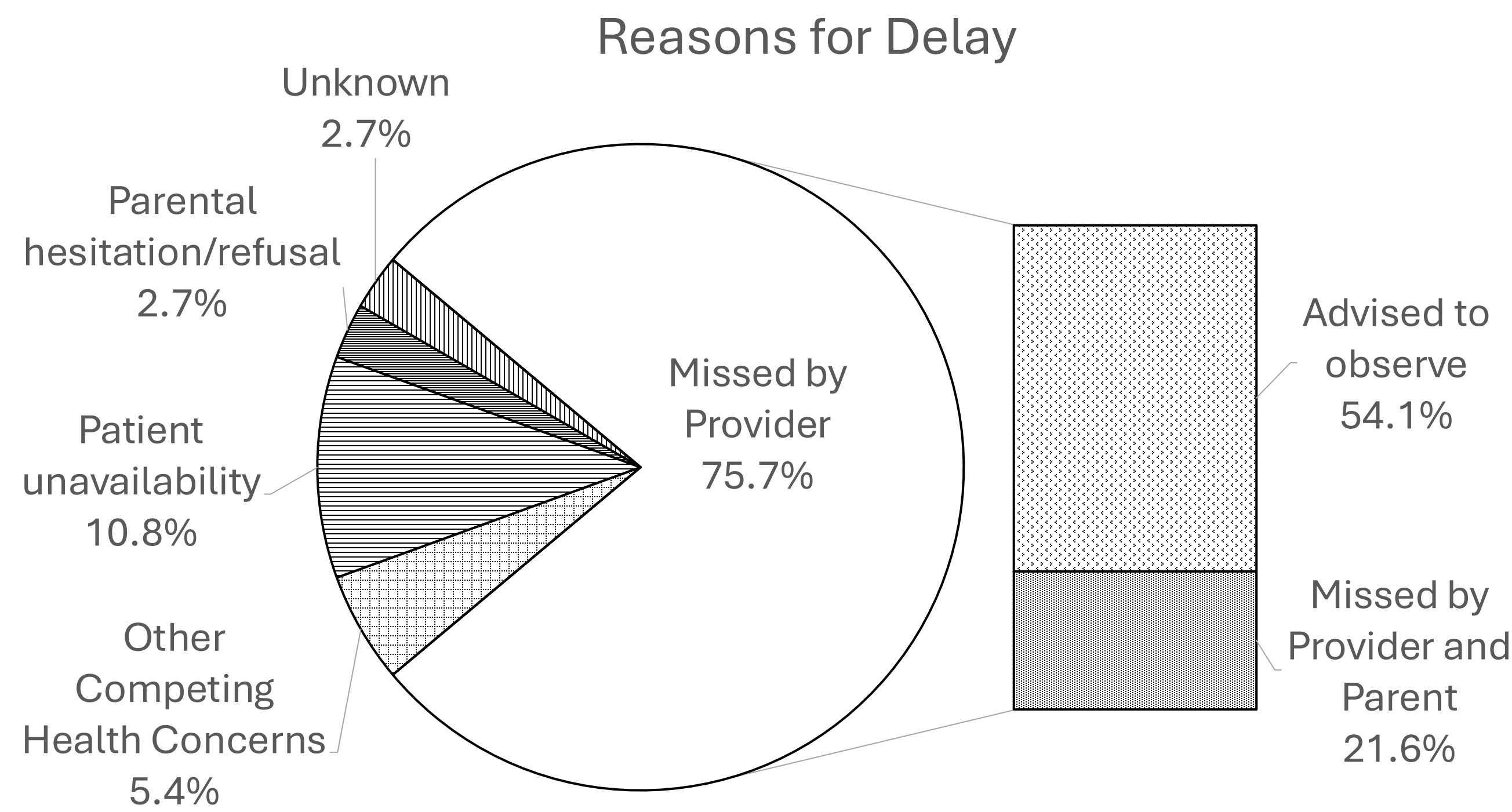
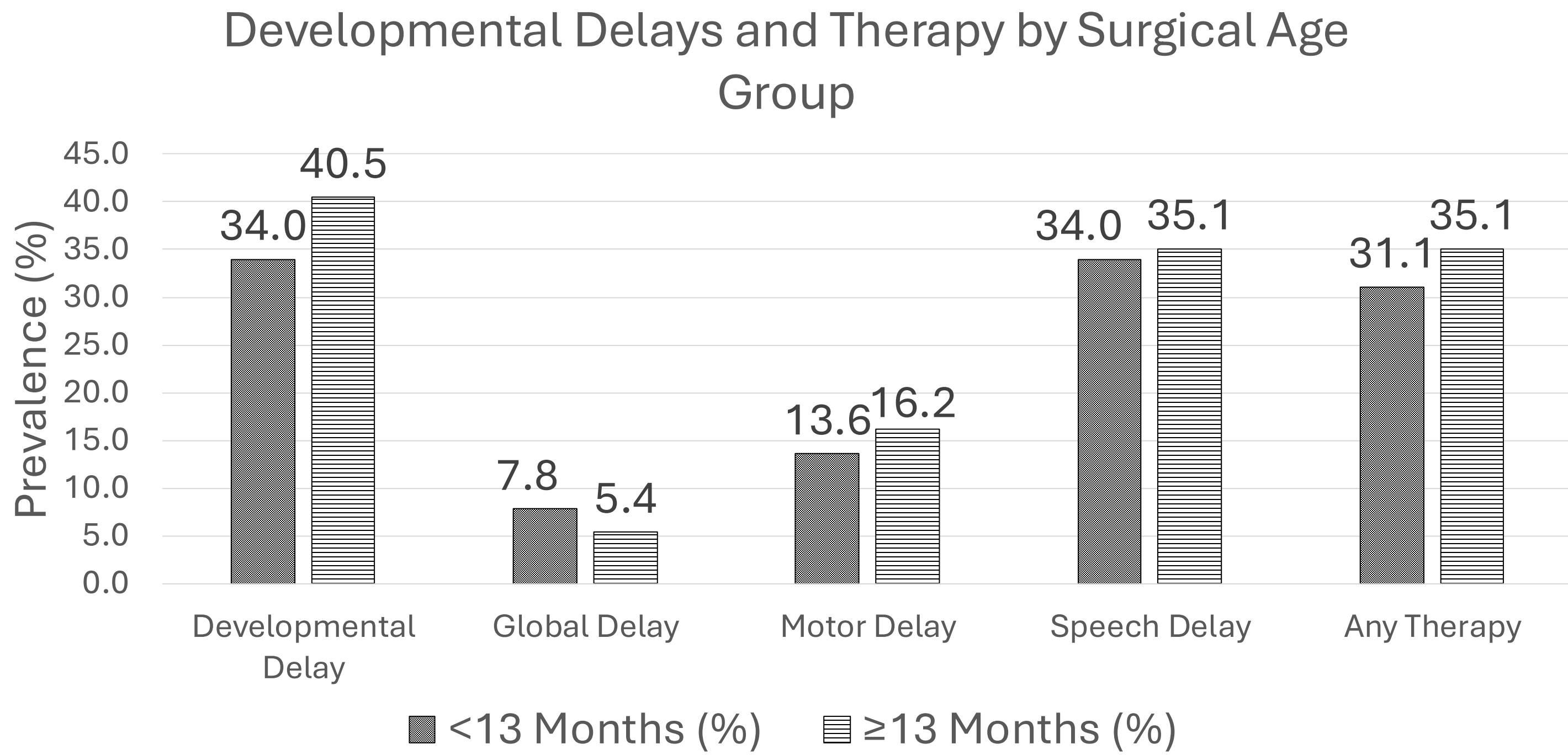
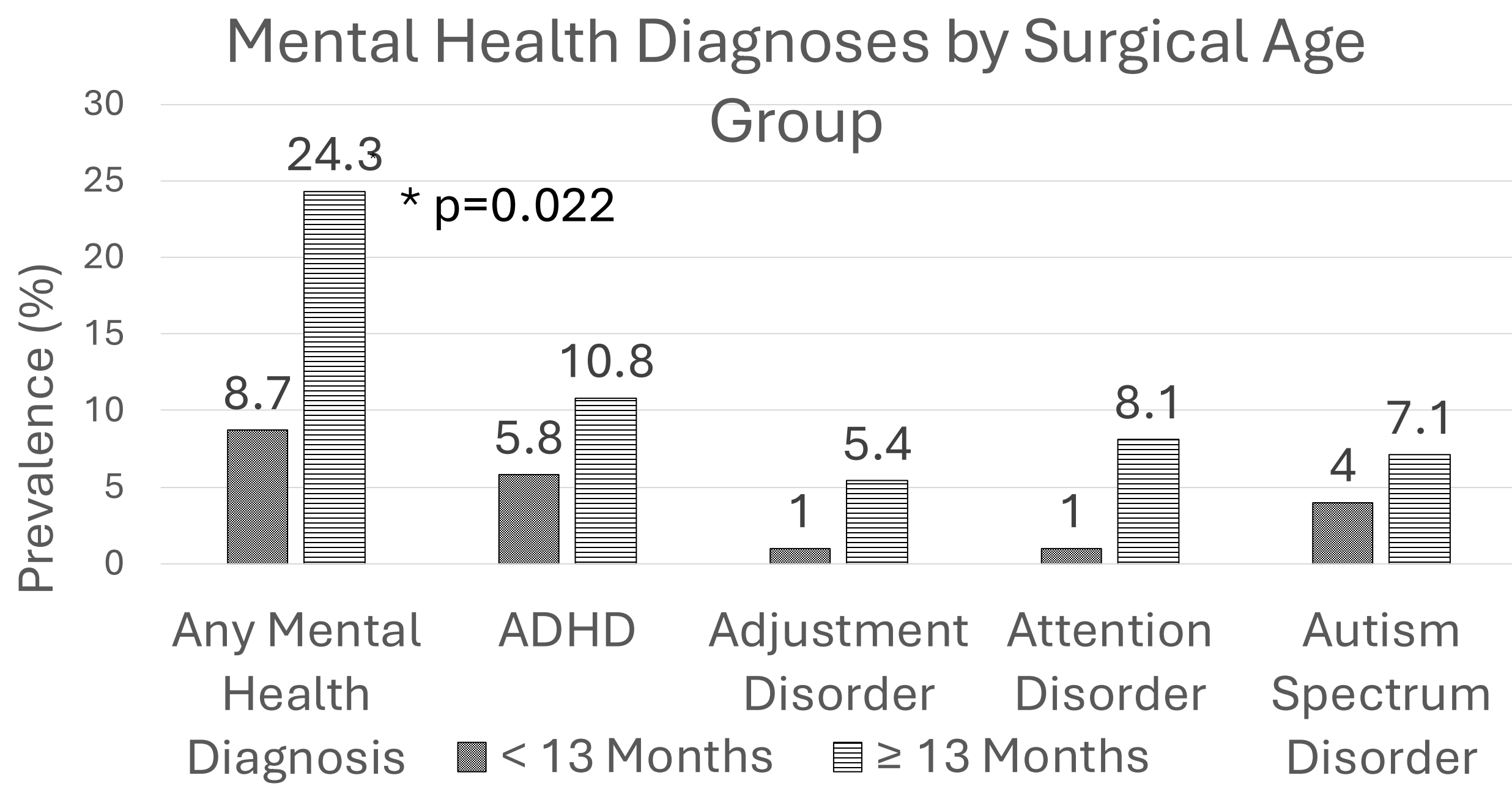
Patients:

- Nonsyndromic single-suture craniosynostosis (NSCS)
- Underwent open cranial vault reconstruction (CVR)
- ≥1 year multidisciplinary follow-up (plastic surgery + neurosurgery)

Statistical Analysis:

- t-test, Wilcoxon, Chi-square, Fisher’s exact
- Multivariable logistic and linear regression
- Significance: $p < 0.05$
- Software: R (v4.4.1)

Results



Citations

- Governale LS. Craniosynostosis. *Pediatr Neurol*. 2015;53(5):394-401. doi:10.1016/j.pediatrneurol.2015.07.006
- Shlobin NA, Baticulon RE, Ortega CA, et al. Global Epidemiology of Craniosynostosis: A Systematic Review and Meta-Analysis. *World Neurosurg*. 2022;164:413-423.e3. doi:10.1016/j.wneu.2022.05.093
- Xue AS, Buchanan EP, Hollier LH. Update in Management of Craniosynostosis. *Plast Reconstr Surg*. 2022;149(6):1209e-1223e. doi:10.1097/PRS.00000000000009046
- Stanton E, Urata M, Chen JF, Chai Y. The clinical manifestations, molecular mechanisms and treatment of craniosynostosis. *Dis Model Mech*. 2022;15(4):dmm049390. doi:10.1242/dmm.049390
- Mathijssen IMJ. Updated Guideline on Treatment and Management of Craniosynostosis. *J Craniofac Surg*. 2021;32(1):371. doi:10.1097/SCS.00000000000007035
- Bruce WJ, Chang V, Joyce CJ, Cobb AN, Maduekwe UI, Patel PA. Age at Time of Craniosynostosis Repair Predicts Increased Complication Rate. *Cleft Palate Craniofacial J*. 2018;55(5):649-654. doi:10.1177/1055665617725215
- Nguyen HT, Washington GN, Cepeda A, et al. Characterization of Regional Morphological Changes in Sagittal Craniosynostosis Following Endoscopic Strip Craniectomy With Post-operative Helmting: Predictors for Success. *J Craniofac Surg*. 2023;34(6):1677-1681. doi:10.1097/SCS.00000000000009433
- Layliev J, Gill R, Spear M, Cifuentes J, Wang L, Kelly KJ. The Optimal Timing for Primary Cranial Vault Reconstruction in Nonsyndromic Craniosynostosis. *J Craniofac Surg*. 2016;27(6):1445-1452. doi:10.1097/SCS.00000000000002730
- Dias MS, Samson T, Rizk EB, Governale LS, Richtsmeier JT, SECTION ON NEUROLOGIC SURGERY SOPARS. Identifying the Misshapen Head: Craniosynostosis and Related Disorders. *Pediatrics*. 2020;146(3):e2020015511. doi:10.1542/peds.2020-015511
- Utria AF, Mundinger GS, Bellamy JL, et al. The importance of timing in optimizing cranial vault remodeling in syndromic craniosynostosis. *Plast Reconstr Surg*. 2015;135(4):1077-1084. doi:10.1097/PRS.0000000000001058
- Puthumana JS, Lopez CD, Lake IV, Yang R. Evaluation of Complications and Outcomes in Craniosynostosis by Age of Operation: Analysis of the National Surgical Quality Improvement Program-Pediatric. *J Craniofac Surg*. 2023;34(1):29. doi:10.1097/SCS.00000000000008872
- Patel A, Yang JF, Hashim PW, et al. The Impact of Age at Surgery on Long-Term Neuropsychological Outcomes in Sagittal Craniosynostosis. *Plast Reconstr Surg*. 2014;134(4):608e. doi:10.1097/PRS.0000000000000511
- Bennett KG, Vick AD, Ettinger RE, Archer SM, Vercler CJ, Buchman SR. Age at Craniosynostosis Surgery and Its Impact on Ophthalmologic Diagnoses: A Single-Center Retrospective Review. *Plast Reconstr Surg*. 2019;144(3):696. doi:10.1097/PRS.00000000000005915

		<13 months n= 103		≥13 months n=37		p-value
		n	%	n	%	
Sex	Male	39	37.9	11	29.7	0.493
	Female	64	62.1	26	70.3	
Suture						0.608
	Sagittal	52	50.5	20	54.1	
	Coronal	16	15.5	7	18.9	
	Metopic	27	26.2	6	16.2	
Race	Lambdoid	8	7.8	4	10.8	0.133
	White	33	32	9	24.3	
	Asian	9	8.7	9	24.3	
	Hispanic	43	41.7	17	45.9	
	Black	1	1	0	0	
EBL/kg						0.371
	Intraop.	24.7	11.9	22.4	12.5	
	Transfusion/kg	20.4	13	19.5	8.3	
	Postop	2.43	6.33	2.22	7.32	
Change in Hg						0.330
	Change in Hct	0.182	0.238	0.146	0.143	
Complications						0.136
	Transfusion Rx	0	0	1	2.7	
	Postop Infection	1	1	0	100	
	Dural tear	2	1.9	0	100	
	Postop Hypotension	1	1	1	2.7	
	Postop Tachycardia	5	4.9	2	5.4	
	Air Embolism	1	1	0	100	
	FOA	6	5.8	3	8.1	
	Chiari	0	100	0	100	
	Decompression	1	1	3	8.1	
Additional Operations						0.057
	CVR	42	40.8	18	48.6	
Intraoperative TXA						0.445
	Yes					

Conclusions

- Later surgery (≥13 months) was associated with longer operative times but not increased perioperative risk.
- Developmental delays and therapy needs were similar regardless of surgical timing.
- Later surgery was associated with a higher overall burden of mental health diagnoses.
- Later surgery (≥13 months) was associated with higher rates of postoperative ptosis.
- Earlier surgery (<13 months) was associated with higher rates of pathologic astigmatism.
- Comorbidities and prematurity were stronger predictors of developmental outcomes than surgical age.
- Delayed surgery was most commonly driven by diagnostic oversight and missed early recognition.
- Later surgery was associated with older age at referral and longer times from referral to surgery.
- Overall delayed surgery appears safe perioperatively but may influence select neuropsychiatric and ophthalmologic outcomes, underscoring the importance of early recognition and referral.