



Superior Outcomes in Endoscopic Strip Craniectomy Before Three Months of Age for Nonsyndromic Craniosynostosis

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Introduction

Management of all craniosynostosis (CS) is primarily surgical, including both **open calvarial vault remodeling (CVR)** and **endoscopic strip craniectomy (ESC)**.¹⁻⁴ In ESC, the fused suture is excised, and barrel staves are created, both in minimally invasive fashion such that postoperative helmet, spring, or distractor device assistance allows for more gradual remodeling.^{5,6}

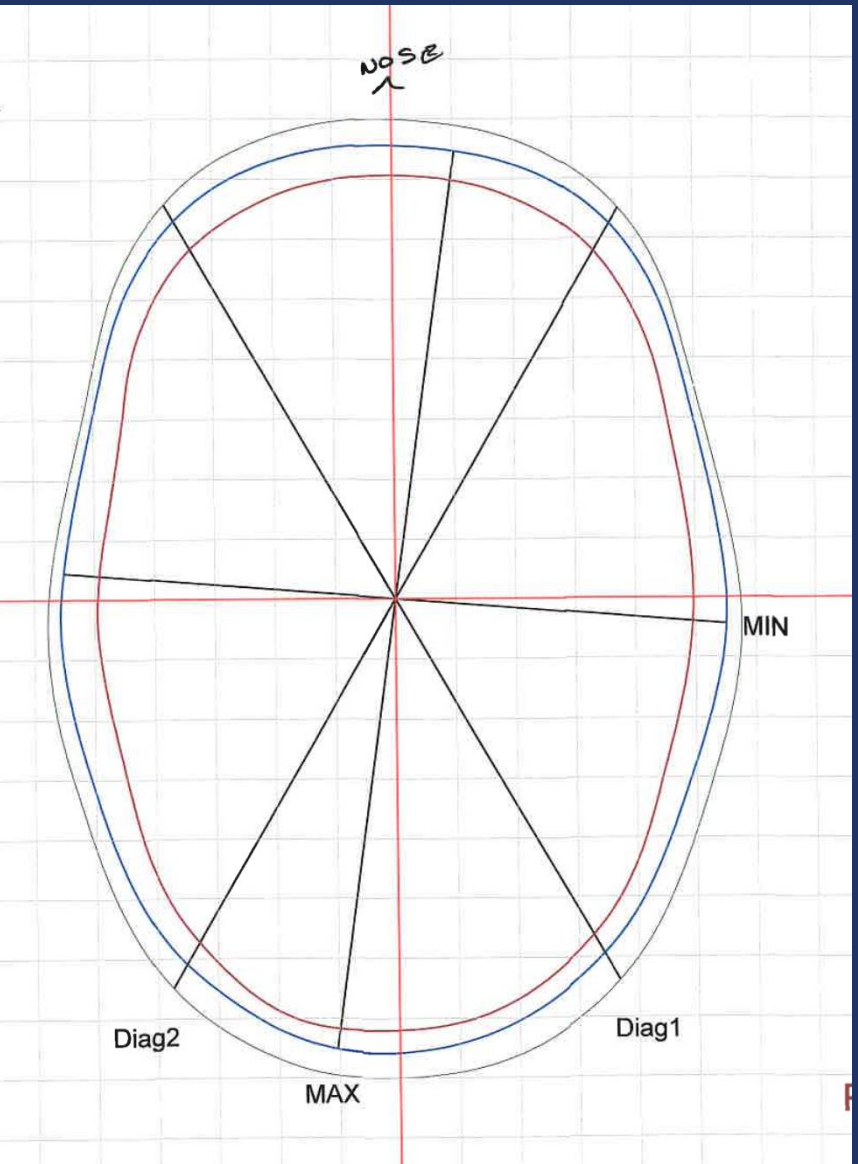
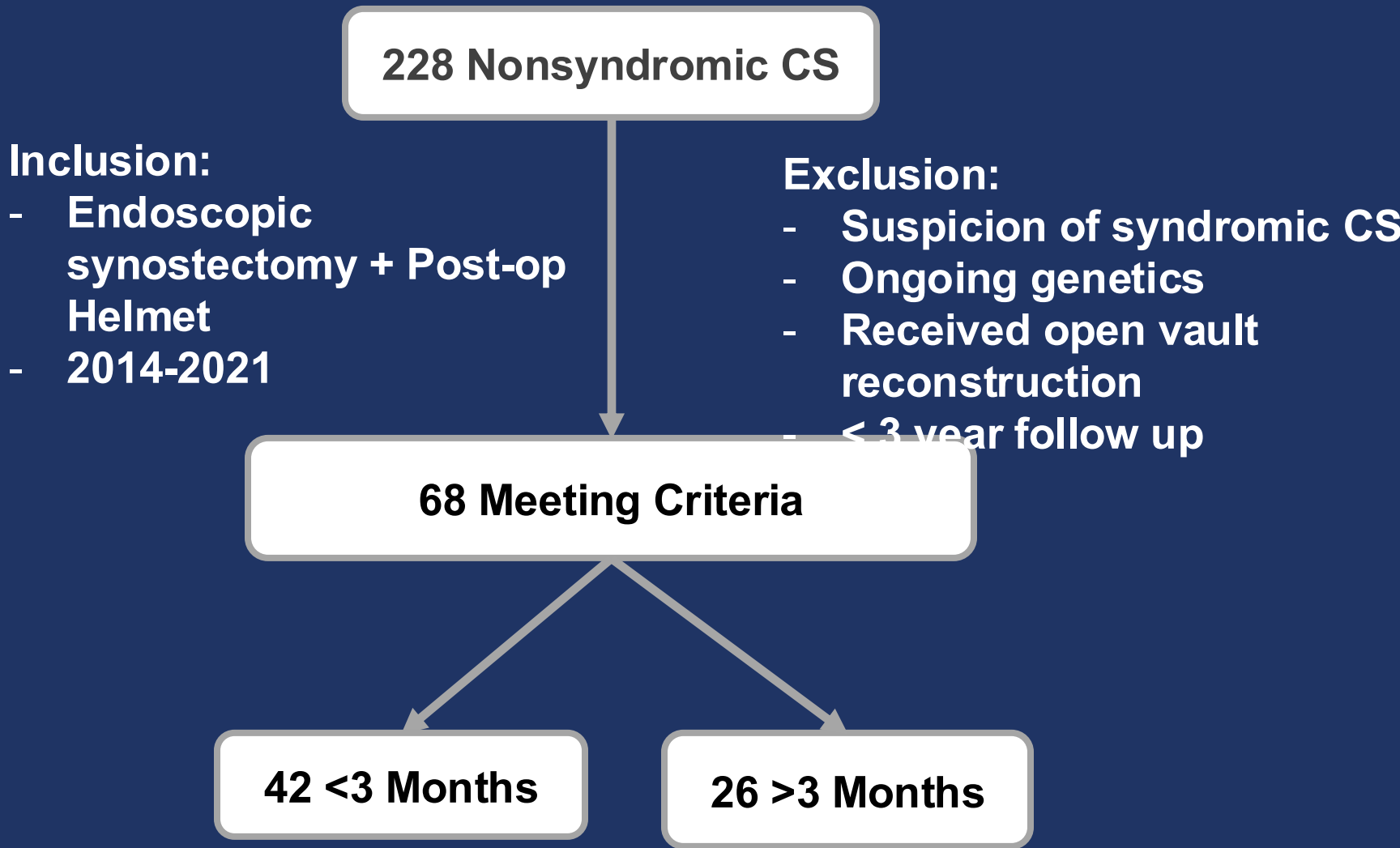
Currently, **ESC is recommended for patients between 3 and 6 months of age** given that rapid cranial growth and age-appropriate cranial malleability facilitate postoperative reshaping.⁶ However, increasing evidence suggests that **surgery at even earlier ages may lead to faster deformity correction and reduced risk of neurological comorbidities**.^{7,8} Although ESC has been successfully performed in children as young as 2 weeks of age,⁹ the literature supporting positive outcomes at operative ages younger than 3 months remains sparse.

Purpose

We sought to compare the **perioperative and long-term outcomes of ESC** performed for NSCS patients **less than 3 months old vs. those for patients 3 months and older** in order to assess the **safety, efficacy, and potential advantages** of providing earlier **endoscopic intervention** for NSCS management.

Methods

- All patients with nonsyndromic craniosynostosis (NSCS) who were seen at Stanford University's Cleft and Craniofacial Clinic and underwent endoscopic strip craniectomy (ESC) with in-house postoperative helmeting between 2014 and 2021 were included.
- All patients who had syndromic CS or suspicion of syndromic CS with ongoing genetic workup; had undergone cranial vault remodeling (CVR); or had less than 1 year of in-house postoperative follow-up were excluded.



- Age at pediatrician-initiated referral impacted age at surgery. Patients referred before 4 months of age were offered ESC. ESC could be performed up to age 6 months by parental request. All ESC cases were performed with perpendicular barrel staves.
- Patients were stratified into 2 groups based on age at surgery of < 3 months or ≥ 3 months for retrospective record review conducted by 3 independent reviewers and including demographic information, medical history, perioperative variables, anthropometric measurements, and neurocognitive and ophthalmologic outcomes.

Results

		<3 months n=42		>3 months n=26		p-value
		Mean	SD	Mean	SD	
Age at Surgery	Years	2.09	0.49	4.01	0.89	<0.001*
Weight at Surgery	Kg	5.23	0.96	6.53	1.89	<0.001*
		n	%	n	%	p-value
Sex	Male	29	71.43	17	62.50	0.574
	Female	13	28.57	9	37.50	
Suture	Sagittal	27	64.28	12	46.15	0.145
	Coronal	9	21.42	3	11.54	
	Metopic	6	14.29	8	30.77	
	Lambdoid	1	2.38	1	3.85	
	>1 Suture	0	0.00	2	7.69	
Race	White	16	38.09	11	42.31	0.606
	Asian	5	11.90	0	0	
	Hispanic	14	33.33	12	46.15	
	Black	1	2.38	2	7.69	
	Other	5	11.90	0	0	
Comorbidities	Cardiac	0	0.00	0	0.00	1.000
	Respiratory	0	0.00	1	4.17	0.407
	Neurologic	2	5.71	0	0.00	0.513
	Renal	3	8.57	1	4.17	0.639

		<3 months n=42		>3 months n=26		p-value
		Mean	SD	Mean	SD	
EBL/kg	mL/kg	8.49	7.11	7.16	5.00	0.431
Intraop Transfusion/kg	mL/kg	11.39	15.46	12.33	16.69	0.826
Postop Transfusion/kg	mL/kg	6.66	10.84	2.94	5.42	0.126
Change in Hg	Unit	1.49	2.29	0.88	3.99	0.467
Change in Hct	Unit	5.29	7.77	2.17	9.82	0.184
Helmet duration	Months	10.15	2.91	9.37	5.26	0.503
		n	%	n	%	p-value
Intraoperative TXA		11	31.43	10	41.67	0.581

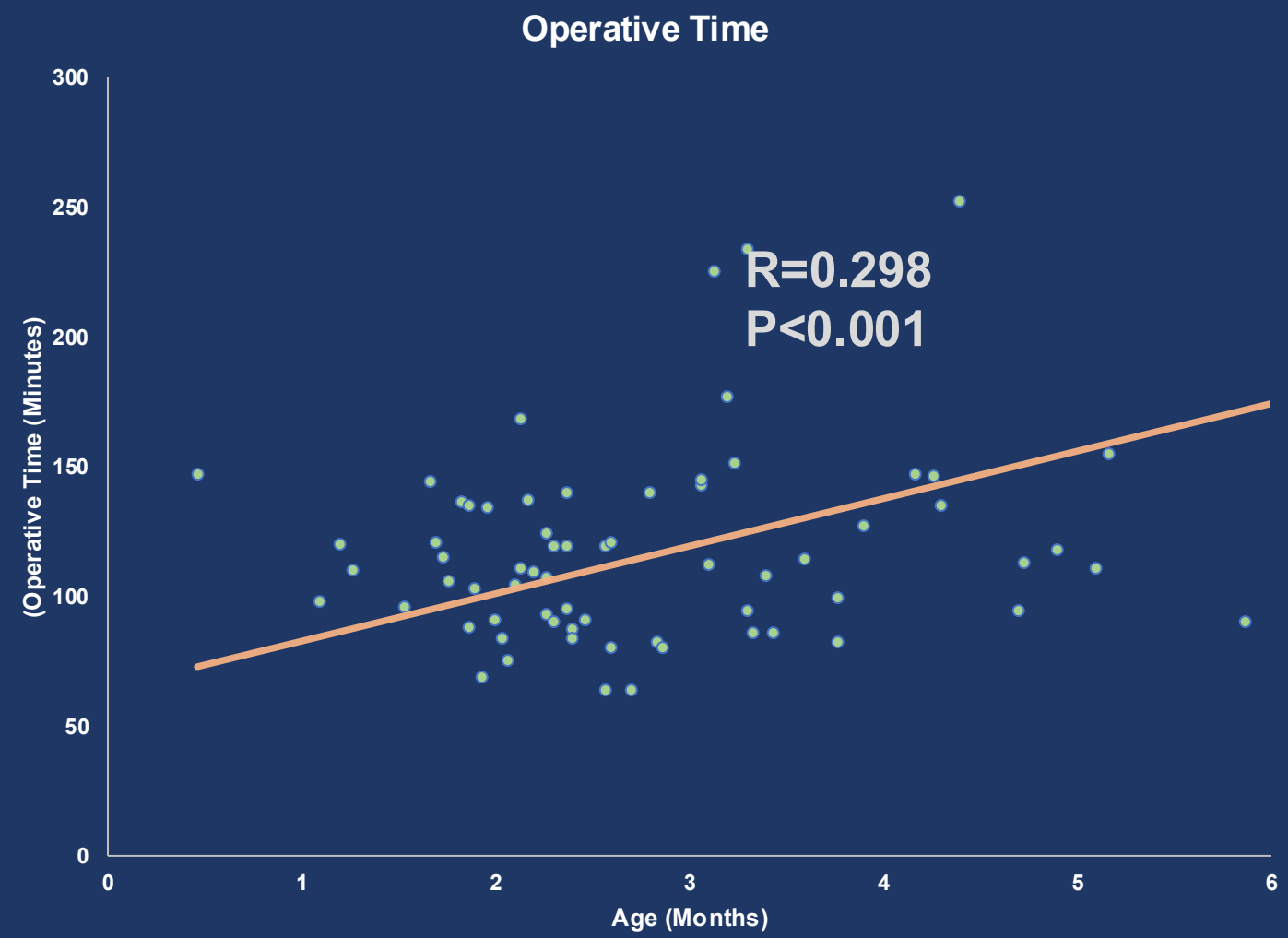
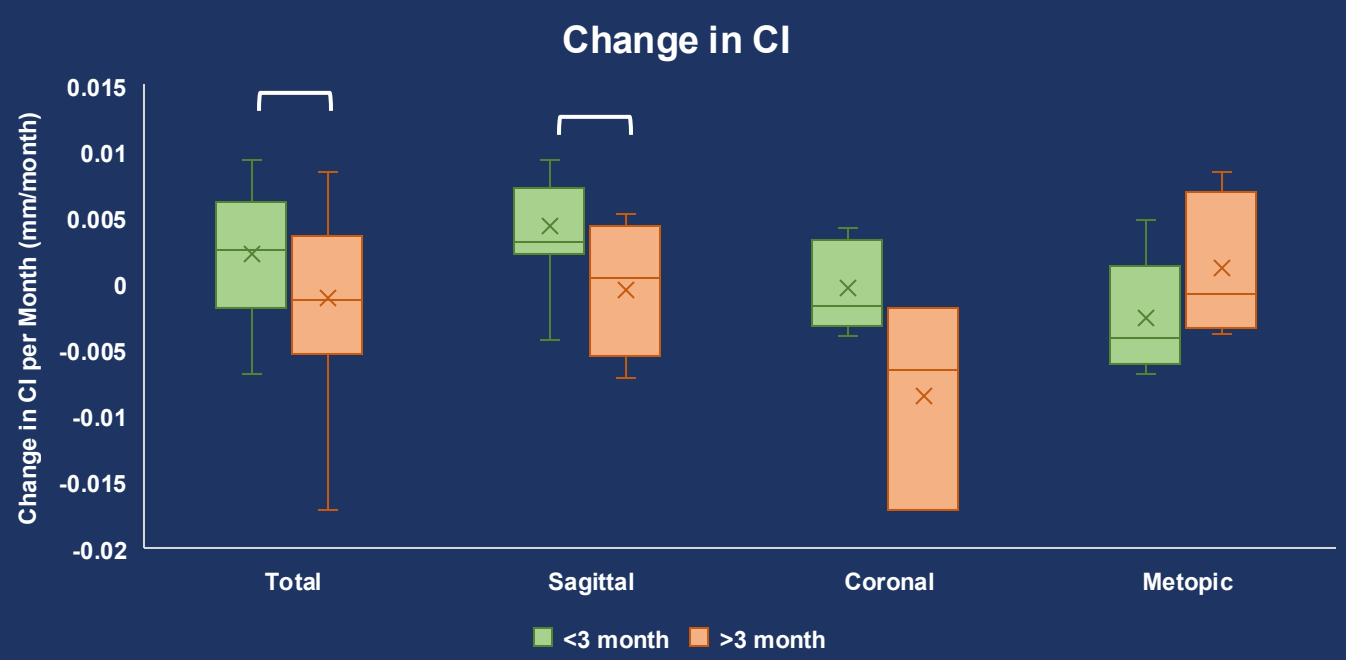
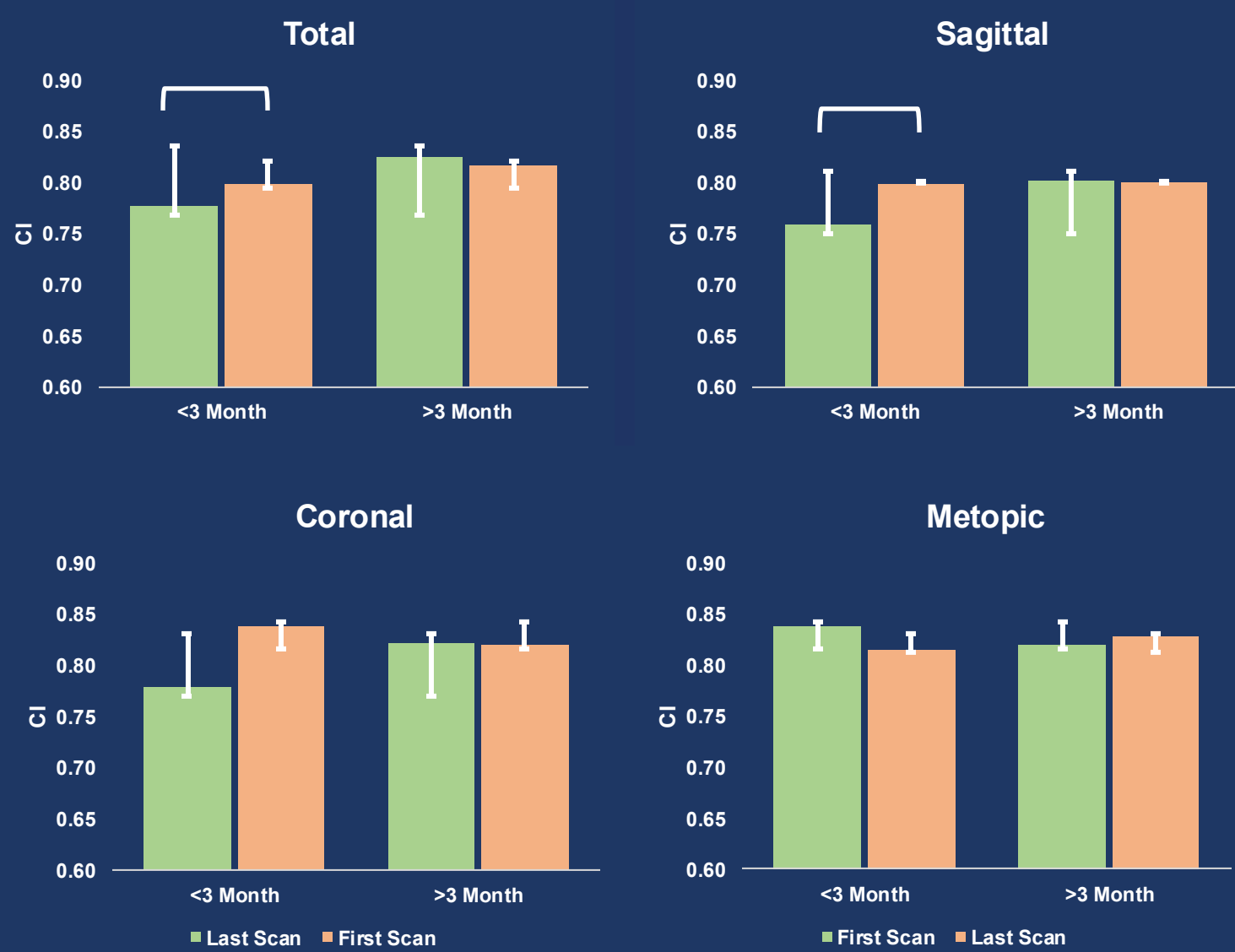


Figure 1. Operative Time vs. Age at Surgery
There was a significant, positive correlation between patient age at initial surgery and operative time (R = 0.298, p < 0.001).



		<3mo	Final Scan >3mo	p-value	Difference Last-First Scan <3mo	>3mo	p-value	Change/Month <3mo	>3mo	p-value
Total	AP	166.10	162.94	0.29	19.00	17.23	0.43	1.944	1.929	0.95
	ML	132.30	132.54	0.90	18.60	13.10	0.01	1.916	1.432	0.01
	CI	0.80	0.82	0.24	0.02	-0.01	0.74	0.002	-0.001	0.74
	RSI	14.35	20.80	0.17	-7.39	-6.68	0.72	-0.800	-0.638	0.71
	CVA	2.70	2.79	0.90	-1.27	-1.79	0.51	-0.136	-0.197	0.46
Sagittal	AP	168.61	165.65	0.53	15.94	16.80	0.78	1.645	1.673	0.93
	ML	134.23	131.51	0.32	18.89	13.35	0.07	1.982	1.281	0.01
	CI	0.80	0.80	0.96	0.04	0.00	0.71	0.004	-0.001	0.71
	RSI	15.18	16.05	0.83	-5.35	-7.41	0.70	-0.629	-0.780	0.80
	CVA	2.91	1.86	0.32	-0.92	-2.23	0.24	-0.111	-0.230	0.32
Metopic	AP	161.16	162.54	0.71	22.46	16.88	0.08	2.348	1.931	0.17
	ML	131.36	134.33	0.35	22.28	15.33	0.99	1.557	1.770	0.60
	CI	0.82	0.83	0.64	-0.02	0.01	0.24	-0.003	0.001	0.20
	RSI	13.96	16.24	0.70	-6.42	-4.83	0.73	-0.729	-0.610	0.82
	CVA	1.90	3.51	0.25	-0.98	-1.53	0.67	-0.096	-0.179	0.59
Coronal	AP	162.02	159.35	0.67	26.58	20.45	0.26	2.619	2.470	0.73
	ML	126.26	130.83	0.40	20.86	12.05	0.13	2.039	1.329	0.13
	CI	0.78	0.82	0.13	0.00	-0.04	0.43	0.000	-0.005	0.31
	RSI	14.52	34.58	0.29	-15.70	-6.73	0.41	-1.488	-0.470	0.49
	CVA	2.76	3.18	0.85	-2.80	-1.08	0.45	-0.265	-0.128	0.53

Table 3, Figure 2 & 3. Craniometric outcomes
NSCS patients with **sagittal CS** operated on at **< 3 months of age** had larger changes in overall cephalic index (CI) (0.04 vs. 0.00 AU, p = 0.014) than their older counterparts. They also had **faster changes in the mediolateral (ML) dimension and CI** per week (1.98 vs. 1.29 mm/week, p = 0.011; 0.004 vs. 0.000 mm/week, respectively).

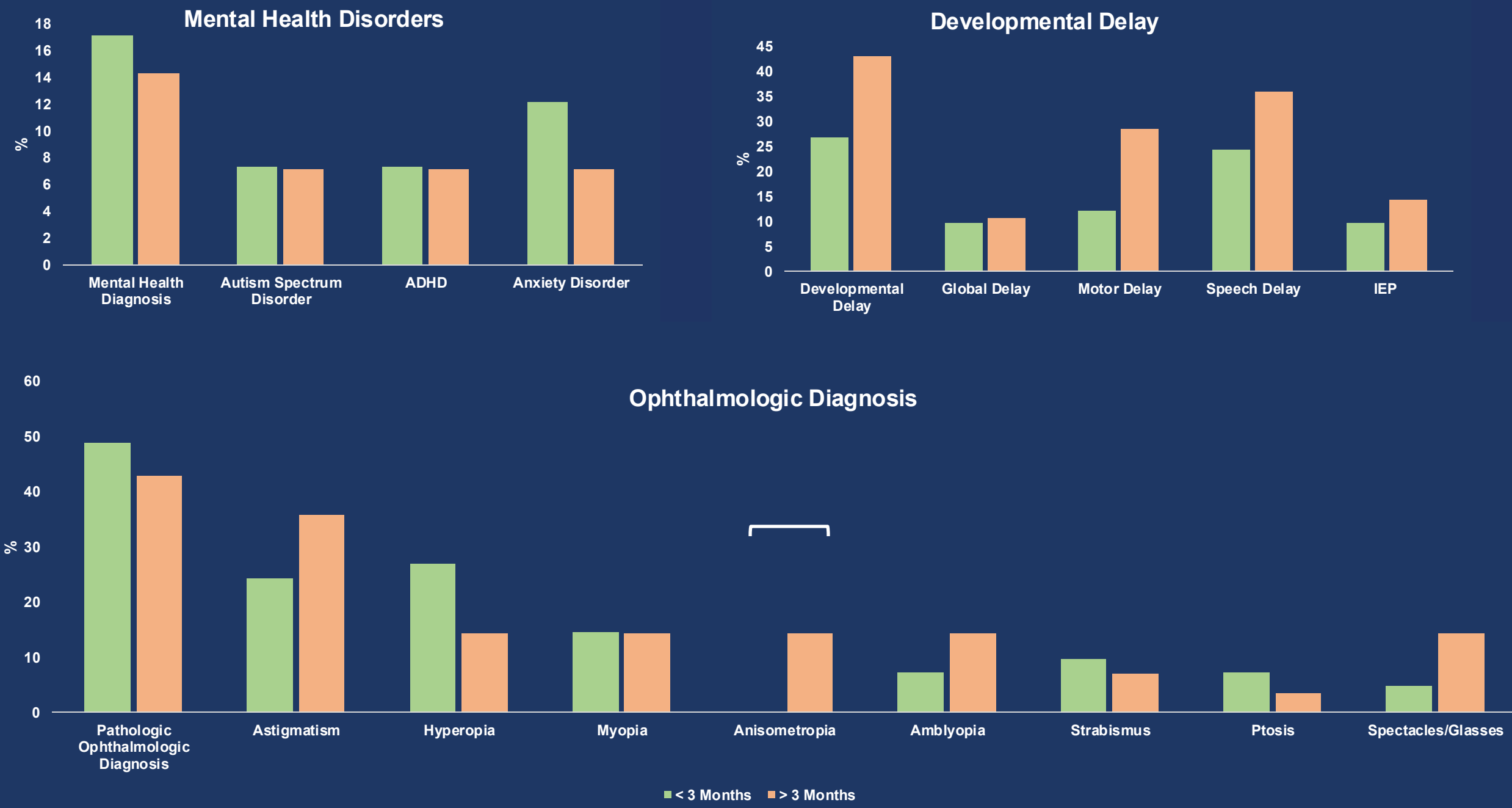


Table 4, Figure 4. Developmental, mental health, and ophthalmologic outcomes.
Significantly fewer patients operated on at < 3 months of age were diagnosed with anisometropia as compared to their older counterparts (0% vs. 15.38%, p = 0.023). This trend persisted when controlled for other relevant variables (OR > 100, p < 0.001). All other outcomes were similar between cohorts.

Conclusions

NSCS patients who underwent ESC before age 3 months demonstrated faster average operative times, a lower prevalence of anisometropia, and faster and larger changes in both their cephalic index (CI) and mediolateral (ML) dimension. This study suggests that **ESC performed before the current recommendation of at least 3 months of age** is not only **safe and effective**, but **may also lead to better perioperative, cosmetic, and neuro-ophthalmologic outcomes**, especially for those with sagittal craniosynostosis.

Citations

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