



A Diffusion Tensor Imaging Comparison of White Matter Development in Nonsyndromic Craniosynostosis to Neurotypical Infants

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Background & Purpose

- Nonsyndromic craniosynostosis (NSC) is associated with neurocognitive deficits
- Intervention at infancy is standard of care to limit the negative effects of NSC on brain development
- This study implemented diffusion tensor imaging (DTI) to investigate white matter microstructure in infants with NSC undergoing cranial vault remodeling compared to age-matched neurotypical controls**

Methods

- Infants with NSC ($n=12$) underwent DTI scans before and after cranial vault remodeling
- Neurotypical infants ($n=5$), age matched to NSC patients at preoperative scans, were compared to preoperative DTI scans
- Pre- and postoperative NSC scans were compared in aggregate, and the sagittal synostosis ($n=8$) patients were evaluated separately
- Finally, neurotypical infants from the University of North Carolina/University of New Mexico Baby Connectome Project (BCP), who underwent DTI scans at timepoints matching the NSC pre- and postoperative DTI scans, were analyzed ($n=9$)
- Trends over the same time period were compared between NSC and BCP scans
- DTI parameters analyzed were fractional anisotropy (FA) and mean, axial, and radial diffusivity (MD, AD, RD)

Results

- Comparison of white matter development in pre- and postoperative NSC scans to neurotypical control scans suggests that NSC, particularly sagittal NSC, may affect the early development of certain white matter tracts

- Microstructural development of the *corpus body*, *genu*, *inferior*, and *superior longitudinal fasciculi* appears to consistently lag behind the development observed in the neurotypical control (BCP) cohort

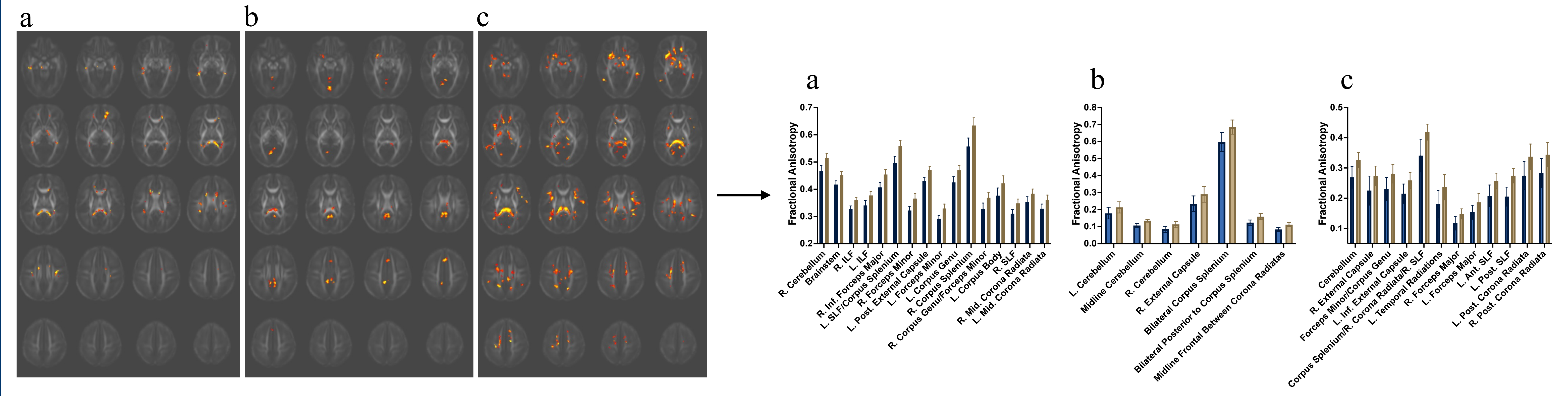


Fig. 1 Coloration shows white matter tracts with significant FA changes across different timepoints for specific patient groups: **a** changes between 5 and 8 months in the BCP cohort ($n=9$, $P<0.0001$); **b** changes between pre- and postoperative scans in the sagittal suture subset of the NSC cohort ($n=8$, $P<0.001$); **c** changes between pre- and postoperative scans in the full NSC cohort ($n=12$, $P<0.001$)

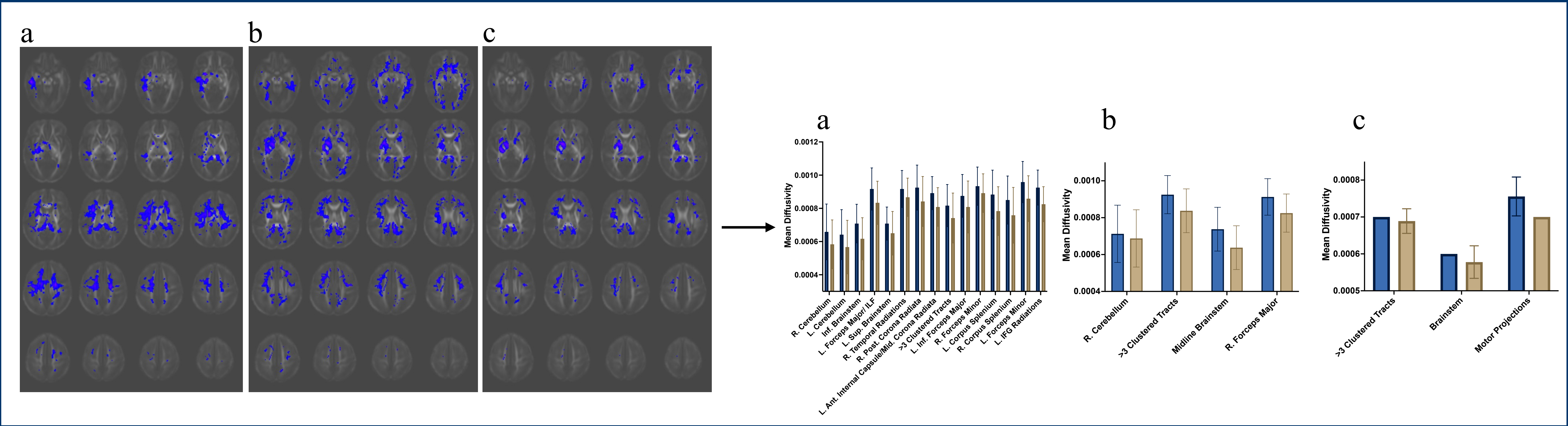


Fig. 2 Coloration shows white matter tracts with significant MD changes across different timepoints for specific patient groups: **a** changes between 5 and 8 months in the BCP cohort ($n=9$, $P<0.0001$); **b** changes between pre- and postoperative scans in the sagittal suture subset of the NSC cohort ($n=8$, $P<0.001$); **c** changes between pre- and postoperative scans in the full NSC cohort ($n=12$, $P<0.0001$)

Results

Table 1 Tracts showing significant changes in FA between scans

DTI Parameter	Fractional Anisotropy		
Patient Group	Baby Connectome Cohort	Full NSC Cohort	Sagittal Suture Subset
Tract Type			
Commissural	Bilateral corpus splenium (+)	Bilateral corpus splenium (+)	Bilateral corpus splenium (+)
	Bilateral corpus genu (+)	Bilateral corpus genu (+)	Bilateral posterior to corpus splenium (+)
	L. corpus body (+)	Bilateral forceps minor (+)	
	Bilateral forceps minor (+)	Bilateral forceps major (+)	
	R. inf. forceps major (+)		
Association	Bilateral SLF (+)	L. ant. SLF (+)	
	Bilateral ILF (+)	L. post. SLF (+)	R. SLF (+)
Projection	Bilateral mid. corona radiata (+)	Bilateral post. corona radiata (+)	Midline frontal between corona radiatas (+)
		R. corona radiata (+)	
Other	R. cerebellum (+)	Bilateral cerebellum (+)	Bilateral cerebellum (+)
	L. post. external capsule (+)	L. inf. external capsule (+)	Midline cerebellum (+)
	Bilateral brainstem (+)	R. external capsule (+)	R. external capsule (+)
		L. temporal radiations (+)	

(+) or (-) indicates whether the change was an increase or decrease, respectively

Table 2 Tracts showing significant changes in MD between scans

DTI Parameter	Mean Diffusivity		
Patient Group	Baby Connectome Cohort	Full NSC Cohort	Sagittal Suture Subset
Tract Type			
Commissural	Bilateral corpus splenium (-)	Bilateral corpus splenium (-)	Bilateral corpus splenium (-)
	Bilateral corpus genu (-)	Bilateral corpus genu (-)	Bilateral forceps minor (-)
	Bilateral corpus body (-)	L. forceps major (-)	Bilateral forceps major (-)
	Bilateral forceps minor (-)		
	Bilateral forceps major (-)		
Association	Bilateral SLF (-)	R. SLF (-)	
	Bilateral ILF (-)	L. ILF (-)	Bilateral ILF (-)
	Bilateral IFOF (-)	R. PIFOF (-)	
Projection	Bilateral corona radiata (-)	R. corona radiata (-)	Bilateral corona radiata (-)
	Bilateral internal capsule (-)	L. mid. corona radiata (-)	
Other		L. ant. internal capsule (-)	
		R. post. internal capsule (-)	
	Bilateral brainstem (-)	Bilateral cerebellum (-)	R. cerebellum (-)
	Bilateral external capsule (-)	Bilateral inf. brainstem (-)	Midline brainstem (-)
	Bilateral motor projections (-)	L. sup. brainstem (-)	Bilateral external capsule (-)
		R. temporal radiations (-)	Bilateral temporal cingulum (-)
		L. IFG radiations (-)	

(+) or (-) indicates whether the change was an increase or decrease, respectively

Conclusions and Clinical Implications

- White matter development from 5-8 months in infants with NSC, particularly sagittal NSC, undergoing cranial vault remodeling appears to be decreased in certain tracts compared to neurotypical controls

- It is possible that this contributes to neurocognitive deficits previously characterized in this patient population

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