



C6 MRI & TBI in Pediatrics

Assessing Severity, Predicting Long-Term
Outcomes, and Guiding Treatment Strategies





Objectives



Understand how early neuroimaging can predict long-term outcomes for pediatric TBI



Discuss how MRI aids in treatment strategy development for children with brain injury

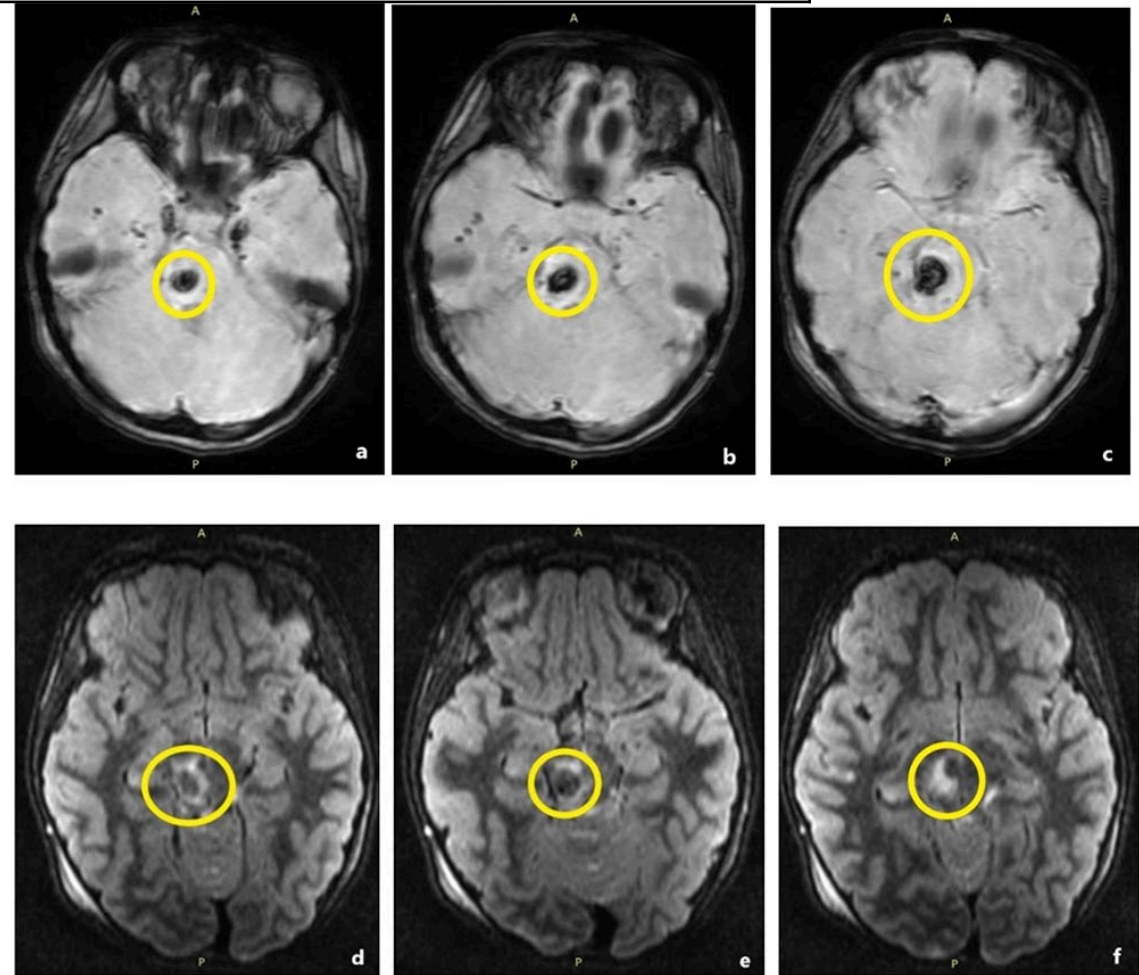




Thesis

In MRI, neuroimaging plays a vital role in assessing the extent of traumatic brain injuries in children. Thus, helping to predict long-term effects and developing treatment plans and future outcomes.

Figure 1. Right occipital epicranial hematoma (white pointed arrow). Images show bilateral cortical contusions on different MR sequences. Various MRI sequences (FLAIR, SWI, T2) reveal hyperintense and hypointense signals, indicating traumatic brain injury, contrecoup lesions, and non-hemorrhagic axonal injury.



Popescu, C. M., Marina, V., Avram, G., & Cristescu Budala, C. L. (2024). Spectrum of magnetic resonance imaging findings in acute pediatric traumatic brain injury: A pictorial essay. *Journal of Multidisciplinary Healthcare*, 17, 2921–2934. <https://doi.org/10.2147/JMDH.S466044>



Overview of Pediatric TBI

TBI is the leading cause of death and disability in children



Results in approximately 630,000 ER visits, 59,000 hospitalizations, and 7,000 deaths annually



Long term consequences include physical, cognitive, and a psychological effects (Ferrazzano, 2019)



Definitions

- Hypoxic-ischemic: Brain injury that occurs when the brain experiences a decrease in oxygen or blood flow (Mass General Brigham, 2022)
- Diffuse Axonal Injury (DAI): Results from blunt injury to the brain (Mesfin, 2023)
- Glasgow Coma Scale (GCS): Measurement of consciousness (Cleveland Clinic, 2024)
- Pediatric Cerebral Performance Category Scale (PCPCS): Functional outcome scale to assess neurological function (Albrecht, 2023)
- Traumatic Brain Injury (TBI): Brain injury caused by outside force (U.S. Department of Health and Human Services, 2024)
- Magnetic Resonance Imaging (MRI): Formation of pictures through radio waves (U.S. Department of Health and Human Services, 2024)



Current standard of care: CT vs. MRI

CT: Pros

- Faster scan time
- Wide availability
- Great for assessing brain bleeds immediately
- Standard of care for diagnosing pediatric TBI
- (Demarco, 2023)

MRI: Pros

- Better at detecting:
 - White matter injuries
 - Brain atrophy
 - DAI and ischemic changes
- More sensitive
- No Radiation
- Non-invasive
- (Demarco, 2023)

CT: Cons:

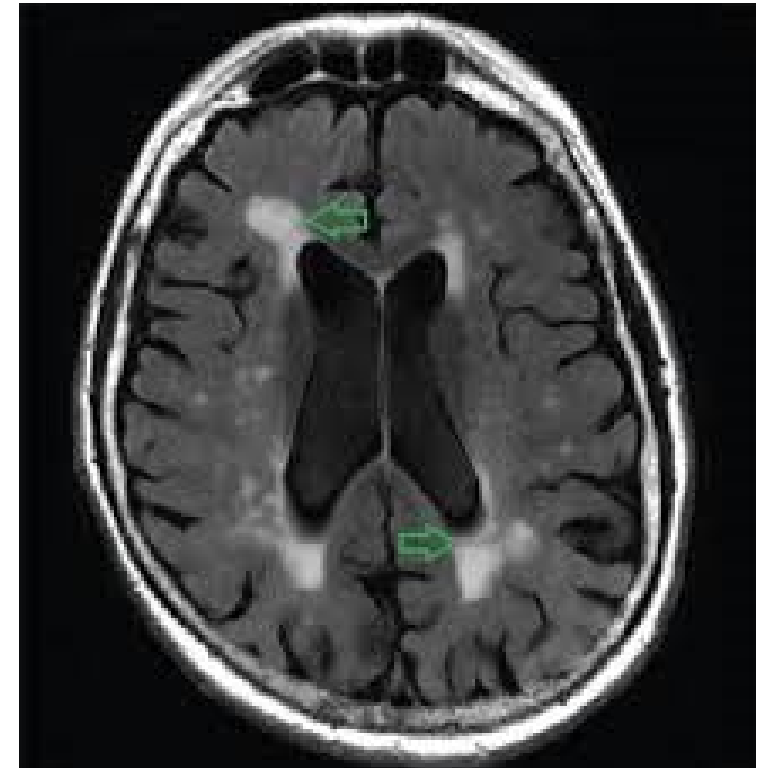
- Less sensitive to subtle injuries
- Issues detecting axonal injury (DAI) and early ischemia in children
- Radiation
- (Demarco, 2023)

MRI: Cons

- Long scan times
- Time-consuming
- Cost more
- Loud
- Small space
- (Demarco, 2023)

Figure 1

White matter lesions detected on MRI



Filley, C. M. (2022, March). What are white matter lesions, and when are they a problem? *Brain and Life*. <https://www.brainandlife.org/articles/what-are-white-matter-lesions-are-they-a-problem>

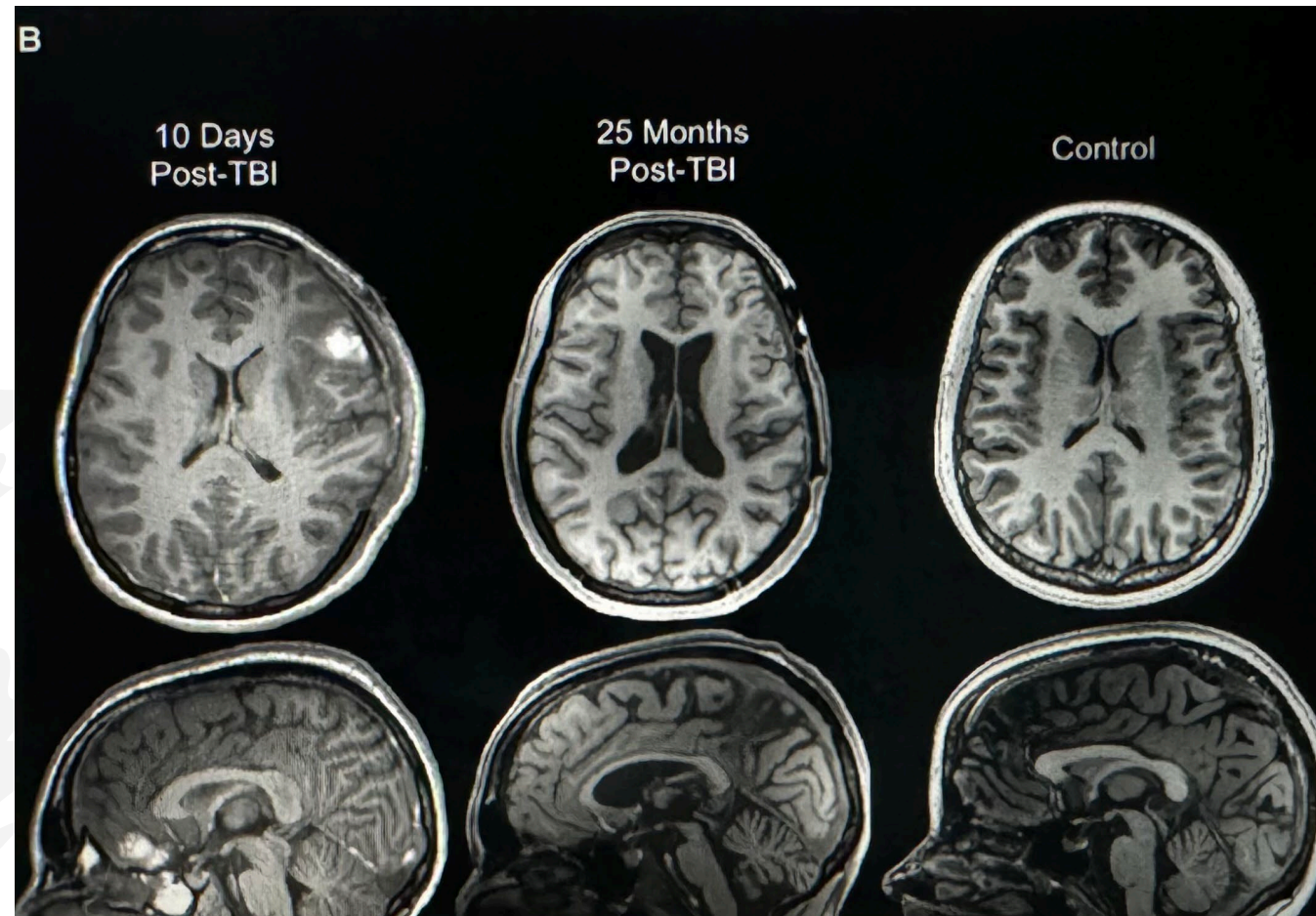


MRI: Long-Term TBI outcomes

- Brain Atrophy: Greater atrophy correlates with course cognitive/functional recovery
- White Matter Injury: Impacts cognitive and functional recovery
- Image shows progression of the brain post-injury from 10 days to 25 months (Ferrazzano, 2021)

Figure 1

MRI volumetric measures of functional outcome after severe pediatric TBI.



Ferrazzano, P., Yeske, B., Mumford, J., Kirk, G., Bigler, E. D., Bowen, K., O'Brien, N., Rosario, B., Beers, S. R., Rathouz, P., Bell, M. J., & Alexander, A. L. (2021). Brain MRI volumetric measures of functional outcome after severe TBI in adolescents. *Journal of Neurotrauma*. <https://doi.org/10.1089/neu.2019.6918>



Prediction of Future Brain Stem Injuries

Findings:

- MRI can detect brainstem contusions and ischemia early
- MRI is a useful tool in predicting long-term cognitive outcomes in pediatric TBI patients (Ferrazzano, 2024)

Key Findings:

- Helps predict prognosis and guide early treatment strategies
- Using the Glasgow Coma Scale and pupil reactivity for better future outcomes (Ferrazzano, 2024)



Guerrero-Gonzalez's Study on Hippocampal and Fornix Changes in Severe Pediatric TBI

Key Findings:

- Hippocampal volume reduction in children with severe TBI is linked to worse memory and learning outcomes
- Fornix white matter alterations are associated with poorer cognitive performance

Implications:

- MRI can predict long term cognitive impairments beyond structural injury
- MRI was able to identify changes early and help predict future outcomes of cognitive impairment in later years (Guerrero-Gonzalez, 2024)

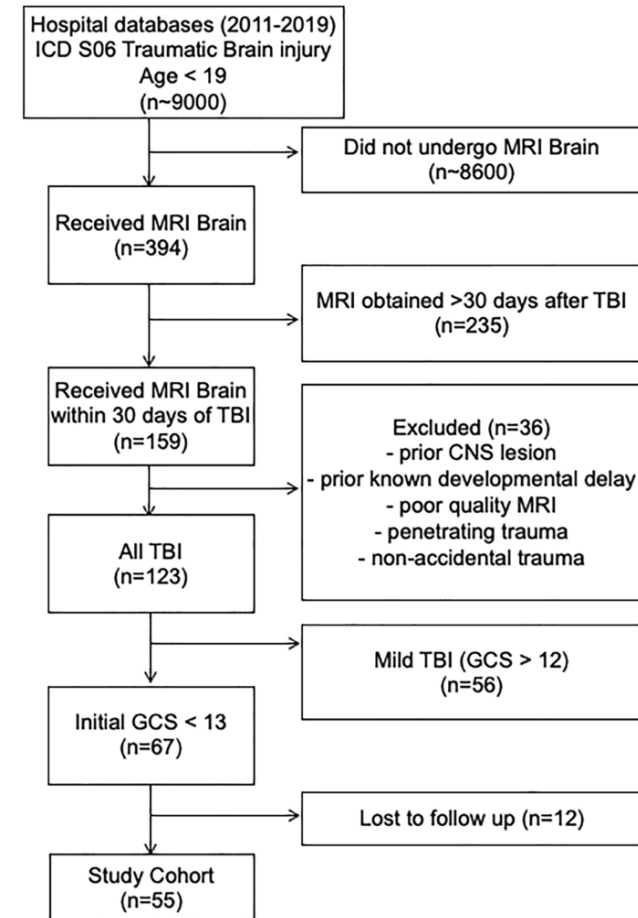


MRI and DAI

- DAI lesions are crucial in the detection of TBI severity
- This study found 87% of pediatric patients had DAI lesions detected on MRI 5 days post injury
- Early lesion detection can result in better long-term functional recovery & rehabilitation needs
- Crucial in future prognosis for patients (Janas, 2022)

Figure 1

Study flowchart of patient selection. CNS = central nervous system, GCS = Glasgow Coma Scale, ICD = International Classification of Diseases, MRI = magnetic resonance imaging, TBI = traumatic brain injury.



Janas, A. M., Qin, F., Hamilton, S., Jiang, B., Baier, N., Wintermark, M., Threlkeld, Z., & Lee, S. (2022). Diffuse axonal injury grade on early MRI is associated with worse outcome in children with moderate-severe traumatic brain injury. *Neurocritical Care*, 36(2), 492–503. <https://doi.org/10.1007/s12028-021-01336-8>



The Impact of Socioeconomic and Developmental Factors

TBI patterns:

- Vary by age
- Region
- Socioeconomic conditions. (Figaji, 2023)

Adolescents vs. Young Children:

- Younger children face greater developmental and psychological consequences. (Figaji, 2023)

Non-Accidental Injuries:

- High mortality rates in infants due to abusive head trauma. (Figaji, 2023).



Future Outcomes

Standardize MRI protocols for pediatric TBI

Research into biomarkers for earlier and more accurate predictions

International collaboration to improve care guidelines and accessibility



Conclusion



Pediatric TBI is a critical health issue, but early use of MRI can make a significant difference in treatment outcomes for patients



MRI helps predict long-term outcomes, improving cognitive and functional recovery for pediatric patients



More research is needed to standardize MRI protocols and to improve outcomes for children with TBI globally

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