Diffusion tensor imaging in the developing preterm brain

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Neurodevelopmental outcomes following preterm birth

- Incidence of cerebral palsy in preterm infants is 5-10% (Andersen, 2011)

- Preterm birth is associated with a high prevalence of neurocognitive impairment in childhood (Delobel-Ayoub et al, 2009; Marlow et al, 2005)

Background - Preterm diffuse white matter injury

**Green:** No difference in FA between preterm and term control infants
**Blue:** FA significantly lower in the preterm group

*Anjari et al. NeuroImage 2007*
Background – Impact of immaturity at birth on white matter development

GA at birth
28^{+5} (24^{+4} – 35^{+2}) weeks
FA in optic radiations correlates with visual function

Bassi et al, 2008
Anisotropy in the developing cortex

24 weeks gestational age

40 weeks

McKinstry et al, 2002
Fractional Anisotropy in preterm infants

Srinivasan et al, in preparation
Preterm infants at term compared to term controls

\[ p < 0.00001 \]

\[ p = 0.0007 \]

Srinivasan et al, in preparation
Anisotropy in the developing cortex

24 weeks gestational age

40 weeks

McKinstry et al, 2002
Disturbances in the Dendritic Arbor of Pyramidal Neurons

Courtesy of Professor Stephen Back, University of Oregon
Regional brain volume & prematurity at birth

Ball et al. Cerebral Cortex 2011
Thalamo-cortical connectivity

47 preterm infants (26 male)
Median GA at birth 28\(^{+3}\) weeks (range: 23\(^{+4}\) – 34\(^{+6}\))
Median age at scan 41\(^{+3}\) (range: 38\(^{+2}\) – 44\(^{+1}\))

None had cystic periventricular leucomalacia or haemorrhagic parenchymal infarction

18 healthy term born control infants (7 male)
Median GA at birth 39\(^{+2}\) weeks (range: 37 – 41\(^{+6}\))
Median age at scan 41\(^{+6}\) (range: 39\(^{+2}\) – 44\(^{+4}\))

DTI acquired in 32 non-collinear directions at 3T
Image analysis using FSL
Cortical parcellation

Xue et al, 2007
Processing pipeline

1. T2-weighted images
2. Cortical segmentation
   Poisson disk labelling
3. Transformation into diffusion space
   Probabilistic tractography
4. Mean anisotropy mapped back onto cortex
5. Transformation into template space
   via co-registered T2 image
6.
Thalamo-cortical tracts

Ball et al. Cortex 2012
Thalamo-cortical tracts

Ball et al. Cortex 2012
Thalamo-cortical tracts

Ball et al. Cortex 2012
Tract Density Imaging. Calamante et al.

NODDI neurite orientation dispersion and density imaging. Zhang et al.

Constrained Spherical Deconvolution. Tournier et al.
Constrained Spherical Deconvolution

Courtesy of Donald Tournier
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