Clinical Applications of Diffusion Tensor MRI & Fiber Tractography

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DTI & FT Protocol in Yonsei

- 1.5T Intera (Philips Medical Systems) with explorer gradient (60mT/m)
- 6-channel SENSE head coil
- Single shot spin echo EPI with SENSE factor 2
- TR: Shortest, TE: 70msec
- 2.3 mm thickness, no gap, 96 matrix reconstructed to 128 matrix, 2 NSA, 45 (child) to 55 (adult) slices
- Scan time: 7:28 – 9:23 minutes according to slice #
- FOV=220mm (RFOV 100%)
- b=600, 32 diffusion direction (High angular diffusion MRI)
- PRIDE package (Philips Medical Systems)
Fiber Tractography

- Corticospinal tract
- Corpus callosum

Termination of Tracking: $\text{FA} < 0.2 \sim 0.3 \quad \text{Angle} < 0.75 \sim 0.85$
Single vs Multiple ROIs

- PLIC
- Crus Cerebri
- Longitudinal Pontine Fiber
Fiber Tractography

- Corticospinal tract and fibers in brain stem

6 directions

32 directions
Fiber Tractography

- Other fibers

CST, SLF, ILF, Periventricular White Matter
Overview of Clinical DTI

- **Stroke**
  - Initial FA changes in ischemic tissue
  - The value of FA maps in the evaluation of lacunar stroke
  - DTI & FT in acute stroke
- **Pre-surgical planning**
  - CNS neoplasm and AVM
- **White matter disease**
  - Cerebellar degeneration
  - Diffuse axonal injury
  - Wallerian degeneration
- **Pediatric Brain**
  - Congenital anomalies
  - Cerebral palsy (periventricular leukomalacia)
DTI & FT in Stroke

- Initial FA changes in acute stroke
- FA maps in lacunar infarctions
- DTI & FT in acute stroke
FA of Ischemic Tissue

- Initially elevated and decreased progressively
  - Cytotoxic edema with preserved structure
    - Yang et al, Stroke 1999;30:2382-2390
  - Measurement and calculation problem
    - Green et al, Stroke 2002;33:1517-1521
Localization of Lacunar Infarction

F/43  Pure motor stroke

M/70  Ataxic hemiparesis
Localization of Lacunar Infarction

- **Diagnostic accuracy**
  - T2 + DWI: 70 ~ 90%
  - T2 + DWI + FA: 100%

- **Inter-observer agreement**
  - T2WI + DWI
    - Kappa = 0.446 (Moderate)
    - Standard error = 0.158
    - 95% CI = 0.136 to 0.756
  - T2WI + DWI + FA map
    - Perfect agreement (Kappa = 1)

*Jeong HK et al, Proceedings of Korean Soc Radiol, 2003*
DTI & FT in Acute Stroke

- M/65 Lt MCA infarction
DTI & FT in Acute Stroke

- Day 1
- Day 7
Presurgical Planning

- Evaluation of corticospinal tract
- Problems of peritumoral edema
F/65 Metastasis – Aphagia, normal motor function
M/63 Diffuse Astrocytoma – Lt side weakness
M/63 Diffuse Astrocytoma – Lt side weakness
M/20 AVM – Motor Sx (-)
F/52 Meningioma – Lt side weakness
F/52 Meningioma – Lt side weakness
DTI in CNS Neoplasm

- **Invasion vs peri-tumoral edema**
  - FA is decreased in both situations.
  - FT is based on the measurements of FA and angles between ellipsoids.
  - Therefore, determination of tumor extent by DTI seems to be inaccurate.
  - Further investigation is needed.
DTI & FT in White Matter Disease

- Cerebellar degeneration
- Diffuse axonal injury
- Wallerian degeneration
Neurodegenerative Diseases of Cerebellum

Normal

PHT user

OPCA

Lee SK, Mori S, Kim DI et al. Epilepsia 2003;44
Neurodegenerative Diseases of Cerebellum

Lee SK, Mori S, Kim DI et al. Epilepsia 2003;44

Normal  PHT user  OPCA
Wallerian Degeneration in Chronic Infarct

- F/75 Spastic hemiplegia, Old Lt MCA infarct
Diffuse Axonal Injury
DTI & FT in Pediatric Diseases

- Cerebral palsy
- Callosal agenesis
- Joubert syndrome
- Cortical dysplasia
Periventricular Leukomalacia

- Normal child
- Spastic cerebral palsy
PVL – Corpus Callosum

- Normal child
- Spastic cerebral palsy
PVL – Periventricular Fibers

- Normal child
- Spastic cerebral palsy
PET & MRI of PVL
Partial Agenesis of CC

Lee SK, Mori S, Kim DI et al. AJNR  (In press)
Complete Agenesis of CC

Lee SK, Mori S, Kim DI et al. AJNR  (In press)
Band Heterotopia

- FA increases in the area of band heterotopia
Band Heterotopia
Joubert Syndrome

- M/18m Unable to walk, delayed development
Joubert Syndrome

- Increased connection from cerebellum to motor stripe via superior cerebellar peduncle
Current Problems of DTI-FT

- Fiber tracking is operator dependent
  - Knowledge for detailed neuroanatomy
- Solutions
  - Standardization of ROI
  - Quantitative, volumetric data processing
- Threshold values affect fiber connectivity
- Standardization of individual variation is necessary
Conclusion

- Fiber tractography directly visualizes the aberrant or modified fiber connections in congenital or acquired diseases.

- Powerful microanatomical imaging eventually represents the neurologic function.

- In a broad sense, DTI & FT are the objective functional imaging because structural change accompanies functional modification.
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