



# Standardisierung von MR-Sequenzen in der Neuroradiologie: MS und Tumoren

Abteilung für Neuroradiologie  
Universität Heidelberg  
[Martin.bendszus@med.uni-heidelberg.de](mailto:Martin.bendszus@med.uni-heidelberg.de)



# Standardisierung

- MRT
  - Sequenz(parameter)
  - Schichtpositionierung
- Befundung

# Klassifikationen

- MS
  - 2. Revision der McDonald-Kriterien (2001)
  - Basierend auf Swanton (2006)
  - Frühdiagnose MS (Dissemination in Ort und Zeit)
- Gliome
  - RANO (Response assessment in neuro-oncology) basierend auf Macdonald-Kriterien (1990)



# Multiple Sklerose

# MS Frühdiagnosekriterien

- Dissemination im Ort:
  - $\geq 1$  Läsion in  $\geq 2$  Lokalisationen  
(juxtakortikal, periventrikulär, fossa posterior, spinal)
- Dissemination in der Zeit:
  - $\geq 1$  neue Läsion (Gd+ oder T2-w) mindestens 30 Tage nach erstem Schub
  - $\geq 1$  Läsion ohne und mit KM-Aufnahme

# MR-Standards MS

	Sequence	Isolated Syndrome	Follow-up Scan
1	3 plane (or other) scout	Recommended	Recommended
2	Sagittal Fast FLAIR	Recommended	Optional
3	Axial FSE PD/T2	Recommended	Recommended
4	Axial Fast FLAIR	Recommended	Recommended
5	Axial pregadolinium T1	Optional	Optional
6	3D T1	Optional	Optional
7	Axial gadolinium-enhanced T1	Recommended	Optional

When Acquired Immediately Following an Enhanced Brain MRI*			When Acquired without a Preceding Enhanced Brain MRI		
	Sequence	Recommendation		Sequence	Recommendation
1	3 plane (or other scout)	Recommended	1	3 plane (or other scout)	Recommended
2	Postcontrast sagittal T1	Recommended	2	Precontrast sagittal T1	Recommended
3	Postcontrast sagittal FSE PD/T2†	Recommended	3	Precontrast sagittal FSE PD/T2†	Recommended
4	Postcontrast axial T1	Through suspicious lesions	4	Precontrast Axial FSE PD/T2‡	Through suspicious lesions
5	Postcontrast axial FSE PD/T2‡	Through suspicious lesions	5	3D T1§	Optional
6	Postcontrast 3D T1§	Optional	6	Postcontrast-enhanced sagittal T1¶	Recommended
			7	Postcontrast-enhanced axial T1	Through suspicious lesion(s)



# MR-Standards MS

- Immer gleiche Sequenzparameter
- Immer gleiche Anflutungszeit von KM (T2-w Sequenz nach KM-Injektion)
- 3D-FLAIR: Vorteile in Reproduzierbarkeit und SNR
- 3D-GE T1 vs. T1-w SE/TSE: komplexe Diskussion, wichtig: einheitlicher Standard



# Gliome





# RANO

	<b>Complete response</b>	<b>Partial response</b>	<b>Stable disease</b>	<b>Progressive disease</b>
T1-Gd enhanced area (2-D)	0	$\geq 50\% \downarrow$	$< 50\% \downarrow$ - $< 25\% \uparrow$	$\geq 25\% \uparrow^*$
Non-measurable disease	0	= or $\downarrow$	= or $\downarrow$	= or $\uparrow^*$
T2/FLAIR	= or $\downarrow$	= or $\downarrow$	= or $\downarrow$	= or $\uparrow^*$
New Lesions	no	no	no	no or yes*



# EORTC: Basic MRI-Protokoll

## **3D T1w pre-contrast (MPRAGE, 3D IR FSPGR T1w)**

minimum TE

TI, TR and flip angle according to manufacturer specific / field strength specific recommendations

Slice/3D slab orientation: sagittal or transverse, FOV: 256 mm x 256 mm Matrix: 256x256 Slice thickness:  $\leq 1.5$  mm Full brain coverage

## **DWI**

single shot EPI sequence

minimum TE

TR > 3000 ms

b: 0 and 1000 s/mm<sup>2</sup> (3 directions)

Slice orientation: transverse

Slice thickness: 5 mm

## **2D FLAIR**

TE: 90-140ms

TR: 6000-10000 ms

TI: 2000-2500 ms (use TI according to optimized protocol for specific inversion pulses and field strength)

Slice orientation: transverse

Slice thickness: 5 mm

## **3D FLAIR (OPTIONAL)**

3D Turbo Spin Echo (TSE) / Fast Spin Echo (FSE) sequence

TE: 90-140ms

TR: 6000-10000 ms

TI: 2000-2500 ms (use TI according to optimized protocol for specific inversion pulses and field strength)

Slice orientation: sagittal or transverse

Slice thickness:  $\leq 1.5$  mm

Slice positioning as in **sequence 1 (3D T1w pre-contrast)**



# EORTC: Basic MRI-Protokoll

## **Contrast agent injection**

0.1 mmol/kg BW of a Gd-based contrast agent

## **T2w-TSE**

Turbo Spin Echo (TSE) / Fast Spin Echo (FSE) sequence

TE: 80-120ms

TR:  $\geq 2500$  ms

SENSE / SMASH / GRAPPA / ASSET allowed

Slice orientation: transverse Slice thickness: 5mm

## **3D T1w post-contrast (MPRAGE, 3D IR FSPGR T1w)**

Sequence parameters and slice positioning as in **sequence 1 (3D T1w pre-contrast)**

# EORTC/ASNR/NBTS

## MINIMUM STANDARD 1.5T & 3T MRI PROTOCOL

	<b>3D T1w Pre<sup>b</sup></b>	<b>Ax 2D FLAIR<sup>j</sup></b>	<b>Ax 2D DWI</b>	<i>Contrast Injection<sup>a</sup></i>	<b>Ax 2D T2w<sup>h,i</sup></b>	<b>3D T1w Post<sup>b</sup></b>
Sequence	MPRAGE <sup>e,f</sup>	TSE <sup>c</sup>	SS-EPI <sup>g</sup>		TSE <sup>c</sup>	MPRAGE <sup>e,f</sup>
Plane	Sagittal/ Axial	Axial	Axial		Axial	Sagittal/ Axial
Mode	3D	2D	2D		2D	3D
TR [ms]	2100 <sup>m</sup>	>6000	>5000		>2500	2100 <sup>m</sup>
TE [ms]	Min	100-140	Min		80-120	Min
TI [ms]	1100 <sup>n</sup>	2000-2500 <sup>k</sup>				1100 <sup>n</sup>
Flip Angle [Degrees]	10-15	90/≥160	90/180		90/≥160	10-15
Frequency	≥172	≥256	≥128		≥256	≥172
Phase	≥172	≥256	≥128		≥256	≥172
NEX	≥1	≥1	≥1		≥1	≥1
Frequency Direction	A/P	A/P	R/L		A/P	A/P
FOV	256	240	240		240	256
Slice Thickness	≤1.5mm	≤4mm <sup>l</sup>	≤4mm <sup>l</sup>		≤4mm <sup>l</sup>	≤1.5mm
Gap/Spacing	0	0	0		0	0
Diffusion Options <sup>p</sup>			<i>b</i> = 0, 500, 1000 s/mm <sup>2</sup> ≥3 directions			
Parallel Imaging	Up to 2x	Up to 2x	Up to 2x		Up to 2x	Up to 2x
Scan Time (Approx) [Benchmarked on 3T Skyra]	5-10 min [5:49 for 1mm isotropic]	4-8 min [3:22 for 2D FLAIR]	2-4 min [1:22 for 3 direction DWI and 3 b-values]		4-8 min [5:10 for dual echo]	5-10 min [5:49 for 1mm isotropic]



# EORTC: Advanced MRI-Protokoll

**3D T1w pre-contrast (MPRAGE, 3D IR FSPGR T1w)**

**DWI**

**3D FLAIR (OPTIONAL)**

**Contrast preload bolus (for MR-perfusion)**

0.05 mmol/kg BW of a Gd-based contrast agent

**2D FLAIR**

**GE-EPI perfusion**

single shot EPI sequence

30-40 ms (3T) or 40-50 ms (1.5 T)

Minimum TR, must be  $\leq 2000$  ms

Spectral fat suppression

SENSE / SMASH / GRAPPA / ASSET for minimization of susceptibility artifacts

Number of dummy scans  $\geq 1$  (dummy scans = excitation cycles without data acquisition; performed to obtain steady state).

Number of repetitions:  $\geq 75$

Readout bandwidth: 1200-1800 Hz/Px

Slice orientation: transverse

Slice thickness: 5mm

Number of slices: same as sequence **2 (DWI)**

Matrix: 128 x 128 or higher

Bolus injection: 10 mmol of a Gd-based contrast agent; injection rate: 3 to 5 ml/s (power injector); saline flush of  $\geq 20$ ml, 3 to 5 ml/s (power injector, same rate as bolus Gd injection)

**T2w-TSE/FSE**

**3D T1w post-contrast (MPRAGE, 3D IR FSPGR T1w)**

# Work in progress

- Standardisierte advanced Protokolle (EORTC, ASNR, NBTS)
  - MR-Perfusion (DSC)
  - Diffusion
- Standardisierte multi-center Bildakquise und Postprocessing (EORTC)