BSNR Standards Sub-Committee

Core imaging protocol for brain tumours

Summary

Recommended core sequence set for the diagnosis and follow up imaging of intracranial tumours. These sequences are those endorsed by EORTC and ACR amongst others. The sequences are readily achievable on almost all current MR equipment.

The examination sequence set includes

1. Parameter-matched IR prepared T1w GRE volumes with isotopic voxels
2. Axial T2w FSE images immediately post contrast and before T1 volume (to standardise post contrast T1 acquisition time)
3. Pre-contrast axial 2D T2w-FLAIR (3D FLAIR volume if preferred/available)
4. Pre-contrast axial 2D 3 direction diffusion-weighted images

Manufacturer and field strength-specific sequences are provided in appendix A.

Preferred local sequences may be added as required. The interval between contrast injection and start of the T1w 3D series (on the standard protocol determined by the T2w series) should be maintained.

Introduction

Over 10,000 new brain tumours are diagnosed in the UK each year. Glioblastoma is the most frequent tumour comprising over half of all gliomas. It is a complex and often treatment resistant tumour. Effective treatment options are limited. With current standard of care which comprises maximum safe surgical resection followed by radiotherapy plus concomitant and adjuvant temozolomide, treatment median survival remains low at 14-16 months. Fewer than 10% of patients survive 5 years beyond diagnosis.

There is a need for further treatment options in malignant glioma. In addition, recent genetic analysis shows marked glioblastoma tumour heterogeneity between patients, which appears to predict therapy response. MR imaging is the most commonly used surrogate marker for tumour response to therapy.

The purpose of this document is to provide a standard framework for brain tumour MR imaging, allowing consistency between examinations and between patients, particularly if serial imaging is performed on different MR equipment. It is also necessary that it is feasible within a reasonable timeframe on most MR machines currently installed, and that there is some future planning with regard to the use of T1 and T2 mapping, T1 subtraction and volume tumour analysis.

Standardisation of imaging protocols offers improvements in imaging consistency between episodes and between different scanners, allows more accurate comparison of imaging over time, and provides more accurate inter-site comparisons in therapy trials.

The imaging sequences provided are not intended to limit individual centres' practices and additional sequences can be added as local preference dictates. These sequences do however provide a basis for future imaging development, and as a benchmark against future sequence developments.

Some neuroscience centres will already be using advanced imaging protocols. These can be integrated using the EORTC advanced imaging protocol, which combines the core sequences with perfusion imaging and DTI data (appendix B).

1. **General infrastructure and equipment**

    a. Imaging departments should be equipped with contemporary MR equipment with a static field strength of 1.5T or more.

    b. Imaging departments undertaking imaging for patients with brain tumours should ensure that they have facilities for imaging patients with limited mobility and other cognitive and physical deficits.

    c. Local /regional PACS and image transfer systems should be available to allow the comparison of current and previous studies, including reports. Such equipment should be capable of 3D imaging volume comparisons in-line within PACS.

    d. Written agreements and operating procedures should exist between regional neuroscience centres and their associated hospitals/other health boards with regard to responsibility for primary scan interpretation, and the process for imaging review and second opinions centrally.

2. **Imaging**

    a. Imaging requests should include relevant information regarding tumour type, treatment modalities and timing, clinical status and steroid use.

b. If imaging is performed within regional hospitals, or through a 'hub and spoke' model of care, any central reviews or reports should be clearly documented in the radiology record.

c. Ideally serial imaging on the same imaging equipment; if not possible then the same field strength and contrast agent is advisable.

d. Specific imaging parameters vary between manufacturer and machine; many of the variants are as described in appendix 1 and in the relevant publication [ref]

e. Postoperative imaging should be performed as soon as feasible once the patient is clinically stable, and certainly within 72hrs.

3. Recommended Imaging Protocol

CORE PROTOCOL (1.5T / 3T)

No.	Sequence	Acquisition plane	Slice thickness
1.	3D T1w MPRAGE volume	Sag / Ax	≤ 1.5mm
2a.	3D FLAIR volume	Sag / Ax	≤ 2mm
OR			
2b.	2D FLAIR	Ax	≤ 4mm
3	2D DWI ≥ 3 dir	Ax	≤ 4mm
CONTRAST INJECTION			
4.	2D T2w	Ax	≤ 4mm
5.	3D T1w MPRAGE volume	Ax	≤ 1.5mm

ADVANCED PROTOCOL

No.	Sequence	Acquisition plane	Slice thickness
1.	3D T1w MPRAGE volume	Sag / Ax	≤ 1.5mm
2a.	3D FLAIR volume	Sag / Ax	≤ 2mm
OR			
2b.	2D FLAIR	Ax	≤ 4mm
3.	**2D Diffusion Tensor**	**Ax**	**Local parameters**
4.	2D T2w	Ax	≤ 4mm
DYNAMIC CONTRAST INJECTION			
5.	**Dynamic (DSC/DCE) Perfusion**	**Ax**	**Local parameters**
6.	3D T1w MPRAGE volume	Ax	≤ 1.5mm

Details of the rationale for sequence selection and more detailed imaging factors may be found in Appendix A

4. Imaging time points

The use of standardised imaging protocols reduces variation and allows for better intra-subject comparison over time. This is also improved if standardised imaging time points are adopted in relation to surgery and chemo radiotherapeutic interventions. There is limited objective data available, and pragmatic guidelines have been developed to allow tumour monitoring without excessive imaging burden to the patient or health care system.

Imaging overuse may be a psychologically damaging experience for the patients. There is also the important risk of false-positive and false-negative results from imaging, inappropriately influencing treatment decisions. This is most evident in the now well-recognised 'pseudo progression' or treatment fare response of some GBM subtypes to combined chemoradiotherapy, mimicking progression.

Appropriate imaging timepoints

High grade glioma, low grade glioma on active treatment

1. Diagnosis
2. Preoperative – if no contemporary imaging (within 4/52), including for neuronavigation
3. Immediate postoperative (≤72 hrs) *
4. Pre-chemo/radiotherapy commencement
5. Monitoring chemoradiotherapy within treatment course
6. Post therapy follow-up

Low grade glioma

1. Diagnosis
2. Follow-up at 3 months (presumed LGG on observation)
3. Preoperative – if no contemporary imaging, including neuronavigation
4. Immediate postoperative (≤72 hrs) *
5. Pre-chemo/radiotherapy commencement
6. Monitoring chemoradiotherapy within treatment course
7. Post therapy

APPENDIX 1

CORE IMAGING PROTOCOL

No.	Sequence	Acquisition plane	Slice thickness	TR(ms)	TE(ms)	TI (ms)	Flip angle	FOV(mm)	Approx scan time
1.	3D T1w MPRAGE volume	Sag / Ax	≤ 1.5mm	2100	Min	1100	10-15	256	5-10 min
2a.	3D FLAIR volume	Sag / Ax	≤ 2mm	6000-10000	90-140	2000-2500	-	≤ 250	4 min
OR									
2b.	2D FLAIR	Ax	≤ 4mm	>6000	100-140	2000-2500	90/≥160	240	4-8 min
3	2D DWI	Ax	≤ 4mm	>5000	Min	-	90/180	240	2-4 min
CONTRAST INJECTION									
4.	2D T2w	Ax	≤ 4mm	>2500	80-120	-	90/≥160	240	4-8 min
5.	3D T1w MPRAGE volume	Ax	≤ 1.5mm	2100	Min	1100	10-15	256	5-10 min

Reference:
Consensus recommendations for a standardized Brain Tumor Imaging Protocol in clinical trials, Ellingson et al, Neuro-Oncology 17(9), 1188–1198, 2015.

Appendix 2

BSNR Standards Subcommittee (2015 – 2018)

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