

Table E1: Overview of Studies on Radiomic Applications for Brain Tumor Evaluation

Molecular or clinical endpoint predicted	Modality and sequence(s) used	Total patient number	Features*	Classifiers**	AUC	Acc	Ref.
Differentiation of GBM and brain mets or met subtypes	MRI T1 C+	439	TR	CL	0.96	85	Artzi et al, 2019 (39)
GBM Survival	MRI T1 C+ FLAIR T2	217	TR	CL	N/A	N/A	Bae et al, 2019 (38)
Craniopharyngioma: BRAF and CTNNB1 mutations	MRI T1 C+	44	TR	CL	0.89–0.93	86%–93%	Chen et al (46)
GBM Survival (low vs high risk/low risk: 12 months)	MRI T1 C+	127	TR	CL	0.815–0.851		Chen et al 2019 (83)
GBM Survival	MRI T1 C+ Perfusion DWI	93	TR	CL	NA	NA	Kim et al, 2019 (85)
Prediction type of brain mets (breast, SCLC, NSCLC, GI and melanoma)	MRI T1 C- T1 C+ FLAIR	189 patients, 658 mets	TR	CL	0.83–0.89		Knies et al, 2019 (49)
GBM vs PCNSL	MRI T1 C+	76	TR	CL		75%	Kunimatsu et al, 2019 (44)
GBM IDH1 mutation status	MRI T1 C+ FLAIR	88	TR	CL		83.4%	Lee et al, 2019 (65)
GBM OS and PFS (12 month)	MRI Perfusion DWI MRS	80	TR	CL	0.81 (OS) 0.77 (PFS)		Li et al, 2019 (84)
HGG (WHO III–IV) Survival (short vs long: 650 days)	MRI T1 C+ DTI rs-fMRI	68	DL	CL	90.46%	90.66%	Nie et al (2019) (33)
Pituitary adenomas Prediction of cavernous sinus invasion	MRI T1 C+ T2	194	TR	CL	0.826–0.871		Niu et al (2019) (88)
Meningioma subtype Prediction (Meningiothelial, Fibrous, Transitional)	MRI T1 C+	241	TR	CL	0.913–0.951		Niu et al (2019) (47)
Differentiate GBM from mets	MRI T1 C- T1 C+ T2	412	TR	CL	0.9	83%	Qian et al (2019) (40)
Classification of brain tumor (GBM, mets, meningioma, PCNSL)	MRI T1 C- T1 C+ T2 FLAIR T2-GRE Perfusion DTI	141	TR	CL		92.7–97%	Shrot et al (2018) (41)
Gliomas (WHO 2007 I–IV)	MRI Perfusion	217	TR	CL	0.911–0.94		Su et al, 2019 (57)

Differentiating glioma grade (low vs high + pairwise) Ki-67 LI	DWI T1C+ T1FLAIR, T2FLAIR, T2FSE						
GBM OS	MRI T1 C- T1 C+ FLAIR	159	TR	CL	NA		Tixier et al (2019) (110)
Gliomas WHO II-IV Differentiate LGG from HGG	MRI T1 C- T1 C+ T2 FLAIR DTI Perfusion MRS	40	TR	CL	0.955	95.5%	Vamvakas et al (2019) (58)
HGG survival long (> 22 mo) vs short (< 22 mo)	MRI T1 C+ T2	221	TR	CL		87.93%	Wu et al, 2019 (86)
Gliomas IDH1 status	MRI T1 C- T1 C+ T2 FLAIR	126 TCIA	TR	CL	0.931	88.5%	Wu et al (2019) (66)
GBM survival	MRI T1 C- T1 C+ T2 FLAIR	105 TCIA	TR	CL	NA	NA	Zhang et al (2019) (87)
Gliomas WHO II or III IDH status ± TERT promoter mutation	MRI T1 C- T1 C+ FLAIR	199	TR	CL		56-87%	Arita et al 2018 (61)
Mets: Response to Stereotactic Radiosurgery	CT	110	DL	DL	0.761-0.856		Cha et al 2018 (36)
Glioma grading (high vs low)	MRI T1 C- T1 C+ T2 FLAIR	285 Two public datasets	TR	CL	0.903	88.54%	Cho et al (2018) (55)
Glioma grading (high vs low)	MRI T1 C+ FLAIR DWI	94	TR	CL	0.9		Ditmer et al (2018) (56)
Pilocytic astrocytoma vs GBM	MRI T1C+	66		CL		86%	Dong et al, 2018 (45)
GBM vs PCNSL	MRI T1 C+ T2 DWI	143	TR	CL	0.956	94.7%	Kim et al, 2018 (42)
Glioma WHO grade II or III IDH1 and 1p/19q status	MRI T1 C- T2 FLAIR	108	TR	CL	0.8224 (IDH1) 0.6854 (1p/19q)		Kuthuru et al, 2018 (64)
GBM IDH1 status	MRI T1 C- T1 C+ T2 FLAIR	651 TCIA & 3 local institutions	TR (Segmentation using CNN)	CL	0.96	97%	Li et al, 2018 (34)
GBM OS (long-term group ≥ 12 mo vs short-term < 12 mo)	MRI T1 C- T1 C+ T2 FLAIR	119 TGIA	TR	CL	0.7915	80.67%	Liu et al, 2018 (80)
Glioma WHO II or III PFS	MRI T2	300 Chinese Glioma	TR	CL	NA	NA	Liu et al, 2018 (81)

		Genome Atlas and TCIA					
Differentiate GBM and PCNSL	MRI T1 C+ T2 DWI	70	TR	CL	0.86–0.98		Nakagawa et al (2018) (43)
Glioma WHO I-IV Survival (36 mo)	PET (¹¹ C-MET)	70	TR	CL	0.72–0.9		Papp et al (2018) (37)
Gliomas WHO II: IDH1 and 1p/19q status	MRI DTI	93	TR	CL	0.853 (IDH1) 0.8071p/19q in IDH1mutant group		Park et al, 2018 (62)
Glioma WHO II and III IDH1 and 1p/19q status	MRI T1 C- T1 C+ FLAIR DTI	175	TR	CL	0.778		Park et al, 2018 (63)
Brain mets post SRS: True progression vs radionecrosis	MRI T1 C+ FLAIR	66 patients 82 lesions	TR	CL	0.79		Peng et al, 2018 (75)
GBM OS (short vs long) or 3-class (short, medium and long)	MRI T1 C+ T2 FLAIR	163 BraTS 2017 dataset	TR	CL		98.7% (2-class) 88.95% (3-Class)	Sanghani et al, 2018 (82)
Gliomas & mets Differentiate vasogenic edema from nonenhancing tumor	MRI T1 C+ T2 FLAIR Perfusion	9 HGG patients + 9 mets patients	TR	CL		91.6%–97.6%	Sengupta et al (2018) (59)
LGG (WHO II) with IDH1-mutated tumors: classification based on 1p/19q status	MRI FLAIR T1 C- T2	47	TR	CL	0.87	87%	Shoftly et al (2018) (68)
Prediction of nonfunctioning pituitary adenoma subtypes (null cell adenomas from other nonfunctioning pituitary adenomas)	MRI T1 C- T1 C+	112	TR	CL	0.8042	81.1%	Zhang et al (2018) (48)
LGG 1p/19q status	MRI T1 C+ T2	159	DR	DL		87.7%	Akkus et al, 2017 (67)
GBM + LGG (II, III, IV) Distinguishing GBM from grade II or III glioma	MRI T1 C+	107 TCGA	TR	CL	0.94	93%	Li-Chun Hsieh et al, 2017 (53)
Glioma (WHO II and III) p53 status	MRI T2	272	TR	CL	0.763	70.7%	Li et al, 2017 (71)
GBM OS (long-term ≥ 12 mo vs short-term OS < 12 mo)	MRI T1 C+	133 TCGA	TR	CL	0.8104	78.20%	Liu et al, 2017 (78)
HGG (WHO III-IV) IDH status	MRI T1 C- T1 C+ T2 FLAIR	120	TR	CL	0.9231	89%	Zhang et al (2017) (60)
Glioma (WHO grade I-IV) classification LGG vs HGG	MRI T1 C+ FLAIR DWI	120	TR	CL		94.5% (HGG vs LGG) and 96.1% (WHO grade)	Zhang et al (2017) (54)

Classification WHO II, III, vs IV	Perfusion (C+) + ASL						
GBM Survival (< 400 days vs ≥ 400 days) Spatial Imaging (Habitat) Biomarkers	MRI T1 C+ T2 FLAIR	54 TCGA	TR	CL		86.36%–87.5%	Zhou et al (2017) (79)
GBM Global DNA methylation subgroups MGMT promoter methylation status Hallmark copy number variations	MRI T1 C- T1 C+ FLAIR DWI Perfusion SWI	152	TR	CL		63% (EGFR amplification) 61% (RTK II)	Kickingereder et al, 2016 (94)
Recurrent GBM (WHO IV) on bevacizumab monotherapy or bevacizumab and irinotecan combination therapy OS, PFS	MRI T1 C- T1 C+ T2 FLAIR DWI	126	TR	CL	NA	NA	Chang et al, 2016 (76)
GBM MGMT promoter status	MRI T1 C+ T2	155	TR	CL	0.85		Korfiatis et al, 2016 (69)
Primary or mets Differentiate Radiation necrosis from recurrent brain tumor	MRI T1 C+ T2 FLAIR	58	TR	CL	0.79 (primary) 0.79 (mets)	80%	Tiwari et al (2016) (74)
HGG (WHO III or IV) Survival (good > 650 days) vs bad (< 650 days)	MRI DTI fMRI	68	TR	CL		75%	Liu et al, 2016 (77)
GBM OS (long/medium/short: 6 mo, 6–18 mo, 18+ mo) Molecular subtype (classic, mesenchymal, proneural, and neural)	MRI T1 C- T1 C+ T2 FLAIR DTI Perfusion	105	TR	CL	0.84–0.91 (survival) 0.75–0.92 (molecular subtype)	77.14–88.57% (survival) 75.76%–87.88% (molecular subtype)	Macyszyn et al (2016) (70)
Gliomas (WHO III-IV) Survival (long vs short–22 mo)	MRI T1 C+ DTI fMRI	69	DL	DL + CL		89.85%	Nie et al (2016) (32)
GBM Differentiate pseudo progression from true progression	MRI DTI	161	TR	CL	0.87		Zhang et al (2016) (73)
Brain mets Distinction from radiation necrosis	MRI T1c+	73 patients 115 lesions	TR	CL	0.94		Larroza et al, 2015 (72)
Glioma grading WHO II vs III-IV	MRI MRS	28	TR	CL	0.911		Ranjith et al (2015) (51)

The table is meant to provide an overview of the current literature and by necessity may result in over-generalization of the results. Interested readers are encouraged to consult the primary articles for detailed results and analysis of study design, strengths and weaknesses. Unless not available, the values (AUC, accuracy) provided are generally for the test or validation set.

* Features extracted are either classified as Traditional Radiomics (TR), referring to hand-crafted features or deep radiomics (DR), referring to lesion analysis and features extraction using deep learning. Please note that some studies also used other features or clinical characteristics in addition to radiomic features that are not specified here.

** The classifier used is categorized as either classic (CL), comprising classic machine learning approaches or in a few studies standard statistical approaches or as deep learning (DL).

Abbreviations: Acc = accuracy, AUC = area under the curve, GBM = glioblastoma, HGG = high grade glioma, IDH1 = isocitrate dehydrogenase 1, LGG = low grade glioma, MGMT promoter = O(6)-methylguanine-DNA methyltransferase promoter, NSCLC = non-small cell lung cancer, PCNSL = primary CNS lymphoma, OS = overall survival, PFS = progression free survival, SCLC = small cell lung cancer.