Ultrahigh Field MRI – Imaging Brain Tumors

29

What is Ultrahigh Field MRI?

Ultrahigh Field MRI is categorized as any MRI machine that operates between 7 and 9.4 Tesla. [11]

The benefits of Ultrahigh Field MRI

The biggest perk of using ultrahigh field MRI is the contrast. The higher resolution allows for better separation of the gray and white matter in the brain. It has also allowed for the quantification of cortical volume, the grey matter in the brain. Cortical volume is used to monitor disease progression[2]. This increase in contrast also allows us to see radiation induced microbleeds, tumor angiogenesis, venous microvasculature, and calcium and iron deposits. Signal to noise ratio also increases due to the higher field strength. The increase in signal to noise ratio allows for smaller pathologies that would normally blend in to stand out and be seen. Ultrahigh Field MRI also increases sensitivity to the changes in blood oxygen level dependent (BOLD) signal. This increased sensitivity makes brain activity more noticeable. This visualization of the brain activity allows for more reliable localization of essential cortical motor and language or memory areas. Surgeons use this localization information when preparing for surgery so they know which areas to avoid to prevent causing the patient permanent brain damage. The increased sensitivity to BOLD signal also makes it possible to better grade tumors noninvasively based on the microvasculature[9].

Limitations to Ultrahigh Field MRI

Like any medical imaging technology there are limitations to Ultrahigh Field MRI. As field strength increases distortion of geometry and intensity also increases. This distortion can cause shifting and broadening of the spectral lines of metabolites, leading to insufficient lipid saturation and degradation in the signal to noise ratio and the spectral separation. There have been shimming methods developed in the prescan procedure to correct these issues. The distortions are noticed most between the center of the brain and the periphery. This distortion can cause changes in the contrast that could potentially lead to misinterpretation of results.[3] The increase in magnetic strength also causes the specific absorption rate limit for fast/turbo spin-echo and FLAIR sequences to be met. The easiest way to counteract the limit is to increase the scan time, but this isn't ideal due to patient movement. So a different solution is to image parallel and then lower the flip angle. Lowering the flip angle can be achieved by implementing adiabatic pulses, which are less sensitive to the B1 field variations[4].

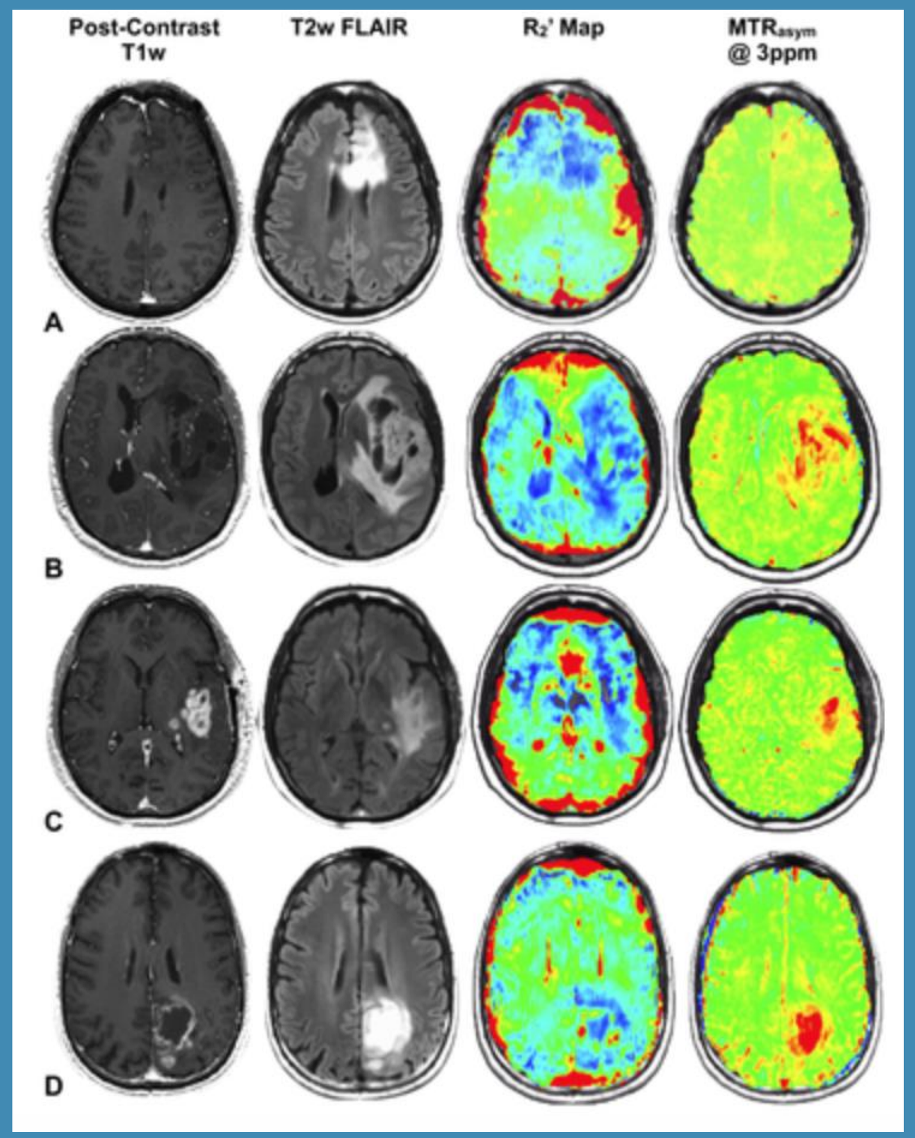

Figure 1: Appearance of gliomas using varous MRI scan types[9]

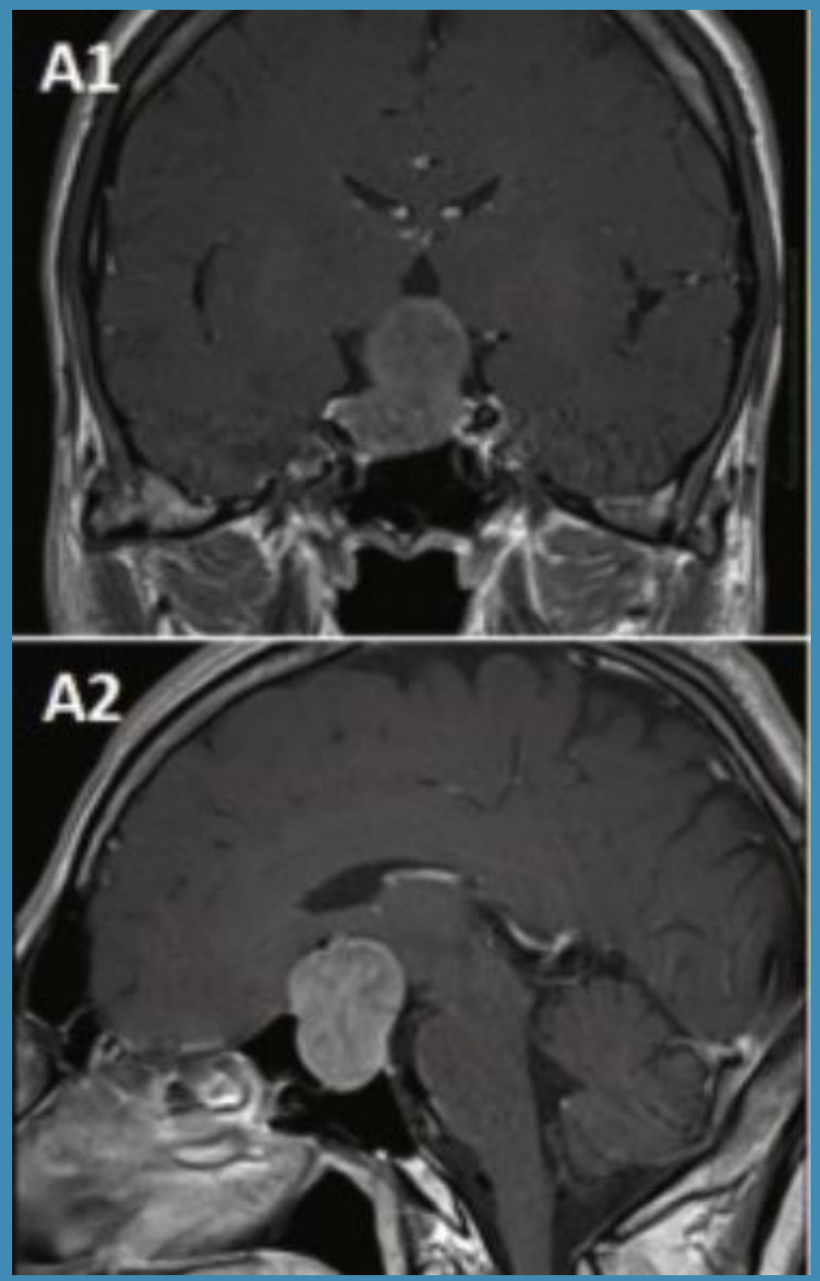

Figure 2: Different views of a pituitary adenoma MRI[10]

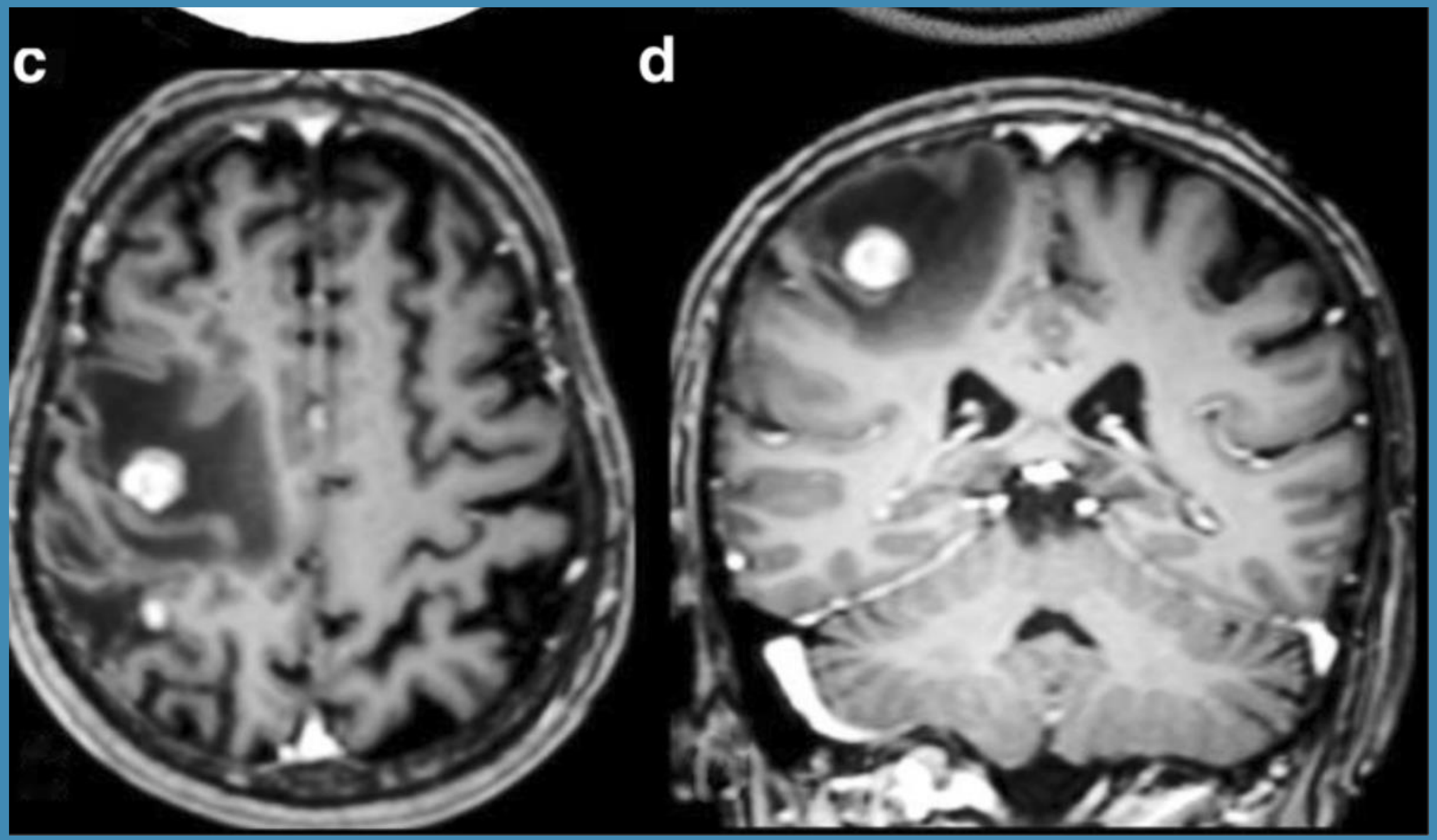

Figure 3: Brain Metastases on an MRI[11]

Types of Brain Tumors Imaged with MRI

Gliomas

Gliomas are the most common type of brain tumor. It originates from glial cells and is a wide category that ranges from grade II to grade III[5]. The most diagnostic sequences for gliomas are T1-post-contrast images and FLAIR scans (See figure 1). Using multiple FLAIR textures makes different things stand out in brains scans. The best way to diagnose a glioma is to look at the signal heterogeneity and border sharpness. Higher signal homogeneity makes the tumor look more uniform, the higher edge contrast shows sharper and more distinct borders. Scans that show poorly defined FLAIR borders indicate tumor infiltration from the tumor bed to adjacent tissue. Gliomas are better visualized with ultrahigh field MRI because of the greater contrast between gray and white matter. The BOLD signal changes also come into play here. The better visualization of microvasculature allows for more accurate tumor grade[6].

Pituitary Adenomas

Pituitary Adenomas (See figure 2) are slow growing and usually benign. This means that the tumors won't spread to other parts of the body, but they can grow and put pressure on nearby structures and nerves that connect the eyes to the brain[7]. This is what causes the symptoms of a pituitary adenoma. Dynamic MRI utilizes gadolinium base contrast intravenously to see if the tumor is secreting acetylcholine or if it non-functioning. Ultrahigh Field MRI allows for better visualization of these tumors, some adenomas that were visualized on a 7T scanner weren't visualized on the 3T[8].

Brain Metastases

The brain is a common stop for cancer to metastasize to because it has a high blood supply. MRI images better visualize the metastases because of the high soft tissue contrast (See figure 3). The gadolinium contrast used in MRI also better visualizes the metastases than the iodinated contrast used for CT. Brain Metastases are seen fairly equally on 1.5T and 7 T scanners, so Ultrahigh Field MRI doesn't really benefit in these cases[1].

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