2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

7-Tesla vs. 1.5-Tesla or 3-Tesla Magnetic Resonance Imaging (MRI) in the Management of Traumatic Brain Injury: A Systematic Review

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Abstract—**Traumatic brain injury (TBI) can arise from events such as concussion, brain contusion or axonal injury, and result in cerebral microhemorrhages or ischemic lesions. To detect these injuries, 1.5-Tesla (1.5T) and 3T MRI visualize hyper- or hypo-intense lesions of pathology. Because 7T MRI was approved for clinical use by the FDA only recently in 2017, we conducted a systematic review of direct comparisons between 7T MRI and lower field analysis in the diagnosis and management of TBI. Our search yielded a total of three reports with 29 research subjects. The three reports describe 7T as providing higher resolution and the ability to detect a greater number of lesions in pathologic cases. However, it is unclear whether these advantages provide a significant clinical benefit that would justify its widespread adoption in assessing TBI.**

Clinical Relevance— **This systematic review seeks to find evidence as to whether 7T MRI provides a diagnostic advantage over 1.5T or 3T MRI in the management of TBI.**

I. INTRODUCTION

Determining the advantages of 7T over 3T MRI has become a pressing objective following the 2017 FDA approval of 7T for clinical use. Although studies that directly compare analysis at these field strengths have been recently reviewed for neuro-oncology and neurodegeneration, a synthesis of existing comparisons in TBI has not been made. Therefore, we sought to systematically review studies that measure the management of TBI according to 1.5T/ 3T vs. 7T MRI.

II. METHODS

A systematic search following PRISMA (Preferred Reporting for Systematic Reviews and Meta-Analysis) guidelines was performed on PubMed and Web of Science with the following search strategy: ("3 Tesla" OR "3T" OR "1.5 Tesla" OR "1.5T") AND ("7T" OR "7 Tesla" OR "ultra-high field" OR UHF) AND (comparison OR versus OR compare OR vs OR against) AND (brain OR cranium OR cranial OR cerebrum OR cerebellar OR neuro*). This search yielded 368 reports after removing duplicates. When imposing a selection criterion that included direct comparison of 1.5T/3T vs. 7T for TBI, three studies remained.

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III. RESULTS

28 live TBI patients [1-3] and 1 cadaver 14-16 h postmortem [4] were analyzed. The Moenninghoff study prospectively scanned 10 patients with previously diagnosed diffuse axonal injury (DAI), while the Obusez study prospectively scanned (7T MRI) 18 TBI patients and compared 7T images to 1.5T or 3T scans previously obtained at their institution. Following MRI scans (Table 1), images in all studies were assessed by experienced neuroradiologists. 11 of the 18 subjects in the Obusez study with mild TBI demonstrated more microhemorrhages when measured with 7T compared to measurement at 1.5T or 3T. Furthermore, 3 of the 18 participants received a corrected diagnosis of vascular pathology based on the 7T scans. Similarly, in 10 patients with DAI, the Moenninghoff study detected 485 traumatic cerebral microbleeds (TMBs) at 3T, 584 TMBs at 7T, and 684 TMBs at 7T with 10x higher spatial resolution. However, Spearman correlations between the number of TMBs and length of coma, Glasgow Coma Scale, or health-related quality of life did not indicate any prognostic advantages to 7T.

TABLE I. MRI INSTRUMENTATION AND SEQUENCES

Study	Field strength	Planes	Sequences
Obusez, 2018 [ref. 1]	1.5 T	Axial, sagittal	T1, T2, SWI, DWI, T2 FLAIR
	3 T		
	7 T		
Moenninghoff 2015 [ref. 2,3]	3 T	Axial	SWI
	7 T		
	7 T HR		
Gascho, 2021 [ref. 4]	3 T	Axial, sagittal, transverse	T1, T2, TSESPAIR, TFE, VenBOLD
	7 T		T1, T2, MP2RAGE, SPACE, SWI

IV. DISCUSSION & CONCLUSION

The potential to alter or reverse the diagnosis achievable at 3T may warrant wide-spread adoption of 7T MRI in the assessment of TBI. Since only three reports with 29 total subjects could be obtained according to our search criteria, more prospective studies are urgently needed that directly compare TBI assessments with 1.5T or 3T vs. 7T MRI.

REFERENCES

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