

## Difference in the ascending reticular activating system injury between mild traumatic brain injury

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### Introduction

We investigated differences in the ascending reticular activating system (ARAS) injuries between patients with mild traumatic brain injury (mTBI) and cerebral concussion by using diffusion tensor tractography (DTT).

### Methods

Thirty-one patients with mTBI, 29 patients with concussion, and 30 control subjects were recruited. We used DTT to reconstruct the lower ventral and dorsal ARAS, and the upper ARAS. The fractional anisotropy (FA) value and the fiber number (FN) of the lower ventral and dorsal ARAS, and the upper ARAS were determined.

### Results

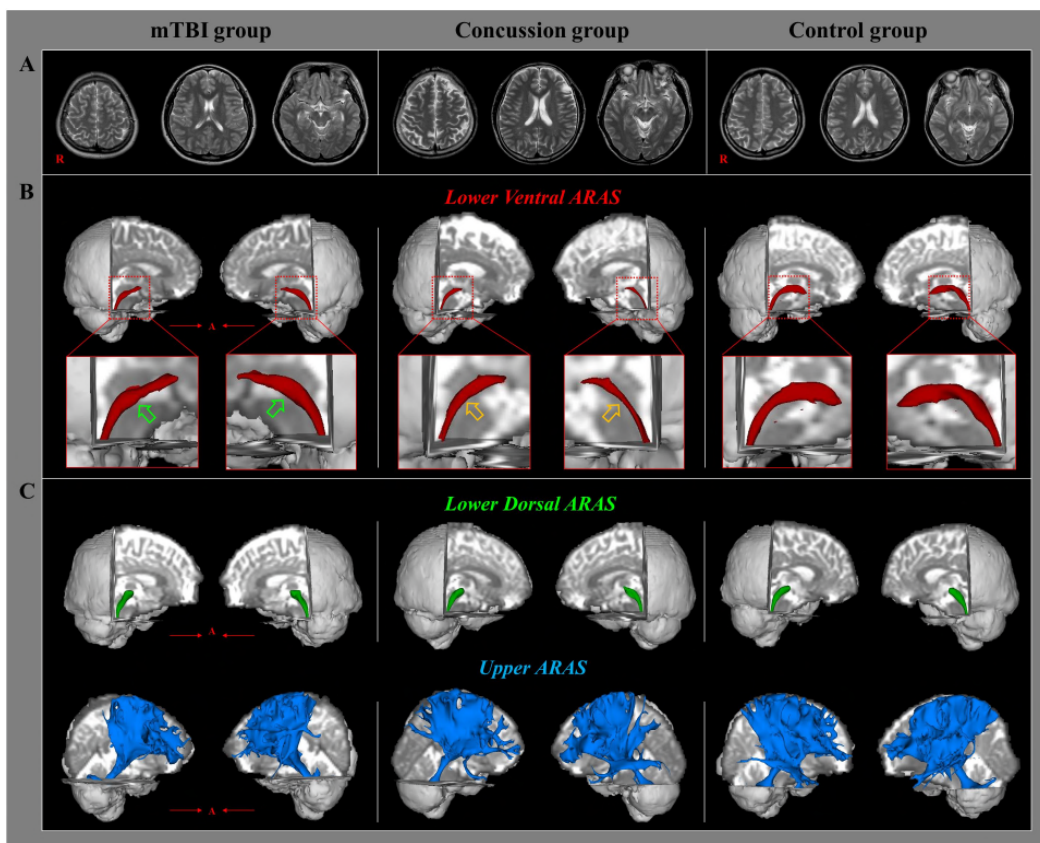
Significant differences were observed in the FA values of the lower ventral and dorsal ARAS on both sides between the mTBI and control groups and between the concussion and control groups ( $p < 0.05$ ). The FN value was significantly different in the lower ventral ARAS on both sides between the concussion and control groups and between the mTBI and concussion groups ( $p < 0.05$ ).

### Conclusion

Both the mTBI and concussion patients suffered injuries in the lower ventral and dorsal ARAS, with the concussion patients exhibiting more severe injury in the ventral ARAS than that in the mTBI patients. These results suggest that the terms mTBI and concussion should be used differentially, even though they have used interchangeably for a long time

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(A) T2-weighted brain magnetic resonance images at the time of diffusion tensor imaging scanning in representative patients with mild traumatic brain injury (mTBI; 51-year-old female) and concussion (48-year-old female) and in a control subject (50-year-old female). (B) Results of diffusion tensor tractography (DTT) for the lower ventral ascending reticular activating system (ARAS): the lower ventral ARAS of the mTBI (green arrows) and concussion (orange arrows) groups are thinner compared with the control group and that of the concussion group is thinner than that in the mTBI group (orange arrows). (C) Results of DTT for lower dorsal and upper ARAS show similar findings among the three groups.

**Table 1.** Demographic data of the mild traumatic brain injury and concussion groups<sup>a</sup>

Variables <sup>a</sup>	mTBI group <sup>a</sup>	Concussion group <sup>a</sup>
Patients, n (%) <sup>a</sup>	31 (50.81%) <sup>a</sup>	29 (49.18%) <sup>a</sup>
Age (year) <sup>a</sup>	45.85 (10.03) <sup>a</sup>	47.57 (13.43) <sup>a</sup>
Sex, male/female <sup>a</sup>	15/16 <sup>a</sup>	13/17 <sup>a</sup>
Duration to DTI (months) <sup>a</sup>	3.03 (6.02) <sup>a</sup>	3.85 (6.32) <sup>a</sup>
LOC (minutes / hours) <sup>a</sup>	7.11 (6.47) <sup>a</sup> (minutes) <sup>a</sup>	3.13 (1.80) <sup>a</sup> (hours) <sup>a</sup>

Values represent mean ( $\pm$ standard deviation). mTBI: mild traumatic brain injury; DTI: diffusion tensor imaging; LOC: loss of consciousness<sup>a</sup>

Demographic data of the mild traumatic brain injury and concussion groups

**Table 2.** Comparison of diffusion tensor tractography parameters for the ascending reticular activating system between the mild traumatic brain injury and concussion groups

ARAS: ascending reticular activating system, FA: fractional anisotropy, FN: fiber number, mTBI: mild traumatic brain injury, Rt: right, Lt: left, means  $\pm$  standard deviation, \* $p < 0.05$ .

	Right		Left				
	FA	FN	FA	FN			
Lower ventral ARAS							
mTBI group	0.37 $\pm$ 0.04	293.68 $\pm$ 117.06	0.37 $\pm$ 0.03	301.72 $\pm$ 114.30			
Concussion group	0.37 $\pm$ 0.06	221.73 $\pm$ 121.89	0.36 $\pm$ 0.06	226.61 $\pm$ 59.99			
Control group	0.41 $\pm$ 0.03	343.71 $\pm$ 67.62	0.41 $\pm$ 0.05	346.13 $\pm$ 107.25			
Lower dorsal ARAS							
mTBI group	0.39 $\pm$ 0.04	356.06 $\pm$ 163.36	0.39 $\pm$ 0.02	375.66 $\pm$ 182.10			
Concussion group	0.39 $\pm$ 0.06	339.27 $\pm$ 163.71	0.39 $\pm$ 0.04	356.10 $\pm$ 0.04			
Control group	0.42 $\pm$ 0.03	382.03 $\pm$ 141.58	0.42 $\pm$ 0.03	412.03 $\pm$ 145.11			
Upper ARAS							
mTBI group	0.36 $\pm$ 0.02	10500.41 $\pm$ 4617.71	0.37 $\pm$ 0.02	11153.43 $\pm$ 4241.51			
Concussion group	0.35 $\pm$ 0.02	15111.86 $\pm$ 4240.95	0.35 $\pm$ 0.02	11378.35 $\pm$ 5060.18			
Control group	0.36 $\pm$ 0.01	10311.16 $\pm$ 3240.42	0.36	10282.91 $\pm$ 3663.50			
<i>P</i> – value							
Lower ventral ARAS							
	<i>Rt</i>	<i>Lt</i>		<i>Rt</i>	<i>Lt</i>		
<i>FA</i>	mTBI – Control	0.00*	0.01*	mTBI – Control	0.09	0.08	
	Concussion – Control	0.01*	0.00*	FN	Concussion – Control	0.00*	0.00*
	mTBI - Concussion	0.61	0.58		mTBI - Concussion	0.01*	0.05*
Lower dorsal ARAS							
	<i>Rt</i>	<i>Lt</i>		<i>Rt</i>	<i>Lt</i>		
<i>FA</i>	mTBI – Control	0.05*	0.01*	mTBI – Control	0.69	0.09	
	Concussion – Control	0.04*	0.00*	FN	Concussion – Control	0.35	0.09
	mTBI - Concussion	0.86	0.44		mTBI - Concussion	0.59	0.99
Upper ARAS							
	<i>Rt</i>	<i>Lt</i>		<i>Rt</i>	<i>Lt</i>		
<i>FA</i>	mTBI – Control	0.69	0.15	mTBI – Control	0.30	0.44	
	Concussion – Control	0.08	0.63	FN	Concussion – Control	0.48	0.34
	mTBI - Concussion	0.13	0.36		mTBI - Concussion	0.31	0.84

**Comparison of diffusion tensor tractography parameters for the ascending reticular activating system between the mild traumatic brain injury and concussion groups**