Use of Diffusion Tensor Imaging to Examine Microstructural Changes Following Lingual Strengthening Exercise

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Background

-Lingual Strengthening Exercise (LSE) is a clinical treatment for dysphagia
-LSE has been shown to significantly increase Maximum Isometric Pressure (MIP) generation
-Central effects of LSE have yet to be explored

Significance

Having a better understanding of alterations in white matter structure as a result of LSE can indicate impact of exercise on neural processing and signaling to the periphery. This is important in determining optimal dosing parameters for this intervention as a treatment of dysphagia.

Study Aim

The purpose of this pilot study was to measure microstructural white matter changes following lingual strengthening exercise in a group of patients with dysphagia.

Summary of Methods

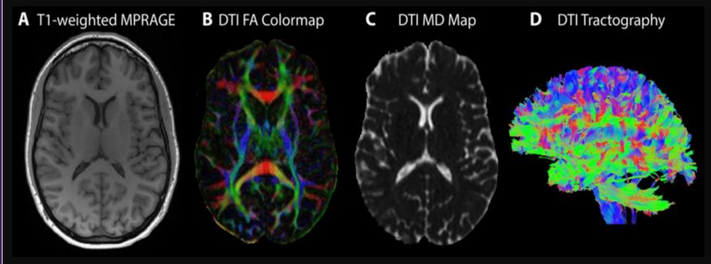
- Older individuals with dysphagia, various etiologies (n=7; avg age = 70y)
- DTI images acquired pre and post LSE
- Tract-Based Spatial Statistics evaluated voxel-based group differences for values of fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (AD), radial diffusivity (RD), and local diffusion homogeneity (LDH)
- Paired t-tests for differences between pre- and post-treatment DTI metrics

Lingual Strengthening Exercise

LSE Protocol (Dose)
-20 repetitions
-3x/day
-3 days/week
-8 weeks

Participants with dysphagia participated in an 8-week LSE protocol using the Madison Oral Strengthening Device (MOST) Maximum Isometric Pressure (MIP) was increased after exercise at both the front sensor (avg=46.41 hPa) and back sensor (avg=104.33 hPa).

DTI - Diffusion Tensor Imaging



Diffusion tensor imaging (DTI) is a neuroimaging approach used to identify differences in microstructural changes in white matter tracts driving neural connectivity in the brain.

Tract-Based Spatial Statistics (TBSS) were employed to evaluate voxel-based group differences for the values of fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (AD), radial diffusivity (RD), and Local Diffusion Homogeneity (LDH). Paired t-tests were performed pre-treatment and post-treatment change

Results

Table 1. DTI metric differences between Post- and Pre-Interventions.

	Regions	Intervention	Mean (SD)	$t_{(6)}$	p
MD Mean Diffusivity	Right inferior fronto-occipital fasciculus	Post	1.05 (0.02)	2.60	.04
		Pre	1.04 (0.02)		
	Right uncinate fasciculus	Post	1.01 (0.02)	-2.44	.05
		Pre	1.03 (0.02)		
AD Axial Diffusivity	Left inferior fronto-occipital fasciculus	Post	1.01 (0.02)	-2.55	.04
		Pre	1.03 (0.02)		
	Right inferior fronto-occipital fasciculus	Post	1.02 (0.02)	-2.67	.03
		Pre	1.03 (0.02)		
	Left uncinate fasciculus	Post	0.98 (0.05)	-7.69	.00
		Pre	0.99 (0.04)		
RD Radial Diffusivity	Right inferior fronto-occipital fasciculus	Post	1.08 (0.03)	2.55	.04
		Pre	1.07 (0.04)		
LDH Local Diffusion Homogeneity	Left anterior thalamic radiation	Post	0.98 (0.02)	2.97	.02
		Pre	0.96 (0.03)		
	Right anterior thalamic radiation	Post	0.98 (0.02)	2.73	.03
		Pre	0.97 (0.02)		

Note: (1) SD: standard deviation. (2) The mean values (and SD) about MD, AD and RD are (x 10^{-3} mm^2/s).

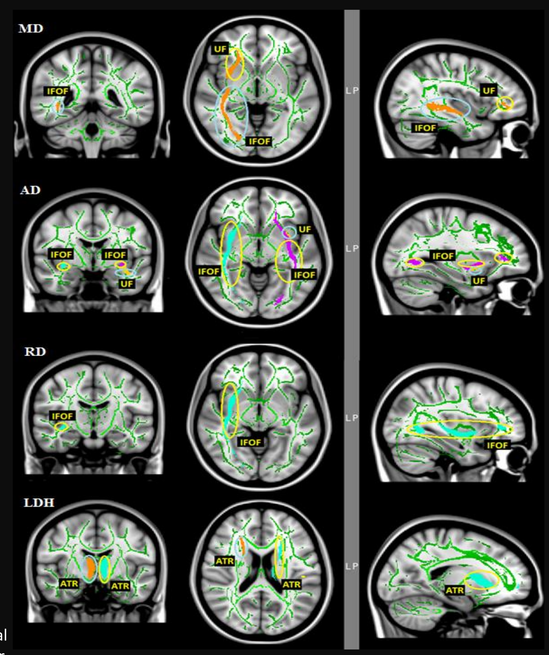


Figure 1. DTI metric differences between Post- and Pre-Interventions. IFOF: inferior fronto-occipital fasciculus; UF: uncinate fasciculus; ATR: anterior thalamic radiation. R: right; L: left; A: anterior; P: posterior.

Summary of Findings

- Markers of improved connectivity between language processing and goal-oriented behavior
  - Increased MD and RD in right inferior fronto-occipital fasciulus (IFOF)
- Alterations in episodic memory
  - Decreases in MD and AD in the right uncinate fasciculus (UF)
- Markers in improved somatosensory relay to cortex
  - Increased LDH in bilateral anterior thalamic radiation (ATR)

Conclusion

These microstructural changes observed via DTI, in this heterogenous group of patients with dysphagia, suggest that LSE may alter critical central neural pathways related to learning and sensorimotor relay.

Future Directions

-Develop a better understanding of mechanisms driving change in lingual function after exercise
-DTI and other imaging techniques should be applied in future controlled studies of homogenous patient populations
-Delineate contribution of central changes underlying noted changes in lingual function as a result of exercise.

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