Relationship between cervical muscle morphology evaluated by MRI, cervical muscle strength and functional outcomes in patients with degenerative cervical myelopathy.

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RELATIONSHIP BETWEEN CERVICAL MUSCLE MORPHOLOGY EVALUATED BY MRI, CERVICAL MUSCLE STRENGTH AND FUNCTIONAL OUTCOMES IN PATIENTS WITH DEGENERATIVE CERVICAL MYELOPATHY

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ABSTRACT

The purpose of this study was to investigate the relationship between cervical muscle degenerative changes observed on MRI, muscle strength and symptoms severity in patients diagnosed with degenerative cervical myelopathy (DCM).

Cervical muscle measurements of total cross-sectional area (CSA), functional CSA (fat free area, FCSA) and ratio of FCSA/CSA (e.g. fatty infiltration) were obtained from T2-weighted axial MR images from C2-C3 to C6-C7 in 20 patients. Muscle strength was assessed manually using a microFET2 dynamometer.

Greater mean CSA and FCSA was associated with greater overall muscle strength. The mean ratio of FCSA/CSA was not significantly associated with cervical muscle strength in any direction. However, greater FCSA/CSA ratio (e.g. less fatty infiltration) was associated with lower disability score (p=0.02, R^2=0.15).

Our findings suggest that clinicians should pay greater attention to cervical muscle morphology and function in patients with DCM.

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INTRODUCTION

Reduced cervical muscle strength has been reported in patients with whiplash-associated disorders (WAD) or insidious onset neck pain,[1-3] however the relationship between cervical muscle size and strength deserve further attention in patients with neck pain, specifically in patients with degenerative cervical myelopathy (DCM). Although, some evidence suggests a positive correlation between muscle CSA and muscle strength, [4,5] others found no such correlation. [6,7] The relationship between muscle size and muscle strength may not have the same clinical applicability in DCM, as patients with myopathy likely have alterations in the morphology of the cervical contractive and noncontractive tissues. [8]

Our previous study on paraspinal morphology was the first to establish an association between cervical muscle morphology with clinical symptoms and functional status of patients with DCM.[8] However, the relationship between cervical muscle morphology, muscle strength, clinical symptom and functional status warrants further investigation in order to confirm the clinical relevance of cervical muscle morphology parameters (observed on MRI) and their effect on muscle function (e.g. strength). As physiotherapy and rehabilitation have a strong implication in the management of this condition, a better understanding of the characteristics and implications of cervical muscle morphology in patients with DCM may provide valuable insight for more effective and targeted rehabilitation.

METHODS AND MATERIALS

Cervical muscle measurements of total cross-sectional area (CSA) (Fig. 1), functional CSA (fat free area, FCSA) (Fig.2) and ratio of FCSA/CSA (e.g. fatty infiltration) were obtained from T2-weighted axial MR images from C2-C3 to C6-C7 in 20 patients diagnosed with DCM. Muscle strength was assessed manually using a microFET2 dynamometer in flexion, extension, right side-bending and left side-bending. Strength measurements were repeated 3 times in each position with 30-second to 60-second rest between trials. The average value (in newtons) was calculated, as well as the overall muscle strength (sum of the average value in the 4 tested positions) and used in the analyses.

The association between cervical muscle morphology parameters, muscle strength, symptoms severity and functional status (e.g. mJOA, NDI, PHQ, SF-12, EQ-5D) was investigated using multivariate regression analysis.

RESULTS

Cervical muscle CSA was positively associated with all muscle strength measurements in the univariate analyses, with the exception of left-side bending. Age and BMI remained statistically significant or were confounders in the multivariate analyses and were entered as covariates in the multivariable models. Greater deep cervical extensors mean CSA (e.g. muscle size) was associated with greater strength in flexion (p=0.03, R^2=0.25), extension (p<0.01, R^2=0.72), right side-bending (p=0.03, R^2=0.24), and overall muscle strength (p=0.01, R^2=0.59) (Table 1).

Greater mean FCSA (e.g. greater lean muscle mass, excluding fatty infiltration) was associated with greater strength in all directions, as well as greater overall muscle strength. Again, age and BMI were significant covariates and entered in the multivariate analyses. The mean FCSA explained 37%, 76%, 39%, 20% and 65% of the total variance in flexion, extension, right-side bending, left-side bending and overall muscle strength, respectively.

While the mean ratio of FCSA/CSA (e.g. degree of fatty infiltration) was not significantly associated with cervical muscle strength in any direction. None of the MRI muscle parameters were significantly associated with symptoms severity or functional status, with the exception of greater mean FCSA/CSA (less fatty infiltration) which was associated with higher mJOA score (lower disability) (p=0.02, R^2=0.20).

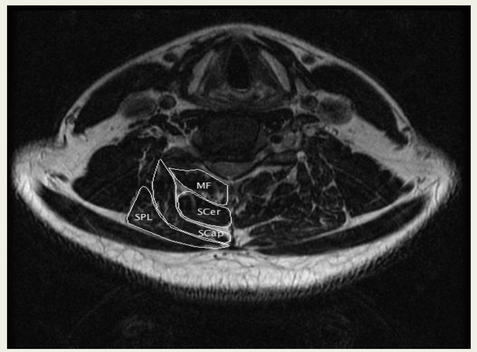

Figure 1. Measurement of total cross-sectional area (CSA) for the multifidus (MF), semispinalis cervicis (SCer), semispinalis capitis (SCap) and splenius capitis (SPL).

RESULTS

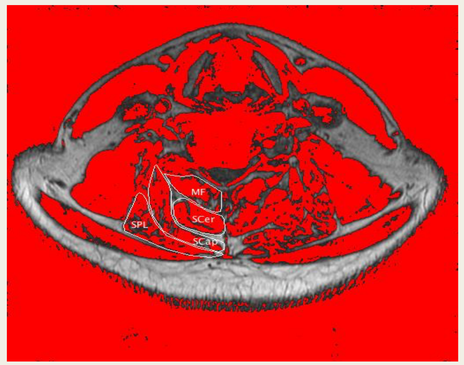

Figure 2. Thresholding technique to highlight fat-free muscle area and obtain functional cross-sectional (FCSA) measurements.

	Standardized regression coefficient	P-value	Adj-R^2
C2-C7 mean CSA			
Flexion	.53 [.10-.96]	0.02	0.25
Extension	.89 [.46, 1.32]	<0.01	0.72
Right side bending	.52 [.09-.96]	0.02	0.24
Left side bending	.43 [-.05, .92]	0.07	0.11
Overall strength	.82 [.29, 1.35]	<0.01	0.59
C2-C7 mean FCSA			
Flexion	.60 [.21, .99]	<0.01	0.37
Extension	.93 [.50, 1.36]	<0.01	0.76
Right side bending	.62 [.23, 1.00]	<0.01	0.39
Left side bending	.50 [.05, .95]	0.03	0.20
Overall strength	.85 [.33, 1.39]	<0.01	0.65

Table 1. Associations between the muscle parameters of interest and muscle strength.

DISCUSSION

This study provides early evidence that lean muscle mass of the deep cervical muscles, quantified via MRI, was positively associated with cervical muscle strength in patients with DCM. We are not aware of any other study that examined the associated between cervical muscle FCSA and cervical muscle strength in patients with chronic neck pain or DCM.

Moreover, greater fatty infiltration in the cervical extensor muscles was associated with lower mJOA functional score (e.g. more disability).

Such findings suggest that the relationship between cervical muscle composition and function is an area for further study and that clinicians should pay greater attention to cervical muscle morphology and function in patients with DCM.

CONCLUSIONS

Future studies should further evaluate the effects of specific rehabilitative strengthening cervical muscle exercises on CSA and FCSA in patients with DCM.

It would also be valuable to investigate whether changes in CSA or FCSA and muscle strength contribute to variations in patient symptoms, functional outcomes, and prognosis following surgery.

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None of the authors has any potential conflict of interest.