Association between severity of the cervical foraminal stenosis and paraspinal muscle parameters in patients undergoing anterior cervical discectomy and fusion

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INTRODUCTION: The cervical multifidus and rotatores (MR) muscles are innervated by the posterior rami of the spinal nerves of the corresponding level, and it is hypothesized that cervical foraminal stenosis (CFS) affecting the spinal nerves results in changes in these muscles.

METHODS: Patients with preoperative cervical MRI imaging who underwent anterior cervical discectomy and fusion (ACDF) between 2015 and 2018 were reviewed. MR were segmented bilaterally from C3 to C7, and percent fat infiltration (FI) was measured. ITK SNAP version 3.8.0 was employed for the segmentation process of the MR and a custom-written Matlab software calculated the FI. The severity of the NFS was assessed by the Kim classification. Multivariable linear mixed models were conducted and adjusted for age, sex, body mass index and repeated measures.

RESULTS SECTION: 149 patients were included. Linear mixed modelling results showed that a more severe CFS at C3/4 was correlated with a greater FI of MR at C4 (95% CI [0.003; 0.064], p = 0.031), a more severe CFS at C4/5 with a greater FI of MR at C5 (95% CI [0.015; 0.057], p < 0.001), a more severe CFS at C5/6 with a greater FI of MR at C6 and C7 (95% CI [0.019; 0.062], p < 0.001, 95% CI [0.012; 0.058], p = 0.003), and a more severe CFS at C6/7 with a greater FI of MR at C7 (95% CI [0.027; 0.071], p < 0.001).

DISCUSSION: Our results demonstrated level- and side-specific correlations between the FI of the MR and severity of CFS. Given the segmental innervation of the MR, we hypothesize that the observed increased FI could be reflective of changes due to muscle denervation from CFS. Interestingly, our results showed that the severity of CFS at C6/7 was associated with less FI of MR at C3. We hypothesized that a compensatory mechanism could occur to reach a greater stabilization at the upper levels.

SIGNIFICANCE/CLINICAL RELEVANCE: The preservation of the cervical muscles is essential to maintaining sagittal alignment, as the multifidus and rotatores are important neck stabilizers. Functional and strengthening exercises for cervical muscles might prevent decompensation in cases of CFS. Moreover, surgery may be required earlier to treat the pathology and to avoid progression of the FI of the MR.

Table 1: Tabular presentation showing the significant correlations between the fat infiltration (FI) of the multifidus and rotatores (MR) and the severity of CFS at subaxial levels.

	$MR._{FI}.3$	**$MR._{FI}.4$**	**$MR._{FI}.5$**	**$MR._{FI}.6$**	**$MR._{FI}.7$**
CFS C3/4	p = 0.963 Est. < 0.001 (-0.033, 0.034)	**p = 0.031** Est: 0.034 (0.003, 0.064)	p = 0.109 Est. 0.020 (-0.005, 0.046)	p = 0.897 Est. -0.002 (-0.031, 0.027)	p = 0.713 Est. 0.006 (-0.025, 0.036)
CFS C4/5	p = 0.519 Est. -0.009 (-0.037, 0.019)	p = 0.134 Est. 0.020 (-0.006, 0.047)	**p < 0.001** Est. 0.037 (0.015, 0.057)	p = 0.148 Est. 0.019 (-0.007, 0.044)	p = 0.371 Est. 0.012 (-0.014, 0.038)
CFS C5/6	p = 0.813 Est. 0.003 (-0.021, 0.026)	p = 0.790 Est. 0.003 (-0.020, 0.026)	p = 0.094 Est. 0.016 (-0.003, 0.034)	**p < 0.001** Est. 0.041 (0.019, 0.062)	**p = 0.003** Est. 0.035 (0.012, 0.058)
CFS C6/7	**p = 0.033** Est. -0.027 (-0.051, -0.002)	p = 0.958 Est. < 0.001 (-0.023, 0.024)	p = 0.988 Est. < 0.001 (-0.019, 0.019)	p = 0.636 Est. -0.005 (-0.028, 0.017)	**p < 0.001** Est. 0.049 (0.027, 0.071)

Statistical significance was set at p-value < 0.05. Significant values are in bold and in green highlighted. The non-significant correlations are highlighted in red. The estimate (Est.) and confidence interval are shown. FI: fat infiltration; MR: multifidus and rotatores; CFS: cervical foraminal stenosis.