Title: Automatic paraspinal muscle segmentation in patients with lumbar pathology using deep convolutional neural network

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Structured Abstract:

Introduction: Recent evidence suggests an association between low back pain (LBP) and changes in lumbar paraspinal muscle morphology and composition (i.e., fatty infiltration). Quantitative measurements of muscle cross-sectional areas (CSAs) from MRI scans are commonly used to examine the relationship between paraspinal muscle characters and different LBP conditions. However, the manual segmentation required is time-consuming, laborious, and can be inconsistent. To date, no automatic MRI segmentation algorithms exist for patient data, which is likely due to the complex paraspinal muscle anatomy and high variability in muscle composition among the patient population.

Methods: We employed deep convolutional neural networks to automatically perform the segmentation from T2-weighted MRI axial slices at the L4-L5 and L5-S1 spinal levels. In this proposed architecture, we combine the classic U-Net, conditional random fields as recurrent neural network (CRF-RNN), and multi-data training with gradient magnitude map to achieve highly accurate multi-class segmentation.

Results: We use Dice coefficient, sensitivity (recall), positive predictive value (PPV), and mean boundary distance (MBD) to quantitatively assess the segmentation performance of our trained neural networks. For all target muscles, we obtain an average Dice of 93.8%, recall of 93.9%, PPV of 94.2%, and an overall MBD of 1.00 mm.

Discussion: Our results demonstrate that adding gradient magnitude images as additional training set can significantly improve the segmentation accuracy without increase network complexity and adding CRF-RNN is able to reduce issues of island labels. In addition, leveraging the automatic segmentation results, the muscle morphometric analysis demonstrates that female sex and aging is correlated with increased fatty infiltration in multi-fidus and erector spinae muscles (p<0.05) among patients with lumbar pathologies.