

The influence of paraspinal muscle fatty degeneration on bone strength measured by finite element analysis

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INTRODUCTION: Understanding muscle and bone conditions is crucial in patients with spinal disorders, with complex interactions between musculature, bone, fat tissue, and patient characteristics. The adaptation of muscle and bone to mechanical loading underscores their health, and lack of loading has negative consequences. Despite the growing recognition of muscle conditions in spinal disease patients, the specific relationship between paraspinal muscle fatty degeneration and vertebral body strength remains unexplored. This study aims to investigate this relationship using accurate techniques such as finite element analysis (FEA) in a cohort of patients with spinal disorders.

METHODS: In this retrospective cross-sectional study, 135 patients with spinal disease who underwent preoperative lumbar CT and MRI between 2014 and 2020 were included. Patient characteristics including age, gender, body mass index (BMI), and lumbar degenerative changes were collected. The vertebral strength of the L1 vertebral body was measured using FEA (Figure 1), while fat infiltration (FI) of the posterior paraspinal muscles (PPM-FI) and psoas muscles (Psoas-FI) was evaluated on MRI (Figure 2). Multiple regression analysis was conducted, with vertebral strength as the dependent variable, to assess its relationship with muscle fat degeneration.

RESULTS SECTION: The study cohort included 107 patients with a median age of 62.4 years. FI of the Psoas and PPM was 41.4% and 4.9%, respectively. The Spearman's correlation showed that Psoas FI and PPM FI were negatively correlated to vertebral strength ($r = -0.27$; $p = 0.004$ and $r = -0.32$; $p < 0.001$, respectively). The multivariate linear regression model demonstrated that age, Psoas FI, PPM FI, and lumbar degenerative changes were independent factors associated with vertebral strength. FI of Psoas and PPM negatively affected vertebral strength ($\beta = -15613.8$; $p = 0.013$, $\beta = -7677.7$; $p = 0.021$, respectively) (Table).

DISCUSSION: FI of Psoas and PPM have a negative effect to vertebral strength. A comprehensive preoperative assessment, including paraspinal muscle evaluation, may help improve outcomes in patients with spinal disorders.

SIGNIFICANCE/CLINICAL RELEVANCE: Paraspinal muscle fatty degeneration has a negative effect on vertebral strength.

REFERENCES: Keaveny TM, Adams AL, Fischer H, Brara HS, Burch S, Guppy KH, et al. Increased risks of vertebral fracture and reoperation in primary spinal fusion patients who test positive for osteoporosis by Biomechanical Computed Tomography analysis. The Spine Journal 2023

IMAGES AND TABLES:

Figure 1.

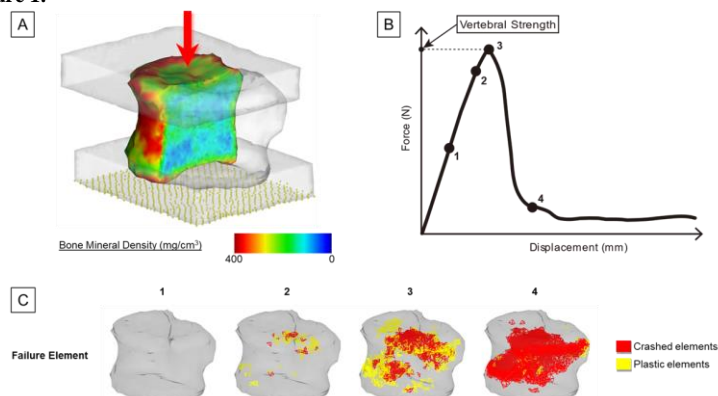
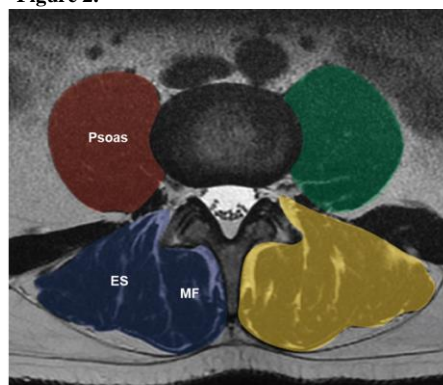


Figure 2.



A and B: A finite element model of L1 vertebra with cement cap and a typical force-displacement curve illustrates compression force. Vertebral strength was defined as the rapid decrease in the force-displacement curve (point 3).

C: Failure elements at each time point in B. In the failure element, red and yellow elements show crashed and plastic, respectively. Failure elements were rapidly increased after the top of the force-displacement curve.

Table. Multivariable analyses

Factors	β	95%CI	p-value
Age	-80.4	-136.6, -24.2	0.006
Sex (Male)	233.5	-357.8, 824.8	0.435
BMI	-7.7	-98.3, 83.0	0.867
PPM-FI	-7677.7	-14180.1, -1175.4	0.021
Psoas-FI	-15613.8	-27922.0, -3305.6	0.013
Degenerative change	489.3	200.5, 778.2	0.001

Bold values indicate significance ($p < 0.05$)

BMI, body mass index; Psoas, Psoas muscle; PPM, posterior paraspinal muscle; FI, fat infiltration