DISCLOSURE: None of the authors has received financial support for this study.

INTRODUCTION: Previous studies investigated the overall mechanical strength of the vertebral body; however, limited information is available on the biomechanical properties of different regions within the vertebral endplate and cancellous bone. In addition, the correlation between mechanical strength and various density measurements has not been studied yet.

METHODS: Thoracic (T10) vertebrae were harvested from fifteen human cadaveric spines (average age: 77 years old). Twelve cylindrical cores of 7.2 mm (diameter) by 3.2 mm (height) were prepared from each vertebral body. Shear was produced using a stainless steel tubular blade and measured with a load cell from a mechanical testing machine. Optical and bulk densities were calculated before mechanical testing. Apparent, material, and ash densities were measured after testing.

RESULTS: Density increased from anterior to lateral regions of both endplate and cancellous bone. Shear strength was significantly lower in the anterior (0.52 ± 0.08 MPa) than in the lateral region (2.72 ± 0.59 MPa) (p=0.017). From the inferior to the superior endplates, shear strength and maximum load to failure decreased by 23% and 33%, respectively (p>0.05). Trabecular bone maximum load carrying capacity was 5 times higher in the lateral (12 ± 2.74 N) (p=0.09) and 4.5 times higher in the central (10 ± 2.24 N) (p=0.2) than in the anterior (2 ± 0.60 N) regions. Mechanical strength positively correlated with ash density and most closely with material density.

DISCUSSION: Shear strength was the lowest at the anterior region and highest at the lateral region for both endplate and cancellous bone. Material density had the best correlation with mechanical strength. However, due to a small sample size, our study was underpowered. We are currently testing more specimens.

SIGNIFICANCE: Results from this study may explain the vertebral fracture patterns in osteoporotic patients. Furthermore, newer spinal implants could optimize the loading in the lateral aspects of both endplate and cancellous bone; thus, reducing the likelihood of screw loosening and the subsidence of disc replacement devices.

Figure 1. Plain radiographs of thoracic vertebrae.
A) Lateral view of a segment of the thoracic column.
B) Axial view of a thoracic vertebra showing the different regions: anterior, central, and lateral.
C) Lateral view: I- Endplate anterior superior; II- Endplate central superior; III- Cancellous anterior superior; IV- Cancellous central superior; V- Cancellous anterior middle; VI- Cancellous central middle; VII- Endplate anterior inferior; VIII- Endplate central inferior.

Figure 2. Mean (SE) density and shear stress values for the three main regions of the vertebral cancellous bone. 
a) optical density (g/cm³); b) material density (g/cm³); c) elemental shear stress (MPa). *: p<0.05
Anterior (N = 10); Central (N = 26); Lateral (N = 27)
Note that the anterior (ant) region had higher optical density than the central (cen) and lateral (lat) regions. However, the anterior region had the lowest material density and mechanical strength.

Figure 3. Mean (SE) density and shear stress values for the three main regions of the vertebral endplate (EP).
a) optical density (g/cm³); b) material density (g/cm³); c) elemental shear stress (MPa). *: p<0.05
Anterior (N = 14); Central (N = 28); Lateral (N = 24)
Note that the anterior (ant) region had higher optical density than the central (cen) and lateral (lat) regions. However, the anterior region had the lowest material density and mechanical strength.

ORS 2016 Annual Meeting Poster No. 0905