Implications of statistically significant different regional C1 and C2 bone mineral densities for upper fracture fixation

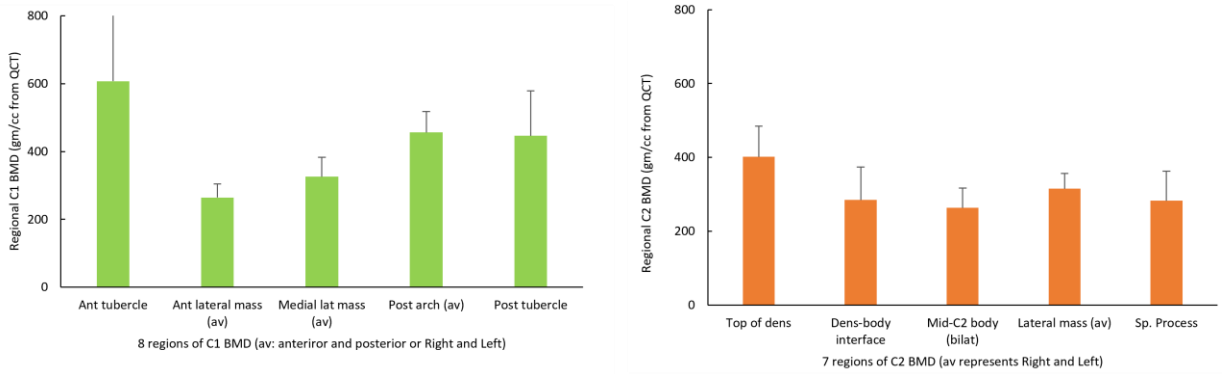
Background: The global population is aging. Elderly patients experience an increased incidence of C1 and C2 fractures, particularly odontoid fractures, due to falls. Surgical stabilization effectiveness depends on screw purchase and local bone strength.

Research Question: Hypothesis: trabecular bone mineral density (BMD), a measure of screw purchase /bone strength, depends on local anatomical regional variations encountered at C1 and C2.

Design and Methods: BMDs of 20 elderly (mean:66-years) human cadaver C1 and C2 were obtained from quantitated Computed Tomography (QCT). Regions for C1: anterior tubercle, bilateral anterior and medial lateral masses, bilateral posterior arches, and posterior tubercle. Regions for C2: odontoid top, base of odontoid-body interface, mid-body, bilateral lateral mass, anterior inferior body near disc, and spinous process. Repeated measure linear-mixed model was used for statistics ($p<0.05$, significance). Tukey's Post Hoc test used to analyze regional BMD variations.

Results: BMD (Figure-1): greatest at C1 anterior tubercle and posterior ring, and least at anterior and medial lateral masses. C2: BMD was greatest at dens top and least in mid-body. Correlation between BMD at dens-vertebral body interface with vertebral body was high (Pearson correlation=0.86). BMD of top of dens was significantly higher ($p<0.05$) than all other regions.

Conclusions/Discussion: Regional BMD variations within C1/C2, and C1-to-C2 proved the hypothesis. This may have surgical implications, especially for odontoid fracture fixation with screws as the mid-body has lowest BMD. For posterior arch fracture stabilization with C1-C2 instability using pedicle/pars/lateral mass/ trans-articular screws, regional BMD variations should be considered to optimize screw length to obtain a secure/stable construct.



Legend: Regional BMD variations in C1 (left) and C2 (right) based on quantitated computed tomography images processed using a pe-calibrated phantom of differing bone mineral densities.