Paper #8: Coupled Symmetry and Pattern of Rib Growth in the Growing Human

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Introduction: While there is substantial information on the changes of the rib cage during childhood and asymmetry of the thorax in children with scoliosis, there are virtually no normative data on the growth of ribs throughout childhood and adolescence.

Material and Methods: The Hamann-Todd Osteological Collection provided the bones of 32 specimens aged 1-18 years. 6226 individual photographs of all vertebral bodies and ribs were obtained from these specimens. Quantitative measurements were taken with image analysis software and the results of two of the measurements, the Outer Costal Length (OCL) and the Base Diameter (BD), are presented here.

Results: With the exception of the ribs at T12, both the OCL and the BD showed a linear, statistically significant growth with age for all ribs, and the linear relationship between the BD and OCD correlated across all ages, indicating that the ribs changed their dimensions in unison. The BD x OCL product indicates that the ribs grow through coupled symmetry, in which ribs in the upper and lower thorax start at the same size and grow at the same rate within the pair; ribs 1 and 12, 2 and 11, 3 and 10. Each rib pair grows at a significantly different rate from the other pairs. Measurements of BD and OCL from a specimen with scoliosis from the collection compared to these normative values were greatly different. The principle that ribs follow a known geometric shape, called the golden spiral, is introduced. Similar to a nautilus shell, rib growth is primarily at the sternal end of the rib spiral.

Conclusions: We believe that this is the first report of the change in length and shape of normal ribs, measured directly from the human specimens in a wide age range of children who did not have scoliosis. This data adds to the understanding of normal rib growth and provides a framework for determining the difference between ribs from normal children and those with scoliosis.