Atlas of Science
another view on science
http://atlasofscience.org

Vertebral asymmetry of the scoliotic spine

Scoliosis is a three-dimensional (3D) deformity of the spine, including lateral deviation in the coronal plane, as well as deformations in the sagittal plane and vertebral rotation in the transverse plane. Adolescent idiopathic scoliosis (AIS) is the most common type of scoliosis and affects 1–4% of adolescents. Despite many years of dedicated research, the etio-pathogenesis of idiopathic scoliosis is, to a large extend, still unknown.

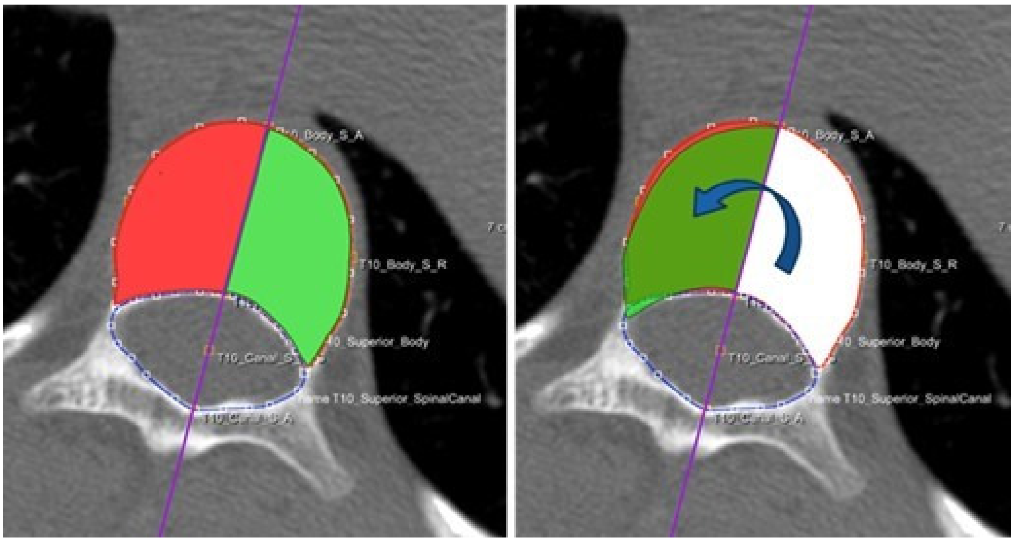

Fig. 1. CT images showing the true transverse reconstructions of a vertebra. After manual segmentation of the vertebral body and spinal canal the software flipped the right side of the endplate across the longitudinal vertebral axis, to calculate the overlap between the left (in green) and right (in red) side of the vertebral body.

Transverse plane asymmetry of the vertebral body and posterior elements, such as the pedicles and laminae, is a well-known part of idiopathic scoliosis. Accurate descriptions of the 3D deformity were already given by 19th century anatomists in cadaveric specimen, followed by more recent studies, describing the transverse asymmetry in pedicle dimensions between the convex and concave side of the curve. Unfortunately, the role of this asymmetry in the unknown etio-pathogenesis of the idiopathic scoliosis, and whether it represents an active asymmetrical growth pattern, or a passive adaptation due to asymmetrical biomechanical loading, remained undetermined so far.

In this study, the vertebral body asymmetry (Fig. 1), defined as left-right overlap of the vertebral endplates (i.e. 100%: perfect symmetry, 0%: complete asymmetry), and pedicle asymmetry (Fig. 2), defined as the difference in the pedicle width, length and angle and length of the ideal screw trajectory between the concave and convex pedicles, was evaluated in the true transverse plane on CT scans of 77 moderate to severe AIS patients and 32 non-scoliotic controls.

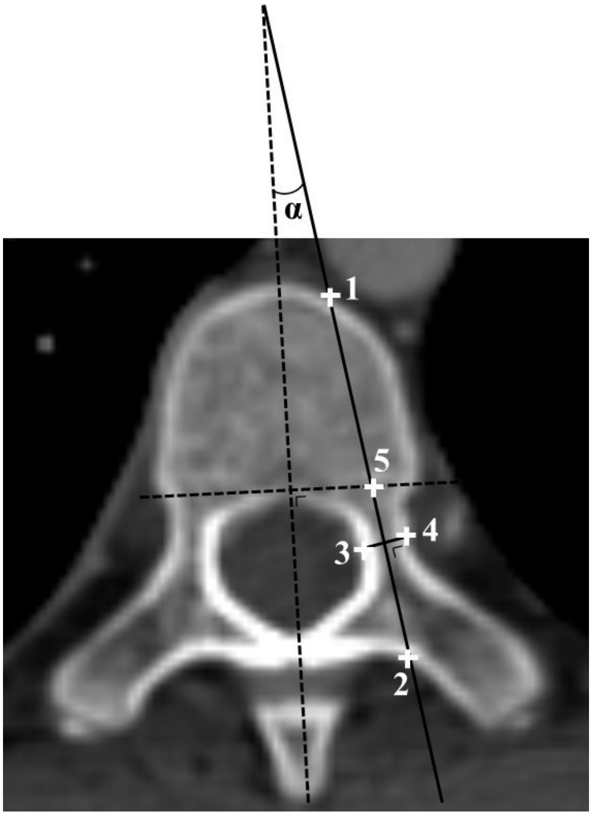

Fig. 2. Pedicle width was defined as the narrowest length between the medial and lateral outer cortex on the right-left axis (point 3-4); pedicle length as the length between the posterior outer cortex of the lamina and the anterior side of the spinal canal on the longitudinal axis (2-5); length of the ideal pedicle screw trajectory as the length between the posterior outer cortex and the anterior outer cortex of the vertebral body on the longitudinal axis (1-2; mimicking the length of the ideal pedicle screw trajectory in the transverse plane) and the transverse pedicle angle as the angle between the pedicle axis and the vertebral axis (α).

We observed that even in non-scoliotic controls a certain degree of vertebral asymmetry exists, but scoliotic vertebrae were on average more asymmetric than controls (thoracic: AIS 96.0% versus controls 96.4%; p=0.005, lumbar: 95.8% versus 97.2%; p<0.001), more pronounced around the thoracic apex (95.8%) than at the end vertebrae (96.3%; p=0.031). In the thoracic apex; the concave pedicle was thinner (4.5 versus 5.4mm; p<0.001), longer (20.9 versus 17.9mm; p<0.001), the length of the ideal screw trajectory was longer (43.0 versus 37.3mm; p<0.001) and the transverse pedicle angle was greater (12.3 versus 5.7°; p<0.001) than the convex one. However, the axial rotation showed no clear correlation with the asymmetry.

Our measurements of the pedicle width asymmetry in idiopathic scoliosis were consistently smaller than the measurements that have been reported in previous studies. CT measurements completely depend on voxel size in relation to the size of the structure to be measured. On our high-resolution CT scan (0.625 mm) we observed that even slight deviation from the ideal transverse plane of the rotated, translated and tilted vertebrae automatically induces apparent, but not necessarily true asymmetry. Furthermore, the measurement of the vertebral body asymmetry is critical as well and depends on where the dividing line between left and right is drawn in these rather irregular structures. Therefore, a semi-automatic and previously validated software was used to create an objective, very reliable and reproducible dividing line between left and right and makes it attractive to use.

In conclusion, our results showed that even in non-scoliotic controls there is a degree of vertebral body and pedicle asymmetry, but scoliotic vertebrae showed slightly more asymmetry, mostly around the thoracic apex. However, there is no uniform relation between the axial rotation and vertebral asymmetry in these moderate to severe patients and these data suggest that asymmetrical vertebral growth does not initiate rotation, but rather follows it as a secondary phenomenon.

Rob C. Brink, René M. Castelein
Department of Orthopaedic Surgery, University Medical Center Utrecht, Utrecht, The Netherlands

Publication

Asymmetry of the Vertebral Body and Pedicles in the True Transverse Plane in Adolescent Idiopathic Scoliosis: A CT-Based Study.
Brink RC, Schlösser TPC, Colo D, Vincken KL, van Stralen M, Hui SCN, Chu WCW, Cheng JCY, Castelein RM
Spine Deform. 2017 Jan