ABSTRACT INTRODUCTION:
Vertebral rotation is an important component of scoliosis.\textsuperscript{1,2} Whereas the typical curves and their associated rotation in AIS have been well described, little is known of possible patterns of rotation in the normal, non-scoliotic spine. Rotation in the normal spine is relevant to the curve patterns seen in AIS.

The purpose of this study was to determine if there is a pre-existent pattern of rotation in the normal non-scoliotic spine.

METHODS:
Twenty-five males and 25 females mean age 33.3 years (range 7-74 years), without clinical or radiological evidence of scoliosis or other spinal pathology had undergone CT examination of the thorax and abdomen for unrelated reasons. Vertebral rotation was measured in the transverse plane at all levels from T2 down to level L5 in men and from T1 down to T13 in dogs, using the method as described below.

Measuring Method
We developed a new semi-automated procedure using an interactive application to calculate the rotation angle of the vertebrae. Vertebral rotation was defined as the angle between the longitudinal axis of each vertebra and the mid-sagittal axis of the trunk (= reference line). The reference line was defined as zero degrees rotation. Rotation to the right was defined as a positive angle, to the left as a negative angle. The reference line was defined at level T5 as the line between the centre of the spinal canal and the centre of the sternum; the longitudinal axis of each vertebra was defined as the line through the middle of the vertebral body and the centre of the spinal canal. In order to be able to calculate the rotation angle of each vertebra fully automatically, we needed to segment the vertebrae and the spinal canal in every selected slice. Furthermore, at level T5 we also segmented the sternum. To determine the centre points we calculated the Center Of Mass of these structures, because they accurately represent the centre of these objects. The ICC’s calculated for inter and intraobserver reliability of our method were respectively 0.96 ± 0.06 and 0.99 ± 0.01 (mean ± SD), which showed our method to be reliable and reproducible.

Statistics
Statistical analysis was performed by means of SPSS statistical software. The observed frequencies of right and left vertebral rotation were used to test the null hypothesis of equal probability with the binominal test. To determine if the mean vertebral rotation angles were statistically significant we used the One Sample T-test. A P-value of 0.05 was considered significant.

RESULTS:
Measurement of the vertebral rotation angle showed a significant mean rotation angle to the left at level T3 (1.0°) and T4 (1.0°) and to the right at level T6 (2.5°) to T11 (1.4°) with a maximum rotation of 2.6° at T7 (P<0.005), see figure 1. No difference could be found between males and females.

In the high thoracic spine (T2-T4) vertebrae show a predominant rotation to the left. At levels T3 and T4, this proportion differed significantly from an equal right-left distribution (P<0.05). In the mid and lower part of the thoracic spine and the lumbar spine (T5-L5) vertebrae show a predominant rotation to the right, which is significant at levels T6 to T10 (P<0.001) and T11 (P=0.02), see table 1.

DISCUSSION:
Our study shows a predominant rotation to the left of the high thoracic vertebrae, and to the right of the mid and lower thoracic vertebrae in the normal, non-scoliotic spine. This rotation is similar to what is found in the most prevalent types of idiopathic scoliosis. We could not demonstrate a rotation to the left in the lumbar area, but it is obvious that rotation reverts to neutral around the thoraco-lumbar junction.

The fact that rotation in the non-scoliotic spine is not neutral or randomly distributed is an important finding, because it may explain to a large extent the most prevalent patterns of rotation in AIS. Apparently, once the spine starts to decompensate due to a still unknown cause, it logically follows this already built in rotational tendency.

REFERENCES: