Introduction: The Neurocentral Synchondrosis (NCS) is a physis in the spine located at the junction of the pedicle and vertebral body. It is considered important in the growth of the both the vertebral body and the posterior arch. Under normal conditions, symmetric growth occurs bilaterally at each NCS resulting in normal spine growth without deformity. It may be hypothesized that an asymmetric disturbance of the NCS would result in relative excess growth on the unaffected side and may lead to both coronal and axial plane deformity. The purposes of this study are to perform epiphysiodesis of the NCS using unilateral single or double transpedicular screws producing idiopathic-like scoliosis in a growing pig model, to correlate scoliotic curve magnitude with degree of NCS closure.

Materials and Methods: This study was approved by the Institutional Animal Care and Use Committee. Eight 2-month old neutered male domestic pigs were used. After general anesthesia, the animal was placed in the prone position. A midline posterior skin incision was made from T7 to T14. The pigs were randomly assigned to three groups: control group (n=2: no pedicle screw fixation; single screw group (n=3): the animals underwent single pedicle screw (3.5 x 26 mm cortical screw) fixation of the right pedicles from T7 to T14; and double screw group (n=3): as in the single screw group only two screws were placed in each pedicle.

No postoperative immobilization was utilized. Radiographs were obtained every 2 months. All animals were euthanized at 6 months. Axial computed tomography (CT) scans was performed using a high speed CT scanner. Axial rotation of each vertebra was measured using Synapse Analysis System. The spines were then separated into individual vertebra. Each vertebra was sectioned in the transverse plane into four 4 mm thickness segments. The specimens were fixed in 70% ethanol, undecalcified, and embedded in methylmethacrylate. Each specimen was cut, ground, and polished to a final thickness of 30-40 μm slices. The slices were stained using a rapid bone stain. Histomorphometric analysis were performed using a digitizing image analysis system coupled to a light microscope at 4X and 20X with the following parameters: 1) spinal canal area; 2) pedicle length and width; and 3) histological grading of the NCS closure using a 6-point (0 to 5) histological scale: 0 = no NCS closure; 1 = less than 25% NCS closure; 2 = 25-50% NCS closure; 3 = 50-75% NCS closure; 4 = 75-100% NCS closure; and 5 = 100% NCS closure.

Results: All animals survived without neurological complications and remained normal and healthy for 6 months. At the time of sacrifice, a scoliotic curve was seen in no animal in the control group, 1 of 3 (47 degree) in the single screw group, and 3 of 3 (30 degree, 42 degree, and 42 degree) in the double screw group (figure 1). All curves were located at the level of the operated segments with the convexity on the side of screw fixation. In the animals with scoliotic curve, the vertebrae were axially rotated toward the screw side with average16 ± 7.4 degree. The spinal canal area was 145.4 ± 7.1 mm2 in the control group, 146.9 ± 12.3 mm2 in the single screw group, and 144.5 ± 6.6 mm2 in the double screw group. There was no significant difference amongst the three groups.

There were no significant differences in the pedicle morphology between the left and right side in the control group. In the single screw group, the left pedicle length (13.9 ± 1.3 mm) was 9% greater than the screw side (12.6 ± 2.5 mm) (P=0.008) and no significant difference was found in the pedicle width. In the double screw group, the left pedicle length (14.9 ± 1.8 mm) was 23% greater than the screw side (11.5 ± 2.2 mm), and the screw side pedicle width (8.4 ± 1.6 mm) was 16% greater than the left (7.1 ± 1.1 mm) (P<0.001).

The NCS closure grade scale on the screw side was 0 in the control group, 2.9 ± 2.2 in the single screw group, and 4.4 ± 1.1 in the double screw group (figure 2). Comparison of the NCS among the three groups showed the NCS closure in the double screw group was significantly greater than the one in the single screw group, and both were greater than the control group (P<0.001). The NCS closure was strongly correlated with the scoliotic curve magnitude with the equation y = 1.04 + 0.084 x (P=0.001).

Discussion: This study demonstrated that 1) the scoliosis with rotational deformity was produced with hemiepiphyseodesis of the NCS in a growing animal model; 2) no spinal stenosis is created; 3) asymmetric growth of the unaffected pedicle produces the deformity; and 4) the amount of the NCS closure correlates with scoliotic deformity. More NCS closure would result in greater scoliotic deformity. In conclusions, unilateral pedicle screw fixation crossing the NCS in a growing pig model produces asymmetric growth of the NCS to create scoliosis with the convexity on the side of screw fixation. Unilateral double pedicle screw provided more epiphysiodesis of the NCS to consistently produce a structural curve. This strategy may have some future role in the treatment of very young patients with early onset spinal deformity.