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 were to perform epiphysiodesis of the NCS using unilateral single or double transpedicular screws producing idiopathic-like scoliosis in a growing pig model, to histologically evaluate the growth inhibition of the NCS by pedicle screw fixation and to correlate curve magnitude with the fusion rate of the synchondrosis.

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 bilateral paraspinal muscle was exposed. The pigs were randomly assigned to three groups: control group (n=2); the incision was left open; the 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 4% paraformaldehyde for 48 hours, and then decalcified using 14% EDTA. Radiographs of the specimens verified bone decalcification and then the specimens were embedded in paraffin. Multiple 5-um slices were obtained from each cut surface and deparaffinized. The sections will be stained with hematoxylin and eosin (HE). Histological analysis will be performed using a digitizing image analysis system coupled to a light microscope at 20X (Axial-Version, Carl Zeiss, Germany). Quantitative histology of the NCS was performed measuring NCS fusion rate, hypertrophic zone, proliferative zone, and chondrocyte size.

1) The NCS closure rate was assessed at each section using the following pattern: NCS closure rate (%) = Distance of Absent NCS / NCS width x 100%.
2) The anterior hypertrophic (AHZ), posterior hypertrophic (PHZ) and proliferative (PZ) zones were measured at each NCS (Figures 1). The hypertrophic zone will be measured from the first chondrocyte with a height of > 10 um to the last intact lacuna with a hypertrophic cell, as previously described.
3) Chondrocyte height (CH) and width (CW) were measured (Figures 2).

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 (33.3 degree) in the single screw group, and 3 of 3 (30 degree, 42 degree, and 42 degree) in the double screw group (Figure 3). 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 average 16 ± 7.4 degree. The NCS fusion rate in the double-screw group (92%) was greater than the single-screw group (49%) which was greater than the control group (0%) (P<0.05) (Figure 4). The NCS closure was correlated with the scoliotic curve magnitude with the equation y (NCS closure rate) = 1.04 + 0.084 x (curve magnitude).

Conclusion: NCS has a bipolar arrangement with even growth toward both anteriorly to the vertebral body and posteriorly to the pedicle. Under normal conditions, symmetric growth occurs bilaterally at each NCS resulting in normal spine growth without deformity. A pedicle screw crossing the NCS creates fusion around the screw-site with decreased height of the hypertrophic and proliferative zones and a decrease in chondrocyte height / width resulting in scoliosis with the convexity on the side of screw fixation. Unilateral double pedicle screws provide a greater epiphysiodesis effect on the NCS and correlated with a greater degree of deformity.

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