ENDOSCOPIC MECHANICAL SPINAL HEMIEPIPHYSIODESIS MODIFIES SPINE GROWTH

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INTRODUCTION – Current methods of scoliosis correction are invasive and expensive. Recent technical advances may allow for earlier, minimally invasive surgical methods for select patients. While the clinical history of unilateral spinal growth arrest is cautionary at best, a few experimental studies suggest that spinal growth may be mechanically controlled.1,2,3,4

The purpose of this study was to develop a simple endoscopic implant capable of modifying spine growth without fusion. Related goals were to isolate necessary implant design features and to determine if the mechanism of curvature induction included changes in growth plate structure.

METHODS – In eight live skeletally immature domestic pigs, staples were implanted across the growth plates of one side of the mid-thoracic vertebrae just anterior to the rib heads using anterior endoscopic procedures approved by an IACUC. At least 6 staples of a single design were implanted per pig. Five staple designs of successively increasing complexity have been tried. Results were assessed biweekly with radiographs, and CT scans were obtained after spine harvest. Follow-up time was 6-9 weeks. Coronal sections were cut for histologic analysis. The design variables were staple anatomic location, fixation methods, blade size, and ease of endoscopic implantation. Three of the implants were custom made using digital solid modeling, stereolithography and advanced casting techniques.

RESULTS – Two (Fig. 1a, 3a) of the five implant designs resulted in mild (20-25°) (Fig 1b, 1c) to moderate (35-40°) (Fig 3c) increases in curvature within 2 months using staples that crossed the invertebral disc and two longitudinal growth plates. Growth plate structure showed graded differences from stapled (Fig 2B) to unstapled (Fig 2A) sides, and between stapled and unstapled (Fig. 2C) vertebrae in chondrocyte size and organization, and in the bone density at the metaphyseal margin. Staple blade lengths of nearly half the width of the vertebrae induced physeal changes that gradually decreased across the entire vertebrae. Improvements in fixation methods were most effective in increasing spine curvature. The most successful design to date (Fig 3a) included two screws and relatively wide, short, angled, and barbed blades.

DISCUSSION – This pilot study showed that a simple implant and minimally invasive methods can induce spine curvature without fusion. The mechanism included structural changes to the growth plate consistent with direct physeal compression. The specific design of the staple was crucial to fixation, and therefore to the amount of curvature induced.

Factors potentially critical to clinical significance include differences in anatomy and growth rates between species, and in normal versus pathological growth. Further studies are required to determine the consistency of curvature induction and control of the plane of curvature. Torsional deformity has not yet been addressed. However, this study showed that spine growth can be altered using surgically relevant, minimally invasive procedures.


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