Spinal Hemiepiphysiodesis Correlates with Structural Changes to Vertebral Growth Plates and Disc Consistent with Asymmetric Compression

Donita I. Bylski-Austrow¹,², Eric J. Wall¹,², David L. Glos¹, Edgar T. Ballard¹, Andrea Montgomery¹, Alvin H. Crawford¹,²
¹Orthopaedics, Cincinnati Children’s Hospital Medical Center, Cincinnati, OH; ²University of Cincinnati, Cincinnati, OH
Sherrie.powers@cchmc.org

Introduction: Hemiepiphysiodesis remains a potential method to treat idiopathic scoliosis early and much less invasively (1). In long bones, staples have been shown to change the structure and function of the growth plate, particularly in the hypertrophic zone (2). In the spine, while the intervertebral disc strongly affects stresses transmitted to the physes, compression of tail motion segments altered physeal structure (3). The purpose of this study was to determine if structural changes to the vertebral growth plate were correlated with increased thoracic curves. The hypotheses were that the height of the hypertrophic zone and size of hypertrophic cells decreased after treatment at the stapled levels and side, on the convex curve side, compared to the contralateral side and control unoperated levels.

Materials and Methods: Custom staples were implanted into the left side of 6 mid-thoracic vertebrae of five skeletally immature domestic pigs using thoracoscopic procedures (IACUC-approved). The controlled mechanical variable was intervertebral joint displacement unilaterally, that is, no motion at the staple base only. Radiographic results for these animals have been previously reported (1).

After 8 weeks, the spines were harvested and mid-coronal sections were photographed and prepared for histology: decalcified, and stained with H&E. Hypertrophic zone height (hz), height (hc), and width (wc) of hypertrophic cells were measured at one stapled (T8-9) and one unstapled (T4-5) level. One growth plate per level, cranial or caudal, was used, and 4 sampling locations, 1.5 mm in length, denoted as the normalized distance from the stapled edge (20%, 40%, 60%, 80%). Microscopic images were acquired and assembled for each half physis. Disc heights were measured at each level. Statistical analyses included mixed model, repeated measures ANOVA (SAS 9.1) and regression of the means across the coronal plane.

Results: Zone height, cell height, and cell width were lowest on the stapled side of the stapled level, with significant differences in the overall statistical model (p<0.02). For hypertrophic zone height, differences between stapled and control levels on the stapled side, were highly significant. At the control level, zone heights did not vary with distance from the staple across the coronal plane. At the stapled level, zone heights increased from the stapled side to the opposite side, with an expected value of that of the control level at the opposite cortex. Gradients in mean cell size at the control and stapled levels were not significantly different from zero. However, a trend to direct variation with distance from the staple at the stapled level and an inverse relationship at the control level suggested an incipient compensatory curve. Disc heights of stapled vertebrae were 60% of control values.

Discussion: Stapling decreased growth plate hypertrophic zone height and cell size consistent with an asymmetrically compressed growth plate. The apparent inverse cell size gradient at the unoperated level in a quadruped suggested that asymmetric muscle forces were generated sufficient to alter cell size. Results suggest that some methods of spinal hemiepiphysiodesis may be capable of slowing progression of a developing scoliotic curve by differential growth inhibition.

References: