MICRO-ARCHITECTURAL BONE ADAPTATIONS IN MATCHED THORACIC FACET PAIRS FROM PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

*Ford, T C.; +**Shea, K G.; *Bloebaum, R D.; ***D’Astous, J L.; **King, H

*VA SLC Health Care System, Salt Lake City, Utah. +**Intermountain Orthopedics, Boise, ID. (208) 489-4219, Fax: (208) 383-1130, KGShea@aol.com

Introduction:

Wolf’s Law predicts that there is a direct relationship between the stress environment and the structure of bone (2). Animal studies have shown the increased compressive stress on cortical bone leads to decreased porosity and increased cortical thickness, while the same cross section of bone undergoing tensile stress shows increased porosity and decreased cortical thickness. Scoliosis deformities are considered to potentially produce different stress/strain environments due to the pathological curve, which may affect the cortical bone structure of the vertebra and corresponding spinal facets. Our hypothesis is that asymmetric loading of bone tissue induced by scoliosis will elicit different cortical bone adaptations within opposing spinal facets. The purpose of this study was to analyze the facets in scoliotic patients to determine if there are differences in the morphology of contra-lateral spinal facets. The rationale for this study is that if there are differences in contra-lateral spinal facets, the data may be used to understand the biomechanical stresses in the vertebra of scoliotic patients, and may also help in validating animal models of scoliosis.

Methods:

IRB approval, and informed consent and assent were obtained. Eight patients with adolescent idiopathic scoliosis with an average age of 14 years (12-17) underwent standard posterior fusion. Routine facet removal was performed. Matched anatomic level facet pairs were obtained from 3 levels: 1) at the apex of the curve, 2) one level above the apex, 3) one level below the apex. The apex of the curve was defined as the vertebra with the maximum angle of deviation from the mid-sagittal plane. The facets on the concave side were considered to be under compression while the convex side under tension. These facets were anatomically oriented and mounted in PMMA. The cranial surface was ground, polished, and imaged using backscattered electron (BSE) imaging in the SEM. Facets were analyzed for cortical bone porosity and cortical thickness using NIH imaging software. The data was tested for normality and a Paired t-test was used to determine significance.

Results:

From 8 patients a total of 18 matched anatomic specimens were analyzed. The average porosity for the compression facets was 16.5 ± 5.8%. For the tension side the average porosity was 24.1 ± 6.2%. The compression side was significantly less porous than the tension side with a mean difference of 8% (P ≤ 0.03). The average cortical thickness for the compression facets was 810 ± 258 µm. For the tension facets the average cortical thickness was 374 ± 123 µm. The facets in compression had a significantly thicker cortex than the facets in tension; the mean difference was 436 µm (P < 0.01).

Conclusions:

The results of this study demonstrate that scoliotic deformities apply opposing stress environments to spinal facets. This validates the hypothesis that bone under compressive stress will exhibit a decreased cortical porosity and increased cortical thickness when compared to cortical bone under tensile stress. The results of this analysis complement previous investigation on animal models using a known compression/tension environment (1). Future studies of human facets in scoliosis offer the opportunity to further define the micro-architectural response of human bone subject to different compression/tension stresses. Further understanding of bone remodeling in spinal deformity may help validate animal models, and provide insight into the pathophysiology of scoliosis.

References:


Acknowledgments: Work supported by the DVA Medical Research Funds. & Division of Orthopedic Surgery, U. of Utah. ***Shriners Hospital for Children, Salt Lake City, Utah.

Figure 1A-B: Matched thoracic spinal facets taken from apex of scoliotic curve. Figure A being under compressive stress while figure B being under tensile stress. Note differences in cortical porosity.

Table 1: Average cortical thickness measurements in µm. Compression (C) 810 ± 258 µm; Tension (T) 374 ± 123 µm.