Comparison of a Fluoroscopic Three Dimensional Imaging System and Conventional CT in Detection of Pars Fractures in the Cadaveric Lumbar Spine

INTRODUCTION: Lumbar spondylolysis is defined as a defect or fracture of the pars interarticularis and can occur with or without anterior spondylolisthesis. This lesion is suspected to arise from repetitive trauma to the posterior elements of the spine and is a major cause of back pain in children; spondylolysis is found in approximately 6% of the pediatric/adolescent population as a whole and up to 15% of adolescent athletes. Cross-sectional imaging is often used to identify and characterize this condition and computed axial tomography (CT scan) is currently the gold standard exam for determining whether a fracture is present. While widely used, CT scan has several drawbacks which limit its application. Conventional CT scans are obtained with the patient lying supine on the scanning table, a position which may result in partial or complete reduction of an anterolisthesis and thus partially mask the severity of the condition. Furthermore, CT scan uses ionizing radiation which limits the frequency that follow-up scans can be obtained to monitor the progress of this condition. New fluoroscopic imaging systems with multiplanar capabilities can be used with the patient in a standing, weight-bearing position and may provide equivalent imaging with less radiation exposure. This study had three objectives: 1) To validate a fluoroscopic multiplanar imaging in identification of simulated spondylolytic fractures through the pars interarticularis in cadaveric lumbar vertebrae; 2) To compare sensitivity and specificity of spondylolysis identification between this fluoroscopic imaging system, plain radiographs and conventional CT scan; and 3) To compare radiation dose between these three imaging modalities.

METHODS: 13 cadaveric lumbar spine segments from four cadaveric specimens were included in the study. Spinal levels with gross structural damage, prior instrumentation or previous pars fracture were excluded. The 26 available pars were randomized using a computerized random number generator to be left intact or to undergo simulated fracture. Based on the randomization, 15 pars were randomized to undergo simulated fracture and 11 pars were left intact. Simulated fractures were created using a 1.3mm thick oscillating microsurgical saw, taking care to not damage adjacent bony structures [Figure 1].

Evaluation of plain radiographs for spondylolysis had an average sensitivity of 98% and specificity of 97%. Evaluation of the specimens using low dose fluoroscopic images, high dose fluoroscopic images and CT scan images correctly identified the status of all pars based on axial, coronal and sagittal plane images and therefore sensitivity and specificity were both 100% for these modalities.

Kappa analysis demonstrated a value of 0.89 for radiographic interpretation indicating excellent agreement. Kappa values describing agreement between readers for axial, coronal and sagittal plane image interpretation for fluoroscopic imaging and CT scan were equal to 1.0, representing perfect agreement.

DISCUSSION: Although other studies have evaluated the accuracy of fluoroscopic three dimensional imaging of the spine, few applications have as compelling a rationale for fluoroscopic imaging as the evaluation of spondylolysis in children. In addition, erect imaging could be performed with the Eleva System which may enhance detection of associated spondylolisthesis. This study sought to evaluate the ability of a three dimensional fluoroscopic imaging system to identify pars fractures. Three blinded observers were independently able to correctly identify all fractures of the pars in our experimental model on both the low and high radiation dose fluoroscopic images as well as using CT scan images with significantly less ionizing radiation exposure used for the fluoroscopic imaging. Given the high degree of efficacy in this cadaveric model, further study is necessary to evaluate fluoroscopic three dimensional imaging systems in patients with back pain suspected of having spondylolysis, especially given the differential radiation exposure in comparison to conventional CT scan.

Limitations of this study include its idealized conditions with respect to imaging bony anatomy in the absence of overlying soft-tissue which can complicate image acquisition and interpretation. Additionally, although the saw blade used was the smallest available, the resulting osteotomies were approximately 2mm wide due to blade excursion, a defect which may be larger than nondisplaced fractures in vivo.

RESULTS: Average radiation doses were 12 millirad for plain radiographs, 62 millirad for low radiation dose fluoroscopic imaging, 113 millirad for high radiation dose fluoroscopic imaging and 680 millirad for CT scan [Figure 5].