Analyzing Early Onset Scoliosis In 3d: How Does Growing Rod Surgery Affect The Three Planes Of Deformity?

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Disclosures:
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Introduction: Growing rods are used to surgically treat a wide variety of complex spinal deformities in young children with early onset scoliosis. Such complex deformities are 3-dimensional in nature and involve coronal, sagittal and transverse planes, yet previous and current research efforts continue to solely focus on the coronal and sagittal planes when evaluation patient outcomes. Axial vertebral rotation and other 3-dimensional aspects of the spinal deformity are not easily discernable using conventional 2D radiographic imaging.

EOS Imaging is a relatively new low-dose radiation radiographic imaging system that produces high quality radiographic images with significantly less radiation exposure compared to conventional radiography. Additionally, it allows for a 3D reconstruction of the has the capacity to allow 3D spine reconstructions to be created from biplanar posteroanterior and lateral) standing radiographs. Accurate 3D global and local information about position, rotation and morphology have the potential to improve deformity assessment, advance understanding of the early onset scoliosis deformation and ultimately optimize the treatment strategies. The purpose of the current study is to perform the first 3D radiographic analysis of an early onset scoliosis patient using EOS Imaging technology.

Methods: Overall 10 patients enrolled into the IRB-approved Growing Spine Study Group (GSSG) prospective study at Rady Children’s Hospital San Diego undergo pre-operative and post-operative EOS Imaging. Radiographic data was assessed at the following time points:
1. Pre index surgery (n=10)
2. Post index surgery (n=10)
3. Pre lengthening procedures (if lengthenings are performed within the follow-up period; n=6)
4. Post lengthening procedures (if lengthenings are performed within the follow-up period; n=6)

EOS Imaging Pre and Post Spinal Reconstructions
EOS Patients were scanned in upright position using EOS Imaging pre- and post-operatively as a regular part of their treatment. Once enrolled in the study, 3D EOS reconstructions with 2000 points per VB and element average size of 3mm2 will be created from preoperative images and superimposed on corresponding post-operative reconstructions by geometrical transformations (rotation, translation) and an iterative algorithm to align the pelvis in both models (Figure A). Reconstructions of each vertebra and the entire spine from each patient at each time point were generated using sterEOS software.

The vertebral surface mesh and the position, orientation and clinical measurements were evaluated using reference models and a custom MATLAB application. Superposition of pre- and post- surgical models makes possible to do measurements and comparative calculations between both models. For the patients with pre and post lengthening EOS scans, similar evaluation and analysis will be performed for their pre- and post-lengthening procedures as well as their overall development over time form pre-op to the last lengthening data (C).

The custom MATLAB software allows evaluating all parameters that might be of interest for the clinical and research standpoint such as apical vertebral rotation and translation (Figure D and E). It also allows for determining the maximum plane of deformation and the degree of maximum deformation which is frequently different than the coronal and sagittal view form the standard radiographic evaluation (F and G).

Besides the analysis of the spinal contour, our custom software allows to reconstruct the rods used in surgery from the biplaner EOS Images. This makes it possible to follow the changes in rod contour for the patients that have lengthening procedures performed from the first implantation to the last EOS image follow up. This unique feature allows for the first time to see and evaluate how the rod is deforming and changing due to the growing of the patient and due to the lengthening procedures (H).

Results: 3D reconstructions were generated for the patients involved in the study. The unique representation of the deformity allows the surgeons and engineers to view the changes in spine contour and rods (sequence I). Growth of the patient, the change in curvature and apical rotation is analyzed. Differences between patients are evaluated.
Discussion: The current study is represents the first step in understanding early onset scoliosis and its treatment. Methods are build up on previously published work (Glaser et al. 2012). The 3D representation of spine and instrumentation will help surgeons and engineers design better instrumentation and surgical intervention to help patients with these difficult disease.

Significance: This is the first study to analyze Early Onset Scoliosis in 3D. We followed the patients over multiple surgical procedures and determined the change in growth, cobb angle, 3D scoliosis evaluation and apical vertebra rotation. The results of this study have the potential to change the way Early Onset Scoliosis is evaluated and treated.

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References: Glaser DA, Doan J, Newton PO. Comparison of 3D Spinal Reconstruction Accuracy: Biplanar Radiographs with EOS