SPINE KINEMATICS: VALIDATION OF AN AUTOMATED SHAPE-MATCHING ALGORITHM FOR BIPLANE RADIOGRAPHY

Kage CC, Askbari-Shandiz M, Foltz MF, Lawrence RL, Brandon TL, Helwig NE, Ellingson AM

University of Minnesota

This project was supported by NIH/NICHD K12HD073945, F31H087069, NIH/NIAMS K01AR070894, NIH/NIAMS T32AR050938, and Minnesota Partnership for Biotechnology and Medical Genomics (MNP IF #14.02).

Not applicable.

Background and Purpose: Biplane radiography provides non-invasive, 3D, dynamic kinematic analysis. This detailed analysis is of clinical interest to better understand normative and pathologic kinematics. Data acquisition for this modality is complex and requires validation of each system prior to in vivo collection. To extract kinematic information, a process known as shape-matching (detailed in methods) is performed, which is time consuming when performed manually. The purpose of this study was to validate a custom, automated shape-matching algorithm against the gold standard of radiostereometric analysis (RSA) during cervical and lumbar spine flexion/extension (FE) and lateral bending (LB).

Subjects: One male cadaveric specimen (55 years) was used for analysis.

Methods and Materials: Tantalum beads were implanted into levels C4-C6 and L3-L4 for RSA. Computed Tomography (CT) was acquired to register bead locations and construct 3D bone models. Cervical and lumbar FE and LB were passively simulated within a custom biplane radiography system (Cervical: three trials each direction, Lumbar: two trials each direction). A shape-matching algorithm was used to create digitally reconstructed radiographs (DRR's) by simulating x-rays through the CT bone model to generate two, 2D projections. The algorithm then aligned the DRR's to each biplane radiographic projection to determine the position and orientation of the bone in space through time.

Analyses: Position and orientation of the bones were compared between the algorithm's output and RSA. Root mean square error (RMSE) was calculated to determine overall accuracy.

Results: Overall RMSE for the cervical spine ranged between 0.21-0.49mm and 0.42-1.80º; lumbar spine ranged between 0.35-1.17mm and 0.49-1.06º.

Conclusions: This study demonstrates the accuracy of our biplane data collection and automated shape-matching algorithm in tracking intersegmental spine motion.

Implications: The applications of biplane technology are vast and include dynamic segmental analysis of spine instability, neuroforaminal volumes, and facet kinematics in a variety of clinical populations.