3D Surface Topographic Optical Scans Yield Highly Reliable Spine Range of Motion Measurements in Adolescents

Ankush Thakur[1], Kira Page, Jessica Heidenberg Heyer, Benjamin Newcomb Groisser[2], Howard J Hillstrom[1], Caroline Casey Gmelich, Matthew E Cunningham[3], Michael Timothy Hresko[4], Don Li, Kyle Morse, Hila Otremski, Alon Wolf, Ron Kimmel, Roger F Widmann[5]
[1]Hospital For Special Surgery, [2]Technion, [3]Hosp for Special Surg-Cornell, [4]Boston Children's Hospital, [5]Hosp for Special Surgery

INTRODUCTION: Spine range of motion has a large impact on daily activities and overall health, yet most current assessment techniques require ionizing radiation or have poor reliability. The goal of this study is to introduce novel and reliable surface topographic measurements for the assessment of coronal and sagittal range of motion of spine in adolescents. Additionally, we would like to determine if these measurements can distinguish between adolescents with lumbar scoliosis and healthy controls with no spine deformity.

METHODS: Informed consent was obtained from patients with spinal deformity and matched controls to undergo 3D topographic scans. A finger to floor scan was performed after positioning the patient in Adam's forward bending posture whereby they were instructed to reach for the floor to their maximum extent. A lateral bending scan was performed after positioning the patient in A-pose (arms positioned to the sides at a 45 degree angle). The subject was asked to bend to the left to their maximum extent and then bend to the right to their maximum extent while reaching their fingers to the floor. An analysis of variance (ANOVA) was used to test the hypothesis that adolescent idiopathic scoliosis (AIS) patients and controls would exhibit differences in eight bending parameters. ICCs were calculated for each novel topographic measure to determine reliability.

RESULTS: Inter-rater reliability for lateral bending fingertip asymmetry (LBFA) and lateral bending acromia asymmetry (LBAA) displayed poor reliability, while the coronal angle asymmetry (CAA), coronal angle range of motion (CAR), forward bending finger to floor (FBFF), forward bending acromia to floor (FBAF), sagittal angle (SA), and sagittal angle normalized (SAN) demonstrated good to excellent reliability. There was a significant difference between controls and lumbar scoliosis patients for LBFA, LBAS, CAA, and FBAF (p-values <0.01). Table I summarizes these results.

DISCUSSION AND CONCLUSION: Surface topography yields a reliable and rapid process for measuring global spine range of motion in the coronal and sagittal planes. Using these tools we were able to distinguish between lumbar scoliosis patients and controls. In the future, we hope to be able to assess and predict perioperative spinal mobility changes.

Table I.

Measure	Description	ICC	p-value (Patients vs Controls)
LBFA	Asymmetry of left vs right bend finger to floor.	.496	.011
LBAA	Asymmetry of left vs right bend acromia marker to floor.	.433	.001
CAA	Asymmetry of left vs right bend torso angle from C7 to PSIS midpoint.	.756	<.001
CAR (degrees)	Left + right bend torso angle measured from C7 to PSIS midpoint.	.783	.178
FBFF	Finger to floor distance in maximum forward flexion. Normalized to height.	.984	.626
FBAF	Average of AC joint distance to floor in maximum forward flexion. Normalized to height.	.746	.018
SA (degrees)	Maximum forward bend angle measured from C7 to PSIS midpoint.	.994	.086
SAN (degrees)	Maximum forward bend angle measured from C7 to PSIS midpoint, subtracting reference angle in A-pose.	.977	0.118