Thursday, 7 October 2021, 14:00–15:30

Growing Spine, Complications and Patient Safety

26

THE NUTRITIONAL PARAMETERS AS PREDICTOR OF POSTOPERATIVE COMPLICATION IN ELECTIVE POSTERIOR LUMBAR INTERBODY FUSION: A SINGLE INSTITUTION EXPERIENCE WITH 776 PATIENTS.

Min-Seok Kang, Tae-Hoon Kim

Dept of Orthopedic Surgery, Konkuk University Medical Center, Konkuk University School of Medicine, Seoul, South Korea

Background: Serum Albumin (Alb), Prognostic Nutritional Index (PNI) and Nutritional Risk Index (NRI) are parameters for a patient's nutritional condition, and they are known that effective predictors for the prognosis of cancer and geriatric surgery. However, there is a lack of research on the association between these nutritional indicis and postoperative complications in elective posterior lumbar interbody fusion surgery (PLIF).

Methods: Between 2005 and 2018, 1119 patients with degenerative lumbar disc diseases underwent elective PLIF at single institution were recruited in this study. We investigated postoperative complications (cardiovascular, pulmonary, renal, neurologic, psychiatric including dementia, and surgical related problem including epidural hematoma, paralysis, and surgical site infection). The PNI was calculated by the following formula; (10 serum albumin, g/dl) + (0.005 total lymphocyte count, per mm3). The NRI was calculated as NRI = (1.519 x serum albumin, g/dl) + (41.7 x weight, kg)/ideal body weight, kg). All participants were divided into two cohorts according to the postoperative complications. The differences between two groups for each parameter were evaluated. These risk factors for postoperative complication were identified using logistic regression analysis. Then, receiver operating characteristic (ROC) analysis was used for nutritional parameter's optimum cut-off value for postoperative complications.

Results: A total of 776 patients (247 male, 529 female) were enrolled in the final analysis. Mean age was 74.8 years. The overall complication rate was 23.7%. Surgical site infection (SSI) was the most common complication with 9.0%, whereas deep SSI occurred at 2.7%. It was followed by renal, psychiatric, and pulmonary complications at 2.4%, 2.3%, 2.2%, respectively. The age, Alb, and PNI in the non-complications group were noted to be 75.06, 3.87, and 49.06, respectively, with significantly differences from 76.65, 3.67, and 46.72, respectively, in the complications group ($p<0.05$). However, the BMI, total lymphocyte count, and NRI were not observed to be inter-groups differences ($p>0.05$). Univariant logistic regression analysis suggested that significant risk factors for overall complications were Alb (p=0.003, OR 0.536) and PNI (p=0.012, OR 1.006). Multivariant logistic regression analysis suggested that independent risk factors for postoperative complications were Alb (p=0.013, OR 0.706) and PNI (p=0.030, OR 0.622). In the ROC analysis, cut off value of Alb and PNI were 3.7 (AUC=0.576, p=0.002) and 47.3 (AUC=0.556; p=0.019).

Conclusions: The nutritional status is a critical factor on postoperative complications in the patients who had elective posterior lumbar interbody fusion surgery. In particular, PNI and serum albumin are independent predicting factors of postoperative complications, and cut-off value is demonstrated 47.3 and 3.7, respectively.

Disclosures:
author 1: none; author 2: none

27

ADVERSE EVENTS AND HUMAN PERFORMANCE DEFICIENCIES IN SPINAL SURGERY AT A TERTIARY CARE UNIVERSITY HOSPITAL

Hanno S. Meyer, Arthur Wagner, Thomas Obermüller, Chiara Negwer, Maria Wostrack, Sandro Krieg, Jens Gempt, Bernhard Meyer

Department of Neurosurgery, Klinikum rechts der Isar, School of Medicine, Technical University of Munich, Germany

Introduction:
Adverse events (AE) in surgery are a relevant cause of disability or death. The frequency of AE is a key quality indicator that plays an important role in the future of health care, especially in surgery. The implementation of quality management and systems-based solutions in surgical care, such as checklists or standard operating procedures, has improved patient safety. However, potentially avoidable patient harm has persisted. Little is known about the role of human error in spinal surgery. This study aims at quantifying the frequency and severity of AE and the contribution of human error to AE in spinal surgery at a level 1 spine center of a tertiary care university hospital.

Methods:
This was a prospective study including all patients undergoing spinal surgery at our institution between September 2019 and September 2020. All AE per case (until discharge or within 30 days of surgery) were identified, recorded and classified according to the American College of Surgeons (ACS) and the Spine Adverse Events Severity System (SAVES-V2 grades 1-6) by consensus of all senior surgeons of our department. In addition, human error in AE was identified and classified using a human performance deficiency (HPD) classifier published by Suliburk et al. HPDs were assigned to 5 major categories: planning or problem solving, execution, rules violation, communication, and teamwork.

Results:
The case mix index of all spine patients was 2.97. There were 503 cases with AEs (26.2% of all in-patients). The most frequent types of AE were urinary events, followed by iatrogenic surgical injuries and unplanned returns to the OR (Table 1). In 25.6% of these cases, the major AE was associated with human error, mostly with execution (19.7%) or planning (4.4%) deficiencies. 39.4% of all cases with AEs were severe (SAVES grade 3 or higher). In the subgroup of patients with AEs related to human error, there were more severe AEs than in the subgroup with spontaneous AEs (56.6% vs. 33.4% with SAVES grade 3 or higher; p<.001). 146 patients (7.6%) had multiple AEs. This subgroup also had more severe AEs (60.3% SAVES grade 3 or higher).

Discussion:
AE occur frequently in spinal surgery at a level 1 spine center (about one in four patients). This is high when compared to typical complication rates reported in surgical case series, but not surprising considering our case mix and the fact that our data was collected prospectively, on a daily basis and until discharge of each patient.
It is important to realize that AE occur frequently not only when discussing with the patient, but also when discussing quality-based accreditation and reimbursement in upcoming health care reform. Of note, the high frequency of HPD in AE shows that there is still potential to further eliminate avoidable patient harm.

Type	No. of pts.	Fraction of all pts.
Urinary Event	183	36.4%

Iatrogenic Surgical Injury	115	22.9%
Unplanned return to OR	88	17.5%
Venous Thrombembolism	71	14.1%
Respiratory Event	64	12.7%
Neurological Injury	55	10.9%
Wound Event	52	10.3%
Unexpected Bleeding or Transfusion	28	5.6%
Death	20	4.0%
Cardiac Event	18	3.6%
Sepsis	8	1.6%
Other	6	1.2%
Diagnostic Failure	5	1.0%

Disclosures:
author 1: none; author 2: none; author 3: none; author 4: none; author 5: none; author 6: consultant=Brainlab, Ulrich Medical, other financial report=Nexstim, Spineart, Medtronic ; author 7: grants/research support=ZEISS, consultant=BRAIN LAB; author 8: grants/research support=Ulrich Medical, Icotec, Brainlab, Depuy, Medtronic, Relievant, BMBF, consultant=Ulrich Medical, Icotec, Brainlab, Depuy, Medtronic, Spineart, royalties=Medacta, Spineart

28

FIXED CORONAL MALALIGNMENT (CM) IMPACTS INDEPENDENTLY DISABILITY IN ADULT SPINAL DEFORMITY (ASD) PATIENTS WHEN CONSIDERING THE OBEID-CM (O-CM) CLASSIFICATION.

Ibrahim Obeid, Anouar Bourghli, Daniel Larrieu, Javier Pizones, Frank Kleinstuck, Ferran Pellisé, Ahmet Alanay, Markus Loibl, David Kieser, Louis Boissière, ESSG European Spine Study Group

Clinique du Dos, Bordeaux-Terrefort, Bruges, France

Background Postoperative Flatback is thoroughly described for sagittal plane consideration and its correlations with disability is now accepted. Fixed CM has less been described and some authors report no significant association with the clinical outcome. The O-CM classification analyses CM and incorporates specific modifiers for each curve type. Despite the importance of sagittal alignment and age, CM impact might be underestimated in the fused. Spine.

Purpose To evaluate the impact of CM on PROMs and O-CM modifiers according to age, sagittal alignment and PROMs in fused spine.

Methods A retrospective review of a prospective multicenter ASD database with patients who underwent a lumbar fusion for more than 3 levels. We included 743 ASD patients with long lumbar fusion (more than 3 levels), with at least two years of follow-up. Patients were classified according to the 6 modifiers of O-CM classification and we compared them to coronally aligned patients. Central Sacral Vertical Line (CSVL) above 2, 3 and 4 cm impact on PROMs was analyzed. Multivariate analysis was performed on the relationship between PROMS and age, global tilt (GT) and 0-CM modifiers.

Results Multivariate analysis, considering age and sagittal alignment as cofounding factors, showed an independent correlation between CM and PROMs from 2cm. Disability increases linearly with CSVL. Patients classified in 2B modifier have a worst SRS-22 total score, social life and self-image.

Conclusion In fused spine, CM independently affects disability in ASD patients. Disability increases linearly with CSVL. Despite previous reports who failed to find correlation of CM with PROMs, our study showed that considering each modifier improves the accuracy of the analysis. Fixed postoperative coronal malalignment, according to O-CM, correlates independently from sagittal plane with worse PROMs. Although even mildly positive fixed coronal balance is somewhat detrimental, severity of symptoms increases with progressive postoperative coronal imbalance.

Table O-CM modifiers and patient distribution

Main types	Subtypes	Main features	Number of patients included
Type 0 No CM		CSVL<2 cm	551
Type 1 Concave CM		Coronal malalignment towards the concavity of the main curve	
	Type 1A2 Main L/TL curve	Main curve with apex between T12 and L4	68
Type 2 Convex CM		Coronal malalignment towards the convexity of the main curve	
	Type 2a2 Main L/TL with rigid lumbar sacral junction	L4-S1 degenerated or stiff	94
	Type 2B Main lumbar sacral curve	Main curve apex below L4	30
1a1, 1b and 2a1 types are not represented because they consider flexible lumbar spines			

Disclosures:
author 1: grants/research support=Depuy synthes, consultant=Medtronic DePuy synthes, royalties=Spineart clariance alphatec ; author 2: none; author 3: none; author 4: consultant=Medtronic; author 5: grants/research support=Depuy Synthes, consultant=Depuy Synthes; author 6: grants/research support=DePuySpine Synthes / Medtronic, consultant=Medtronic / Stryker; author 7: grants/research support=Depuy, Medtronic, consultant=Globus, Zimmer, royalties=Zimmer; author 8: none; author 9: none; author 10: consultant=Neo, Medicrea, Spineart; author 11: grants/research support=Depuy Synthes, Medtronic

THE DIAGNOSTIC ACCURACY OF MRI AND NON-ENHANCED CT FOR HIGH-RISK VERTEBRAL ARTERY ANATOMY FOR THE SAFETY IN SUBAXIAL ANTERIOR CERVICAL SPINE SURGERY

Ichiro Okano, Stephan Salzmann, Fabian Winter, Erika Chiapparelli, Yushi Hoshino, Jennifer Shue, John Carrino, Andrew Sama, Frank Cammisa, Federico Girardi, Alexander Hughes

Spine Care Institute, Hospital for Special Surgery, New York, USA

INTRODUCTION: Reportedly, anomalous medial migration of the vessel can be a risk factor for VAI during anterior procedures. Computed tomography angiography (CTA) has been considered the gold-standard for the evaluation of various arterial anatomies. Nonetheless, CTA is not a routine preoperative assessment for subaxial anterior cervical spine surgery. MRI and non-enhanced CT are more commonly utilized as routine preoperative imaging studies, but it is still unclear if these modalities can safely exclude the risk for intraoperative VAI due to the anomalous course of the VA. The aim of this cross-sectional observational study is to evaluate the diagnostic accuracy of MRI and non-enhanced CT for high risk VA anatomy in the subaxial cervical spine.

METHODS: The records of 248 patients who underwent CTA for any reason at a single academic institution between 2007 and 2018 were reviewed. We included MRI and non-enhanced CT taken within 1 year before or after CTA. An axial VA position classification was used to grade VA anomalies in the subaxial cervical spine. The classification consists of a number that characterizes the location of the VA from the medio-lateral aspect of the vertebral body. A „0“ indicates no shift of the VA towards the midline of the vertebral body; a „1“ describes a midline shift of 0-25%; „2“ 25-50%; „3“ 50-75%; and „4“ 75-100%, respectively. We assessed all V2 (intraforaminal) segment VA anatomy in three slices (disc, pedicle, subpedicle levels) for each vertebral level between C2/3 disc to C7 subpedicle level. The sensitivity, specificity, and diagnostic likelihood ratios of MRI and non-enhanced CT for high risk VA position were calculated.

RESULTS: A total of 175 CTAs met the inclusion criteria. The mean (SD) age was 63.8 (14.9), 53.1% of the patients were female. Among them, 151 patients had MRI and 122 patients had non-enhanced CT. 101 patients had both MRI and non-enhanced CT. On CTA, the prevalence of an „at risk“ VA position defined as grade 1 or over and „high risk“ VA position defined as grade 2 was 4.3 and 0.4%, respectively. There were no slices showing grade 3 or 4. In multivariate analysis including demographic factors, advanced age, disc and pedicle levels, lower cervical levels, and left side were independent risk factors for medially migrated VA position on CTA. Among measurable slices, the sensitivities of MRI and non-enhanced CT for the detection of „at risk“ VA position were only fair, and the sensitivity of MRI was lower than that of non-enhanced CT (0.31 vs 0.37, $p<0.001$), but the specificities were similarly high in both modalities (0.97 vs 0.97). With the combination of MRI and non-enhanced CT, the sensitivity significantly increased to 0.50 ($p<0.001$ vs MRI and vs CT alone).

CONCLUSIONS: Our results showed that a medially migrated VA was observed in 4.3% of slices. Axial images of MRI and non-enhanced CT demonstrated high specificities but only fair sensitivities. Non-enhanced CT demonstrated better diagnostic values than MRI. Combining both modalities, the sensitivity was improved, but a substantial proportion of medialized VA could not be diagnosed. Adding other imaging modalities, such as MRA, reconstruction images and/or thinner cut axial images on CT, might be beneficial, especially in cases with certain risk factors, such as advanced age, left side lesion, or multilevel surgeries.

	Diagnosis of grade 1 or over		
	MRI	CT	MRI and CT
Number of observation	145	129	169
Number of observation on CTA	143	136	103
Apparent prevalence (%)	4.1	4.6	7.1
True prevalence (%)	4.0	4.8	4.4
Sensitivity (95% CI)	0.308 (0.233-0.390)	0.368 (0.287-0.455)	0.495 (0.396-0.595)
Specificity (95% CI)	0.971 (0.964-0.976)	0.971 (0.963-0.977)	0.948 (0.939-0.957)
Positive predictive value (95% CI)	0.303 (0.230-0.385)	0.388 (0.303-0.477)	0.306 (0.238-0.381)
Negative predictive value (95% CI)	0.971 (0.965-0.976)	0.968 (0.961-0.974)	0.976 (0.969-0.982)
Diagnostic accuracy (95% CI)	0.944 (0.936-0.951)	0.941 (0.932-0.950)	0.929 (0.918-0.939)
Positive likelihood ratio (95% CI)	10.56 (7.63-14.36)	12.49 (9.07-17.03)	9.61 (7.40 -12.48)
Negative likelihood ratio (95% CI)	0.71 (0.63-0.79)	0.65 (0.57-0.73)	0.53 (0.44-0.64)
Pairwise p-values	MRI vs CT	MRI vs MRI&CT	CT vs MRI&CT
Sensitivity	<0.001	<0.001	<0.001
Specificity	0.633	<0.001	<0.001

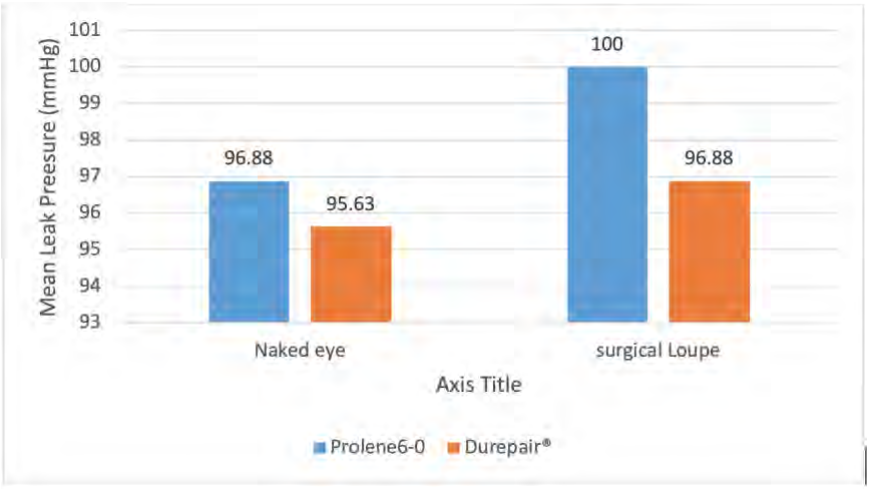
Disclosures:
author 1: none; author 2: none; author 3: none; author 4: none; author 5: none; author 6: none; author 7: consultant=Pfizer, Covera, Simplify Medical, Globus Medical; author 8: grants/research support=Spinal Kinetics, Inc., consultant=Clariance Inc; Kuros Biosciences AG; Medical Device Business Services Inc,stock/shareholder=Vestia Ventures MiRus Investment LLC; ISPH II LLC; ISPH 3 LLC; VBros Venture Partners X; Centinel Spine, royalties=Ortho Development Corp,other financial report=DePuy Synthes Products, Inc,employee=Hospital for Special Surgery; author 9: grants/research support=4WEB Medical/4WEB, Inc. Beatrice & Samuel A. Seaver Foundation Mallinckrodt Pharmaceuticals, consultant=4WEB Medical/4WEB, Inc. Spine Biopharma, LLC ,stock/shareholder=4WEB Medical/4WEB, Inc. Bonovo Orthopedics, Inc. Healthpoint Capital Partners, LP ISPH II, LLC ISPH 3 Holdings, LLC Ivy Healthcare Capital Partners, LLC Medical Device Partners II, LLC Medical Device Partners III, LLC Orthobond Corporation Spine Biopharma, LLC Tissue Differentiation Intelligence, LLC VBVP VI, LLC Woven Orthopedic Technologies,other financial report=Healthpoint Capital Partners, LP Orthobond Corporation Spine Biopharma, LLC Woven Orthopedic Technologies; author 10: consultant=Depuy Synthes Spine; NuVasive, Inc.; EIT Emerging Implant Technologies; Spineart USA, Inc; Ethicon, Inc,stock/shareholder=Bonovo Orthopedics, Inc.; Liventa Bioscience; Paradigm Spine, LLC; Healthpoint Capital Partners, LP; Alphatec Holdings, LLC; LANX, Inc.; Centinel Spine, Inc.; Tissue Differentiation Intelligence; Spinal Kinetics, Inc., royalties=Nuvasive, Inc.; Ortho Development Corp; Zimmer Biomet Holdings, Inc.; author 11: grants/research support=Nuvasive, Inc.; Kuros Biosciences A.G.

DURAL REPAIR EFFICACY ASSESSMENT OF DIFFERENT TECHNIQUES, A CADAVERIC STUDY COMPARING THE NAKED EYE AND SURGICAL LOUPES

Roongrath Chitragran, Sompob Poopitaya, Sakpan Panyaporn

Spine surgery unit, Department of Orthopaedics, Phramongkutklao Hospital and College of Medicine, Bangkok, Thailand

BACKGROUND CONTEXT: A watertight dural repair is crucial for a successful dural tear suture. Microscopic or surgical loupes are recommended to use for magnification and assistance to repair the dura. However, many spine surgeons repair dural tears under their naked eye. To our knowledge there are no studies about the efficacy of repairing dural tears by the naked eye, compared with surgical loupes or microscope.
PURPOSE: To compare the efficacy of dural repairing techniques using the naked eye or surgical loupes.
STUDY DESIGN: Cadaveric experimental study
OUTCOME MEASURES: Time used for repair and post-suture CSF water leakage pressure.
METHODS: Four fresh human cadaveric specimens was utilized to harvest the spinal cord. Dural tear and CSF leakage was simulated with a water pressure control system (a Arthrex AR-6475 arthroscopic pump). We compared surgical repair using the naked eye and surgical loupes. Surgical closure was achieved using Prolene 6-0 and Durepair® . A total of 32 experimental dural tears was sub-divided in to 4 groups. The four groups was Prolene6-0 with naked eye n=8 , Prolene 6-0 with surgical loupe n = 8 , Durepair® with naked eye n=8 and Durepair® with surgical loupe n=8 . The total time used for suture, and post-suture CSF water leakage pressure were recorded and compared between the sub-groups using analysis of independent t-test. Comparison of the data was performed using analysis of one way ANOVA
RESULTS: Our results showed that surgical loupe assisted dura closure and suture were significantly faster than the naked eye in both Prolene 6-0 (Surgical loupe = 4.87±0.19 min , naked eye = 7.18±0.36 min $p < 0.001$). and Durepair® groups (surgical loupe = 9.84±0.21 min , naked eye = 13.27±0.42 min $p < 0.001$). CSF Leakage pressure in the surgical loupe groups were higher than the naked eye groups in both Prolene 6-0 (surgical loupe = 100.00±5.35 mmHg , naked eye = 96.88±7.99 mmHg $p = 0.373$) and Durepair® (surgical loupe = 96.88±4.58 mmHg, naked eye = 95.63±4.17 mmHg $p=0.577$) but there was no significant difference. Prolene6-0 was significantly faster to use for suture than Durepair® in both suture by the naked eye and surgical loupe assisted ($p<0.001$). Prolene6-0 showed a higher leakage pressure than Durepair® in both naked eye suture and surgical loupe assisted but with no significant difference(naked eye $p= 0.701$, surgical loupe $p = 0.230$)
CONCLUSION: Repairing a dural tear without utilizing surgical loupes consumed more time and did not achieve similar maximum leak pressure as when using surgical loupes. Durepair® consumed more time than Prolene 6-0 while leakage pressure similar. We recommended the use of surgical loupes when performing dural repair. Durepair® is suitable to repair larger dural defect that cannot be closed using a simple suture technique and it does not add any advantage in standard dural suture.



Disclosures:
author 1: none; author 2: none

SAFETY AND EFFECTIVENESS OF APICAL VERTEBRAL DEROTATION AND TRANSLATION (AVDT) FOR ADOLESCENT IDIOPATHIC SCOLIOSIS USING SCREWS AND SUBLAMINAR BANDS

Andrea La Maida, Andrea Della Valle, Enrico Gallazzi, Marcello Ferraro, Davide Cecconi, Bernardo Misaggi

ASST Centro Specialistico Ortopedico Traumatologico G. Pini - CTO, Milano, Italy

Introduction: The optimal technique to surgically correct Adolescent Idiopathic Scoliosis is still today matter for debate. Ideally, the optimal surgical technique should allow for substantial correction of the curve on the coronal plane and restoration of the correct thoracic kyphosis, while being safe. High density constructs have shown greater coronal correction, and are thus considered the 'gold standard'. Here we present a new correction technique based on the combination of screws and sublaminar bands in the apex of the curve (AVDT—apical vertebral derotation and translation technique). Aim of this study is to evaluate the corrective power and safety profile of the presented technique.

Study Design: Retrospective Cohort Analysis

Methods: Through a database search, patients surgically treated for AIS in a single Institution were retrieved. We divided the patient cohort into two groups based on the type of instrumentation and the corrective surgical technique adopted. Patients in group A (N=66) underwent a corrective surgery with all screws or hybrid screws-hooks construct and single rod derotation maneuver. Patients in group B (N=127) underwent a corrective surgery with hybrid screws-sublaminar bands construct and AVDT Technique. In brief, the technique involves the use of low-density implant, with monoaxial screws in the convex side and sublaminar bands in the concave side of the deformity, with a correction based on a simultaneous direct derotation and translation of the curve apex using screws in the convexity and sublaminar bands in the concavity. Radiographic coronal and sagittal parameters, surgical time, blood loss and complication rates were compared between two groups.

Results: The overall cohort consisted in 193 patients, (39 males and 154 females (M:F ratio = 1:3.9) with a mean age of 15.7 years). The mean improvement of the Main Thoracic curve was 70% in the group A and 60.6% in the group B, while the mean improvement of the TL/L curve was 65.5 and 72.4%, respectively (p=ns). No significant differences were found concerning the sagittal parameters; however, Group B. Group A had a total rate of complications of 9.1% (6/66) while group B had a rate of 6.29% (8/127, p=ns). Group A and group B does not show significant differences in risk of wound infection (p=0.21), neurologic complication (p=0.97) and risk of implant related complications (p=0.62). Group B showed a reduction of the surgical time (average reduction of 38 min) and of the blood loss (mean reduction of 188 ml), compared to Group A.

Conclusions: The AVDT technique appears to be effective in coronal and sagittal plane correction, with a similar rate of implant related complications when comparing the all screws or hybrid screws-hooks construct and single rod derotation technique. AVDT Technique is easy, with less operative time, less blood loss and a comparable corrective power and safety profile to high density construct.

Disclosures:
author 1: none; author 2: none; author 3: none; author 4: no indication; author 5: none; author 6: no indication

A NOVEL CLASSIFICATION OF 3D RIB CAGE DEFORMITY IN SUBJECTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

Ayman Assi, Mohamad Karam, Wafa Skalli, Claudio Vergari, Raphael Vialle, Raphael Pietton, Aren Joe Bizdikian, Khalil Kharrat, Jean Dubousset, Ismat Ghanem

Faculty of Medicine, Saint Joseph University, Beirut, Lebanon

Introduction:
Subjects with adolescent idiopathic scoliosis (AIS) present rib cage deformity which can affect respiratory functions. The 3D rib cage deformities in AIS and their relationship to the spinal deformity are still unelucidated.
Purpose:
To describe the 3D morphology of the rib cage in subjects with AIS and to assess the relationship between rib cage and spinal deformities.
Methods:
In this cross-sectional study, 200 AIS and 71 controls (C) underwent low-dose biplanar X-rays and had their spine and rib cage reconstructed in 3D. Classic spino-pelvic parameters were calculated in 3D as well as rib cage morphological parameters: gibbosity (°), volumetric spinal penetration index (VSPI in %: occupied volume of spinal penetration in the rib cage total volume), thickness (mm), rib cage volume (cm3). Subjects with AIS were classified as group I having mild rib cage deformity (gibbosity and VSPI<95th percentile of controls ; n=88), group II with severe rib cage deformity (gibbosity and VSPI>95th percentile of controls ; n=112) sub-grouped into IIa (high gibbosity>9°; n=48), IIb (high VSPI>6.3%; n=48) and IIc (high gibbosity & VSPI; n=16).
Results:
When compared to group I, both group IIa and IIb had a higher Cobb angle (33° vs. 54° & 46° resp., p<0.05) and torsion index (11° vs. 14° & 13° resp., p<0.05). Group IIa had a higher gibbosity than group I and group IIb (15° vs. 5° & 6° resp., p<0.05). Group IIb showed more severe hypokyphosis (T1T12: IIb=21°; IIa=33°; I=36°; C=42°; p<0.05) with a higher VSPI (IIb=7%; I,IIa & C=4%; p<0.05), a reduced thickness (IIb=135mm; I & IIa=148mm; p=0.002) and rib cage volume (IIb=4731cm3; I=5257cm3; p=0.01). Group IIc showed characteristics of both groups IIa and IIb (figure 1). VSPI was negatively correlated to T1T12 kyphosis (r=-0.47; p<0.001) in group II. Gibbosity was positively correlated to Cobb (r=0.54; p<0.001) and torsion index (r=0.41; p<0.001) in groups IIa and IIc.
Conclusion:
This study suggests a novel 3D classification of rib cage deformities in AIS. Four groups were identified: group I with mild rib cage deformity; group II with severe rib cage deformity, further stratified into group IIa with high gibbosity, group IIb with high volumetric spinal penetration index, and group IIc with both high gibbosity and VSPI. This new classification of 3D rib cage deformity in AIS suggests that the management of cases with high VSPI (groups IIb and IIc) should focus on restoring as much kyphosis as possible to avoid possible respiratory repercussions, since bracing can reduce thoracic kyphosis even more. Treatment indications in groups I and IIa would follow the consensual basic principles reported in the literature.

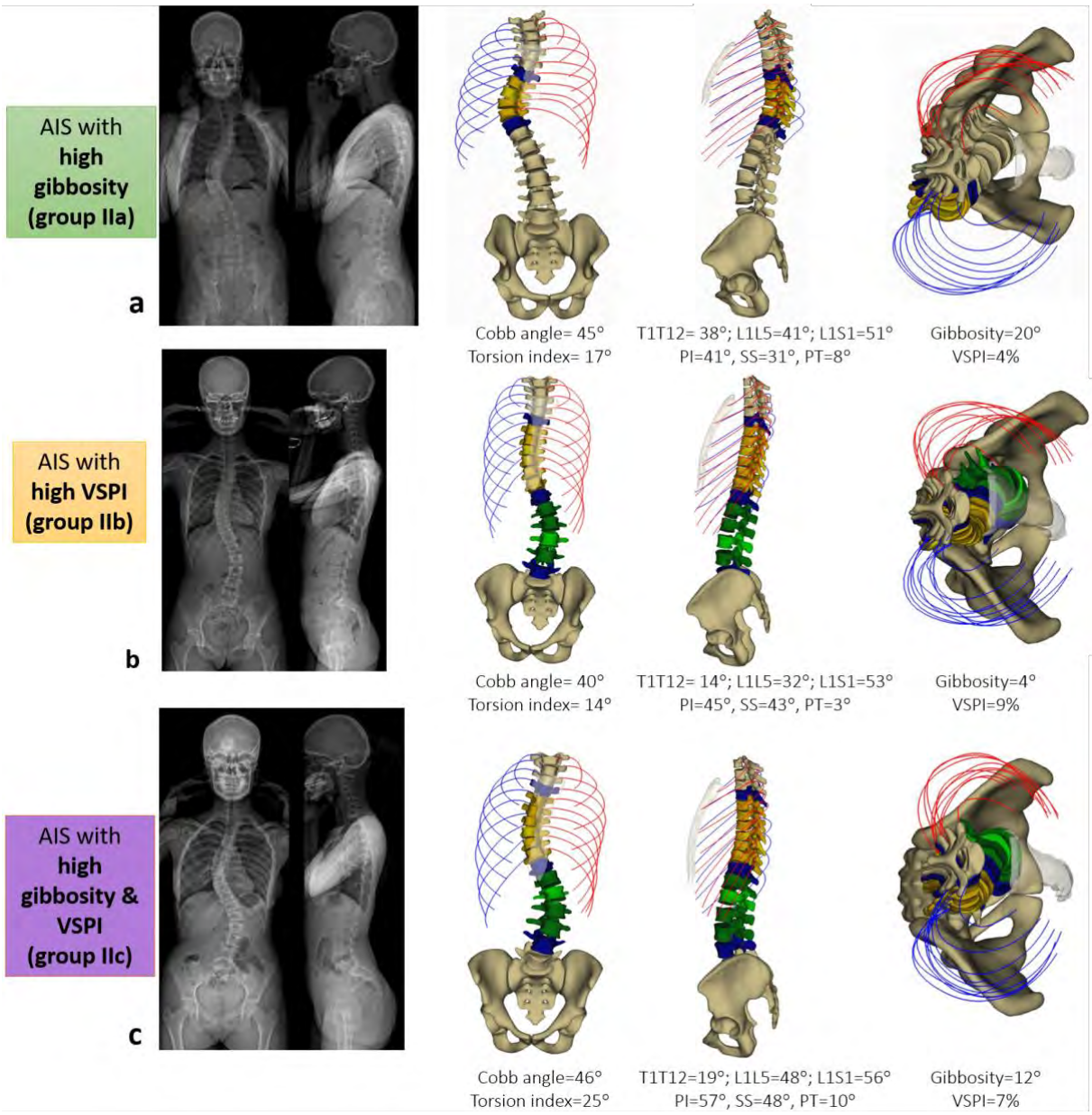


Figure 1: Examples of subjects with severe rib cage deformity: a) subject with high gibbosity, b) subject with high VSPI and c) subject with high gibbosity and VSPI.

Disclosures:
author 1: none; author 2: none; author 3: none; author 4: none; author 5: consultant=Stryker Spine, Eos Imagine, Nuvasive, Spineguard; author 6: none; author 7: none; author 8: none; author 9: other financial report=medtronic france license; author 10: none

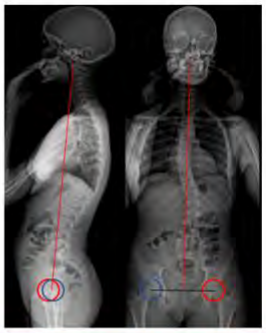
GLOBAL POSTURAL MALALIGNMENT IN ADOLESCENT IDIOPATHIC SCOLIOSIS: THE AXIAL DEFORMITY IS THE MAIN DRIVER

Mohamad Karam, Ismat Ghanem, Claudio Vergari, Maria Saade, Celine Chaaya, Ali Rteil, Elma Ayoub, Marc Fakhoury, Elena Jaber, Eddy Saad, Khalil Kharrat, Wafa Skalli, Ayman Assi

Faculty of Medicine, Saint Joseph University, Beirut, Lebanon

Introduction:
The spinal deformity in Adolescent Idiopathic Scoliosis (AIS) was shown to induce postural malalignment, mainly assessed by evaluating spinopelvic parameters. Global postural malalignment and its relationship to the scoliotic deformity is still to be elucidated.
Purpose:
To investigate global postural malalignment in AIS and its relationship to the 3D scoliotic deformity.
Methods:
254 AIS and 64 controls underwent low dose biplanar X-rays and had their spine and pelvis reconstructed in 3D. In addition to the classic spino-pelvic parameters, global postural alignment was assessed by calculating the frontal and sagittal OD-HA (angle between C2 dens to hip axis with the vertical). AIS subjects were classified as malaligned if OD-HA was >95th percentile of controls. Determinants of postural malalignment were investigated among 3D spinal deformity parameters.
Results:
In the sagittal plane, subjects with AIS were normally aligned (OD-HA between -6.3 and 2.3° similar to controls). In the frontal plane, 182 AIS were normally aligned (Group 1) but 72 were malaligned (Group2: frontal OD-HA>1.9°). Group 2 had a more severe spinal deformity in both frontal and axial planes compared to Group 1 (Cobb:42±16° vs. 30±18°; Apical vertebral rotation (AVR):19±10° vs. 12±7°, all $p<0.05$), while the sagittal plane deformity was comparable between both groups (T1T12: Group 1=35±13° & Group 2=32±12° vs. controls=42±7°, $p<0.001$). Subjects in Group 2 were mostly classified as Lenke 5 and 6 (61%). Further investigations showed that 15 patients having a frontal malalignment (Group 2) had a mild scoliosis (Cobb<30°); these patients had a higher AVR (12±4°, figure 1) compared to Cobb-angle-matched patients in Group 1 who had a significantly lower AVR (8±3°, $p<0.001$). The frontal OD-HA was mainly determined (adjusted-R2=0.22) by the AVR ($\beta=0.44$, $p<0.001$) and partially by the Lenke type ($\beta=0.20$, $p=0.002$).
Conclusion: This study showed that frontal malalignment is more frequent when the major structural scoliosis is located at the thoracolumbar and lumbar levels and its main driver seems to be the apical vertebral rotation. This highlights the importance of monitoring the axial plane deformity in order to avoid worsening of the frontal postural global alignment in patients with adolescent idiopathic scoliosis.

Figure 1- Example A from Group 1 (normally aligned); example B from Group 2 (frontally malaligned with high Cobb and high AVR); example C from Group 2 (frontally malaligned with mild Cobb but high AVR).



Parameters	Example A (Group 1)	Example B (Group 2)	Example C (Group 2)
Lenke type	L3	L5	L5
Frontal OD-HA(°)	0.8	4.2	2.2
Cobb (°)	33	42	25
Apical vertebral rotation (°)	14	23	21
PI (°)	42	37	36
T1T12 (°)	36	28	38

Disclosures:
author 1: none; author 2: none; author 3: none; author 4: none; author 5: none; author 6: none; author 7: none; author 8: none; author 9: none; author 10: none; author 11: none; author 12: none; author 13: none

A NOVEL GROWTH MODULATION SCALE TO PREDICT CURVE BEHAVIOR AFTER VERTEBRAL BODY TETHERING

Altug Yucekul, Ipek Ege Gurel, Ilkay Karaman, Demirci Muhammed Nuri, Irem Havlucu, Tais Zulemyan, Yasemin Yavuz, Caglar Yilgor, Ahmet Alanay

Department of Orthopaedics and Traumatology, Acibadem University School of Medicine, Istanbul, Turkey; Acibadem University School of Medicine, Istanbul, Turkey; Comprehensive Spine Center, Acibadem University Maslak Hospital, Istanbul, Turkey; Department of Biostatistics, Ankara University Faculty of Medicine, Ankara, Turkey

Background: Prediction of curve behavior after Vertebral body Tethering (VBT) is essential to achieve successful results. Risser has been a standard maturity assessment method for AIS patients. Currently, Sanders Simplified Skeletal Maturity Staging (SSMS) is widely used to aid decision-making. Thumb-Ossification Composite Index (TOCI), a more recent method, uses ossification of thumb epiphyses which matures earlier than remaining epiphyses to offer a more precise grouping around peak height velocity. However, SSMS is more accurate in grouping post-peak period using all distal, middle and proximal phalanges. During puberty, growth peak occurs separately at lower limbs and trunk. Hence, Cervical Vertebral Maturity (CVM), using cervical spine morphology, possesses a potential to estimate spinal growth modulation better as it uses skeletal markers of the axial skeleton.

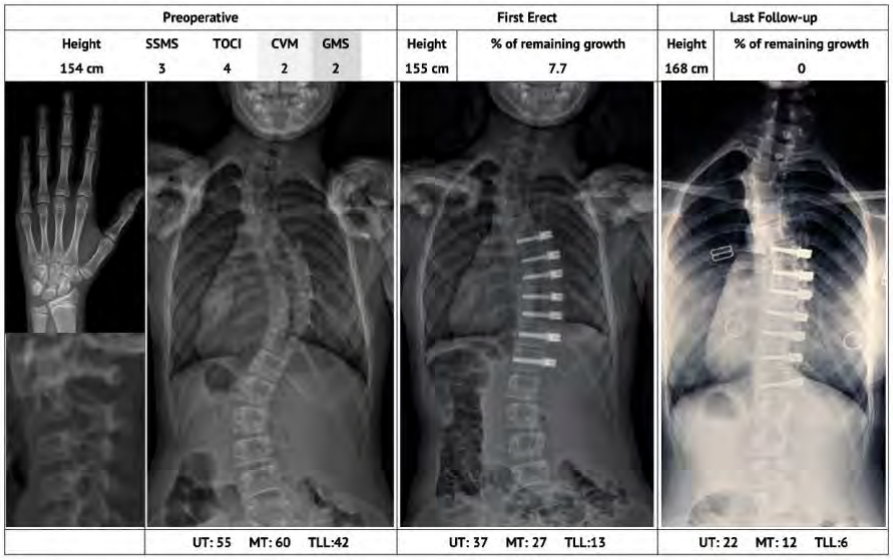
Purpose: To determine the predictive ability of various methods and analyze the effects of integrating different methods for prediction of longitudinal growth and growth modulation after VBT.

Methods: A retrospective analysis of prospectively collected data was carried. Demographic and radiographic data were analyzed in a VBT cohort. Risser, SSMS, TOCI and CVM were used to determine skeletal maturity. Stages of two appendicular skeleton assessment methods, SSMS and TOCI, were incorporated into a Combined Hand Maturity Scale (CHMS). A Growth Modulation Scale (GMS) was created by integrating CVM to CHMS. Predictive abilities were compared for height gain and curve behavior in tethered segments. To minimize the effect of surgical correction, ratio of follow-up correction to surgical correction was used. Logarithmic and polynomial regression models were run to assess longitudinal growth and growth modulation, respectively.

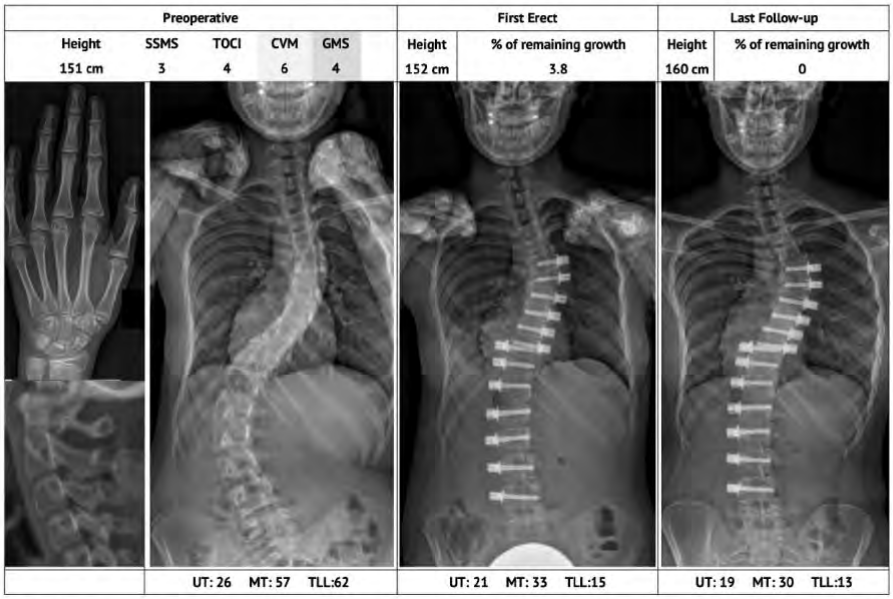
Results: 38 patients (37F, 1M, mean age: 12.8±1.5y, mean follow-up: 29.3 (24-50) months) were included. Preoperatively, 18 (48.6%) were premenarchal. The median stages were: Risser: 1 (0-5), SSMS: 4 (1-7), TOCI: 6 (1-8) and CVM: 4 (1-6). Preop mean height of 155.9cm (130-171) was increased to 162.1cm (150-177) at latest follow-up. The mean preop MT curve magnitude of 49 ±11 was corrected to 25 ±7.6 at first erect, which was modulated to 17 ±12.2 . CHMS and GMS had the highest R-squared values for longitudinal growth and growth modulation prediction, respectively (Figure).

Conclusion: SSMS, TOCI and CVM were used to create integrated scales to predict longitudinal growth and follow-up curve behavior. Axial and appendicular assessment methods such as SSMS, TOCI and CVM performed similarly for estimation of remaining longitudinal height gain. However, CVM, as an axial skeleton assessment method, was found to be more successful for prediction of growth modulation after VBT. Incorporating SSMS and TOCI into CHMS resulted in increased growth prediction. Growth Modulation Scale (GMS), accounting for both appendicular and axial skeleton markers, resulted in best growth modulation prediction offering a better clinical judgment of initial surgical correction and estimation of follow-up curve behavior after VBT surgery. External validation of the GMS in larger cohorts is warranted.

	Longitudinal Growth Prediction, R^2	Growth Modulation Prediction, R^2
Risser	38.1	47.2
SSMS: Sanders Simplified Skeletal Maturity Staging	82.4	67.6
TOCI: Thumb-Ossification Composite Index	83.2	62.6
CVM: Cervical Vertebral Maturity	81.1	74.6
CHMS: Combined Hand Maturity Scale (SSMS + TOCI)	87.2	64.9
GMS: Growth Modulation Scale (SSMS + TOCI + CVM)	81.0	82.3



Patient 1: Sanders 3 and GMS 2, had 7.7% growth and modulation in all three curves



Patient 2: Sanders 3 but GMS 4, although had 3.8% growth, displayed no significant modulation.

Disclosures:
author 1: none; author 2: none; author 3: none; author 4: none; author 5: none; author 6: none; author 7: none; author 8: none; author 9: grants/research support=DePuy Synthes, Medtronic, consultant=Globus Medical

3D RADIOLOGICAL OUTCOMES FOR PATIENTS WITH MODERATE IDIOPATHIC SCOLIOSIS CURVES TREATED WITH INTERNAL (ANTERIOR VERTEBRAL GROWTH MODULATION) VS EXTERNAL BRACING: 2 YEARS OBSERVATIONAL STUDY

Stefan Parent, Matias Pereira Duarte, Carl-Éric Aubin, Nikita Cobetto, Marjolaine Roy-Beaudry, Christian Bellefleur, Isabelle Turgeon, Hubert Labelle, Soraya Barchi

CHU Sainte-Justine, Montreal, Canada

Background/Introduction

For idiopathic scoliosis (IS), bracing has demonstrated 72% success in preventing curve progression in patients with 20-40° curves. AVBGM aims to gradually correct scoliosis while preserving spine motion in skeletally immature patients with 30-65° progressive curves and significant growth potential. Although indications for each treatment are clear, in clinical practice there exists a grey area between these options. The relative 3D deformity control performance over a 2-years period between these fusionless treatments is still uncertain.

Purpose of the study

The aim of this study is to analyze 3D morphological parameters modifications at a two years follow-up period for patients with moderate range idiopathic scoliosis curves (30-50°) after bracing and Anterior Vertebral Body Growth Modulation (AVBGM) treatments.

Hypothesis

AVBGM achieves 3D deformity correction after 2-years follow-up while brace treatment limits curve progression for moderate idiopathic scoliosis.

Design

Observational Cohort study.

Methods

A retrospective review of a prospective IS patients' database, recruited between 2013 and 2018 was performed. Inclusion criteria were skeletally immature patients (Risser 0-2), with Cobb angles between 30-50° and a 2-year follow-up after bracing or AVBGM. 3D radiological parameters were evaluated. Unpaired t-test was used.

Results

39 patients (12.7 y.o. ±1.3) with Cobb angles ≥30° treated with brace and 41 patients (11.8 y.o. ±1.2) with Cobb angles ≤50° who received AVBGM were reviewed. 3D deformity measurements statistical analysis showed that at 2-year follow-up, only the 3D spine length and apical vertebral heights changed significantly with brace treatment. On the other hand, AVBGM treatment achieved statistically significant correction differences in thoracic and lumbar Cobb angles, TrueKyphosis (segmental derotated kyphosis of T5-T12), 3D spine length and selective left apical vertebra height ($p<0.0005$) (table). 35% of brace patients had a curve progression of >5° at final follow-up while it was 0% for AVBGM.

Conclusion

Even though these 2 cohorts are not fully comparable, bracing seems to control progression for a significant portion of patients with moderate scoliosis curves, while AVBGM significantly corrected and maintained 3D deformity parameters at 2-year follow-up.

Table - Tridimensional measurements										
	Brace Group					AVBGM Group				
	First Visit		2 years F-up		P	PreOP		PostOp 2 years F-up		P
3D Parameters	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Thoracic Cobb angle (°)	33,4	6,8	31,2	13,0	*0,697*	44,8	5,4	18,8	10,7	*0,000*
Lumbar Cobb angle (°)	29,8	8,6	25,6	12,5	*0,086*	27,4	12,5	17,3	9,8	*0,000*
Thoracic Cobb in the Plane of Max. Curvature (°)	40,1	5,9	39,6	9,5	*0,683*	47,0	6,5	25,3	13,5	*0,000*
Lumbar Cobb in the Plane of Max. Curvature (°)	41,2	10,2	41,3	14,9	*0,688*	53,3	12,2	43,4	18,1	*0,000*
Kyphosis T1-T12 (°)	31,7	11,0	30,4	10,8	*0,374*	23,1	14,3	27,1	15,8	*0,109*
True Kyphosis (T5-T12) (°)	17,0	10,5	15,4	12,0	*0,477*	4,3	11,1	14,1	15,1	*0,000*
Lordosis L1-S1 (°)	-44,6	8,6	-42,8	8,0	*0,090*	-42,4	9,2	-42,2	10,9	*0,899*
Apical Vertebral Rotation (°)	7,9	4,0	7,7	5,0	*0,795*	8,1	2,9	6,9	5,7	*0,183*
Pelvic Incidence (°)	54,8	11,8	54,1	11,9	*0,486*	54,4	12,0	53,6	11,1	*0,583*
Plumbline T1 - S (mm)	39,3	17,6	37,2	20,1	*0,566*	32,6	18,8	36,1	17,5	*0,228*
3D Lenght (T1-S1) (mm)	401,4	26,9	436,3	19,0	*0,000*	399,5	31,3	430,4	23,3	*0,000*
Apical Vertebral Right Height (mm)	19,5	2,7	21,3	3,1	*0,000*	18,5	1,7	18,8	1,8	*0,306*
Apical Vertebral Left Height (mm)	19,3	3,9	21,2	4,2	*0,000*	15,5	1,3	17,6	1,6	*0,000*

Disclosures:
author 1: grants/research support=DePuy Synthes Spine, Canadian Institutes of Health Research, Pediatric Orthopaedic Society of North America, Scoliosis Research Society, EOS imaging, Canadian Foundation for Innovation, Setting Scoliosis Straight Foundation, Natural Sciences and Engineering Council of Canada, Fonds de recherche Québec - Santé, Orthopaedic Research and Education Foundation, , consultant=K2M, EOS-imaging, DePuy Synthes Spine, ,stock/shareholder=Spinologics, royalties=EOS-imaging,other financial report=Academic Research chair in spine deformities of the CHU Sainte-Justine (DePuy), Orthopaediatrics; author 2: none; author 3: grants/research support=Natural Sciences and Engineering Research Council of Canada (Industrial Research Chair program with Medtronic of Canada), GreenSun Medical, consultant=Medtronic; author 4: employee=Polytechnique Montreal, Institut TransMedTech and CHU Sainte-Justine; author 5: none; author 6: none; author 7: none; author 8: stock/shareholder=Spinologics Inc.; author 9: none