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2026 第三屆脊柱側彎關懷月研討會：矢狀面曲線的重要性，術後加速康復暨手術工作坊

Scoliosis 2026: Sagittal Alignment Matter, Enhanced Recovery After Surgery and Simulated Surgery Workshop

時　　間：115 年 6 月 27 日(星期六) 08:20~17:30
地　　點：上午：臺北榮民總醫院 致德樓第十會議室
　　下午：中正樓三樓麻醉部會議室及手術房

08:30-08:40	***Opening Remarks***	曾令民副院長 Ling-Ming Tseng 吳文田理事長 Wen-Tien Wu

Ⅰ. Pediatric Ideal Sagittal Alignment: What We Can Do Now ?

座長：曾效祖 醫師 (Shiau-Tzu Tzeng)

08:40-09:00	兒童正常矢狀位排列發育：現有證據綜述 Normal sagittal alignment development in pediatric population: Current evidences review	楊志勇醫師 Chi-Yung Yeung
09:05-09:35	手術室中達到理想矢狀位對位的技巧：AIS 融合手術與非融合手術(線上演講) Tips for achieving ideal sagittal alignment in OR: AIS fusion surgery and nonfusion surgery	Suken Shah (美國)
09:40-10:00	支架治療中恢復矢狀排列的技巧(線上演講) Tricks for restoring the sagittal alignment in brace management	Garikoitz Aristegui (西班牙)
10:00-10:20	綜合討論 Panel discussion	曾效祖醫師 Shiau-Tzu Tzeng
10:20-10:30	***Coffee Break***	

Ⅱ.Scoliosis Research: From Lab to Life

座長：劉承揚 教授 (Cheng-Yang Liu)

10:30-10:45	可攜式三維背部掃描儀於青少年特發性脊柱側彎早期篩檢之開發 Development of a Portable 3D Scanner for Early Detection of Adolescent Idiopathic Scoliosis	Hideto Kameshima (日本)

10:45-11:00	基於解剖結構的肋骨錨定椎體辨識在全脊柱X光片中的應用 Anatomy-Informed Rib-Anchored Vertebral Identification in Full-Spine Radiographs	呂芷儀 Chih-Yi Lu
11:00-11:15	透過深度學習技術進行全脊柱矢狀面序列自動辨識與曲度分析 Automatic Recognition of Whole-Spine Sagittal Alignment and Curvature Analysis Through A Deep Learning Technique	葉祐成醫師 Yu-Cheng Yeh
11:15-11:30	綜合討論 Panel Discussion	劉承揚教授 Cheng-Yang Liu

Ⅲ. The Key to Safe Scoliosis Correction and Enhanced Recovery

座長：宋俊松 醫師 (Chun-Sung Sung)

11:35-11:55	麻醉專業在側彎手術上的實務應用：術中神經監測及喚醒試驗 Anesthesia for Scoliosis Surgery: Intraoperative Neuromonitoring and the Wake-up Test	吳襄齡醫師 Hsiang-Ling Wu
11:55-12:20	兒童側彎手術的疼痛照護及術後加速康復經驗分享 Pain Management and Enhanced Recovery After Surgery (ERAS) for Pediatric Scoliosis: Clinical Perspectives	鄧惟濃醫師 Wei-Nung Teng
12:20-12:30	綜合討論 Panel Discussion	宋俊松醫師 Chun-Sung Sung

12:30-13:30 Lunch Time

Ⅳ. From Practice to Perfection: Hands-on Simulation in Pediatric Scoliosis Care

座長：奉季光 醫師 (Chi-Kuang Feng)

地點：中正樓三樓麻醉部會議室及手術房 AOR14 and AOR15

13:30-13:40	椎弓根解剖：正常狀況與脊椎側彎病例 Pedicle anatomy: Normal and Scoliosis Cases	涂振宏醫師 Chen-Hung Tu
13:40-13:50	徒手椎弓根螺釘置入術 Free Hand Technique for Pedicle Screw Insertion	姚又誠醫師 Yu-Cheng Yao
13:50-14:00	如何彎曲矯正脊椎側彎的鋼棒 How to Bend the Rod for Scoliosis Correction	許逵翔醫師 Kuei-Hsiang Hsu
14:00-14:20	研討會案例討論 Case Discussion for Workshop	奉季光醫師 Chi-Kuang Feng
14:30-17:30	徒手技法，導航與機器人輔助技法研討會(地點：手術房) Free Hand Technique, Navigation and Robotic Assisted Technique Workshop	奉季光醫師 Chi-Kuang Feng 姚又誠醫師 Yu-Cheng Yao

17:30 Closing Remarks

Normal sagittal alignment development in pediatric population: Current evidences review

兒童正常矢狀位排列發育：現有證據綜述

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Sagittal alignment of the spine in the pediatric population is a dynamic process that evolves with growth and development, playing a crucial role in maintaining global balance and minimizing energy expenditure. In early infancy, due to posterior pelvic tilt, insufficient muscular support, and lack of upright posture, the spine appears relatively straight with minimal thoracic kyphosis and lumbar lordosis. As children acquire head control, sitting, and ambulation, gradual development of physiological curvatures occurs, accompanied by changes in pelvic orientation.

During childhood, spinal alignment becomes more structured, although continuous adaptations occur in response to growth and daily activities. In adolescence, rapid growth and postural compensation may lead to transient variations in sagittal parameters; however, most individuals eventually achieve an energy-efficient and balanced alignment. Recent studies have highlighted the importance of spinopelvic parameters, particularly pelvic incidence, as a key anatomical constant that influences lumbar lordosis and overall sagittal profile. Pelvic tilt and sacral slope are also closely related to postural regulation and compensatory mechanisms.

Despite increasing evidence, variations exist across different age groups, ethnic populations, and measurement techniques, resulting in a lack of universally accepted normative values. Establishing age-specific reference parameters is therefore essential for accurate clinical assessment. A comprehensive understanding of normal sagittal alignment development not only facilitates early identification of pathological conditions, such as hyperkyphosis or hypolordosis, but also provides a foundation for appropriate treatment planning and long-term outcome optimization in pediatric spinal disorders.

Tricks for restoring the sagittal alignment in brace management

支架治療中恢復矢狀排列的技巧

Garikoitz Aristegui

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Background: The brace treatment has the aim to prevent the progression of scoliosis in the growth child with the objective of improving the quality of life. The quality of life during the adult life is very much correlated with the sagittal alignment and balance. The relationship is very clear.

The bracing treatment is not just about paying attention to the frontal plane, to the correction of the Cobb angle, is about looking at the three dimensions. The main objective of bracing is to provide the 3D correction of the spine keeping the best sagittal alignment and balance.

One part of the morphology of scoliosis is the lateral translation, following the torsion phenomenon, and the influence of the anterior spinal overgrowth. This pathomechanism is modifying the physiological sagittal profile and looking at the x-Ray we will see a paradoxical kyphosis.

The effect of the torsional forces over the trunk is to increase the collapse of the body volume projecting the spine forward and lateral in the thoracic region, and lateral and backward in the lumbar region.

To restore the sagittal alignment with the bracing treatment we should create contact areas in the prominences, thoracic and lumbar prominence in the dorsal part, and also in the prominences we have in the ventral part of the body asymmetrically. At the same time the contact areas must be correlated with the expansion areas, with the expansion rooms to allow tissues to migrate, to do the correction through the expansion technique in all different regions.

Conclusion: The correction of the scoliosis is through the understanding and capacity of restoring the sagittal profile. The best frontal correction is not the optimum correction for scoliosis. This is described as a state of the art in the design of the brace.

Development of a portable 3D scanner for early detection of adolescent idiopathic scoliosis

可攜式三維背部掃描儀於青少年特發性脊柱側彎早期篩檢之開發

Hideto Kameshima, Masakatsu Noguchi, Yuji Nishio, Yukio Sato
龜嶋英人、野口昌克、西尾裕志、佐藤幸男
Spacevision, Inc. and SMILE CURVE Inc, Japan

Background: Moiré topography has been used for scoliosis screening in Japan because of its non-invasive nature and high sensitivity to small changes in back surface. However, conventional Moiré systems are large and difficult to operate, leading to limited reproducibility. In addition, interpreting fringe patterns required significant effort. This study aimed to develop a compact, lightweight, and practical 3D scanner (Senaka Scan) to enable scalable screening for scoliosis.

Methods: We developed a portable 3D scanner using structured light projection and stereo camera imaging to capture the three-dimensional shape of the body surface as a depth image. A texture image was simultaneously acquired from the same viewpoint. Pseudo-fringe patterns were generated from the depth image and overlaid onto the texture image to reproduce Moiré-like patterns. The device was designed for screening with a compact and lightweight structure.

Results: The device achieved an image acquisition time of 0.5 seconds and approximately 5 seconds for three-dimensional reconstruction. Moiré-like fringe patterns comparable to conventional methods were reproduced from depth and texture images. Back asymmetry can be quantitatively evaluated by measuring left–right height differences. The 3D shape data also enables applications such as spinal alignment estimation and automated analysis. Its compact and lightweight design ensures high portability and suitability for screening settings.

Conclusion: This study demonstrates the feasibility of a compact, lightweight, and high-speed scanner for accurate measurement of body surface deformities. Automated quantification of left–right asymmetry simplifies and improves conventional Moiré-based screening. The system enables assessment of body surface abnormalities, including scoliosis, and has potential for application in screening programs in Japan, Taiwan, and globally.

Anatomy-informed rib-anchored vertebral identification in full-spine radiographs

基於解剖結構的肋骨錨定椎體辨識在全脊柱 X 光中的應用

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Accurate vertebral identification is a prerequisite for automated spinal analysis in full-spine radiographs, because labeling errors can directly affect downstream tasks such as endplate selection and Cobb angle measurement. However, most existing deep learning methods rely primarily on vertebral appearance and assign labels directly from model predictions, without explicitly incorporating anatomical constraints or class consistency. In particular, rib-related cues that may help distinguish thoracic from lumbar vertebrae are rarely used, mainly because rib annotations are generally unavailable in full-spine radiographic datasets.

In this study, we propose an anatomy-informed framework for vertebral identification that incorporates rib-derived evidence as an auxiliary anatomical cue. To address the lack of rib annotations in X-ray images, we use the open-source chest CT dataset RibSeg v2 to generate digitally reconstructed radiographs (DRRs) and corresponding rib masks. Contrastive Unpaired Translation (CUT) is used to convert the DRRs into X-ray-like images while preserving anatomical structure. The translated images and corresponding rib annotations are then used to train a rib segmentation model, which is subsequently applied to Taipei Veterans General Hospital (TVGH) full-spine radiographs to extract vertebra-centered rib evidence. Importantly, no rib annotations from the TVGH dataset are required. The predicted rib masks are further incorporated in a post-processing step to assist vertebral identification, with particular emphasis on identifying the thoracolumbar boundary, especially the distinction between T12 and L1.

Preliminary experiments on the TVGH dataset show that the baseline object detection model, which assigns vertebral labels by directly selecting the top-1 prediction with the highest confidence, achieves an identification accuracy of 0.89. By further incorporating rib mask-based post-processing to refine the discrimination between T12 and L1, the accuracy improves to 0.93. These findings suggest that rib-derived anatomical cues can improve vertebral labeling consistency and enhance prediction performance in anatomically ambiguous regions.

This work provides a practical strategy for introducing rib-based anatomical priors into vertebral identification without requiring manual rib annotations on full-spine radiographs, and may contribute to more anatomically consistent automated spinal analysis.

Automatic recognition of whole-spine sagittal alignment and curvature analysis through a deep learning technique

透過深度學習技術進行全脊柱矢狀面序列自動辨識與曲度分析

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葉祐成

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Background: Artificial intelligence based on deep learning (DL) approaches have enabled automatic recognition of the anatomic landmarks and subsequent estimation on various spinopelvic parameters.

Objective: To develop a fully automatic spinal sagittal curvature analysis system and mathematically determine the location of inflexion points (IPs) and apices (APs) in whole-spine lateral radiographs.

Methods: Based on 1800 annotated images of various spinal disease etiologies, we developed a DL model for automatic spinal curvature analysis of whole-spine lateral plain radiographs. The DL model consisted of a landmark localizer for detection of 25 vertebral landmarks, and a numerical algorithm for generation of an individualized spinal sagittal curvature. The characteristics of the spinal curvature, including the IPs, APs, and curvature angle, could thus be analyzed based on mathematical definitions. To evaluate of the performance of the landmark localizer, the localization errors of each landmark were calculated of the predictions of 300 test images. The inter-rater reliabilities between a senior orthopedic surgeon, a radiologist, and the DL model were assessed using intraclass correlation coefficient (ICC).

Results: The accuracy of the landmark localizer was within acceptable ranges (median error 1.7 – 4.1 mm), and the inter-rater reliabilities remained good to excellent (all ICC > 0.85) between the proposed DL model and any of the two experts when measuring spinal curvature characteristics.

Conclusion: The proposed DL model achieved good to excellent reliabilities with human experts in predicting the locations of inflexion points, apices, and curvature angles. Future applications could be explored to validate the system and improve clinical efficiency.

Anesthesia for scoliosis surgery: Intraoperative neuromonitoring and the wake-up test

麻醉專業在側彎手術上的實務應用：術中神經監測及喚醒試驗

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Intraoperative neuromonitoring (IONM) and the wake-up test are two essential strategies for safeguarding neurological function during spine surgery, particularly in procedures with a high risk of spinal cord injury such as scoliosis correction. IONM provides continuous, real-time assessment of neural pathway integrity through modalities such as somatosensory evoked potentials (SSEP) and motor evoked potentials (MEP). These techniques allow early detection of compromised spinal cord function, enabling timely surgical or anesthetic interventions before irreversible damage occurs. As a result, IONM has become the standard of care in many complex spinal procedures.

Despite its advantages, IONM has limitations, including susceptibility to anesthetic effects, physiological variability, and occasional signal loss or ambiguity. In such situations, the wake-up test remains a valuable adjunct. This technique involves temporarily lightening anesthesia to allow the patient to follow simple motor commands, thereby directly confirming the integrity of voluntary motor function. Although highly specific, it is less commonly used today due to its invasive nature and associated risks, such as patient movement, airway complications, and psychological distress.

Anesthetic management plays a critical role in optimizing both modalities. Total intravenous anesthesia (TIVA) is often preferred to preserve IONM signal quality, while minimizing or avoiding neuromuscular blockade is essential for accurate MEP interpretation. For wake-up tests, short-acting agents and careful titration are necessary to achieve a balance between adequate analgesia and rapid emergence.

In summary, IONM serves as a sensitive and continuous monitoring tool, while the wake-up test provides direct functional confirmation when needed. Their complementary use enhances intraoperative decision-making and improves patient safety in spine surgery.

Pain management and Enhanced Recovery After Surgery (ERAS) for pediatric scoliosis clinical perspectives

兒童側彎手術的疼痛照護及術後加速康復經驗分享

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Pediatric scoliosis correction surgery is associated with severe postoperative pain and a prolonged recovery course; therefore, comprehensive pain management throughout the surgical journey and enhanced recovery strategies are particularly important. In recent years, Taipei Veterans General Hospital has progressively extended its experience in pain management for adult spine surgery to pediatric scoliosis surgery, with further modifications tailored to the specific needs of children, thereby developing a care model better suited to clinical practice.

This lecture will begin by comparing adult and pediatric scoliosis surgery, highlighting the differences in pain presentation, medication use, psychological support, family involvement, and postoperative recovery goals. Whereas adult patients often present with chronic pain, comorbidities, and a higher risk of opioid-related complications, pediatric patients require age-appropriate pain assessment, active family participation, and multidisciplinary integrated care that balances safety with early mobilization.

The lecture will also share the clinical experience of Taipei Veterans General Hospital in multimodal analgesia, the application of regional anesthesia, prevention of postoperative nausea and vomiting, and early ambulation and rehabilitation, illustrating how adult spine surgery pain management strategies can be adapted and applied to pediatric patients. It is hoped that this presentation will provide practical clinical insights into pain management and postoperative recovery for pediatric scoliosis surgery, and help promote safer, more comfortable, and more efficient care pathways.

Pedicle anatomy: Normal and scoliosis cases

椎弓根解剖：正常狀況與脊椎側彎病例

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Over the past few decades, pedicle screw fixation has served as a primary approach for scoliosis correction, providing the three-dimensional stability required for spinal realignment. While advancements in CT-based navigation and robotic assistance have contributed to the field, an ongoing focus on pedicle morphology continues to play an essential role for surgical safety. This necessity arises from the morphological variations inherent in the scoliotic spine, which present structural challenges compared to normal spinal anatomy.

This review aims to provide a preliminary comparative analysis of the notable anatomical differences between scoliotic and normal vertebrae. The discussion seeks to explore the asymmetric dimensions of scoliotic pedicles, observing the variations found between the concave and convex sides of the spinal curve. By contrasting these pathological findings against normal anatomical standards, this session discusses specific constraints—such as pedicle narrowing and cortical bone changes—that surgeons encounter during spinal reconstructions.

In conclusion, thoughtful consideration of these anatomical variations can be helpful in reducing neurological risks and supporting better outcomes in complex spinal correction.

Free hand technique for pedicle screw insertion

徒手椎弓根螺釘置入術

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The evolution of spinal instrumentation has established pedicle screw fixation as the gold standard for achieving multi-planar stability. While image-guided systems are increasingly prevalent, the Lenke thoracic pedicle free-hand insertion technique remains a foundational skill for spine surgeons, offering high accuracy and reduced radiation exposure. This presentation delineates the systematic approach to safe, “blind” screw placement through anatomical mastery and tactile precision.

A critical prerequisite for success is the Watanabe pedicle classification. By categorizing pedicles based on their morphology and the presence of a cancellous bone channel (Types A through D), surgeons can anticipate technical challenges and adjust their trajectory or tool selection accordingly. This classification serves as a roadmap, identifying “at-risk” levels where the pedicle may be sclerotic or extremely narrow.

The core of the procedure relies on the probe method, a disciplined five-step sequence. After identifying the entry point at the junction of the transverse process and the pars interarticularis, a curved pedicle probe is used to navigate the canal. This stage relies heavily on the “tactile feel” of the bone’s density. Following path creation, the tract is rigorously evaluated using a ball-tipped sounding probe to palpate five distinct bony walls, ensuring no medial or visceral breach has occurred.

By integrating Watanabe’s morphological insights with Lenke’s surgical maneuvers, the free-hand technique proves to be a reliable and efficient method for thoracolumbar reconstruction. Mastery of this technique not only enhances surgical flow but also reinforces the surgeon’s fundamental understanding of three-dimensional spinal anatomy.

How to bend the rod for scoliosis correction

如何彎曲脊椎側彎的矯正鋼棒

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Rod contouring is a critical step in scoliosis surgery, as it directly determines the final sagittal and coronal alignment of the spine. Proper rod bending not only facilitates deformity correction but also minimizes mechanical complications such as implant failure, junctional kyphosis, and loss of correction.

The fundamental principle of rod bending is to restore physiological sagittal alignment, especially thoracic kyphosis and lumbar lordosis, rather than focusing solely on coronal correction. Preoperative planning, including assessment of pelvic parameters and flexibility of the curve, is essential to guide the target rod shape. In general, hypokyphotic thoracic curves require aggressive kyphotic contouring, while lumbar segments should be contoured to match the patient's pelvic incidence.

Various techniques can be applied during rod contouring. Differential rod bending, overbending, and in situ adjustment are commonly used to enhance three-dimensional correction. Concave-side rod placement with pre-contoured kyphosis is often preferred to facilitate derotation maneuvers, followed by convex rod application for stabilization. Attention should also be paid to smooth transitions between segments to avoid stress concentration.

Material properties of the rod, such as titanium versus cobalt-chrome, also influence the bending strategy and correction power. Stiffer rods provide stronger corrective forces but may increase the risk of proximal junctional problems.

In conclusion, rod bending is not merely a technical step but a strategic component of scoliosis correction. A well-contoured rod, based on individualized sagittal goals and biomechanical considerations, is key to achieving durable and balanced deformity correction.

Free hand technique, navigation and robotic assisted technique workshop

徒手技法與機器人輔助技法研討會

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The surgical correction of scoliosis remains one of the most demanding disciplines within spinal orthopedics, primarily due to the complex three-dimensional spinal deformities and the proximity of vital neural and vascular structures. Central to these procedures is the precise placement of pedicle screws. This abstract explores the evolving landscape of surgical skill acquisition, contrasting the traditional free-hand pedicle screw technique with the burgeoning integration of robotic navigation-assisted technology.

The Foundation: Free-Hand Pedicle Screw Technique

Historically, the free-hand technique has been the gold standard. It relies heavily on a surgeon's profound understanding of vertebral anatomy, tactile feedback, and the use of intraoperative fluoroscopy. Training for this technique is rooted in the "haloing" effect of long-term mentorship, where residents and fellows develop a "blind" spatial awareness.

1. Skill Acquisition: Training involves repetitive practice on cadaveric models and synthetic bones to master the entry points and trajectories specific to deformed scoliotic vertebrae.
2. Challenges: The learning curve is steep. In cases of severe axial rotation, the pedicle's morphology is often altered, significantly increasing the risk of cortical breach, which can lead to neurological deficits or vascular injury.

The Innovation: Robotic Navigation-Assisted Technology

The advent of robotic platforms and real-time navigation has shifted the surgical paradigm from tactile intuition to digital precision. These systems utilize preoperative CT scans to map a 3D trajectory, which a robotic arm then executes with sub-millimeter accuracy.

1. Technological Integration: Training in this domain requires a different skill set—one that emphasizes digital fluency, system calibration, and "human-in-the-loop" oversight.
2. Benefits: Research indicates that robotic assistance can normalize the skill gap between novice and expert surgeons, providing higher rates of accurate screw placement (Gertzbein-Robbins Grade A or B) even in complex apical curvatures.

Comparative Training Methodologies

The core of modern scoliosis surgical education is finding the equilibrium between these two modalities. While robotic assistance offers a "safety net," over-reliance can lead to the atrophy of traditional anatomical intuition—a critical fail-safe should technology malfunction intraoperatively.

1. Haptic vs. Visual: Free-hand training prioritizes haptic (touch-based) feedback, whereas robotic training prioritizes visuospatial data interpretation.
2. Radiation Exposure: A significant component of training involves managing radiation; robotic systems often reduce total fluoroscopy time, protecting both the trainee and the patient.
3. Simulation-Based Learning: Modern curricula now incorporate high-fidelity simulators that allow trainees to practice free-hand techniques while simultaneously toggling navigation overlays to verify their accuracy in real-time.

Conclusion

Effective training for scoliosis surgery must be bifocal. Surgeons must achieve mastery in the free-hand technique to maintain fundamental safety and clinical judgment, while simultaneously embracing robotic navigation to enhance precision and patient outcomes. As the technology matures, the focus of surgical education will likely shift from manual dexterity alone to a sophisticated synthesis of anatomical expertise and technological proficiency.