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# 2024 兒童脊柱側彎照護 當代影像技術與轉譯研究

## Image Can Help: Pediatric Scoliosis Care 2024 Current Techs and Translation Research

時　間：113 年 6 月 22 日(星期六) 08:30~12:00
地　點：臺北榮民總醫院 致德樓第八、九會議室

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| ***08:30-08:50*** | ***Opening Remarks*** | 郭萬祐 教授<br>Wan-Yuo Guo<br>蘇宇平 部主任<br>Yu-Ping Su |
| | **座長：林重榮 主任 (Chung-Jung Lin)** | |
| 09:00-09:10 | 兒童脊柱側彎照護:趨勢及在台灣未滿足的需求<br>Pediatric Scoliosis Care: Current Trends and Unmet Needs in Taiwan | 奉季光 醫師<br>Chi-Kuang Feng |
| 09:10-09:25 | 無幅射數位條紋投影輪廓術來量測脊柱側彎角度<br>Non-Radiation Measurement of Cobb Angle Via Fringe Projection Profilometry | 劉承揚 教授<br>Cheng-Yang Liu |
| 09:25-09:40 | 擴增/虛擬實境輔助脊柱側彎運動訓練的前驅研究<br>AR/VR for Scoliosis Specific Exercise Training-Pilot Study | 許維君 教授<br>Wei-Chun Hsu |
| 09:40-09:55 | 虛擬手術規劃與 3D 列印技術在兒童側彎手術的應用<br>Virtual Surgical Planning and 3D Printing for Pediatric Scoliosis Surgery | 俞文展 助理研究員<br>Wun-Chan Yu |
| 09:55-10:10 | 綜合討論<br>Panel Discussion | 林重榮 主任<br>Chung-Jung Lin |
| ***10:10-10:30*** | ***Coffee Break*** | |
| | **座長：盧家鋒 教授 (Chia-Feng Lu)** | |
| 10:30-11:00 | 零回波時間磁共振造影技術:脊柱側彎骨骼應用<br>Bone Imaging with ZTE-MRI and its Application to Pediatric Scoliosis | 林建源技術應用經理<br>Chien-Yuan Lin |
| 11:00-11:45 | 互動式深度學習 醫學影像快速圈選與分析<br>Rapid Image Annotation and Analysis with Interactive Deep Learning for Medical Image | 李根嘉 技術長<br>Gen-Jia Li |
| 11:45-12:00 | 綜合討論<br>Panel Discussion | 林重榮 主任<br>Chung-Jung Lin |

# Pediatric scoliosis care: Current trends and unmet needs in Taiwan

# 兒童脊柱側彎照護：趨勢及在台灣未滿足的需求

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**奉季光**
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### Multidisciplinary Management of Pediatric Scoliosis

Pediatric scoliosis, especially early-onset scoliosis, requires a collaborative approach involving multiple specialties. Drawing on recent experiences from Europe and America, treatments are divided into non-surgical and surgical interventions.

### Non-Surgical Treatment

Key non-surgical treatments encompass rehabilitation therapy, early intervention programs, nutrition, bone strengthening, enhancement of respiratory and cardiopulmonary functions, and management of associated conditions. These components are vital for comprehensive patient care.

### Surgical Treatment

Surgical approaches are categorized into fusion and non-fusion corrective procedures. Non-fusion strategies involve implants that induce growth or extend the spine, controlling scoliosis progression while allowing normal growth.

### Assessment Techniques

Before treatment, physical assessments are supplemented by medical imaging. The use of three-dimensional ultrasound to assess spinal curvature angles is increasingly popular, due to its ability to reduce radiation exposure. However, the limitations of ultrasound include the lack of axial images and the time-intensive nature of 3D ultrasound techniques. Innovations like zero echo time MRI and digital moiré projection contouring are being explored to overcome these challenges.

### Rehabilitative Therapy

Rehabilitative exercise therapy is a highly specialized, patient-tailored treatment. The development of rehabilitation professionals and the use of technology to increase service capacity are promising. Technologies that present common exercises through virtual reality could enhance home accessibility for patients, making daily treatment more feasible.

### Surgical Training and Innovation

The traditional apprenticeship in surgical training requires extensive learning. Advances in three-dimensional imaging and realistic 3D printing aids are enhancing surgical quality and accelerating skill transfer. This progress is crucial in surgical education, especially for complex and rare conditions.

# Non-radiation measurement of cobb angle via fringe projection profilometry

# 無幅射數位條紋投影輪廓術來量測脊柱側彎角度

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**Background:** Adolescent idiopathic scoliosis (AIS) is a common spinal deformity in individuals aged ten and above, characterized by unknown etiology, resulting in spinal curvature and asymmetric trunk. Symptoms may include postural asymmetry, uneven shoulder height, and pelvic imbalance. Early diagnosis and treatment are crucial, involving physical therapy, orthotic bracing, and surgery, depending on severity and patient conditions. Early diagnostic methods include school screenings, Scoliometer, X-rays, and MRI/CT scans. However, despite being quick, the former two often yield judgment errors, with Scoliometer showing a correlation coefficient of 0.677 with Cobb angles. X-ray remains the most widely used despite radiation exposure concerns, while MRI and CT are more accurate but time-consuming and costly.

**Methods:** Our study employs fringe projection profilometry (FPP) using a projector to cast a known pattern onto the surface of the subject's back. A camera then captures images of the back with the superimposed pattern. These images serve as input data for a convolutional neural network (CNN), which outputs the Cobb angle and identifies the location and direction of scoliosis. We aim to establish an imaging system combined with a deep learning model to dynamically measure the morphology of the human back for clinical evaluation of scoliosis.

**Results:** Collaborating with Dr. Chi-Kuang Feng from the Taipei Veterans General Hospital, we recruited 147 participants for clinical trials. Our system takes only 1 ± 0.03 seconds to complete measurements with an ROI size of 1280 x 720, achieving 90 % accuracy in angle prediction and 75 % in location prediction. Biostatistical analysis indicates the effective angle range of our study is between 10 - 25 degrees, with 47 samples within this range, showing a discrepancy of ± 3.01 degrees from the gold standard, confirming the system's clinical value.

**Conclusion:** While currently a cross-sectional study, limiting its application to all scoliosis populations, the preliminary results demonstrate that our developed system can quickly and accurately assess scoliosis with clinical diagnostic value. We plan to continue patient recruitment in hospitals and refine the system, aiming for eventual medical device market approval to enhance public health.

# AR/VR for scoliosis specific exercise training-pilot study

# 擴增 / 虛擬實境輔助脊椎側彎運動訓練的前驅研究

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*國立臺灣科技大學 醫學工程研究所*

The statistics revealed that 3~5% of 11~16-year-old adolescents suffer from idiopathic scoliosis. The literature points out that patients with scoliosis have dysfunctions such as autonomic nerves, proprioception, and balance control, as well as asymmetric weight bearing of the lower limbs and abnormal gait pattern. Clinically, back brace and rehabilitation exercises are used to improve or prevent the deterioration of the spine curvature angle, so as to maintain the patient's quality of life and avoid surgical operations. Studies showed that the 3 months exercise program can improve the endurance of the back muscles and correct the curvature of the spine, thereby improving its dynamic posture control and balance ability. However, our research team has concluded that in Cobb's angle correction, C type has a significant effect, but S type seems no improvement. Is it because the Chinese people have insufficient exercise time and impractical training movements, resulting in poor efficiency? How to quantify the exercise time, guide the correct posture, and exercise intensity to achieve the best individualized effect?

Therefore, the proposed research direction is to develop a virtual reality core muscles interactive exercise game focusing on the training of the trunk core muscle group and the asymmetrical limbs guidance training of different hands and feet, and strengthen its vision, vestibule, and proprioception. The developing exercise is compared with method adopted in the clinics. At present, the physical therapist with a Schroth certificate in the rehabilitation department of Taipei Veterans General Hospital has confirmed the selected actions many times, and has observed and learned the scoliosis correction course of the therapist. The animation 3D software Blender has been used to make brief rehabilitation actions.

Exercise can strengthen the muscle strength of the trunk and lower limbs in patients with scoliosis, and improve their dynamic posture control and balance ability; but in the Cobb's angle correction, the S-type patients do not improve or even worsen. The virtual reality core muscle group interactive game, based on the training method, focuses on the training of the torso core muscles and the asymmetrical limbs guidance training of different hands and feet. It strengthens the interactive integration of vision, vestibule and proprioception somatosensory , and can guide the correct exercise posture to improve the asymmetric core muscles on both sides of the spine, control or reduce the Cobb's Angle in patients with S-scoliosis.

# Virtual surgical planning and 3D printing for pediatric scoliosis

# 兒童脊椎側彎虛擬手術規劃與 3D 列印

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**Background: P**edicle screw insertion in scoliosis correction is challenging, especially for the pediatric cases. The spinal deformities and undersized pedicle diameter increase the risk of pedicle breach, which may cause spinal cord injury. To reduce the uncertainty, several surgical guidance techniques have been introduced in the past decades. Thanks to the avoidance of intraoperative radiation and ,in contrast to surgical navigation, the more affordable expenditure for patients and hospitals, virtual surgical planning (VSP) and 3D printed surgical guide (3DP SG) have become one of the promising guidance techniques over the past decade.

**Methods:** The optimal pedicle screw trajectory was planned in 3D Slicer, the medical image computing platform, according to spine CT images of scoliosis patients. The planned trajectory was inspected in axial, sagittal and coronal planes, ensuring no pedicle breach. Subsequently, patient-specific surgical guides, designed according to vertebral contour and planned trajectory, were materialized using a stereolithography 3D printer with biocompatible resin. Finally, the scoliotic spine models were 3D printed in order to confirm the stability of surgical guide when mounting on the spine.

**Results:** Nine pediatric scoliosis cases were enrolled in our experiment in 2023. The surgical planning and 3D printing workflow were established and fine-tuned based on the CT images and 3D printed scoliotic spine. The perfect fit between the surgical guide and vertebrae assisted surgeons in reducing the uncertainty of insertion trajectory. In a small portion of pedicles, unexpected trajectory inaccuracy was observed under the X-ray. Since the planned trajectories had been reconfirmed, the error must have been contributed by the post-VSP processes, such as foot plate design or deformation during 3D printing.

**Conclusion:** Virtual surgical planning and 3D printed surgical guide are beneficial for routine scoliosis correction operation in terms of uncertainty reduction, intraoperative radiation avoidance, and affordable expenditure. Identifying and improving the unexpected inaccuracy caused by post-VSP processes will be our next focus.

# Bone Imaging with ZTE-MRI and its application to pediatric scoliosis

# 零回波時間磁共振造影技術：脊柱側彎骨骼應用

**Chien-Yuan Lin**
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Magnetic resonance imaging (MRI) can non-invasively assess the proton pool and therefore provide excellent contrast of soft tissues, but has traditionally failed to visualize cortical bone due to its low proton density and rapid signal decay in transverse relaxation time ($T2^* \sim 0.4$ ms). A newly-proposed three-dimensional (3D) zero-echo time (ZTE) MRI sequence utilizes a hard pulse excitation immediately followed by 3D radial k-space encoding to achieve a nominal echo time of zero, allowing for the visualization of the full transverse spin of cortical bone.

ZTE-MRI, offering the advantage of non-ionizing radiation, has been increasingly used for the evaluation of bone in various anatomical regions, including the cranium, extremities, sacroiliac joint, and spine. However, the application of this technique and the quality of whole-spine imaging remain largely unknown.

Scoliosis is a multifactorial 3D spinal deformity that requires continuous radiation-based follow-up of spinal curvatures using X-ray or CT, particularly in the pediatric population, for diagnosis and surgical planning. Radiation-free ZTE-MRI could provide an alternative solution for the evaluation of scoliosis.

This presentation will cover the physics of ZTE-MRI and its application for the assessment of 3D spinal deformity in pediatric scoliosis patients.

# Rapid image annotation and analysis with interactive deep learning for medical image

# 互動式深度學習醫學影像快速圈選與分析

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This presentation explores rapid image annotation and analysis with interactive deep learning for medical images, beginning with an overview of key artificial intelligence (AI) models that have significantly impacted various fields. It covers ChatGPT for advanced natural language processing, Google Translate for language translation via deep learning, and the Transformer model, which is pivotal for text and image processing. The Vision Transformer (ViT) is highlighted for its application in image recognition, while Generative Adversarial Networks (GANs), particularly Pix2Pix, are discussed for their role in high-quality image generation.

Next, the presentation delves into the Amira software, a powerful tool for medical image analysis. Amira's integration of machine learning enhances its image processing capabilities. The presentation introduces Amira's new interactive AI segmentation tool, which allows for precise and efficient image annotation. Noise2Void, an unsupervised deep learning technique within Amira, is explained for its ability to denoise images without requiring clean reference images. Additionally, Amira's support for deep learning models facilitates both semantic and instance segmentation, crucial for detailed medical image analysis.

The advanced features of Amira-Avizo software are then explored, emphasizing its comprehensive 3D visualization and data analysis capabilities. A custom-developed iterative buds-growing neural network within Amira/Avizo is introduced, showcasing its ability to improve segmentation accuracy through iterative learning. Practical applications and case studies are presented to demonstrate the real-world benefits of these advanced tools in medical imaging, highlighting improvements in diagnostic accuracy and research outcomes.

In conclusion, the presentation summarizes the significant points discussed, reinforcing the importance of advanced AI models and tools in medical image analysis. Future trends and potential developments in AI for medical imaging are considered, emphasizing areas for further research and innovation.