

13th Annual Spine Academic Day

SPINEEFEST

UNIVERSITY OF TORONTO SPINE PROGRAM

JUNE 14, 2021

5:00 PM EST

VIRTUAL

REGISTRATION



Surgery

UNIVERSITY OF TORONTO

Spine Program

University of Toronto Spine Program

SPINEFEST

Monday, June 14, 2021. 5:00PM– 7:30PM

VIRTUAL

CONTENT

	ABOUT SPINEFEST 2021
	- Learning Objectives and Accreditation
	- Previous Visiting Professors
	ABOUT UNIVERSITY OF TORONTO SPINE PROGRAM
	- Vision and Integration
	- Faculty
	REMARKS FROM PROGRAM CO-DIRECTORS
	AGENDA
	TATOR & HALL
	PROGRAM CO-DIRECTORS
	VISITING PROFESSOR & SPEAKERS
	SCIENTIFIC ABSTRACTS
	ACKNOWLEDGMENTS

ABOUT SPINEFEST 2021



SpineFEST, which was first established 13 years ago, is the Annual Academic Spine Day and the key spine event at the University of Toronto (U of T). SpineFEST brings together the U of T spine community to disseminate knowledge of advances in spine surgery, spine care management, and spine research. The day serves as a unique educational platform for clinicians and researchers from a broad spectrum of disciplines including neurosurgery, orthopaedic surgery, and a multidisciplinary group of clinicians and academic professionals from a variety of disciplines including chiropractic, physiatry, physical therapy, nursing, family medicine, pain medicine, biomedical engineering, and basic/clinical and translational science.

LEARNING OBJECTIVES OF SPINEFEST 2021:

- Recognize the dynamic nature of progress in MIS deformity surgery;
- Learn the indications for MIS correction of deformity;
- Understand the advantages of MIS surgery for correction of deformity;
- Learn how to incorporate MIS techniques in the management of spine oncology.

ACCREDITATION

Royal College of Physicians and Surgeons of Canada – Section 1: This event is an Accredited Group Learning Activity (Section 1) as defined by the Maintenance of Certification Program of the Royal College of Physicians and Surgeons of Canada, approved by Continuing Professional Development, Temerty Medicine, University of Toronto up to a maximum of 2.5 credits.

PREVIOUS VISITING PROFESSORS AT THE TATOR – HALL LECTURE

2020 Professor Marcus Stoodley, Macquarie University, Sydney, Australia

2019 Professor Praveen Mummaneni, The University of California, San Francisco

2018 Professor Sanford Emery, West Virginia University

2017 Professor Zoher Ghogawala, Tufts University School of Medicine

2016 Professor Daniel Riew, Columbia University Medical Center

2015	Professor Wilco Peul, Leiden University Medical Centre
2014	Professor Kenneth Cheung, University of Hong Kong
2013	Professor Alexander Richard Vaccaro, Thomas Jefferson University
2012	Professor Jean Dubousset, The University of Paris
2011	Professor Jens Chapman, University of Washington
2010	Professor Edward Benzel, Cleveland Clinic
2009	Professor Jeffrey Wang, University of California

ABOUT The UNIVERSITY OF TORONTO SPINE PROGRAM 

VISION

Innovation and excellence in the delivery of spine care with a unique collaborative program of clinical expertise, research, teaching, and education.

INTEGRATION

The University of Toronto Spine Program is a multidisciplinary collaborative unit which combines neurosurgery and orthopaedic surgery and the broad spectrum of nonoperative clinical and research disciplines which are engaged in spine. The U of T Spine Program is integrated across citywide clinical and research programs at the affiliated teaching hospitals; Toronto Western Hospital (TWH) at University Health Network (UHN), Sunnybrook Health Sciences Centre (SHSC), Hospital for Sick Children (HSC), St. Michael’s Hospital (SMH) at Unity Health Toronto (UHT), and Mount Sinai Hospital (MSH)

FACULTY

TORONTO WESTERN HOSPITAL @ UHN

- Michael G. Fehlings MD PhD FRCSC FACS
- Fan Jiang MD FRCSC
- Stephen Lewis MD MSc FRCSC
- Christopher Nielsen MD FRCSC
- Eric Massicotte MD MSc FRCSC

HOSPITAL FOR SICK CHILDREN

- David Lebel MD PhD FRCSC
- Stephen Lewis MD MSc FRCSC
- James Drake BSE MB BCh MSc FRCSC
- Reinhard Zeller MD FRCSC

ST. MICHAEL’S HOSPITAL @ UHT

SPINEFEST 2021 Brochure

Y Raja Rampersaud MD FRCSC

Alexander Velumian PhD

TORONTO REHABILITATION INSTITUTE @ UHN

Karl Zabjek BSc MSc PhD

Margarete Akens Dr med vet PhD

SUNNYBROOK HEALTH SCIENCES CENTRE /RESEARCH INSTITUTE

Leo da Costa MD

Mahmood Fazl MD FRCSC

Joel Finkelstein MD MSc FRCSC

Michael H. Ford MD FRCSC

Michael Hardisty PhD

Jeremie Larouche MD FRCSC

Barry W. Malcolm MD FRCSC MBA

Meaghan O'Reilly PhD

Farhad Pirouzmand MD MSc FRCSC

Arjun Sahgal BSc MD FRCPC

Victor Yang MD PhD PEng FRCSC

Cari Whyne PhD

Albert Yee MD MSc FRCSC

Jefferson Wilson MD, PhD FRCSC

Henry Ahn MD PhD

Howard Ginsberg MD PhD FRCSC

Christopher Witiw MD PhD FRCSC

MOUNT SINAI HOSPITAL

Carlo Ammendolia DC PhD CCRF

Rita Kandel MD FRCPC

UNIVERSITY OF TORONTO

W Mark Erwin PhD DC

Cindi M Morshead BSc PhD

Molly S Shoichet PhD FRSC

REMARKS FROM PROGRAM CO-DIRECTORS



Colleagues,

We are almost there! With the easing of COVID related restrictions, we look forward to resuming a more normal situation at our hospitals and University in the coming months. We want to extend our appreciation to the University of Toronto Department of Surgery Spine Program Council, administrative staff, educators, and trainees for the continued dedication and professionalism in making this past academic calendar a significant success during challenging pandemic times. The Program's academic calendar of 2020/2021 has been a productive one as the Program fosters meaningful citywide collaborations within the University and participates and leads on several key regional and international initiatives. Our Program has grown a respected academic footprint locally, nationally, and globally. Collaboration, inter-professional, and inter-disciplinary knowledge exchange remain the key element to our success.

This U of T Spine Program celebrates its 13th Annual Spine Academic Day "SpineFEST." At this time of the year, we gather to highlight our spinal community's accomplishments and disseminate recent clinical and scientific advances. As the restrictive measures continue, SpineFEST continues to be held virtually, again, this year. We are pleased to have had Dr. Richard Fessler, a world-renowned spine surgeon and Professor of Neurosurgery at Rush University Medical Center, visit us virtually on Monday evening June 14th, to provide his keynote address as our Tator-Hall Lecturer. Professor Fessler will discuss the management of minimally invasive (MIS) correction of adult spinal deformity. Please join us in welcoming Professor Fessler to SpineFEST 2021! The New Faculty talk will be presented by Dr. Christopher Witiw, who will discuss MIS techniques in spinal oncology. The meeting will continue to highlight spine research from the faculty and trainee. In addition, there will be a follow-up from the 12th Annual meeting with an update on clinical care and translational research being done on craniocervical junction disorders and Ehlers Danlos Syndrome. Oral presentations will be provided by Best Abstract winners from both clinical and basic science perspectives. SpineFEST this year received around 30 excellent scientific abstracts ([👉 abstract](#)), most of which have been presented online on ([👉 VoiceThread](#)). All participants are welcome to communicate with trainees online until the day of the event on June 14th.

Recent activities have leveraged our education platform to create a national spine surgery fellowship training curriculum for cognitive and procedural competencies. Building on this, our program, over many years, has established and enhanced Neurosurgery and Orthopaedic Surgery spinal training opportunities between Toronto Academic Health Sciences Network (TAHSN) teaching hospitals (Toronto

Western Hospital (TWH-UHN); Sunnybrook Health Sciences Centre (SHSC); Saint Michael's Hospital (SMH) and Hospital for Sick Children (HSC). We have built a top-tier academic hub that attracts 12-15 national and international clinical fellows and many additional visiting surgeons each year.

Over the past years, our program continues to offer both a one-year core fellowship training experience and a two-year fellowship program with a first-year comprehensive spine training experience followed by a second year focused on advanced subspecialty exposure. While the fellowships are primarily focused at one of the TAHSN hospitals, great options exist for a citywide experience. Many thanks to Drs. Albert Yee, Michael Fehlings, Stephen Lewis, Eric Massicotte, Joel Finkelstein, Howard Ginsberg, Henry Ahn, and Reinhard Zeller for their valued help shaping our citywide fellowship training opportunities. Building on our national fellowship curriculum, our Program also continues with the surgical case-log for our citywide spine fellows with over 2000 cases and procedures recorded. We thank Drs. Jeremie Larouche, Dr. Tony Bateman, and Ms. Nadia Jaber for creating a successful case-log program for our fellows.

We are excited to announce that an application to the Royal College of Physicians and Surgeons of Canada has been submitted by the Canadian Spine Society towards establishing an RCPSC Area of Focused Competence (AFC) Diploma for Spine Surgery. The University of Toronto Spine Program has partnered closely with the Canadian Spine Society and other centres across the country to advance this effort. Thanks to Drs. Albert Yee, Jeremie Larouche, Michael Fehlings, Scott Paquette, Hamilton Hall and Ms. Nadia Jaber for taking the lead in engaging several university spine programs and fellowship directors across Canada in this initiative. Several members in our Program Education Subcommittee have expressed keen interest in being involved as the initiative develops; a terrific opportunity for our Program to continue developing materials that will shape the future of spine surgical education in Canada. It will provide a valued competence-based model for our international community of surgical educators as well.

Each year we launch our academic calendar of events with a welcome dinner for our incoming fellows. This past year, the event was organized virtually to provide an update on our citywide research opportunities. Thanks to Dr. Carlo Ammendolia and Dr. Karl Zabjek for keeping us updated on the progress of spine research in Toronto. We also organize a mini bootcamp course in the fall for our fellows and senior residents to discuss Traumatic Spinal Cord Injury, the ASIA neurological assessment, surgical/non-surgical management, and current clinical trials. Thanks to Dr. Sukhvinder Kalsi-Ryan for coordinating the course with Drs. Fehlings, Yee, Jeremie Larouche and Jeff Wilson. Each year, Dr. Stephen Lewis chairs a citywide fellow surgical skills course, introducing advanced anatomy of the spine with fellows performing anterior and posterior surgical approaches as well as spinal instrumentation. Over the past several years, Dr. Lewis extended this course to include advanced complex procedures including

deformity osteotomy, minimally invasive surgery, and trauma techniques. The course encompasses a combination of wet lab, simulation, faculty lectures and case-based discussions throughout the day. It was unfortunate that the third wave of COVID-19 peaked in May; the course has been rescheduled to the Fall. Each year, we continue to complement the residents' surgical training with our Royal College Mock Oral on Spine course Co-Chaired by Drs. Fehlings and Yee. On March 15th our citywide spine fellows took a key leadership role in teaching the senior residents and organizing a selection of representative case scenarios in Royal College examination format. The fellows also provided valuable tips and updated literature reviews on several spine disorders in this virtual course,. We thank Drs. Julia Bowes, Nandan Marathe, Ohad Einav, Dora Pelletier, and Carolyn Lai, also our alumni Dr. Mario Ganau for taking the lead in teaching our residents. We also host a citywide Fellow Journal Club several times a year to discuss recent and controversial spine articles with a collection of relevant cases. This year, journal clubs were conducted virtually and hosted by our faculty from several hospitals. We thank Drs. Fehlings and Yee for hosting a Journal Club on frailty in spine disorder and spine surgery, and Dr. Jeff Wilson for hosting one on sports-related spinal injury.

The Program invites several world-renowned Professors each year to a Hospital-Based Visiting Professorship. A few previously scheduled lectures have been postponed to resume when the pandemic restrictions are lifted and larger in-person meetings are permitted. Meanwhile, our Program hosted a virtual Visiting Professorship on April 9th jointly with the Department of Surgery, Division of Orthopaedic Surgery, and Division of Anatomy. The event featured Professor Sigurd Berven from the University of California San Francisco as our Harland-Smith Lecturer. He provided a very informative and thoughtful lecture on the use of interbody implant and advanced minimally invasive techniques in spine surgery. The importance of understanding human anatomy as relevant to advance surgical techniques was highlighted. Following the lecture, our Program hosted Dr. Berven in a special case-based session with citywide fellow presentations to discuss complex interbody implant cases and complex deformity. Thanks to Dr. Berven for his insightful input and our citywide fellows, Drs. Nandan Marathe, Brett Rocos, Julia Bowes, and Isaaq Carenno for providing exciting and thought-provoking cases. We also held a virtual Tator-Turnbull Spinal Cord Injury (SCI) Symposium on October 23rd. This event was hosted jointly with the TWH Spinal Cord Injury Program and the Collaborative Program in Neuroscience to pay tribute to the enormous contribution of Dr. Charles Tator and Ms. Barbara Turnbull in driving advances in SCI research and related advocacy. We were delighted to have had Dr. Wolfram Tetzlaff provided an exciting keynote presentation on the role of the ketogenic diet in cell therapy and other preclinical strategies in SCI. Dr. Fehlings provided an overview of the U of T Spine Program and the Krembil Brain Institute Research. Dr. Cathy Craven also provided an update on the Lyndhurst SCI Rehab Program.

With the challenges imposed by the pandemic restrictions, our Program has been keen on bringing together citywide surgeons and trainees in multiple virtual activities. A series of Case-Based Forum has been initiated to present controversial and complex cases, and to discuss best practices in surgical approaches and treatment management. We thank Drs. David Lebel, Reinhard Zeller and Stephen Lewis from HSC, and Drs. Joel Finkelstein and Leo Da Costa from SHSC for organizing excellent presentations. We have also made hospital-based spine weekly rounds available to citywide surgeons fellows and residents. These rounds typically discuss weekly on-call, pre-op and post-op case planning and management, including reviewing relevant literatures on the topics. Thanks to Drs. Fehlings, Stephen Lewis, Raja Rampersaud and Eric Massicotte for providing this outstanding opportunity. A special thanks to Dr. Arjun Sahgal for his continued valued input on oncology cases.

On the advocacy level, the Program continues to be proactive to raise awareness of spine conditions. Efforts in raising awareness and promoting best practices are being undertaken. The Ontario Degenerative Cervical Myelopathy Summit, which was organized and Co-Chaired by Dr. Fehlings and Dr. James Milligan (a family physician from the Mobility Clinic in Kitchener-Waterloo) in November 2020, has brought together a team of Canadian health professionals and federal representatives to discuss the topic to develop a white paper with a set of priorities to tackle relevant healthcare challenges. It aims to advance an Ontario-based DCM health care strategy and knowledge translation. Regarding Craniocervical Junction (CCJ) disorders, including Ehlers Danlos Syndrome (EDS), Dr. Fehlings and colleagues have engaged the local spine community in attending to the challenges around this disorder. There remains a lack of evidence-based practice and research. Dr. Fehlings is leading research efforts which address this knowledge gap. His team is currently undertaking systematic reviews on the diagnostic criteria for CCJ in EDS to develop diagnostic and management pathways; efforts are being made in collaboration with the EDS Clinic Program at UHN.

We want to take this moment and celebrate the graduation of our 2020/2021 citywide spine fellows. Congratulations to Drs. Nandan Marathe, Isaac Aguirre Carreno, Brett Rocos, Julia Bowes, Hari Ramakonar, Ohad Einav, Laura-Nanna Lohkamp, Dora Pelletier, J r mie Nallet, Peter Pr mmel, Kelechi Eseonu, Dhawi Aali Alotaibi, and Manuel Fuetsch. We acknowledge their relentless efforts and dedication in completing advanced fellowship training during this challenging year. We wish them all the best for a successful and rewarding professional career. We look forward to a continued future engagement in our Program's activities.

We wish to recognize the support from the U of T Department of Surgery and Divisions of Neurosurgery and Orthopedic Surgery. We also would like to thank all our Program faculty members and industry partners, Medtronic, Zimmer Biomet, De Puy Synthes and Stryker, for their continued support over many

years and particularly during the past year. We thank our Program members; we are privileged to benefit from their diverse and specialized knowledge. Special thanks to Ms. Nadia Jaber, our Program Manager, for her outstanding expertise and valued Information and Communication Technology skills. They have been invaluable towards moving forward our collaborative agenda and virtual academic activities during this rapidly evolving time.

Sincerely,

Michael Fehlings & Albert Yee, Co-Directors
 Nadia Jaber, Program Manager

AGENDA **SPINEFEST 2021 WEBINAR JUNE 14TH (5:00 to 7:30 PM EST)** 

**SESSION I:
 TATOR-HALL LECTURSHIP
 MINIMALLY INVASIVE SURGERY
 Chair: Michael Fehlings**

TIME	LENGTH	TALK	PRESENTER & MODERATORS
17:00	5 MIN	Introductory Comments	Michael Fehlings & Albert Yee
17:05	5 MIN	Greetings from the U of T	James Rutka and Peter Ferguson
17:10	5 MIN	Tator-Hall Welcome Remarks	Charles Tator & Hamilton Hall

TATOR - HALL VISITING PROFESSOR LECTURE

17:15	5 MIN	Introduction to the Keynote Speaker	Michael Fehlings
17:20	40 MIN	MINIMALLY INVASIVE CORRECTION OF ADULT SPINAL DEFORMITY: WHO, WHEN, WHY.	KEYNOTE SPEAKER: Richard G. Fessler, MD, PhD, Professor, Department of Neurosurgery, Rush University Medical Center, Chicago, Illinois

NEW FACULTY PRESENTATION

18:00	10 MIN	INCORPORATING MINIMALLY INVASIVE TECHNIQUES IN THE MANAGEMENT OF SPINAL ONCOLOGY	Chris Witiw, Saint Michael's Hospital
18:10	20 MIN	Panel Discussion	
18:30		End of Session I	

5 MIN BREAK

E-POSTER ON VOICETHREAD AVAILABLE ALL DAY [HERE](#)

**SESSION II:
RESEARCH TRAINEE PRESENTATIONS
Chair: Albert Yee**

INVITED TRAINEE PRESENTATION

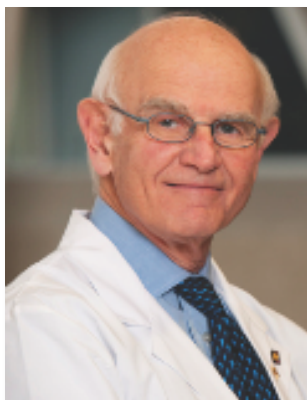
18:35	2 MIN	Introduction	Albert Yee & Michael Fehlings
18:37	7 MIN	BUSINESS TECHNIQUES TO IMPROVE HEALTH SYSTEM DELIVERY OF SPINE CARE	Jay Toor, Resident, Orthopaedic Surgery
18:44	7 MIN	BIOENGINEERED HUMAN STEM CELL STRATEGIES TO REGENERATE THE INJURED SPINAL CORD	Chris Ahuja, resident, Neurosurgery
18:51	7 MIN	SPINAL MANIFESTATIONS IN EHLERS DANLOS SYNDROME- A SYSTEMATIC REVIEW OF DIAGNOSTIC CRITERIA FOR CRANIOCERVICAL INSTABILITY	A follow up presentation from the 12th Annual SpineFEST Day Laura- Nanna Lohkamp, spine fellow, TWH
19:01	10 MIN	Panel Discussion	

BEST ABSTRACT ORAL PRESENTATION

		1st Place Best Abstract (Basic Science)	
19:11	5 MIN	ENHANCED OUTCOMES AND REDUCED PERIOPERATIVE NEUROLOGICAL COMPLICATIONS IN THE SURGICAL	James Hong - Post Doc - Fehlings Lab - Krembil Research Institute

		MANAGEMENT OF DEGENERATIVE CERVICAL MYELOPATHY: EXAMINING THE IMPACT OF REMOTE ISCHEMIC PRECONDITIONING	
19:16	5 MIN	1st Place Best Abstract (Clinical) SEQUENTIAL ROD ROLLING FOR SURGICAL CORRECTION OF LENKE TYPE 2 ADOLESCENT IDIOPATHIC SCOLIOSIS: A 3D ANALYSIS	Jérémie Nallet - Spine Fellow, HSC
19:21	5 MIN	Panel Discussion	
19:26	4 MIN	AWARD PRESENTATIONS	
19:30	Wrap up		

TATOR & HALL



Dr. Charles Tator is a Professor in the Department of Surgery, at the University of Toronto, and a neurosurgeon at the Toronto Western Hospital. He is the former Chair of Neurosurgery at the University of Toronto. He started the first Acute Spinal Cord Injury Unit in Canada in 1974, and has reported on the epidemiology, prevention and treatment of spinal cord injury. He has undertaken seminal translational and clinical research in spinal cord injury. In 1992, he founded ThinkFirst, Canada, a national brain and spinal cord injury foundation whose mission is to reduce the incidence of catastrophic injuries in Canada. In 2012, ThinkFirst merged with three other charities to form Parachute Canada, the country’s foremost injury prevention agency, of which he is a founding Director. In 2008, the University of Toronto Press published his book “Catastrophic Injuries in Sports and Recreation, Causes and Prevention-a Canadian Study.” He has held two research chairs at the University of Toronto, the Dan Family Chair in Neurosurgery and the Campeau Family-Charles Tator Chair in Brain and Spinal Cord Research. In 2000, he received the Order of Canada, and in 2009 he was inducted into the Canadian Medical Hall of Fame. In 2017, he was promoted to Officer within the Order of Canada, and was also inducted into Canada’s Sports Hall of Fame for his work on prevention of sports injuries.



Dr. Hamilton Hall is a Professor in the Department of Surgery at the University of Toronto and on the orthopaedic staff at the Sunnybrook Health Sciences Centre. He completed his medical degree at the University of Toronto then joined CARE and was stationed at a rural hospital in Malaysia. Dr. Hall returned to Toronto for his orthopaedic residency which concluded with a fellowship in medical education at the University of Dundee, Scotland. In 1974, because of his interest in patient education and rehabilitation, Dr. Hall founded the Canadian Back Institute which expanded into the CBI Health, now the largest home care and rehabilitation company in Canada. He is co-founder and Executive Director of the Canadian Spine Society and has served on the editorial boards of Spine, The Spine Journal and The BackLetter.

Dr. Hall has received Outstanding Paper and Poster awards from the North American Spine Society and the International Society for the Study of the Lumbar Spine. He is a recipient of the Laurie Chute Award for Best Undergraduate Clinical Lecturer Award at the University of Toronto, the NASS Henry Farfan Award for outstanding contributions to the field of spine care and two Lifetime Achievement Awards, one from Stryker Spine and the other from the Canadian Spine Society. In 2019 he was inducted into the Toronto Orthopaedic Hall of Fame. Dr. Hall's concept of a syndrome approach to classifying mechanical back pain is an essential component of several Canadian provincial initiatives to improve spine care. In addition to over 140 published articles and book chapters and over 1200 invited presentations, many as Visiting Professor, to universities in North America, Europe and Asia, he is author of the best-selling Back Doctor series of books for the lay public.

CO-DIRECTORS



Dr. Michael Fehlings is a Professor of Neurosurgery, Co-Director of the Spine Program and Vice Chairman (Research) in the Department of Surgery at the University of Toronto. He holds the Halbert Chair in Neural Repair and Regeneration and combines an active clinical practice in complex spinal surgery at the Toronto Western Hospital with a translationally oriented research program focused on discovering novel treatments for the injured brain and spinal cord. He has authored over 1000 peer-reviewed articles (h-index 100) chiefly in the area of central nervous system injury and complex spinal surgery. His work has been featured in Nature, Nature Neuroscience,

Science Translational Medicine, Nature Reviews Neurology, JAMA, Lancet Neurology, and the New England Journal of Medicine. Dr. Fehlings has held a number of prominent leadership roles, including current President of the International Neurotrauma Society, the Chair of the AO Foundation Clinical Investigation and Documentation Advisory Committee, past Chair of the AOSpine International Spinal Cord Injury Knowledge Forum, past President of the Cervical Spine Research Society, and leader of several international clinical research trials. Dr. Fehlings is a Fellow of the Royal Society (Canada) and a Fellow of the Canadian Academy of Health Sciences. He has received numerous international recognitions including the Royal College Gold Medal, Olivecrona Award, Ryman Prize, Magnus Medal in Neurosurgery and the Jonas Salk Award.



Dr. Albert Yee is the Holland Bone and Joint Program Chief and the Head of the Division of Orthopaedic Surgery at Sunnybrook Health Sciences Centre, where he holds the Marvin Tile Chair in Orthopaedic Surgery. Dr. Yee is an Orthopaedic Spine Surgeon at Sunnybrook Health Sciences Centre, an Associate Scientist (Physical Sciences Platform) at Sunnybrook Research Institute and a Consultant in Surgical Oncology at the Odette Cancer Centre. He is a Full Professor at the University of Toronto, Department of Surgery and Full Member of the Institute of Medical Sciences with a cross appointment in the Institute of Biomaterials and Biomedical Engineering. He is the Vice Chair of Research in the Division of Orthopaedic Surgery and Co-Director of the University of Toronto's Department of Surgery Spine Program. Dr. Yee is the Past President of the Canadian Orthopaedic Research Society as well as Canadian Spine Society, and is a Co-Chair of Bone & Joint Canada. He is the Canadian Lead for the Young Investigators Initiative (YII) of Bone & Joint Canada, and the US Bone & Joint Initiative, a grant mentorship and career development program. Dr. Yee has over 100 peer reviewed publications and has received academic honours including the American British Canadian (ABC) International Travelling Fellowship (American Orthopaedic Association / Canadian Orthopaedic Association, 2013), the Charles H. Tator Surgeon-Scientist Mentoring Award (2012), and the Canadian Orthopaedic Foundation J. Edouard Samson Award (2011). In 2019, he was awarded the distinction of Fellow of International Research (FIOR) by the International Combined Orthopaedic Research Society (ICORS). Dr. Yee's laboratory focuses on translational orthopaedic research utilizing pre-clinical surgical models to evaluate novel minimally invasive vertebral metastatic therapies (e.g. Photodynamic Therapy, Radiofrequency Ablation). His work has led to first in human clinical trials and FDA approval with commercialization of new minimally invasive spine technology. He has interest in understanding mechanisms of disease in cancer invasiveness to bone with an aim towards identifying potential new promising therapeutic targets.



VISITING PROFESSOR & KEYNOTE SPEAKER



Dr. Richard G. Fessler is Professor of Neurosurgery at the Rush University Medical Center and former Vice Chair of Neurosurgery at the Feinberg School of Medicine of Northwestern University, and the John Harper Seeley Professor and Chief of Neurosurgery at the University of Chicago Hospitals and Clinics. He was the founder and Director of the Institute for Spine Care at the Chicago Institute of Neurosurgery and Neuroresearch (CINN), Director of Clinical Services and Education at the University of Florida Brain Institute, and the Dunspaugh-Dalton Chair of Brain and Spinal Surgery. Dr. Fessler completed his Medical Doctorate with honors, and Surgical and Neurosurgical residencies at the University of Chicago, a Doctorate of

Philosophy in Pharmacology and Physiology, and a Master of Science in Psychology. His undergraduate degree was from Lawrence University, Appleton, WI, also in Psychology, where he also earned a certificate of education.

Dr. Fessler is internationally known for his contributions to endoscopic and microendoscopic surgical developments. He has been instrumental in developing many of the current minimally invasive surgical techniques. He received the Kambin Foundation Annual Research award for his research in MIS. Dr. Fessler is known for his pioneering research into human embryonic spinal cord transplantation for the treatment of spinal cord injury. He also led and co-led studies including first study on the human transplant to evaluate the safety and efficacy of human embryonic spinal cord transplantation for the treatment of syringomyelia, and other studies to evaluate the safety of transplantation of the stem cell GRNOPC-1/ASTOPC-1 into humans suffering acute spinal cord injury.

Dr. Fessler took leadership in several neurosurgical organizations and societies and served on several government federal health committees and missions including serving as Medical Specialist and Flight Surgeon for NASA/Space Shuttle. Dr Fessler is well published with over 240 peer-reviewed publications, and 37 books and over 200 book chapters in medical texts. He sat on several Editorial Boards including Neurosurgery, Spine Surgery, and Neuro-Orthopaedics, and is frequently invited for visiting professorships worldwide.

SPEAKER - NEW FACULTY



Dr. Christopher Witiw entered the neurosurgery residency program at the University of Toronto after completing his MD at the University of Manitoba in 2012. During his residency he completed a MS degree with a focus on Health Economics at The University of Chicago after receiving an award from the Canadian Institutes of Health Research. His thesis on the value of surgery for Degenerative Cervical Myelopathy was awarded the prestigious Outstanding Paper Award from the North American Spine Society in 2016. He has received numerous other awards including the Shafie S. Fazel Outstanding Resident Surgeon and Investigator Award from the University of Toronto Department of Surgery and the Alan R. Hudson Neurosurgery Resident Teaching Award from the University of Toronto Division of Neurosurgery. After obtaining his FRCSC in Neurosurgery in 2018, Chris undertook a subspecialty fellowship in Complex and Minimally Invasive Spine Surgery at Rush University Medical Center in Chicago. Chris returns to Toronto as a Surgeon Investigator at St. Michael's Hospital where his clinical work is directed toward treating the full spectrum of spinal disorders. He has a specific interest in minimally invasive approaches to spinal conditions. Chris' research work is centered on Health Economics and Health Services pertinent to spinal pathology and he is especially interested in 'big data' analytics as a means to optimize efficiency and quality of spine surgery.

SESSION II - SPEAKERS



INVITED RESEARCH TRANEES



Dr. Chris Ahuja is a PGY 5 neurosurgery resident. He was in the SSTP working towards his PhD with Dr. Michael Fehlings, studying bioengineered human neural stem cell therapies for traumatic spinal cord injury in Dr. Fehlings lab at UHN. He completed his medical training at Queen's University in Kingston before joining the Division of Neurosurgery at the University of Toronto. He served on the University of Toronto Department of Surgery's Research Committee and Translational Research Committee, as well as the University's Medical Innovation Toronto (MiTO) Executive Committee. His work focused on strategies to modify the extracellular matrix to generate an environment that is more conducive to cell-based regeneration.

INVITED RESEARCH TRANEES



Dr. Jay Toor is entering his final year of Orthopaedic Surgery residency and graduated the Surgeon Scientist Training Program with a MBA specializing in Supply Chain Management. His academic interest is optimizing hospital efficiency and translating business techniques to improve healthcare delivery. He founded a software and consulting company that has successfully overhauled surgical device inventory at several hospitals leading to significant financial savings. His research work is also focused on deploying Artificial Intelligence to optimize hospital resource allocation to address surgical backlogs, improve surgical patient throughput rates and

generate cost savings.

FOLLOW-UP ON 12TH ANNUAL SPINEFEST



Dr. Laura-Nanna Lohkamp completed her Neurosurgery residency at the Charite Berlin, followed by pediatric subspecialisation in Lyon, France and at the Hospital for Sick Children, including 6 months of pediatric orthopaedic spine training. She also completed her Master's degree from the International University Dresden/Harvard. Laura is currently completing her spine fellowship training at the Toronto Western Hospital/University of Toronto Spine Program. Her Clinical focus is adult and pediatric spine surgery.

BEST ABSTRACT WINNER (BASIC SCIENCE)



Dr. James Hong is a post-doctoral fellow at the Fehlings laboratory at the Krembil Research Institute, Toronto Western Hospital. His doctoral thesis focused on the temporal profiling of local and peripheral changes after traumatic cervical and thoracic injury. He is the author of 11 articles in the field, and currently works on the development of therapies and next-generation sequencing analysis of degenerative cervical myelopathy and traumatic cervical spinal cord injury. He will present the unpublished results of his most recent collaborative work with Dr. Hiroyuki Katoh investigating the efficacy of

a non-invasive strategy for enhancing functional recovery following surgical decompression of degenerative cervical myelopathy.

BEST ABSTRACT WINNER (CLINICAL)



Dr. Jérémie Nallet completed his medical studies at the University of Bourgogne Franche-comté, France. He started his residency in general surgery in Besançon in 2013. In 2015, he decided to specialize in pediatric orthopaedic surgery. In 2018, he got the French Board Certification in Orthopaedic and Traumatology Surgery. Currently, he is completing his fellowship training in Pediatric Spine Surgery at Hospital for Sick Children and set to complete his Master degree in Biomechanic engineering at Ecole Nationale des arts et métiers (ENSAM), Paris. Jérémie is involved in humanitarian activities for

Pediatric Orthopaedic surgery with « la chaîne de l'espoir », for which he completed an assignment in Jordan.

SCIENTIFIC ABSTRACTS



[VIEW E-POSTER ON VOICETHREAD HERE](#)

University of Toronto Spine Program

SPINEFEST

Monday, June 14, 2021. 5:00PM– 7:30PM

VIRTUAL

SCIENTIFIC ABSTRACTS

#	AUTHOR	TITLE
1	Jonathon Chon , Teng Chio, Jian Wang, Vithushan Surendran, Lijun Li, Mohammad-Masoud Zavvarian, Kataryzna Pieczonka, Michael G. Fehlings	Drug Repurposing: Delayed Administration of High Dose Human Immunoglobulin G for Treatment of Traumatic Cervical Spinal Cord Injury
2	E Crawford P Balasubramaniam, A Wasim, M Shrikumar, T Chen, T Anthony, A Philips, A Nathens, M Chapman, J Larouche, J Finkelstein	Prolonged Duration of Norepinephrine Infusions is Associated with Sacral Ulcers (SU) in Adults with Complete Spinal Cord Injuries (SCI)
3	Ali Moghaddamjou , Alex B. Bak, Francois Mathieu, Jerry Ku, Michael G. Fehlings	Familial Arachnoiditis with Syringomyelia: Analysis of a Family of 15 Affected Individuals and a Systematic Review
4	Ali Moghaddamjou , Jefferson R. Wilson, Michael G. Fehlings.	Natural History and Spontaneous Recovery of Neurological Function in Patients with an ASIA A Spinal Cord Injury: Analysis of Multicentre Data in 943 Cases
5	Geoff Klein , Isaac Carreno, Joel Finkelstein, Young Lee Arjun Sahgal, Cari Whyne, Anne Martel, Michael Hardisty	Using Convolutional Neural Networks to Predict Scoliosis from 3D Spine CT Scans

6	Katarzyna Pieczonka , Mohamad Khazaei and Michael G. Fehlings	Determining the Mechanisms of Transplanted Oligodendrogenically-Biased Neural Progenitor Cells
7	Christopher R. Pasarikovski, Jerry C. Ku, Joel Ramjist, Yuta Dobashi, Stefano M. Priol, Leodante da Costa, Ashish Kumar, Victor XD. Yang	Minimally Invasive Intrathecal Spinal Cord Imaging with Optical Coherence Tomography
8	Kelly Fullerton , Geoff Klein, Urban Emmenegger, Joel Finkelstein, Frank Lyons, Cari Whyne, Michael Hardisty	Automatic 3D Prostate Cancer Induced Sarcopenia Segmentation
9	William Brett McIntyre , Mohammad Khazaei, Michael G. Fehlings	Regional Identity of Neural Stem Cells is Maintained Throughout the Cell Transplantation Process
10	Lohkamp LN , Marathe N, Fehlings MG	Craniocervical Instability in Ehlers-Danlos Syndrome – A Systematic Review of Diagnostic and Therapeutic Approaches
11	Cari Whyne , Michael Hardisty, and Abdalrahman Alfakir	Measure Patient Adherence to Back Pain Physiotherapy with Artificial Intelligence
12	Mohammedayaz Rangrez , Margarete K. Akens, Michael Hardisty, and Cari Whyne	Temporal Effect of Docetaxel on Tumor Growth and Bone Quality in Rat Model of Vertebral Metastases
13	Brett Rocos , Masayoshi Machida, Karl Zabjek, Reinhard Zeller, David E. Lebel	A comparison of the Reliability and Vulnerability of 3D SterEOS and 2D EOS when Measuring the Sagittal Spinal Alignment of Patients with Adolescent Idiopathic Scoliosis
14	Brett Rocos , Jérémie Nallet, Reinhard Zeller, Stephen Lewis, David E. Lebel	A comparison of 3 Rod and 2 Rod Constructs in the Correction of Severe Paediatric Scoliosis
15	Brett Rocos , Luke Reda, David E. Lebel, Michael K. Dodds, Reinhard Zeller	The Use of Halo gravity Traction in Severe, Stiff Scoliosis
16	Brett Rocos , David E. Lebel, Reinhard Zeller.	Congenital Kyphosis: Progressive Correction with an Instrumented Posterior Epiphysiodesis. A preliminary Report.
17	Brett Rocos , Y. Raja Rampersaud, Stephen J. Lewis	The Role of Early Wound Contamination on Deep Wound Infections in Lumbosacral Fusions
18	Allison Tolgyesi , Normand Robert, Cari M. Whyne, Michael Hardisty	Enhanced μ CT Imaging Enables High Resolution 3D Visualization of Microdamage in Rat Vertebrae.
19	William Luong , Mohamed Khazaei, Christopher S. Ahuja, and Michael G. Fehlings	Investigating Human Neural Precursor Response to Chondroitin Sulfate Proteoglycan
20	Tiffany Lung , James Y. Lee Jessica Widdifield, Ruth Croxford, Jeremie S.	Rate of Revision and Acute Complications of Lumbar Disc Replacement vs Fusion: A population Based Study

	Larouche, Bheeshma Ravi, J. Michael Paterson, Joel A. Finkelstein	
21	Carlo Ammendolia , Corey Hofkirchner, Joshua Plener, André Bussi�eres, Michael Schneider, James J Young, Andrea D Furlan, Kent Stuber, Aksa Ahmed, Carol Cancelliere, Aleisha Adeboyejo, and Joseph Ornelas	Nonoperative Treatment for Lumbar Spinal Stenosis with Neurogenic Claudication. An Updated Systematic Review
22	Nayaab Punjani , Svetlana Altamentova, Jonathon Chio, Jian Wang, Sighild Lemarchant, Yann Godfrin, Michael G. Fehlings	Enhancing Neural Regeneration and Locomotor Recovery with NX Peptide Administration in a Cervical Spinal Cord Injury Rat Model
23	Sydney Brockie , James Hong, Michael Fehlings	Genetic Inhibition of CX3CR1 to Improve Surgical Outcomes in Degenerative Cervical Myelopathy
24	James Hong , Hiroyuki Katoh, Michael Fehlings, Toronto Western Hospital, Tokai University	Enhanced Outcomes and Reduced Perioperative Neurological Complications in the Surgical Management of Degenerative Cervical Myelopathy: Examining the Impact of Remote Ischemic Preconditioning
25	Mandana Movahed , James Hong, Hiroyuki Katoh, Michael Fehlings	Transcriptional Footprint of Ischemia Reperfusion Injury after DCM
26	Jeremie Nallet , Brett Rocos, David Eduard Lebel, Reinhard Zeller	Sequential Rod Rolling for Surgical Correction of Lenke Type 2 Adolescent Idiopathic Scoliosis: a 3D Analysis
27	Marathe N , Lohkamp LN, , Massicotte EM	Surgical repair for dural leaks causing Spontaneous Intracranial Hypotension – A Case Series and review of literature

ABSTRACT # 1

TITLE: Drug Repurposing: Delayed Administration of High Dose Human Immunoglobulin G for Treatment of Traumatic Cervical Spinal Cord Injury

AUTHORS & AFFILIATIONS: Jonathon Chon Teng Chio^{1,2,3}, Jian Wang¹, Vithushan Surendran¹, Lijun Li¹, Mohammad-Masoud Zavvarian¹, Kataryzna Pieczonka¹, Michael G. Fehlings^{1,2,3}

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PURPOSE: Neuroinflammation exacerbates damage caused by initial trauma from spinal cord injury (SCI). Severity of neuroinflammation depends on integrity of the blood-spinal cord-barrier (BSCB), as a compromised BSCB enhances neuroinflammation by facilitating immune cell infiltration. By targeting neuroinflammation, immunosuppressants are used to treat SCI patients. However, as patients experience immune suppression, immunomodulation is more effective than immunosuppression. Human Immunoglobulin G (hIgG) is used in clinic as an immunomodulatory treatment for inflammation. Although we have shown that administration of hIgG (2g/kg) is beneficial after SCI, the optimal time window of administration and mechanism of hIgG are unknown. We hypothesize that hIgG is beneficial when administered at extended time points post-SCI by stabilizing the BSCB.

METHOD: With a clinically relevant rat model of SCI, a single bolus of hIgG (2g/kg) or control buffer was administered intravenously at 15 minutes, 1 hours or 4 hours post-SCI. Spinal cord, serum and spleens were collected to evaluate hIgG's effects.

RESULTS: hIgG co-localized with BSCB. At 24 hours post-SCI, relative to control buffer, hIgG (2g/kg) significantly enhanced BSCB integrity when administered at delayed time points. This was associated with reduced spinal cord neuroinflammation. hIgG (2g/kg) increased serum levels of inflammatory cytokines, reduced neutrophil counts in blood and resulted in spleens with greater amounts of neutrophils. Short term benefits of delayed hIgG (2g/kg) administration correlate with enhanced tissue preservation and functional recovery at eight weeks post-injury.

CONCLUSIONS: As a clinically relevant immunomodulatory treatment, hIgG (2g/kg) can improve health of patients. hIgG alleviates neuroinflammation without increasing immune suppression.

ABSTRACT # 2

TITLE: Prolonged Duration of Norepinephrine Infusions is Associated with Sacral Ulcers (SU) in Adults with Complete Spinal Cord Injuries (SCI)

AUTHORS & AFFILIATIONS: E Crawford^{1,2}, P Balasubramanian¹, A Wasim¹, M Shrikumar¹, T Chen¹, T Anthony¹, A Philips¹, A Nathens^{1,2}, M Chapman^{1,2}, J Larouche^{1,2}, J Finkelstein^{1,2}

1) Sunnybrook Health Sciences Centre. 2) University of Toronto

PURPOSE: Complete SCI remains a devastating injury, made worse by preventable complications. Sacral ulcers (SU) are frequently reported within this population. Standard treatment in this population is to receive norepinephrine to maintain minimum mean arterial pressure (MAP) targets and ensure spinal cord perfusion. This is achieved, in part by peripheral vasoconstriction and reduced blood flow. This led us to our research question: Are norepinephrine infusions associated with SU in patients with complete SCI?

METHOD: Adults with an ASIA A SCI presenting to a level-one trauma centre from 2014-18 were reviewed retrospectively. Patient and injury variables (age, gender, location of SCI [cervical vs. thoracolumbar], Injury Severity Score [ISS]) and treatment factors (surgery, MAP targets, vasopressor treatment) were recorded along with the presence/absence of SU. A multivariable logistic regression analysis was used to determine potential associations with SU. Model fit and accuracy to correctly predict patients with SU, were assessed with Hosmer-Lemeshow test and C-statistic, respectively.

RESULTS: Of the 103 patients identified, 35 (34%) developed SU. Patient age (Mean: 48; SD:21.8), location of SCI (54 cervical, 52.4%) and ISS (Mean 34.6; SD:13.8) did not differ by the development of SU. Eighty-six patients (83.5%) were treated with norepinephrine. There was no difference in the proportion of SU between patients who received norepinephrine versus those who did not. For patients treated with norepinephrine, a multivariable logistic regression analysis found that norepinephrine infusion durations >100 hours (3.41 [1.35-16.37]; OR [95%CI]; p=0.046), and hospital LOS > 3 weeks (4.70 [1.5 to 16.36]; p=0.015) were significantly associated with SU. This model was found to fit the data well and had a c-statistic of 0.805.

CONCLUSIONS: This study reported a prevalence rate of 34% for SU in patients with complete SCI, with patients receiving >100hrs of norepinephrine infusions having 3.41 times the odds of developing a SU, compared to those with shorter durations. Additionally, SU are associated with prolonged hospital LOS. Future research in this area should include prospective, randomized controlled trails and economic analyses.

ABSTRACT # 3

TITLE: Familial Arachnoiditis with Syringomyelia: Analysis of a Family of 15 Affected Individuals and a Systematic Review

AUTHORS & AFFILIATIONS: Ali Moghaddamjou (1), MD; Alex B. Bak (1); Francois Mathieu, MD (1); Jerry Ku (1), MD; Michael G. Fehlings, PhD, MD (1)

1) University of Toronto, Toronto, Ontario, Canada.

PURPOSE: We report a case of a 61-year-old male with non-communicating thoracic syringomyelia living in Canada of Japanese descent with 15 known family members with the same condition (Figure 1). Most cases of idiopathic syringomyelia are sporadic, with no family history of the disease. Familial syringomyelia is an extremely rare form of presentation and is defined by the presence of syringomyelic cavities in 2 or more patients within the same family.

Our patient has been diagnosed in 2011 and after an initial progressive phase causing significant lower extremity spasticity, has remained clinically and radiologically stable. He has no history of trauma, Chiari malformation or associated scoliosis. He has been started on RILUZOLE 50 mg b.i.d. as an off-label use since 2017.

METHOD: On May 2nd, 2020, 10 keywords relating to familial trait and 23 keywords relating to syringomyelia were used as search terms on MEDLINE, EMBASE and Cochrane libraries. Abstracts were screened by two reviewers following the PRIMSA checklist. Papers reporting cases of familial syringomyelia in English were included for quantitative analysis.

RESULTS: The search revealed 476 results of which 25 were included in the qualitative analysis (Figure 2). Overall, there are 131 cases reported of which 16% had associated scoliosis and 65% associated Chiari Malformation (Table 1). Most of the patients had surgery as a treatment (71.74%).

CONCLUSIONS: After a systematic review of the current English literature we can conclude that our case is one of the largest known family clusters of syringomyelia not associated with a Chiari Malformation in North America. While its difficult to demonstrate efficacy, we propose the off-label use of RILUZOLE as a potential conservative therapy. Apart from these results, there is basic science support for the use RILUZOLE for arachnoiditis-associated secondary injury. Given the autosomal dominant pattern in our case, whole exome sequencing would be an interesting avenue of investigation into the pathophysiology of this condition. Currently, there are no known genetic causes.

ABSTRACT # 4

TITLE: Natural History and Spontaneous Recovery of Neurological Function in Patients with an ASIA A Spinal Cord Injury: Analysis of Multicentre Data in 943 Cases

AUTHORS & AFFILIATIONS: Ali Moghaddamjou¹, MD; Jefferson R. Wilson¹, MD PhD; Michael G. Fehlings¹, MD PhD.

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PURPOSE: Predicting spontaneous recovery after traumatic Spinal Cord Injury (tSCI) is important for expectation setting of patients and clinical trial design. Spontaneous recovery needs to be accounted for in trial design to prevent type 1 errors through erroneous randomization. It is recognized that the prediction of patients with an American Spinal Injury Association (ASIA) Impairment Scale (AIS) A that convert is challenging. Better understanding of the natural history of ASIA A patients is required to understand disease trajectory and to decipher treatment effect in trials from spontaneous recovery.

METHOD: Patients with ASIA A injury were identified from 3 prospective, multi-center datasets (NACTN, STASCIS, and SYGEN). All follow-up examinations for each patient were included and transitions with their respective time from injury in hours were tabulated. A-priori we identified age (<60yrs and =>60),

injury region (cervical, thoracic, and lumbar), and early surgery (surgery <24hrs vs >24hrs) as covariates in our analyses. We also tabulated the number of muscle groups below the neurological level of injury from baseline at each examination point. The mstate statistical package in R was utilized to develop flexible Markov models of disease progression. Covariate effects were estimated using Cox regression without any proportionality assumption.

RESULTS: We identified 943 patients with 384 total transitions. On average patients recovered 2.7 muscle groups below their level of injury at the 52 week mark. The cumulative hazard ratio plot overtime reveals an exponential relationship in all transition groups illustrating the time-dependent impact on transition intensities. Dynamic prediction probabilities revealed a total conversion of 34.36% from ASIA A. Cervical injuries showed statistically significant increase in spontaneous transition probabilities.

CONCLUSIONS: We demonstrate that multi-state models can successfully be applied to the progression of tSCI as measured by the transition of AIS grades of AIS A patients. The combined predictive factor of our on AIS conversion is time-dependent requiring comprehensive models incorporating all prediction timepoints. These results also support early aggressive treatment for ASIA A patients and consideration of patient trajectories in decision making.

ABSTRACT # 5

TITLE: Using Convolutional Neural Networks to Predict Scoliosis from 3D Spine CT Scans

AUTHORS & AFFILIATIONS: Geoff Klein^{1,2}, Isaac Carreno^{5,6}, Joel Finkelstein^{4,5,6}, Young Lee³, Arjun Sahgal^{1,3}, Cari Whyne^{1,4}, Anne Martel^{1,2}, Michael Hardisty^{1,4}

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PURPOSE: Vertebral metastases can lead to biomechanical instability, pain, and neurological compromise. Stereotactic body radiation therapy (SBRT) delivers high-dose focal treatment to tumours. A significant side effect of SBRT is vertebral compression fracture, occurring in 10% to 40% of patients following SBRT. Spinal malalignment (scoliotic deformity) has been shown to be related to vertebral fracture risk following SBRT. However, current evaluation of spinal malalignment can be time consuming

with significant inter-observer variation. As such, an automated algorithm to evaluate Cobb angle in 3D CT scans was developed and applied to patients with spinal metastasis treated with SBRT.

METHOD: A 3D U-Net model which determined a Gaussian heatmap for spine localization was used to extract a spline following the curvature of the spine projected in the coronal plane. The gradient of the spline was determined, and the Cobb angle was calculated from the spline. To account for varying voxel spacing and the number of vertebrae in the field-of-view, we used the median angle from an axially sliding window. Ground truth and predicted angles above 10° were classified as scoliotic.

RESULTS: The model was able to predict scoliosis with accuracy of 79.5% and 76.2% on the diagnostic imaging and SBRT planning datasets, respectively. The mean ground truth and predicted Cobb angles in the SBRT treatment planning were $8.8^\circ \pm 7.0^\circ$ (ranging from 0.8° to 28.0°) and $9.5^\circ \pm 7.5^\circ$ (ranging from 1.2° to 35.6°), respectively. The mean ground truth and predicted Cobb angles in the diagnostic imaging dataset were $8.5^\circ \pm 6.7^\circ$ (ranging from 0.2° to 28.6°) and $12.0^\circ \pm 12.6^\circ$ (ranging from 0.4° to 51.4°), respectively.

CONCLUSIONS: A fully automated model was constructed to predict scoliotic spinal curvature in 3D CT spine scans by evaluating the Cobb angle. Spinal curvature is contributing parameter for the SINS classification to determine instability. This algorithm can be used in clinical decision making to aid in spinal curvature classification and scoliosis severity assessment. Future work will focus on improving accuracy, expansion to kyphotic deformity, and combining with other image features related to fracture risk.

ABSTRACT # 6

TITLE: Determining the Mechanisms of Transplanted Oligodendrogenically-Biased Neural Progenitor Cells

AUTHORS & AFFILIATIONS: Katarzyna Pieczonka, Mohamad Khazaei and Michael G. Fehlings
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PURPOSE: Myelin structure is particularly susceptible to dysregulation after spinal cord injury (SCI), ultimately contributing to impaired signal conductivity in the central nervous system and devastating behavioural symptoms. Neural progenitor cell (NPC) transplantation represents a potential regenerative

approach for promoting remyelination following SCI, however the injury microenvironment predominantly directs NPCs to differentiate into astrocytes as opposed to myelinating oligodendrocytes. Our lab has successfully developed a protocol for priming human NPCs into oligodendrogenically-biased NPC (oNPCs), which effectively differentiate into a greater ratio of oligodendrocytes. Importantly, oNPCs have been found to promote remyelination and to ultimately contribute to functional recovery following transplantation into the injured rat spinal cord. However, a detailed analysis of the mechanisms of these cells post-transplantation has not been conducted to date. We aim to utilize RNA sequencing approaches in order to determine the mechanisms by which oNPCs promote recovery following SCI. We hypothesize that oNPC transplantation decreases the expression of negative myelin molecules following SCI.

METHOD: Female immunodeficient Rowett Nude (RNU) rats were subjected to a cervical SCI, and half of the rats were transplanted with oNPCs 1 week post-injury. The oNPCs were prepared from human NPCs by mimicking oligodendrogenic developmental cues *in vitro*. The animals were sacrificed 9 weeks following injury and RNA was isolated from the injury epicenter for subsequent bulk RNA sequencing and analysis.

RESULTS: It is expected that oNPC transplantation reduces the expression of negative myelin molecules such as myelin associated glycoprotein, polysialylated neural cell adhesion molecule, oligodendrocyte-myelin glycoprotein and neurite outgrowth inhibitor A when compared to the non-transplanted injury group.

CONCLUSIONS: This project will provide us with a greater understanding of oNPC mechanisms, which will help us optimize NPC interventions for SCI in the future.

ABSTRACT # 7

TITLE: Minimally Invasive Intrathecal Spinal Cord Imaging with Optical Coherence Tomography

AUTHORS & AFFILIATIONS: Christopher R. Pasarikovski, MD¹, Jerry C. Ku, MD¹, Joel Ramjist², Yuta Dobashi², Stefano M. Priola MD³, Leodante da Costa, MD, MSc², Ashish Kumar, MCh², Victor X.D. Yang, MD, PhD^{2, 4}

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PURPOSE: Imaging of the spinal cord is challenging due to the surrounding bony anatomy, physiologic motion, and the small diameter of the spinal cord. This precludes the use of non-invasive imaging techniques in assessing structural changes related to trauma and evaluating residual function. The purpose of this research was to apply endovascular technology and techniques and construct a minimally-invasive preclinical animal model of intrathecal spinal cord imaging using optical coherence tomography (OCT).

METHOD: Five animals (2 Yorkshire Swine and 3 New Zealand Rabbits) were utilized. A dedicated animal interventional radiology suite equipped with a single-plane C-Arm was used for all procedures. Intrathecal access was gained using a 16-gauge Tuohy, and an OCT catheter was advanced under roadmap guidance technique into the cervical thecal sac. The OCT device generates cross-sectional images with spatial resolution of 10µm. Imaging frequency is 100 frames per second, with a total of 540 cross sectional images generated per pullback. The OCT catheter has a motorized pullback, and a total length of 54mm of the spinal canal is imaged with one pullback.

RESULTS: Image acquisition was successful for all animals. There were no instances of difficult catheter navigation, enabling OCT imaging rostrally to C2. The thecal sac provided excellent thoroughfare for the OCT catheter. The clear cerebrospinal fluid also provided an excellent medium for image acquisition, with no detectable artifact from the contents of the cerebrospinal fluid. The anatomical space of the spinal canal could be readily appreciated including: dural lining of the thecal sac, epidural veins, pial lining of the spinal cord, arachnoid bands, dentate ligaments, and nerve rootlets/roots.

CONCLUSIONS: Minimally invasive intrathecal imaging using endovascular OCT was feasible in this preclinical animal study. Using OCT, excellent visualization of the dura, subarachnoid space, epidural vessels, dentate ligaments, and nerve roots and rootlets was achieved. This technology and imaging technique may allow for high resolution, minimally invasive imaging for pathologies such as structural changes related to spinal cord trauma, spinal neoplasms, vascular malformations, arachnoid webs, arachnoiditis, and cysts.

ABSTRACT # 8

TITLE: Automatic 3D Prostate Cancer Induced Sarcopenia Segmentation

AUTHORS & AFFILIATIONS: Kelly Fullerton^{1,2}, Geoff Klein¹, Urban Emmenegger^{3,4}, Joel Finkelstein^{2,5}, Frank Lyons^{6,7}, Cari Whyne^{1,2,5}, Michael Hardisty^{1,2,5}

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PURPOSE: Highly prevalent in cancer patients, sarcopenia is a generalized and progressive loss of skeletal muscle mass, which is strongly correlated with surgical complications and mortality. This study goal is to build an automated ML-based tool that can yield reliable, rapid, sensitive 3D quantification of sarcopenia using routine spinal prostate cancer CT imaging.

METHOD: This retrospective study analyzed psoas muscle volume (from L2-L5) in prostate cancer patients from routine CT scans. Ground truth segmentations were created using a semi-automated approach with manual correction. Training was done on 26 volumes (21 unique patients') psoas muscles, and an additional 6 volumes (5 unique patients) were used for validation. A U-Net Convolutional Neural Network (CNN) architecture with additional batch normalization was trained with binary cross-entropy loss for 300 epochs (batch sizes = 6) with intensity augmentation, to segment psoas muscle within an ROI (voxel size=1.15x1.15x2.50mm³, dimensions=128x128x64). Predicted masks were evaluated using a dice similarity coefficient (DSC).

RESULTS: The model yielded DSCs of 89% in the validation set. It took an average of 0.175s to segment the psoas muscle over the L2-L5 region (Nvidia Titan RTX GPU, Intel 9900X CPU). A linear relationship was found between the automated 3D and established manual 2D methods evaluating change in volume over time (n=22, R²=0.52, p<0.05). Strong correlations with respect to single timepoints was found for baseline and 1-year follow up (R²=0.61, p<2.0E-24) (R²=0.62, p<4.0E-23).

CONCLUSIONS: This automated ML-based 3D method yielded accuracy, speed and promise for greater sensitivity to initial development of sarcopenia will enable future study of large datasets. Accurate and precise measurement of sarcopenia will allow better disease and treatment monitoring and allow for better prediction of patient outcome.

ABSTRACT # 9

TITLE: Regional Identity of Neural Stem Cells is Maintained Throughout the Cell Transplantation Process

AUTHORS & AFFILIATIONS: William Brett McIntyre^{1,2}, Mohammad Khazaei², Michael G. Fehlings^{1,2}.

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PURPOSE: Traumatic spinal cord injury (SCI) elicits damage to the neural circuitry of the spinal cord (SC), which directly translates to impaired motor/sensory functions. Neural Stem Cell (NSC) transplantation is a promising regenerative strategy to treat SCI because they can replenish lost cells and restore motor/sensory deficits, thus improving these patients' quality of life. However, NSCs exhibit limited success to treat SCI when the identity of the NSC does not match the site of transplantation in the spinal cord. NSC identity is conferred through the expression of Homeobox (Hox) transcription factors, which regulate where the NSCs localize within the brain and spinal cord during development and throughout adulthood. This segmentation process can then promote the formation of appropriate neuronal circuits necessary to perform motor/sensory functions. If identity is maintained in NSCs post-transplantation, this may suggest their developmental role is recapitulated to promote regenerative success within the Central Nervous System (CNS). Thus, it is hypothesized that NSCs from the brain & SC will maintain regionally-specific Hox gene expression.

METHOD: Brain and SC NSCs were dissected, expanded, and differentiated in culture. Next, NSCs were transplanted into either the adult brain and SC (2 cell lines; 2 regions of interest; 4 groups). RT-qPCR and immunohistochemistry markers of regional Hox markers were used to confirm NSC identity.

RESULTS: After in vitro characterization & in vivo transplantation, B-NSCs and SC-NSCs maintained a greater proportion of region specific Hox expression (SC: Hox4-Hox10; Brain: Otx2, Emx2). Each cell

type also exhibited equal tripotency potential, meaning they differentiated into the three major cell types of the CNS: Neurons, Oligodendrocytes, and Astrocytes.

CONCLUSIONS: These results further support that NSCs derived from the brain and SC retain their identity following proliferation and maturation both in vivo and in vitro. B-NSCs and SC-NSCs are also equally suited to replenish the injured CNS as they exhibit similar differentiation potentials. This suggests the correlation between identity and optimal regenerative success may be due to the maintenance of Hox expression. This work presents correlation evidence, however future work will involve evaluating the efficacy of B-NSCs and SC-NSCs in the context of SCI.

ABSTRACT # 10

TITLE: Craniocervical Instability in Ehlers-Danlos Syndrome – A Systematic Review of Diagnostic and Therapeutic Approaches

AUTHORS & AFFILIATIONS: Lohkamp LN¹, Marathe N¹, Fehlings MG¹

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PURPOSE: Ehlers-Danlos Syndrome (EDS) comprises a spectrum of connective tissue disorders affecting 1/5000 patients. Due to associated ligamentous laxity some subtypes of EDS may be associated with craniocervical instability (CCI). Patients with EDS and suspected CCI present with a constellation of functional abnormalities and there is a lack of consensus on the best imaging parameters to achieve the diagnosis. Herein the clinical research goals are to summarize results of a systematic literature review in order to identify knowledge gaps and to provide a scientific overview of the current standard of care in these patients.

METHOD: A systematic literature review was performed using the databases Ovid Medline, Embase, Cochrane Library and PubMed based on the PRISMA guidelines. Articles were included if they described diagnostic or treatment criteria for CCI in EDS patients. These criteria and identified knowledge gaps are summarized.

RESULTS: Seven out of 93 articles reporting on a total of 42 EDS patients met the inclusion criteria. All of these patients were diagnosed with CCI and subsequently underwent surgical intervention. The main diagnostic measures were lateral flexion and extension x-rays of the cervical spine as well as dynamic CT imaging. Thirteen different radiographic parameters were reported pertaining to CCI of which four were the most frequently applied: the atlantodental interval (ADI), the basion-axis interval (BAI), the clivo-axial angle (CXA), and the angular displacement of C1 to C2.

CONCLUSIONS: There is a significant lack of evidence for the choice and application of diagnostic methods and criteria for CCI in EDS patients. A standardized, validated algorithm describing the sequential imaging measures for the correct diagnosis of CCI is lacking. Furthermore, the radiographic parameters to assess CCI warrant assessment in larger cohorts and prospective, controlled studies. Currently, based on the best available evidence we would recommend that patients with EDS and suspected CCI be evaluated for abnormalities in the ADI, BA, CXA and angular displacement of C1-C2. Surgical fixation for suspected CCI should only be used in cases with clear objective evidence on imaging of CCI and concordant symptoms and/or physical signs.

ABSTRACT # 11

TITLE: Measure Patient Adherence to Back Pain Physiotherapy with Artificial Intelligence

AUTHORS & AFFILIATIONS: Cari Whyne & Michael Hardisty & Abdalrahman Alfakir

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PURPOSE: The objective of this project is to develop an in home deployable objective quantitative assessment system for posture and lower back pain (LBP) exercises performed (quality and quantity) using wearable sensors and machine learning (ML) algorithms.

METHOD: Aim 1: Develop an Inertia Movement Unit (IMU) based wearable sensor arrangement for measuring LBP physiotherapy exercise performance and posture. Initial development will focus on the number and positioning of IMU sensors required for LBP physiotherapy adherence and posture assessment. Eight (8) sensors will be placed on test subjects directly with adhesive. The specific exercises and posture which will be considered were chosen based on consultations with an advanced

practiced physiotherapist focused on spinal disorders. For this purpose, we will extend a pre-existing software platform developed by our laboratory (SPARS) to enable multiple IMU data acquisition, pre-processing, and storage using a pre-existing cloud-based infrastructure. Aim 2: To train the SPARS-LBP system to classify LBP physiotherapy exercises and grade posture. Forty healthy volunteers will be instructed to place the sensors at specific locations on their body while they perform the prescribed exercises for LBP and posture poses. ML algorithms using the SPARS-LBP system will be trained to classify exercises and postures from the IMU time series sensor data. The system architecture will then be optimized by considering the trade offs between accuracy, efficiency, and deployability. This will allow for the possibility of sensor reduction and/or rearrangement in the final configuration.

RESULTS: To date, the first iteration of aim 1 has been completed where a full IMU recording system has been constructed. As for aim 2, utilizing the system designed, recording sessions are underway and eighteen sessions have been completed thus far. The analysis of the data is being worked on and thus far the results seem promising.

CONCLUSIONS: This project will yield an objective system for LBP physiotherapy monitoring using a multi-IMU wearable garment and the SPARS ML platform. SPARS-LBP has the potential to improve the effectiveness and efficiency of physiotherapy delivery, allowing problems with performance to be identified early, enable remote monitoring of patient progress, and may lead to improved participation and associated improvements in outcome.

ABSTRACT # 12

TITLE: Temporal Effect of Docetaxel on Tumor Growth and Bone Quality in Rat Model of Vertebral Metastases

AUTHORS & AFFILIATIONS: Mohammedayaz Rangrez^{1,2}, Margarete K. Akens^{2,3,4}, Michael Hardisty^{1,4} and Cari Whyne^{1,4,5}

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PURPOSE: Bone is one of the three common sites of metastasis due to its high remodeling rate and nutrient rich microenvironment. The treatment for bone metastases is often multimodal, requiring chemotherapy such as docetaxel in addition to focal therapy. Despite proven clinical efficacy in treating bone metastases, little is known about the impact of docetaxel on bone quality. This study evaluated the temporal effects of docetaxel on vertebral bone with osteolytic metastasis in a pre-clinical animal model.

METHOD: Osteolytic (OL) bone metastases were introduced in athymic nude rats. Tumour burden was evaluated with bioluminescent imaging (BLI) on day 14 (d14) and d21 post inoculation. Docetaxel (5mg/kg) was injected (i.v) in the early (d7, n=8) or late (d14, n=8) stages of metastases, and compared to untreated controls (n=5). After sacrifice on d21, bone architecture was assessed via stereologic evaluation of μ CT imaging of L2 vertebrae and immunohistochemistry was used to visualize tumour burden in T11 and L5 vertebrae.

RESULTS: Animals with OL metastases showed a significant decrease in body weight that was avoided by early docetaxel treatment (EDT) but not by late docetaxel treatment (LDT). The EDT group showed ($p<0.01$) less tumour burden (BLI and immunohistochemistry) and improved trabecular bone volume fraction compared to both untreated OL and LDT groups. Trabecular number was higher ($p<0.001$) and trabecular spacing was lower ($p<0.001$) in both EDT and LDT groups compared to the untreated OL group. Despite large tumor burden in the LDT group seen in histology, overall bone histoarchitecture was well preserved with less trabecular damage than the untreated OL group.

CONCLUSIONS: This study demonstrates the ability of early docetaxel treatment in preventing tumor metastases and subsequent bone loss; later treatment was not nearly as effective. These findings align with the clinical observation of poor docetaxel response in advanced stages of cancer. A better understanding of the impact of cancer treatment on bone quality can help to guide treatments for osteolytic bone metastases.

ABSTRACT # 13

TITLE: A comparison of the Reliability and Vulnerability of 3D SterEOS and 2D EOS when Measuring the Sagittal Spinal Alignment of Patients with Adolescent Idiopathic Scoliosis

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PURPOSE: An essential component of making the diagnosis of adolescent idiopathic scoliosis (AIS) is standing anteroposterior (AP) and lateral radiographs. Two dimensional (2D) radiographs inevitably fail to reflect every plane of the three dimensional (3D) deformity in scoliosis and as a result have the potential to misrepresent the exact nature of the deformity. In this retrospective cohort study, we have tested the hypothesis that there is no difference in the assessment of the sagittal plane deformity in patients being treated for AIS when measured with either 2D or 3D EOS radiography.

METHOD: A retrospective radiographic analysis was performed on patients with AIS. The cohort was then subdivided into three groups according to the coronal angular deformity (mild group: 45- 69°, moderate group 70- 89°, and severe group 90°+). The sagittal parameters were compared between manual measurement with 2D sterEOS and 3D reconstruction. Descriptive measures were used to summarize the distribution of numeric variables. Inter-study reliability was assessed using Bland-Altman plots and single measure two-way mixed intra-class correlation coefficient (ICC).

RESULTS: 52 patients were included in each group. The inter-study reliability when measuring the TK and LL between the two study modalities was excellent in mild group (ICC:0.90, 95%CI: 0.82~0.94 and ICC:0.84 95%CI: 0.74~0.91), excellent in TK and fair in LL in moderate group (ICC:0.76, 95%CI: 0.61~0.85 and ICC:0.70 95%CI: 0.53~0.81), and fair in TK and LL in severe group respectively (ICC:0.74, 95%CI: 0.57~0.84 and ICC:0.65 95%CI: 0.46~0.84). A Bland-Altman plot showed proportional bias in TK measurements in each group and LL in the moderate group. The difference between 95% upper and lower limits were increased as the coronal angular deformity increased.

CONCLUSIONS: 3D sterEOS is less vulnerable to the influence of coronal plane deformity than 2D EOS in evaluating the sagittal spinal parameters of patients with a coronal deformity exceeding 70°.

ABSTRACT # 14

TITLE: A comparison of 3 Rod and 2 Rod Constructs in the Correction of Severe Paediatric Scoliosis

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PURPOSE: Treating severe scoliosis is challenging and risky with a significant complication rate regardless of treatment strategy. In this retrospective comparative study, we report our results using a three rod (3R) compared to two rod (2R) construct in the treatments of severe, stiff pediatric spine deformities, and hypothesize that the former is safer, provides superior radiological outcomes and is associated with a lower rate of complication.

METHOD: There were 21 patients in the 3R group and 25 in the 2R group. Both groups were comparable in their baseline demographics and radiographic deformity. The mean preoperative major coronal deformity was $100^{\circ}\pm 9$ and $102^{\circ}\pm 10$ in the 3R and 2R respectively ($P=0.6$). The average major curve correction was 51% and 59% in 3R and 2R groups respectively ($p=0.03$). The postoperative thoracic kyphosis was $30^{\circ}\pm 11$ and $21^{\circ}\pm 12$ in the 3R and the 2R groups respectively ($p=0.01$). The surgical time was 476 ± 52 min and 387 ± 84 min in 3R and 2R respectively ($p<0.01$). One patient in the 2R cohort showed permanent postoperative sensory deficit. There were three unplanned returns to operating theatre in the 2R group.

RESULTS: There were 21 patients in the 3R group and 25 in the 2R group. Both groups were comparable in their baseline demographics and radiographic deformity. The mean preoperative major coronal deformity was $100^{\circ}\pm 9$ and $102^{\circ}\pm 10$ in the 3R and 2R respectively ($P=0.6$). The average major curve correction was 51% and 59% in 3R and 2R groups respectively ($p=0.03$). The postoperative thoracic kyphosis was $30^{\circ}\pm 11$ and $21^{\circ}\pm 12$ in the 3R and the 2R groups respectively ($p=0.01$). The surgical time was 476 ± 52 min and 387 ± 84 min in 3R and 2R respectively ($p<0.01$). One patient in the 2R cohort showed permanent postoperative sensory deficit. There were three unplanned returns to operating theatre in the 2R group.

CONCLUSIONS: Coronal correction was better with 2R whereas sagittal balance was superior with 3R. Both techniques achieved balanced spine and found to be safe treating severe scoliosis. The 2R technique was associated with a higher likelihood of requiring revision surgery.

ABSTRACT # 15

TITLE: The Use of Halo gravity Traction in Severe, Stiff Scoliosis

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PURPOSE: The correction of severe, stiff scoliosis in children is challenging. One method used to reduce the risk is pre-operative halo gravity traction (HGT). In this study, we sought to define the efficiency and safety of HGT and characterize the chronology of the correction seen.

METHOD: A consecutive group of paediatric patients with severe spinal deformities were treated with HGT prior to definitive correction. A standard protocol with the daily addition of weight to 50% of bodyweight at 3 weeks was used. Traction remained in place until signs of impending neurological complication or 6 weeks, whichever was sooner.

RESULTS: Twenty-four patients were included with a mean age of 11.8 years. The mean coronal deformity was 123°, with a T1-L5 height of 234 mm. The mean duration of traction was 42 days with a mean improvement in height of 72 mm with 82% occurring over the first 3 weeks. 100% of the angular and 98% of T1-L5 height correction was reached by 6 weeks. One patient showed early signs of a cranial nerve palsy prompting early surgery and 8 patients showed pin loosening, 1 of which required revision of their halo. One patient underwent a slower progression of traction due to transitory urinary disturbance. Following fusion, angular correction of the major curve was 49%.

CONCLUSIONS: HGT is a safe treatment for severe, stiff scoliosis because it can respond to early signs of impending neurological impairment. The first 3 weeks of treatment, reaching 50% of bodyweight as a traction force accounts for 80% of correction, with the remaining 20% in the following 2 weeks. At least 4 weeks of traction is recommended when following this protocol.

ABSTRACT # 16

TITLE: Congenital Kyphosis: Progressive Correction with an Instrumented Posterior Epiphysiodesis. A preliminary Report.

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PURPOSE: Congenital kyphosis is a rare condition. In this case series we sought to identify the outcomes and complications of posterior instrumented fusion and the resultant epiphysiodesis effect in uniplanar congenital kyphosis in paediatric patients.

METHOD: Paediatric patients were included if treated for a uniplanar congenital kyphotic deformity treated with posterior instrumented spinal fusion between October 2006 and August 2017, with a minimum of 2 years of follow up. Patients were excluded if a coronal deformity greater than 10° was present.

RESULTS: Six patients met the inclusion criteria. Mean age at surgery was 3.6 years. The mean kyphotic deformity prior to surgery was 49.7°. All patients underwent posterior instrumented fusion with autogenous iliac crest graft and a cast or brace postoperatively. One patient showed a loss of motor evoked potential on prone positioning which returned to normal on supine positioning. No patient showed any post-operative neurological deficits. One patient was diagnosed with a wound infection which was successfully treated with oral antibiotics. By a follow up of 5.4 years (range 2.2- 10.9 years) there was no failure of instrumentation. An epiphysiodesis effect (a difference of $\geq 5^\circ$ in the kyphotic deformity measured between the immediate post-operative and final follow up lateral whole spine XR) of 16.2° (range 7.2- 30.9°) was seen in 5 patients. The mean annual epiphysiodesis effect was 2.7° (95% CI, 1.4- 4.1°). No kyphosis proximal to the instrumentation was observed for the duration of follow up.

CONCLUSIONS: Posterior instrumented fusion and epiphysiodesis is safe and effective. The epiphysiodesis effect occurs in 5/6 of cases, and our data suggests that the procedure is associated with an acceptable blood loss and a low incidence of neurological complications.

ABSTRACT # 17

TITLE: The Role of Early Wound Contamination on Deep Wound Infections in Lumbosacral Fusions

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PURPOSE: Infection in patients treated with lumbosacral fusion has usually been considered to be caused by intraoperative contamination or hematogenous dissemination. It is not clear if this is the case, or if in these patients with low incisions external inoculation (out-to-in) are more often responsible for early deep post-operative infection requiring surgical debridement.

METHOD: We conducted a retrospective review of all adult patients treated with lumbosacral fusion between January 2014 and January 2021. Patients were included if they underwent at least 1 surgical debridement for infection or dehiscence requiring debridement. Cases of primary tumor were excluded.

RESULTS: 363 eligible cases were identified. 14 patients underwent at least 1 debridement (4.1%) for dehiscence or deep infection. The mean BMI was 32.5 (20.7-44.4) and median number of levels fused was 5. Mean surgical time was 369 mins (195-600) and blood loss 1800 mls (250- 4150). 3/14 patients showed no growth on culture, 1 of which sustained durotomy at the primary procedure. 2/14 showed *S. aureus* infection requiring debridement at a mean of 97 days. 9/14 showed infection with intestinal or urogenital pathogens requiring debridement at a mean of 15 days. Infection with intestinal or urogenital pathogens required significantly earlier debridement ($p= 0.03$) than *S. aureus* and dehiscence ($p= 0.037$).

CONCLUSIONS: Local contamination was the principal cause of deep wound infection in this series. These present significantly earlier than hematogenous infections. Proximity to the bowel and bladder puts this region at risk. We should focus on barrier dressing and urinary diversion with a foley catheter to keep these pathogens away from the wound at a critical healing time.

ABSTRACT # 18

TITLE: Enhanced μ CT Imaging Enables High Resolution 3D Visualization of Microdamage in Rat Vertebrae.

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PURPOSE: Microdamage accumulation in metastatic bone can increase fracture risk. Experimentally, barium sulfate (BaSO_4) can be used to stain bone to visualize cracks and microdamage. Backscattered electron imaging (BSE) provides very high resolution 2D images of bone with excellent contrast of BaSO_4 stained microdamage.¹ The objective of this study was to evaluate the ability of enhanced micro-computed tomography (μ CT) imaging of whole rat vertebrae stained with BaSO_4 to enable microdamage visualization that is spatially correlated to visualization using BSE imaging.

METHOD: First lumbar (L1) vertebrae from nine 8-9 week old athymic rats (Hsd:RH-Foxn1^{rnu}, Envigo, IN, USA) (3 healthy, 3 osteolytic, 3 mixed) were mechanically loaded (50N for 3hrs) and stained with BaSO_4 . Twelve slides from the L1 vertebrae (6 healthy, 3 osteolytic, 3 mixed) were prepared for BSE imaging (2 μm /pixel, Philips/FEI). The slides were imaged using μ CT (μ CT100, Scanco) under varied protocols for high contrast of the BaSO_4 . The μ CT and BSE images were aligned, resampled, registered (affine) and label fields of the BaSO_4 were generated. Spatial correlation, $g(r)$, was used to evaluate agreement between damage in the μ CT and BSE images.¹ Convolution of the μ CT label field (kernel $r=0.02\text{mm}$) created an inflated region. The distance between voxels in the two images were considered to be correlated if $g(r)>1$.

RESULTS: By controlling the μ CT parameters (focal spot size, tube voltage, filtration, and dose), the contrast to noise ratio was enhanced. Increasing data averaging reduced the grainy texture of the images and trabeculae were more clearly distinguished with low current. The enhanced scan parameters were 90kVp, 44 μ A, 200ms integration time, 8 data averaging and a 4.9 μ m voxel size. Spatial correlation ($g(r)=3.88-12.28$) was found between the μ CT and BSE images. Examination of the μ CT and BSE images shows microdamage that is obscured by noise in standard μ CT images.

CONCLUSIONS: Enhancement of μ CT scanning parameters allows for rapid high-resolution 3D imaging able to quantify bone microdamage. This is important for understanding post-yield bone tissue mechanics and quantifying 3D microdamage in healthy and metastatically involved vertebrae and effects of cancer treatments on bone quality.

ABSTRACT # 19

TITLE: Investigating Human Neural Precursor Response to Chondroitin Sulfate Proteoglycan

AUTHORS & AFFILIATIONS: William Luong^{1,2}, Mohamed Khazaei¹, Christopher S. Ahuja^{1,2}, and Michael G. Fehlings^{1,2,3}

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PURPOSE: Human neural precursor cell (hNPC) transplant for chronic spinal cord injury can be optimized for better recovery by understanding interactions with the glial scar. Our aim is to uncover the transcriptional profile of hNPCs in their response to a key glial scar molecule, chondroitin sulfate proteoglycans (CSPGs), and identify genes that can be utilized to degrade the glial scar.

METHOD: Human induced pluripotent stem cell-derived NPCs were developed and plated on different levels of CSPG. RNA was extracted from the cells and analyzed by RNA-sequencing to find differentially expressed genes. Gene ontology analysis was performed to investigate potential mechanisms and processes by which CSPGs affect hNPCs. Differentially expressed genes were validated by at the RNA level by qRT-PCR and protein level by Western blot. Differentiation profiles of

hNPCs in response to CSPG were then compared by staining for neuronal, oligodendroglial and astrocytic markers.

RESULTS: RNA-seq analysis reveal that hNPCs upregulate key genes associated with negatively regulating neurogenesis and neurodevelopment in response to CSPGs exposure. CSPGs inhibit neuronal differentiation of hNPC. The overall transcriptional activity of hNPCs is decreased and hNPCs downregulate genes associated with immune response after CSPGs.

CONCLUSIONS: These differentially expressed genes can be utilized to optimize the degradation of scar tissue in combination of hNPC transplant and differentiation of these cells remains a key barrier to overcome in treating chronic spinal cord injury after cell transplant. Ultimately, these results further our understanding of the chronic injury microenvironment and reveal strategies to improve regeneration of the spinal cord.

ABSTRACT # 20

TITLE: Rate of Revision and Acute Complications of Lumbar Disc Replacement vs Fusion: A population Based Study

AUTHORS & AFFILIATIONS: Tiffany Lung MD, BKin., James Y. Lee MD, BMSc., Jessica Widdifield, PhD., Ruth Croxford, MSc., Jeremie S. Larouche, MD, MSc, FRCS(C)., Bheeshma Ravi MD, PhD, FRCS(C)., J. Michael Paterson, MSc., Joel A. Finkelstein, MD, MSc, FRCS(C)

PURPOSE: The primary objective is to compare revision rates for lumbar disc replacement (LDR) and fusion at the same or adjacent levels in Ontario, Canada. The secondary objectives include acute complications during hospitalization and in 30 days, and length of hospital stay.

METHOD: A population-based cohort study was conducted using health administrative databases including patients undergoing LDR or single level fusion between October 2005 to March 2018. Patients receiving LDR or fusion were identified using physician claims recorded in the Ontario Health Insurance Program database. Additional details of surgical procedure were obtained from the Canadian Institute for Health Information hospital discharge abstract. Primary outcome measured was presence

of revision surgery in the lumbar spine defined as operation greater than 30 days from index procedure. Secondary outcomes were immediate/ acute complications within the first 30 days of index operation.

RESULTS: A total of 42, 024 patients were included. Mean follow up in the LDR and fusion groups were 2943 and 2301 days, respectively. The rates of revision surgery at the same or adjacent levels were 4.7% in the LDR group and 11.1% in the fusion group (P=.003). Multivariate analysis identified risk factors for revision surgery as being female, hypertension, and lower surgeon volume. More patients in the fusion group had dural tears (p<.001), while the LDR group had more “other” complications (p=.037). The LDR group had a longer mean hospital stay (p=.018).

CONCLUSIONS: In this study population, the LDR group had lower rates of revision compared to the fusion group. Caution is needed in concluding its significance due to lack of clinical variables and possible differences in indications between LDR and posterior decompression and fusion.

ABSTRACT # 21

TITLE: Nonoperative Treatment for Lumbar Spinal Stenosis with Neurogenic Claudication. An Updated Systematic Review

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PURPOSE: Lumbar spinal stenosis (LSS) causing neurogenic claudication is a rapidly growing public health problem that can significantly impact quality of life in older adults. Despite most people receiving a course of nonoperative care, our original 2013 review found low or very low-quality evidence that limited our ability to make conclusions on effective nonoperative treatments. The purpose of this study is to systematically review and update the evidence on the effectiveness of nonoperative treatment of LSS with neurogenic claudication.

METHOD: We updated our search in CENTRAL, MEDLINE, EMBASE, CINAHL, and ICL databases from February 2012 to September 2020 for randomized controlled trials in which at least one arm provided data on nonoperative treatments. Risk of bias in each study was independently assessed by two reviewers. Quality of the evidence was evaluated using GRADE.

RESULTS: From the 13,817 citations screened, 156 were assessed and 23 new trials were identified and added to the original 21 trials. Of the 44 total trials identified in both reviews, only 9 were considered low risk of bias. Our current review demonstrates moderate quality evidence from 3 trials that: Manual therapy and exercise provides superior and clinically important short-term improvement in symptoms and function compared to medical care or community-based group exercise; Manual therapy, education and exercise delivered using a cognitive-behavioural approach, demonstrates superior and clinically important improvements in walking distance in the immediate to long-term compared to self-directed home exercises; Glucocorticoid plus lidocaine injection is statistically more effective than lidocaine alone in improving pain and function in the short-term, but not with clinically important improvements. The remaining 20 new trials assessing oral medications, other physical therapy/multimodal treatment, epidural interventions, acupuncture, and spinal manipulation demonstrated low or very low-quality evidence for all comparisons and outcomes, similar to the findings of our original review.

CONCLUSIONS: There is moderate quality evidence that a multimodal approach including manual therapy and exercise, with or without education is an effective treatment, and that epidural steroids are not effective for the management of LSS with neurogenic claudication. The results of this review can inform clinical practice guidelines and aid in clinical decision-making.

ABSTRACT # 22

TITLE: Enhancing Neural Regeneration and Locomotor Recovery with NX Peptide Administration in a Cervical Spinal Cord Injury Rat Model

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PURPOSE: Initial physical trauma in spinal cord injury (SCI) is followed by secondary cascades which involve further cell death in the central nervous system, upregulation of inflammatory cytokines, and scar formation. NX is a peptide derived from a conserved region of sub-commissural organ (SCO)-spondin, a protein proposed to be involved in spinal cord regeneration in vertebrates. NX has demonstrated increased neural growth in vitro and exhibits anti-inflammatory properties. The purpose of this study is to examine the neuroprotective and regenerative properties of NX in a pre-clinical SCI model, through two main aims. Aim 1: assessing locomotor recovery and bladder function and aim 2: determining cellular anatomical changes at the lesion site. It is hypothesized that NX will reduce inflammation, allowing for enhanced neural repair and regeneration at and across the injury site, and improved neurobehavioural recovery.

METHOD: Female adult Wistar rats will receive a clip compression-contusion SCI at the C6/C7 level of the spinal cord, which is a clinically relevant model of traumatic SCI in humans. 72 injured rats will be randomized into 4 groups, in a blinded manner, to receive one daily dose of either NX (8mg/kg) or sterile water, starting 4 hours (h) or 8 h post-SCI. NX or water will be administered intraperitoneally over 8 weeks. 12 sham rats will only receive a laminectomy with no clip-induced SCI, and water treatment beginning at 4 h post-surgery. Neurobehavioral assessments will be performed at numerous intervals until 8 weeks post-SCI, where animals will be sacrificed for histological assessments.

EXPECTED RESULTS: As heightened inflammation is associated with chronic pain; it is predicted that the anti-inflammatory properties of NX will reduce neuropathic pain. Furthermore, NX reduces the expression of markers involved in astroglial scar formation. Hence, reduced scar formation near the lesion site is anticipated, allowing for enhanced neural survival and improved motor function.

CONCLUSIONS: Compared to other proposed treatments for SCI, NX provides a multi-faceted approach that mitigates various aspects of SCI. By reducing inflammation and improving regeneration, NX treatment will enhance functional recovery, reduce neuropathic pain, and improve SCI patients' quality of life.

ABSTRACT # 23

TITLE: Genetic Inhibition of CX3CR1 to Improve Surgical Outcomes in Degenerative Cervical Myelopathy

AUTHORS & AFFILIATIONS: Sydney Brockie – University of Toronto, James Hong – University Health Network, Michael Fehlings – University of Toronto

PURPOSE: Degenerative cervical myelopathy (DCM) is the most common form of spinal cord impairment worldwide and entails one or a combination of degenerative changes that compress the spinal cord. As the population ages, DCM is becoming increasingly prevalent and there is an urgent need for effective treatment approaches. Currently, DCM can be treated with surgical decompression (DEC) but functional recovery is limited by ischemia reperfusion injury (IRI), whereby restoration of blood flow perpetuates inflammation, causing activation of microglia and their subsequent release of nitric oxide, pro-inflammatory cytokines and interleukin factors that contribute to cytotoxic cell death. In the central nervous system, the fractalkine receptor CX3CR1 is expressed predominantly by microglia and plays a critical role in modulating neuroinflammation. We hypothesize that CX3CR1 is elevated following DEC and that its inhibition will attenuate inflammation and improve functional recovery.

METHOD: DCM is induced in C57BL/6 wildtype (WT) and CX3CR1-knockout (KO) mice at 8 weeks of age through the insertion of an ossification-inducing polymer under C5-6 that gradually compresses the cord. After 12 weeks of DCM progression, animals will be treated with DEC and then sacrificed at one of four time points, 24 hours, 1, 2, or 5 weeks post-DEC (n=20 per group per time). Neurobehavioral assessment of motor and sensory function in the fore- and hind-limbs will begin 4 weeks after DCM induction and continue weekly until the experimental endpoint.

RESULTS: Preliminary data from Western blotting and immunohistochemical analysis of wildtype samples after DEC indicate increased expression of CX3CR1 and CX3CR1-expressing cells relative to DCM controls ($p < 0.05$), suggesting a role for fractalkine signaling in IRI.

CONCLUSIONS: Determining the role of CX3CR1 in DEC will provide novel insight into the mechanism of DEC IRI and evaluate its inhibition as a therapeutic target. This study investigates a novel, clinically-relevant approach to improve functional recovery in DCM patients and paves the way for further research on IRI and inflammation-focused therapy.

ABSTRACT # 24

TITLE: Enhanced Outcomes and Reduced Perioperative Neurological Complications in the Surgical Management of Degenerative Cervical Myelopathy: Examining the Impact of Remote Ischemic Preconditioning

AUTHORS & AFFILIATIONS: James Hong*, Hiroyuki Kato[#], Michael Fehlings*, *Toronto Western Hospital, [#]Tokai University

PURPOSE: Degenerative cervical myelopathy (DCM) is caused by progressive compression of the cervical spinal cord. Surgical decompression (DEC), while effective in most cases, results in ischemia reperfusion injury (IRI) and hinders a return to baseline function. Remote ischemic preconditioning (RIPC) is a non-invasive intervention that uses transient ischemia distal to the site of injury to protect the host from ischemic insult. In this study, we posit that RIPC prior to DEC will enhance neurological recovery through the amelioration of DEC-induced IRI.

METHOD: DCM was induced in mice and at 12-weeks they either underwent: 1) RIPC prior to DEC; or 2) DEC alone ($n = 50$, respectively). Acute (24h post-DEC) and chronic (5wk post-DEC) cohorts were subjected to molecular and Catwalk gait analysis.

RESULTS: Acutely, RIPC resulted in a significant decrease of nearly all proinflammatory markers relative to DEC alone ($p < 0.05$) and markedly reduced astrogliosis. Chronically, RIPC animals significantly outperformed both DEC and DCM groups in nearly all gait metrics and returned to pre-DCM baselines ($p < 0.05$). RNA-seq revealed that RIPC negated the change of thousands of DEC-associated genes and

combined with Western blotting we show that RIPC upregulates PPAR γ , an inhibitor of STAT3, which is a critical activator of IRI-mediated astrogliosis.

CONCLUSIONS: In conclusion, RIPC when performed prior to DEC, reduces neuroinflammation and confers robust long-term neurological recovery relative to DEC alone. We are currently planning to move into a Phase I/II clinical trial.

ABSTRACT # 25

TITLE: Transcriptional Footprint of Ischemia Reperfusion Injury after DCM

AUTHORS & AFFILIATIONS: Mandana Movahed, James Hong, Hiroyuki Katoh, Michael Fehlings

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BACKGROUND: Degenerative Cervical Myelopathy (DCM) is a chronic compression on the spinal cord that causes both pathobiological and functional complications. Decompression surgery (DEC) currently is the recommended treatment for this disorder. Although it is effective in most of the cases, 44% of patients still show functional impairments within 6 months post-DEC. We hypothesized that the DEC-related complications are due to the secondary injury to the spinal cord known as Ischemia Reperfusion Injury (IRI), and deciphering IRI cellular mediators can minimize the adverse patient outcomes.

PURPOSE: This project has three different aims: the first is to determine whether there is a defined transcriptomic hallmark for IRI induced by DEC relative to other IRIs. The second is to decipher the role of neuroinflammation and specifically reactive astrocytes in mediating DEC-induced IRI. The third is to investigate the role of STAT3-mediated astrogliosis on functional recovery after DEC.

METHOD: DCM induction was performed on 8-weeks old C57BL/6J mice. 12-weeks post-DCM, These animals underwent either DEC or sham surgery. Then, they were sacrificed at acute (24-hours post-DEC) or chronic (5-weeks post-DEC) time-points for the examination of protein and immunohistochemical readouts. The same analyses will also be done for STAT3 knock-out mice to reduce DEC-related behavioral and pathobiological complications.

RESULTS: By cross-referencing the differentially-expressed genes from a previously performed RNA-Sequencing between DCM (sham DEC) and DEC animals, with those found in other bona fide IRIs (e.g. cerebral and myocardial IRI), we found several common astrocytic-expressed genes. This outcome suggests post-DEC complications may be classified as an IRI and proposes the critical involvement of astrocytes in this process. Western blotting and immunostaining for astrocytic markers also confirmed the significant increase of astrogliosis in the DEC group relative to DCM.

CONCLUSIONS: This study implicates astrogliosis as a critical mediator of IRI and may suggest STAT3 as a crucial acute therapeutic target for the attenuation of DEC-associated IRI. Understanding the cellular mediators of IRI will help more effective management of DEC-related complications and reduces the incidence of incomplete functional recovery in DCM patients after DEC.

ABSTRACT # 26

TITLE: Sequential Rod Rolling for Surgical Correction of Lenke Type 2 Adolescent Idiopathic Scoliosis: a 3D Analysis

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PURPOSE: Many options have been described to restore balance and create stable fusion in severe adolescent idiopathic scoliosis (AIS) including preoperative gravity halo traction, posterior vertebral column resection and three column osteotomies. Unfortunately, each of these come with risks of excess bleeding or neurological injury. The sequential rod rolling (SRR) technique uses a short stiff rod to distract and derotate the main thoracic curve (MT), followed by a second full length rod on the opposite side to distract and derotate the proximal thoracic (PT) curve and finally a short rod on the convexity of the PT to offer a controlled correction of rigid deformities. The aim of this investigation is to describe the technique, its indications, the rotational correction achieved and the complications observed when it is used in the treatment of severe pediatric AIS.

METHOD: A retrospective study was carried out to include including all patients treated with SRR to manage a Lenke 2 curve between 2006 and 2018 in whom a 3D EOS reconstruction was available. The primary objective of this study was to measure the derotation of the apical vertebra of the PT achieved by the sequential rod technique. The secondary objectives include defining the morbidity and complications observed.

RESULTS: Sixteen patients with a mean age of 15 years were included. The mean pre-operative coronal angular deformity was 53° for the PT and 76° for the MT. The mean post-operative coronal angular deformity was 19° for the PT, 22° for the MT. The mean rotation pre operatively was 10° for the apical vertebra of the PT and 23° for the MT. The mean rotation post operatively was 3° for the apical vertebra of the PT and 8° for the MT. Twelve patients had a 2 years post operative follow up. No proximal junctional kyphosis or complications were reported at the 2 year follow up.

CONCLUSIONS: This data shows that SRR achieves a mean coronal PT correction of 66%, and 72% for the MT curve. The average derotation is 7° for the PT and 15° for the MT. No complications were encountered. The SRR technique for Lenke 2 type AIS is a safe and effective technique.

ABSTRACT # 27

TITLE: Surgical repair for dural leaks causing Spontaneous Intracranial Hypotension – A Case Series and review of literature

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PURPOSE: Spontaneous intracranial hypotension (SIH) is an important cause of new daily persistent headache. The predominant clinical symptom is orthostatic headache (OH) caused by a spontaneous cerebrospinal fluid (CSF) leak at the spine. It was recently shown, through an extensive diagnostic protocol including microsurgical exploration, that a 5- to 8-mm long slit of the dura, caused mainly by discogenic micro-spurs, represents the anatomic etiological explanation of SIH in patients refractory to conservative treatment. Herein, we summarize the applied diagnostic algorithm and surgical techniques for CSF leak repair based on their anatomical classification in a case series. Patient outcomes including clinical and imaging parameters are reported.

METHOD: A single-center retrospective chart review of patients with SIH and an identified CSF leak or CSF-venous fistula, who underwent surgical treatment between 01/01/2018 and 30/03/2021, was performed. Records were accessed for clinical, surgical and follow up data as well as imaging results were reviewed.

RESULTS: Seventeen patients underwent surgical repair of a CSF leak, including 8 females and 9 males. The mean age at surgery was 49 years (range 35-62 years). All patients presented with long-standing orthostatic headaches and 4 with symptomatic subdural collections. Diagnostic workup included cranial and spinal MRI, CT-myelography, as well as dynamic digital subtraction myelogram. Six patients were diagnosed CSF-venous fistulas and 11 with anterior or lateral dural tears, all of them located in the thoracic spine. The most common underlying pathology was degenerative disc disease (8 patients), followed by CSF-venous fistulas (6 patients) and no detectable morphological cause (4 patients). Surgery was performed after unsuccessful EBP and included either primary closure of the leak or disconnection of the CSF-venous fistula. The mean follow-up was 8,2 months (range 0-24 months) and demonstrated resolution or improvement of symptoms in 14 patients (82%). Two patients experienced a symptom-free interval followed by recurrence of moderate symptoms, one being diagnosed with a second CSF venous fistula and requirement of a second intervention. Worsening of symptoms was documented in one patient and one patient suffered from a transient post-operative neurological deficit.

CONCLUSIONS: Spontaneous CSF leaks remain a challenging pathology, warranting a dedicated diagnostic and therapeutic approach. A tailored surgical repair is the most reliable treatment option when EBP was unsuccessful and may include open repair combined with or without instrumented fusion or disconnection of CSF-venous fistulas via a minimal invasive surgery.

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