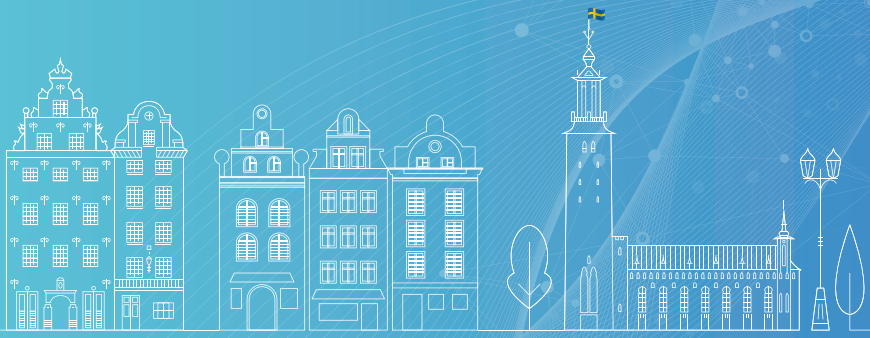
CERVICAL SPINE RESEARCH SOCIETY
EUROPE
www.csrs-europe.org

38th ANNUAL MEETING

CERVICAL SPINE RESEARCH SOCIETY – EUROPE

31 May To 2 June 2023, Stockholm, Sweden

SCIENTIFIC PROGRAM



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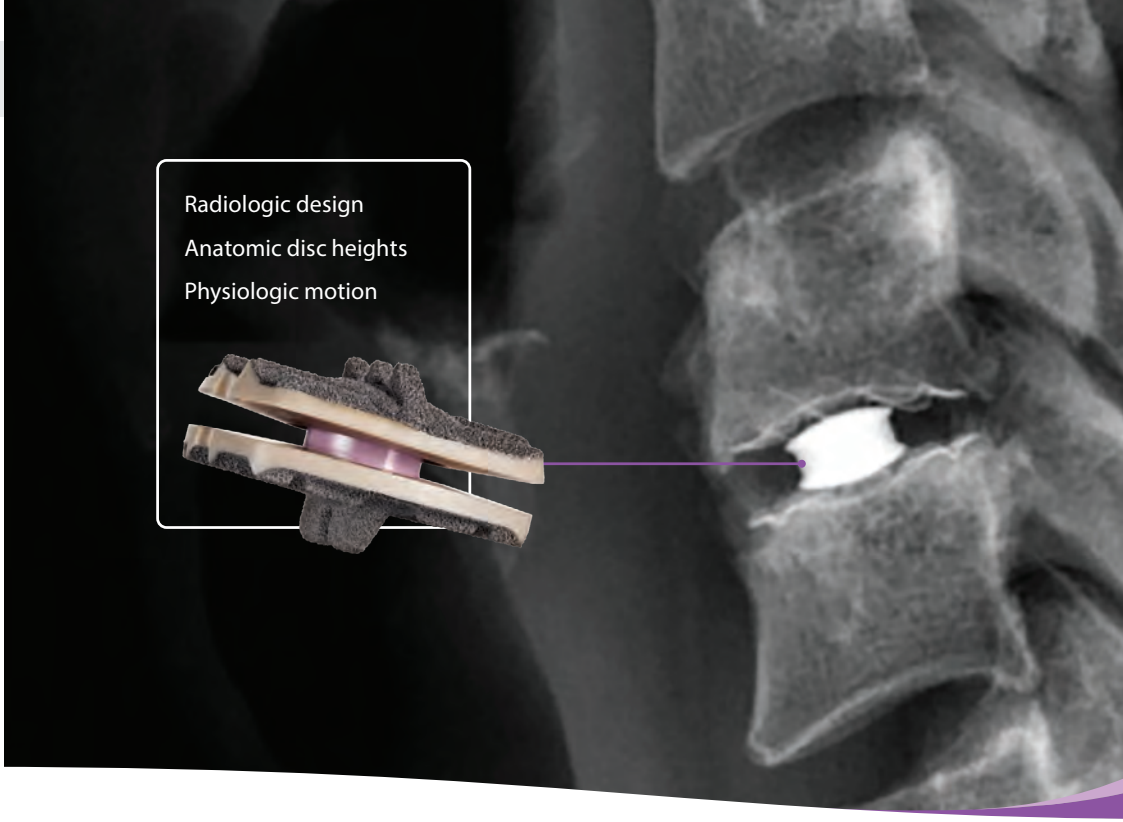

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Venue: Clarion Sign Hotel Stockholm

Östra Järnvägsgatan 33
Stockholm, Sweden
Phone: +46 (8) 462 10 00

Conference Website

www.csrs-europe2023.com
info@csrs-europe2023.com

Hosting Society

Cervical Spine Research Society – European Section (CSRS-E)
www. csrs-europe.org

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Design & print

Design: Selina Ghazarian
Print: Apec Tryck & Förlag AB

DAY 0 – Wednesday 31st MAY	DAY 1 – Thursday 1st June	DAY 2 – Friday 2nd June
	8:15 – 8:30	8:30 - 9:00
	WELCOME ADDRESS	DEBATE 4
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	9:30 – 10:30	10:00 - 10:15
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	10:30 – 11:00	10.15 - 10.45
	COFFEE BREAK	COFFEE BREAK
	11:00 – 11:30	10:45 – 11:15
	DEBATE 1	DEBATE 5
	11:30 – 12:00	11:15 – 11:30
	DEBATE 2	PREVIEW ANNUAL MEETING
	12:00 – 12:30	11:30 – 12:30
	PRESIDENTIAL LECTURE	LECTURE SESSION 6
13:00 – 16:00	12:30 – 13:45	12:30 – 13:15
BOARD MEETING	LUNCH SYMPOSIUM	LUNCH SYMPOSIUM
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	INVITED GUEST LECTURE	PRESIDENTIAL LECTURE
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	16:30 – 17:30	15:45 – 16:15
	LECTURE SESSION 4	ROUND TABLE DISCUSSION
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CONFERENCE RECEPTION		16:45 – 17:45
19:00 – 20:00		LECTURE SESSION 8
WELCOME MINGLE		17:45 – 18:00
		FINAL REMARKS
		19:00 –22:00
		GALA DINNER

My dear guests, colleagues, and friends!

It is a great pleasure for me to invite you to the 38th annual meeting of the Cervical Spine Research Society – Europe. This meeting will be an open platform for high academic and personal discussions, and I do not doubt that it will be the most memorable meeting for all.

Acknowledging the rapidly evolving field of new technologies like artificial intelligence, this meeting will highlight exciting insights into where and how innovations can impact our clinicians and our treatment of cervical spine disorders.

On behalf of the CSRS – Europe, I want to thank all our guests, colleagues and industry partners for their support and continued efforts to facilitate a high-quality academic meeting focusing on cervical spine-related research, education, and academic expert exchange. We are convinced that this year's programme will, once again, stimulate surgeons' thinking and discussions.

The opportunity to meet colleagues and the meeting's scientific content are key success factors of our annual meetings. The tremendous efforts of the CSRS-Europe board, together with our local host in Stockholm, to provide a high-level program will lead to a successful meeting. I sincerely hope that you will enjoy a fruitful discussion and have an enjoyable stay in Stockholm.

Use the time to meet and exchange with your peers, discuss controversies with your colleagues, and chat with your friends! Among the research-related enrichment, this is what makes this kind of meeting so precious and memorable to our Society.

Heiko Koller

President

Munich, Germany

Welcome Address Chairperson Stockholm Conference

Welcome to Stockholm and the 38th Annual meeting of the CSRS Europe from May 31st to June 2nd. Take the opportunity to network, keep up with high-quality research and discuss and debate with colleagues and new friends from all over the world, in the largest city of Scandinavia.

Anna MacDowall

Program committee

Uppsala, Sweden

Presidential lecture

Thursday 1st June ——— 12:00-12:30

James S. Harrop MD, MSHQS is a neurosurgeon and Professor, Departments of Neurological and Orthopedic Surgery at Thomas Jefferson University in Philadelphia, PA. Furthermore, he is the Chief of the Division of Spine and Peripheral Nerve Surgery and Neurosurgery Director of Delaware Valley Spinal Cord Injury (SCI) Center and Director for Adult Reconstructive Spine.

Dr. Harrop received his medical degree at Jefferson Medical College in 1995. He also completed his internship (in general surgery) and his residency (in Neurosurgery) at Thomas Jefferson University Hospital in Philadelphia, PA in 2001. To further his spinal surgery training, Dr. Harrop also completed a combined neurosurgical and orthopaedic spine fellowship at the Cleveland Clinic in Cleveland Ohio in 2002.

Dr Harrop has been in active practice since 2002 and is the Director of the Division of Spine and Peripheral Nerve Surgery at TJU hospital in the Department of Neurological Surgery. He has a busy clinical practice with approximately 350 cases annually consisting of a wide spectrum of neurosurgical disorders (degenerative, trauma, tumor, infection), including over 20 years covering a level I trauma center. In addition, he has an active research program with 600 peer-reviewed publications, numerous clinical trials and grants (NIH, DOD, and PICORI). He has been on the executive and governing boards of numerous spinal societies (CNS, PNS, AOSNA, AOI, CSRS and LSRS). Presently, He is the Past President of the Cervical Spine Research Society (CSRS). Further, he is committed to patient well-being and improving patient care and recently obtained a Master of Science in Healthcare Quality and Safety (MSQHS) and is a Professor in the Department of Public Health.

Dr. Harrop is an experienced lecturer, giving numerous national and international presentations on complex spinal disorders, spinal trauma, neuroscience and neuroanatomy. Present research interests include surgical approaches for spinal cord injury and neural regeneration.

The lecture will focus on the definition of value in spine care. A prospective study on evidence-based medicine (EBM) and guidelines will be discussed, followed by an exploration of how patient-centric spine care is approached based on the values of the patients.

Presidential lecture

Friday 2nd June ——— 14:45-15:15

Dr Gabriel Liu is the Head and Senior Consultant for University Spine Centre at National University Hospital Singapore.
He is an Associate Professor in National University Singapore, Yong Loo Lin School of Medicine Orthopaedic Department.

He practices all Orthopaedic Spine Surgery with a keen interest in Cervical Spine, Adult Spine Deformity, Growing Spine, Arthroplasty and Minimal Invasive Spine Surgery.

He was the past chairman for the East Asia AO Spine Society, the current President of Singapore Spine Society and Cervical Spine Research Society Asia Pacific.

Invited Guest Lecture

Thursday 1st June ——— 15:15-16:00

Michael Björn, Adj. Professor and Research, Fellow at Ericsson Research

Exploring digital senses (ai, vr, digital implants) in future healthcare; looking 30 years ahead

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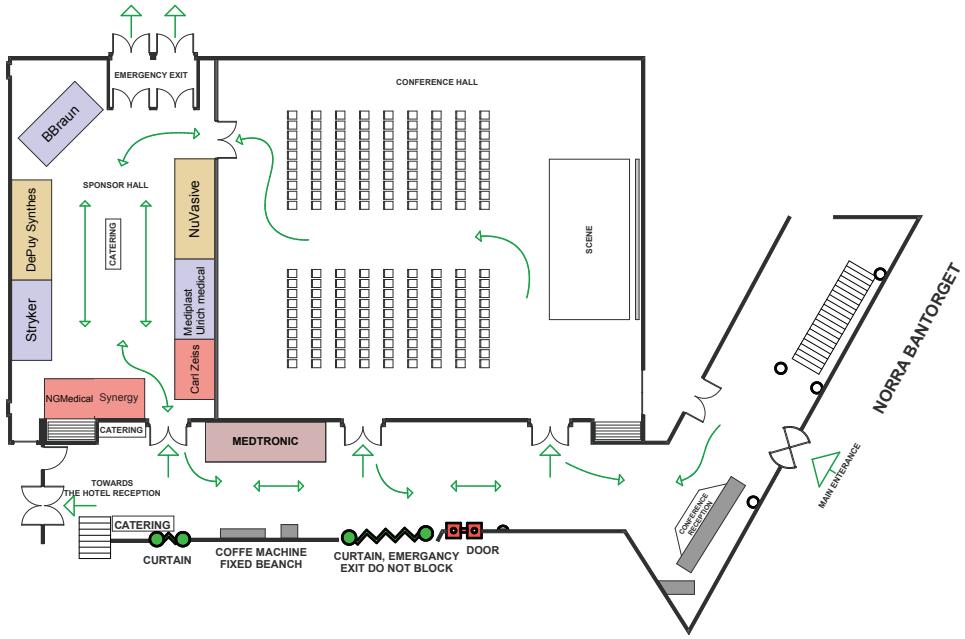

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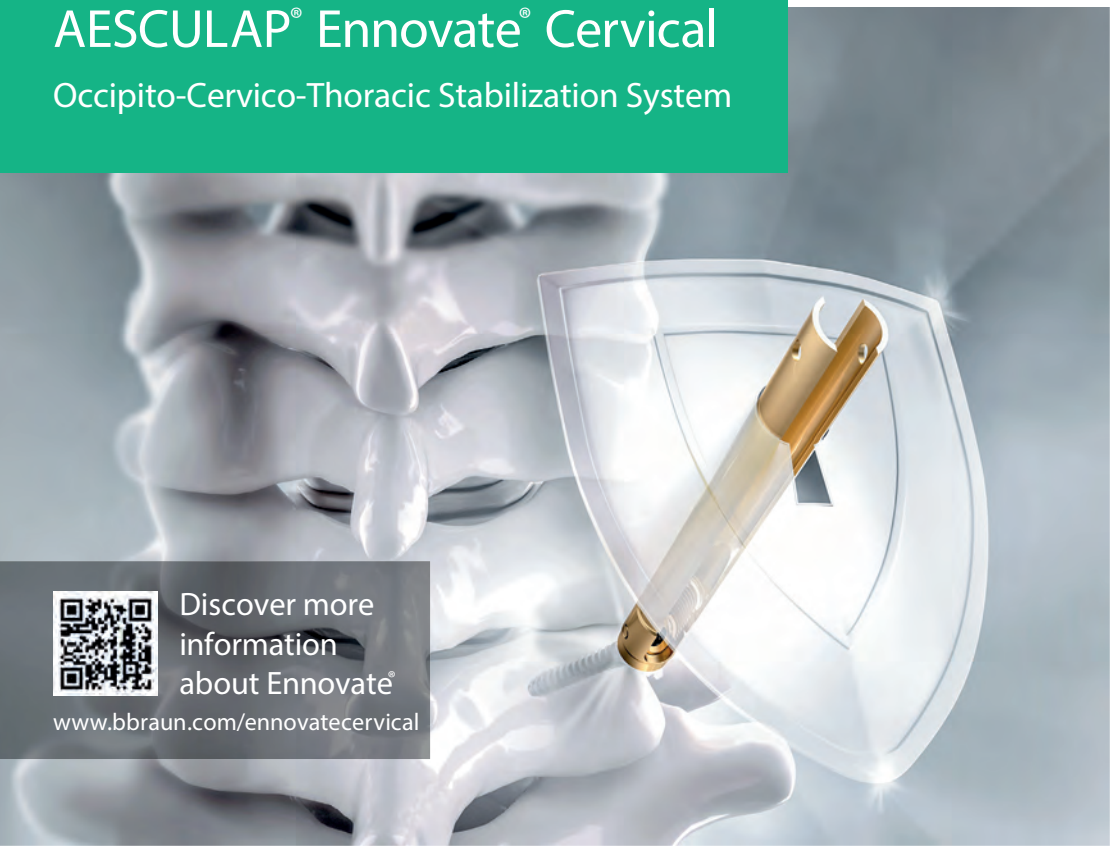

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Oscar Godino, MD | Bellvitge University Hospital
Neurosurgery Department | Barcelona | Spain

During the Coffee Breaks:
Thursday | 10.30 -11.00 &16.00 -16.30
Friday | 10.15-10.45

We are looking forward to meeting you!

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EXHIBITOR

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EXHIBITOR

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FUND

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Globus Medical, Inc. is a leading musculoskeletal solutions company based in Audubon, PA. The company was founded in 2003 by an experienced team of professionals with a shared vision to create products that enable surgeons to promote healing in patients with musculoskeletal disorders.

WELCOME MINGLE

PLACE — Clarion Hotel Stockholm
DATE — Wednesday 31st May 2023
TIME — 19:00-20:00

GALA DINNER

PLACE — FOTOGRAFISKA
DATE — Friday 2nd June 2023
TIME — 19:00-22:00

Reservation:
If you have not already registered, please contact the conference organizer.

Transport:
A bus will be provided to and from the Clarion Sign Hotel Stockholm and Fotografiska, free of charge.

About Fotografiska:
About Fotografiska: Museum in the brick-built, former customs house, presenting contemporary photography exhibition program.
www.fotografiska.com

Thursday 1st June 2023

8:15 – 8:30	Welcome address by **Carmen Vleggeert-Lankamp** and **Anna MacDowall**
8:30 – 9:30	**Lecture session 1** – Mario Boni Grant Nominated Oral presentations Moderators: **Claes Olerud** and **Cedric Barrey** 6 lectures 6 min + 24 min discussion
Johannes Schroeder 1	To fill or not to fill? Fusion Behavior of Cervical PEEK Cages implanted empty 112 compared to Fillings with autologous Bone Graft– a prospective Study.
Martin Pouw 2	Neurological recovery after early versus delayed surgical decompression foracute, traumatic spinal cord injury: a prospective, observational, European multicentre (SCI-POEM) study.
Jenny Kornberg 3	Outcomes and Complications after Two-Level Anterior Cervical Discectomy and Fusion with or without Anterior Plating - A Propensity Matched Cohort study.
Akira Sakaguchi 4	Clinical Comparison between anterior and posterior surgical procedures for cervical myelopathy in patients over 80 years old.
Esther van Santbrink 5	A randomized controlled trial (RCT) with extended long-term follow-up: quality of cervical spine motion after anterior cervical discectomy (ACD) vs. anterior cervical discectomy with arthroplasty (ACDA).
Jason Ye 6	20-year Clinical Outcomes of Cervical Disc Arthroplasty: A Prospective, Randomized, Controlled Trial.
9:30 – 10:30	**Lecture session 2** – The degenerative cervical spine Moderators: **Håkan Löfgren** and **Óscar L. Alves** 8 x 5 min and 2 x 10 min discussion
Carmen Vleggeert -Lankamp 7	Development Of An Automated Segmentation Algorithm In Patients With Rheumatoid Arthritis: An Explorative Study.
Akira Honda 8	Effect of Intraoperative Tranexamic Acid on Perioperative Massive Hemorrhage Requiring Transfusion in Patients Undergoing Elective Spine Surgery: A Propensity Score-Matched Analysis Using a National Inpatient Database.
Chen Ding 9	The Fatty Infiltration into Cervical Paraspinal Muscle as a Predictor of Postoperative Outcomes: a Controlled Study Based on Hybrid Surgery.
Barış Peker 10	Effectiveness of Prophylactic Bilateral C5 Foraminotomy on C5 Palsy Incidence Following Combined Anterior-Posterior Cervical Instrumentation and Decompression Surgery for Degenerative Cervical Spine Diseases.
Hao Liu 11	The effect of cervical spondylosis on heterotopic ossification after cervical disc replacement.

Thursday 1st June 2023

Hao Liu 12	Effects of endplate coverage and intervertebral height change on heterotopic ossification following cervical disc replacement
John Hutchins 13	MRI evaluation of foraminal changes in the cervical spine with assistance of a novel compression device
Ryo Fujita 14	High whole-body bone mineral density in ossification of the posterior longitudinal ligament
10:30 – 11:00	Coffee break
11:00 – 11:30	**Debate 1** – Treatment strategy for chronic or recurrent atlantoaxial rotatory fixation (AARF) after conservative treatment has failed Case presented and moderated by **Philippe Bancel** ● **Claes Olerud** Open reduction with C1-C2 fusion is the gold standard ● **Kazuya Kitamura** Closed reduction and Halo fixation is a motion preserving remodeling therapy
11:30 – 12:00	**Debate 2**– Muscle preserving selective laminectomy or the old traditional style laminectomy Moderator: Case presented and moderated by **Claes Olerud** ● **Tateru Shiraishi** Intermuscular plane approaches ● **Martine van Bilsen** Traditional posterior laminectomy
12:00 – 12:30	**Presidential lecture** by Professor **James Harrop,** former president of the CSRS, North America: Value is Spine surgery; quality vs. cost
12:30 – 13:45	Lunch Symposium, **Medtronic** sponsored symposium
12:45 – 13:05	A view on present and future innovations on Spine Surgery and impact in cervical pathologies: **Richard Assaker**
13:05 – 13:25	How to incorporate AI and patient-specific implants in your practice to optimize cervical spine surgery outcomes: **Lee Tan**
13:25 – 13:45	Advantages and new applications of navigation in complex cervical pathologies: **Lukas Bobinski**
13:45 – 14:45	**Lecture session 3** – Cervical myelopathy and its challenges, part 1 Moderators: **Pavlos Vlachogiannis** and **Ahmed Ibrahim** 8 x 5 min and 2 x 10 min discussion

Thursday 1st June 2023

Ryoma Aoyama 15	Atlantoaxial stenosis after muscle-preserving selective laminectomy
Yuan Xue 16	Brain connectivity markers in degenerative cervical myelopathy patients with depression for predicting the prognosis following decompression surgery
Shota Ikegami 17	Spinal cord MRI signal change at 1 year after cervical decompression surgery is useful for predicting mid-term clinical outcome: an observational study using propensity scores
Kazuya Kitamura 18	Novel and simple test to evaluate the finger dexterity in patients with cervical myelopathy – Finger extension test
Naoki Yamaguchi 19	Segmental modified K-line interval on T2-weighted MRI can predict JOA recovery rate after posterior decompression surgery in patients with cervical spondylotic myelopathy
Hiromichi Hirai 20	Clinical outcomes of surgical management for mild cervical compressive myelopathy based on minimum clinically important difference
Tonje Okkenhaug Johansen 21	Long-term results after surgery for degenerative cervical myelopathy
Maciej Szymanski 22	Comparison of posterior muscle-preserving selective laminectomy and laminectomy with fusion for treating cervical spondylotic myelopathy: study protocol for a randomized controlled trial
14:45 – 15:15	**Debate 3** – Ankylotic fracture management in the elderly, DISH and ankylosing spondylitis Case presented and moderated by **Anna MacDowall** ● **Nikos Schizas** I separate DISH from ankylotic spondylitis, DISH may be treated far more conservatively ● **Ciaran Bolger** I treat DISH and ankylotic spondylitis the same, instrumentations with long level arms
15:15 – 16:00	**Invited Guest Lecture** – Exploring digital senses (AI, VR, digital implants) in future healthcare; looking 30 years ahead by **Michael Björn**, Adj. Professor and Research Fellow at Ericsson Research
16:00 – 16:30	Coffee break

Thursday 1st June 2023

16:30 – 17:30	**Lecture session 4** – Fractures and trauma Moderators: **Emma Svensdotter** and **Federico De Iure** 8 x 5 min and 2 x 10 min discussion
Iris Leister 23	Looking Back to Move Forward: A Retrospective Study on Risk Factors for Dysphagia in Individuals with Traumatic Cervical Spinal Cord Injury
Marcus Björklund 24	Patient Reported Outcomes after treatment of Subaxial Spine Fractures
Iris Leister 25	An effective prehospital management after traumatic cervical spinal cord injury can positively influence the neurological as well as the functional outcome
Narayan Yogandan 26	Implications of statistically significant different regional C1 and C2 bone mineral densities for upper fracture fixation
Siegmund Lang 27	Risk Factors for In-Hospital Mortality in Geriatric Patients with C2 Vertebral Fractures: An Analysis of Concomitant Diagnoses and Treatment Strategies in 10,077 Cases
Christian Müller 28	Degenerative cervical myelopathy: Chronic trauma leads to chronic alterations of Angiopoetin II, an endogenic angiogenetic mediator in CSF. A notice for extended angiogenesis?
Esther van Santbrink 29	Cervical Motion in Elderly
Takeshi Aoyama 30	Anatomical study of transverse foramen and vertebral artery in subaxial cervical spine for safe pedicle screw insertion
17:30 – 18:00	CSRS Europe General Assembly

Friday 2nd June 2023

8:30 – 9:30	**Debate 4** – Biological processes deserve more attention in treating cervical myelopathy Moderator: **Valerie Ter Wengel** ⬢ **Mark Kotter** The sprouting of nervous tissue should be promoted in cervical myelopathy ⬢ **Samira Saadoun** The damaged cervical cord needs space and oxygen
9:00 – 10:00	**Lecture session 5** – Experimental studies and new inventions Moderators: **Mattias Sköld** and **Michael Mayer** 8 x 5 min and 2 x 10 min discussion
Kazuya Kitamura 31	Anatomical landmark to reduce surgical invasiveness to the facet joints in posterior exposure of the cervical spine – A cadaveric and clinical study–
Kangkang Huang 32	Impact of bone-implant gap size on the interfacial osseointegration: an in vivo study
Atsushi Yokota 33	A novel experimental animal model of delayed palsy after posterior decompression surgery of the cervical spine
Ulf Bertram 34	Spinal glymphatic clearance – a long term (7d) display of spinal perivascular spaces in a mouse model
Shingo Aoyama 35	Evaluation of Bone Mineral Density of Vertebral Body in the Cervical Spine
Javier Duart 36	Traslational dynamism allows higher transfer load even after graft shortening, with less plate stress avoiding failure: a combined biomechanical study with FEM and essays in an ACCF model
Sebastian Decker 37	Electromyographic analysis of mechanical load scenarios of the cervicothoracic junction: First in-vivo study to evaluate the potential decrease of myofascial dehiscences following posterior cervicothoracic fusion
Mark Arts 38	Interbody fusion device in the treatment of cervicobrachial syndrome; a prospective 5-year follow up extension study of porous titanium cervical cages

Friday 2nd June 2023

10:00 – 10:15	Presidential change: New president-elect: **Carmen Vleggeert-Lancamp**
10:15 – 10:45	Coffee break
10:45 – 11:15	**Debate 5** – How do you define instability in the degenerated spine Moderated by **Björn Zoëga** ⬢ **Aria Nori** II always use MRI, CT, and flexion-extension radiographs in all my patients, no matter the costs or extent of radiation ⬢ **Helena Brisby** MRI is in most standard cases enough: Helena Brisby
11:15 – 11:30	**Preview Annual meeting** - 2024 AP, 2023 NA and, 2024 Europe
11:30 – 12:30	**Lecture session 6** – dvances in cervical deformity, posterior fusion and sagittal balance Moderators: **Bruce Darden** and **Kristian Høy** 8 x 5 min and 2 x 10 min discussion
Ashley Duncan 39	When to Initiate Post-Operative Physical Therapy in Multilevel Posterior Cervical-Thoracic Fusions?
Ashley Duncan 40	What Effect Does T1 Slope Have on Sagittal Balance and the Relationship with Caudal End of Three or More Level Posterior Cervical Fusions?
Eiji Takasawa 41	Radiographic predictors of subaxial subluxation after atlantoaxial fusion
Kensuke Toriumi 42	The characteristics of cervical extensor muscles in dropped head syndrome
Peter Passias 43	Preoperative Optimization of Modifiable Patient-Related Factors Reduces the Risk of Distal Junctional Kyphosis (DJK): A Virtual Analysis of a Novel Multicenter Complex Adult Cervical Deformity Database
Terumasa Ikeda 44	Impact of intervertebral foramen area after cervical spinal correction surgery
Takachika Shimizu 45	High cervical fixed severe kyphosis in adult cases with Down syndrome
Kenta Takakura 46	Can Thoracic Inlet Angle Be Used as a Substitute for T1 Slope?

Friday 2nd June 2023

12:30 – 13:15	Lunch Symposium, **Stryker** sponsored symposium. Topic: Corpectomies made simple - learn more on our solutions to solve your complex cases: **Patricia Rodrigues**, Product Specialist Spine
13:15 – 13:45	**Debate 6** – Investigating and treating Ehlers-Danlos Syndrome neck pain patients moderator: **Carmen Vleggeert-Lankamp** ● **Jake Timothy** Fusion surgery in selected cases with thorough counselling can be rewarding therapy for Ehlers-Danlos syndrome neck pain patients ● **Ahmed Ibrahim** You should avoid fusion surgery in Ehlers-Danlos syndrome neck pain patients
13:45 – 14:45	**Lecture session 7** –Degenerative disc disease and anterior approach Moderators: **Martin Skeppholm** and **Philippe Bancel** 8 x 5 min and 2 x 10 min discussion
Dong-Ho Lee 47	Efficacy and safety of oblique posterior endplate resection for wider decompression (trumpet shaped decompression) during anterior cervical discectomy and fusion
Yuan Xue 48	Tissue discrimination by bioelectrical impedance during PLL resection in anterior decompression surgery for treatment of cervical spondylotic myelopathy
Xiaqing Sheng 49	Segmental slope is a predictor of fusion rate in single level anterior cervical discectomy and fusion
Tingkui Wu 50	Effect of preoperative segmental range of motion on patient outcomes in cervical disc arthroplasty
Beiyu Wang 51	Cervical disc arthroplasty versus anterior cervical discectomy and fusion for the treatment of single-level disc degenerative disease with preoperative reversible kyphosis
Simões de Souza 52	Noninferiority of posterior versus anterior cervical surgery: 2-year results (FACET)
Simões de Souza 53	Short-term neck pain after posterior foraminotomy compared with anterior discectomy with fusion for cervical foraminal radiculopathy – A secondary analysis of the FACET randomized controlled trial

Friday 2nd June 2023

Jakub Sipos 54	Patient selection for endoscopic posterior cervical foraminotomy vs anterior cervical discectomy and fusion
14:45 – 15:15	**Presidential Lecture** by Professor **Gabriel Liu**, President of CSRS Asia Pacific **Lecture title:** A journey of discovery in the understanding of laminoplasty in treatment of cervical myelopathy
15:15 – 15:45	Coffee break
15:45 – 16:15	**Round table discussion** AI/big data prediction models Introduction and moderator: **Carmen Vleggeert-Lankamp** ● In metastatic spine surgery: **Christian Carrwik** ● In degenerative cervical spine surgery: **Catharina Parai** ● The advantages of deep learning: **Caroline Goedmakers**
16:15 – 16:45	**Award session** Moderators: **Claes Olerud** and **Cédric Barrey** 2019 Award winner-Update: **Marek Holy**, Örebro Multicenter Study on Operative Treatment of Cervical Radiculopathy (OMSAP) 2022 NuVasive research grant winner: **Sebastian Decker** Stabilization characteristics of circumferential reconstruction using unilateral vs. bilateral posterior instrumentation. A biomechanical study on construct stability and clinical rationale for cervical MIS-based instrumentation strategies. 2023 Mario Boni Award winner
16:45 – 17:45	**Lecture session 8** –Degenerative disc disease and anterior approach Moderators: **Shimizu Takachika** and **Björn Zoëga** 8 x 5 min and 2 x 10 min discussion
Hong Wang 55	Anterior Cervical X-shaped-Corpectomy and Fusion vs. Anterior Cervical Corpectomy and Fusion for Two-level Cervical Spondylosis
Hugo Marty 56	Is spinal cord backshift after laminoplasty for spondylotic cervical myelopathy correlated to preoperative cervical spine sagittal alignment?
Eiji Takasawa 57	Trends in Cervical Laminoplasty and 30-Day Postoperative Complications, 2008-2017
Kangkang Huang 58	The application of three-dimensional printed patient-specific drilling templates for expansive open-door laminoplasty: a single-center, prospective randomized controlled study

Friday 2nd June 2023

Takuya Obo 59	Does segmental cervical instability drive the lordosis loss after lamino-plasty in patients with cervical spondylotic myelopathy?
Yoshitada Usami 60	Impact of the preoperative cervical range of motion on C5 palsy after cervical laminoplasty
Kazuhiro Inomata 61	Clinical Association between Preoperative Nutritional Status and Postoperative Cervical Kyphosis after Laminoplasty in Geriatric Patients with Cervical Spondylotic Myelopathy
Keiichi Iseda 62	Importance of predicting alignment aggravation for indication of cervical laminoplasty in patients with kyphosis
17:45 – 18:00	Final Remarks Moderator: **Carmen Vleggeert-Lankamp**

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ABSTRACTS

1

To fill or not to fill? Fusion Behavior of Cervical PEEK Cages implanted empty compared to Fillings with autologous Bone Graft – a prospective Study

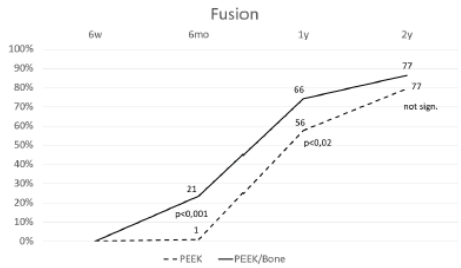
***Johannes Schroeder**
INSTITUTION: ZW-O Spine Center Osnabrueck

Objective: The implantation of a Polyether-Ether-Ether-Ketone (PEEK) cage is a common practice after anterior discectomy in cervical spine. The aim of the study was to evaluate whether filling with autologous bone graft can enhance the fusion rate of PEEK cages.

Methods: We evaluated prospectively 99 consecutive patients with single level cervical radiculopathy or mild myelopathy treated with anterior discectomy and fusion by a PEEK cage filled with autologous bone graft obtained locally. They were compared with the 100 patients treated earlier for the by the same type of PEEK Cage implanted empty. The study was completed by 89 patients and 97 in the comparison group.

Results: Six month after surgery 21 patients of the PEEK/Bone group (24%) compared to only one in the PEKK group were fused already (p<0.001). After one year the fusion rate was 66 (74%) compared to 56 (58%) still significantly better (p<0.02). At the final follow up after two years the fusion rate was equal with 77 cases fused in both groups (86% PEEK/Bone versus 80% plain PEEK, p=0.2).

Conclusions: Autologous bone filling of PEEK Cages can speed up fusion at the 6 month follow up, after one year the effect is minimal and after two year the fusion rate is equal. Filling of cervical cages seems not to have an effect in the long run and can be considered superfluous.



2

Neurological recovery after early versus delayed surgical decompression for acute, traumatic spinal cord injury: a prospective, observational, European multicentre (SCI-PO-EM) study

***Martin H. Pouw (Presenting the results for the SCI-POEM group), Allard J. F. Hosman, Giuseppe Barbagallo, Eugen Cezar Popescu, Henk van de Meent, F. Cumhur Öner, Federico De Iure, Jacopo Bonavita, Michael Kreinest, Richard A. Lindtner, Nasir A Quraishi, Pradeep Thumbikat, Vide Bilić, Jeremy J Reynolds, Maurizio Belci, Alp Özgün Börcek, Seamus Morris, Christoph Hoffmann, Francesco Signorelli, Konstantin Uzunov, Joost J. van Middendorp**
INSTITUTION: Radboud university hospital

Background: The role of the timing of surgical spinal decompression following traumatic spinal cord injury (tSCI) has caused controversy for more than a century. We aimed to determine whether early surgical treatment results in better neurological recovery 12 months after injury than late surgical treatment in patients with acute tSCI.

Methods: In this Prospective, Observational European Multicenter study on the efficacy of acute surgical decompression after traumatic Spinal Cord Injury (SCI-POEM), patients with tSCI requiring surgical spinal decompression presenting to 17 centres in Europe were recruited. Depending on the timing of decompression, patients were divided into early (≤12 hours after injury) and late (>12 hours and (>12 hours and <14 days after injury) groups. The American Spinal Injury Association neurological (ASIA) examination was performed at baseline (after injury but before decompression) and 12 months. The primary endpoint was the change in lower extremity motor score (LEMS) from baseline to 12 months.

Results: The final analyses included 159 patients in the early group and 135 in the late group. Patients in the early group had significantly more severe neurological impairment before surgical treatment. For unadjusted complete-case analysis, mean (95% confidence interval [CI]) change in LEMS was 15·6 (12·1; 19·0) in the early and 11·3 (8·3; 14·3) in the late group, with a mean (95% CI) between-group difference of 4·3 (-0·3; 8·8). Using multiply imputed data adjusting for baseline LEMS, baseline ASIA Impairment Scale (AIS), and propensity score, the mean (95% CI) between-group difference in the change in LEMS decreased to 2·2 (-1·5; 5·9). Subgroup analyses showed that between-group differences in the change in LEMS did not differ significantly between baseline AIS grades or between types of paralysis.

Conclusions: Compared to late surgical decompression, early surgical decompression following acute tSCI did not result in statistically significant nor clinically meaningful neurological improvements 12 months after injury.

3

Outcomes and Complications after TTwo-Level Anterior Cervical Discectomy and Fusion with or without Anterior Plating - A Propensity Matched Cohort study

***Jenny Kornberg, Msc, Kristian Høy MD, PhD , Mikkel Østerheden Andersen, MD , Leah Y Carreon, MD, PhD**
INSTITUTION: Aarhus University Hospital

Objective: Anterior cervical discectomy and fusion (ACDF) is the current standard of treatment for disc herniation and radiculopathy resistant to non-operative care. ACDF can be performed with or without plating. Plating versus stand-alone cage is still a matter of debate.

Methods: Prospectively collected data from the national Danish Spine registry (Danespine), in patients who underwent two-level ACDF at a single center. The patients were divided into two groups, plated or not. In order to minimize baseline differences between the two groups, propensity-score matching was applied, based on age, gender, body mass index, smoking status, pre-op neck and arm pain, EQ-5D and NDI. One-year postoperative x-rays were examined to determine the amount of subsidence.

Results: A total of 96 patients undergoing two-level ACDF surgery had complete pre-op, surgical and one-year follow-up data. Thus, two matched cohorts consisting of 37 patients could be created. Interestingly plated patients reported significantly lower neck-pain (24.1 vs. 40.1 p=0.018) and higher EQ-5D (0.76 vs 0.62 p=0.038) scores one year after surgery compared to those without. At follow-up, there were no difference in subsidence (8 vs 9, p=1.000) or revision rates (1 vs 2, p=0.389) between the two groups.

Conclusions: In a prospectively and propensity matched single Center cohort. Anterior plating for two-level ACDF surgery lead to improved patient-reported outcomes (PROs). No significant difference in postoperative complications regarding subsidence or re-operations between the two groups was seen

Table 1:
Demographic and radiographic data for 74 propensity matched patients who underwent ACDF-surgery with complete follow-up

	No Plate	Plate	P-value
Total, n	37	37	
Subsidence, n	8	9	1.000
Male, n	13	21	0.102
Smoker, n	14	6	0.065
Mean age, yrs (SD)	49.19 (7.61)	50.68 (9.47)	0.459
Mean BMI, kg/m^2 (SD)	26.54 (4.31)	26.54 (4.10)	0.997

BMI, Body Mass index.

Summary of PROs at baseline, follow-up and change.

	No plate, Mean (SD)	Plate, Mean (SD)	P-value
Baseline:			
VAS neck	59.57 (21.84)	54.78 (29.40)	0.430
VAS arm	60.05 (23.85)	65.70 (23.40)	0.307
EQ-5D	0.43 (0.29)	0.53 (0.29)	0.146
NDI	43.14 (15.12)	38.19 (15.44)	0.168
SF-36 PCS	34.49 (7.32)	35.17 (7.71)	0.705
SF-36 MCS	44.16 (11.14)	44.65 (11.80)	0.858
Follow up:			
VAS neck	40.11 (30.38)	24.06 (24.12)	0.018
VAS arm	35.58 (28.12)	27.97 (27.51)	0.282
EQ-5D	0.62 (0.30)	0.76 (0.26)	0.037
NDI	29.97 (16.44)	22.64 (17.97)	0.082
SF-36 PCS	39.74 (9.57)	43.07 (10.50)	0.172
SF-36 MCS	48.01 (12.00)	54.21 (8.34)	0.017
Change:			
VAS neck	20.11 (27.72)	34.73 (36.54)	0.069
VAS arm	24.42 (33.38)	38.63 (31.91)	0.089
EQ-5D	0.19 (0.39)	0.24 (0.35)	0.600
NDI	12.53 (16.74)	18.27 (18.05)	0.176
SF-36 PCS	6.11 (9.70)	7.63 (11.71)	0.564
SF-36 MCS	3.47 (13.07)	9.89 (9.65)	0.028

BMI, Body Mass Index; EQ-5D, Euroqol 5 Dimension; MCS, Mental Component Score; NDI, Neck Disability Index; PCS, Physical Component Score; SF-36, Short Form 36 Health Survey Questionnaire; VAS, Visual Analogue Score.

4

Clinical Comparison between anterior and posterior surgical procedures for cervical myelopathy in patients over 80 years old

***Akira Sakaguchi, Hisanori Mihara, Yasunari Tatara, Takanori Niimura, Naoya Kondo, Kiyotaka Nagashima**
INSTITUTION:Yokohama Minami Kyosai Hospital

Objective: Elderly patients with cervical myelopathy are at risk of becoming bedridden, however, we often hesitate to undergo surgical treatments. In this study, we compared the short-term results of the anterior and posterior surgical procedures to evaluate the risks and benefits.

Methods: Consecutive 56 patients of cervical myelopathy aged 80 years or older who underwent surgery at our department between 2014 and 2021 (24 cases of anterior fixation: anterior group, 32 cases of posterior decompression with or without fusion: posterior group) were included in this study. The evaluated items included age, sex, preoperative status, extension of hospital stay, peri- and post-operative complications, outcome (home discharge /hospital transfer), neurological status (JOA Score and performance scores) before and at one year after surgery. These items were statistically compared between anterior and posterior groups.

Results: The mean age at surgery was 82.9 years for the anterior group and 84.3 years for the posterior group. The mean extended hospital stay was 12.3 days for the anterior group and 8.5 days for the posterior group as compared with clinical path plan. Although there was no difference in comorbidities, postoperative complication rate was significantly higher in the anterior group ($P<0.05$), and delirium was major complications in the anterior group (12/14 patients). There were no significant differences in outcome (discharge or transfer), neurological improvement between the two groups.

Conclusions: There were no significant differences in neurological recovery between the two groups, however, we should pay attention on postoperative complications especially the risk of delirium after anterior procedures.

ABSTRACTS

5

A randomized controlled trial (RCT) with extended long-term follow-up: quality of cervical spine motion after anterior cervical discectomy (ACD) vs. anterior cervical discectomy with arthroplasty (ACDA)

***Valérie N.E. Schuermans, ändras till Esther van Santbrink, Anouk Y.J.M. Smeets, Esther van Santbrink, Inez Curfs, Henk van Santbrink, Toon F.M. Boselie**
INSTITUTION: Maastricht University Medical Centre

Background: The underlying mechanism of adjacent segment pathology (ASP) remains a matter of debate. In addition to natural progression of degeneration, compensation for the loss of motion in the fused segment is thought to cause overstraining of the adjacent segments. ACDA was developed in an effort to reduce the incidence of ASP by preserving motion in the operated segment. The sequence of segmental contributions during flexion and/or extension dynamic X-rays of the cervical spine is a more consistent parameter to analyze motion.

Research question: The aim is to analyze the sequence of segmental contributions of the lower cervical spine during the second half of extension in patients with ACDA, and compare these to patients with ACD. The secondary objectives are to assess other radiological and clinical outcomes.

Design/ Methods: A RCT with long-term follow-up was conducted. Patients referred to our neurosurgical department with radiculopathy due to single level cervical degenerative disc disease (CDDD) and eligible for surgery were asked to participate. Patients were randomized with a 1:1 allocation to ACDA or ACD. In each patient dynamic X-ray recordings were made before surgery, 1-year and at long term follow-up. Images were analyzed using computer software that uses an image recognition-based algorithm to follow motion of the vertebrae during complete flexion and extension.

Results: A total of 27 patients were included, of which 3 were operated in a pilot group for ACDA and 24 were randomized for ACDA (N=12) or ACD (N=12). At baseline, the average age was 41.4 years and 41% was female. Preoperatively, 2/13 (15%) patients in the ACDA group and 7/12 (58%) patients in the ACD group had a normal sequence of segmental contributions. At one year after surgery 8/13 (62%) showed a normal sequence of segmental contributions in the ACDA group versus 3/11 (27%) in the ACD group. After an average of 11-years follow-up, a normal sequence was only observed in 1/11 (9.1%) patients in the ACDA group and 0/7 (0%) of patients in the ACD group. Fusion of the index level was observed in 3/12 patients (25%) of the ACDA group and 5/7 (71.4%) of the ACD group after long term follow-up. Clinical outcomes were similar between groups, there is a trend towards higher reoperation rates after ACD.

Discussion: We observe that one year postoperative, ACDA restores and preserves a sequence of segmental contributions similar to that of young, healthy individuals. However, after 11 years neither fused nor mobile cervical spines move according to that pattern. Throughout the process of ageing, not only the quantity, but also the quality of motion changes. Possibly, the fact that ACDA preserves motion transcends the importance of how it is preserved in the prevention of ASP.

6

20-year Clinical Outcomes of Cervical Disc Arthroplasty: A Prospective, Randomized, Controlled Trial

***Jason Ye is the new presenter, (former presenter Willa Sasso), Jason Ye, Rick Sasso**
INSTITUTION: Indiana Spine Group

Background: Anterior cervical discectomy and fusion (ACDF) has long been the standard of treatment for degenerative cervical disc disease. Complications including loss of index level motion and adjacent level disease prompted development of alternative treatments, such

as cervical disc arthroplasty (CDA). Previous comparison of the two treatments proves noninferiority of CDA and suggests its superiority with long term follow up.

Research Question: What are the of 20-year outcomes of patients with degenerative cervical disc disease treated with CDA compared to ACDF?

Design: A prospective, randomized, single-center, clinical trial.

Methods: 47 patients with single level cervical disease were randomized 1:1 to either CDA or ACDF. 46 patients were eligible for analysis at 20 years. Patient reported outcomes including visual analog scales (VAS) for neck and arm pain, neck disability index (NDI), and reoperation rates were analyzed.

Results: At 20 years, VAS neck pain and VAS arm pain scores were available for 21/25 patients in the ACDF group (84%) and 17/21 patients in the CDA group (81%). Comparison of VAS arm scores at 20 years showed a significant difference between ACDF and CDA (2.48 vs 0.67, p=0.036). VAS neck scores were not significantly different (2.73 vs 0.98, p=0.068, power=0.448).

NDI scores were available for 18/25 (72%) ACDF patients and 16/21 (76.2%) CDA patients. The difference in NDI scores at 20 years was not significant (19.00 vs 9.25, p=0.053, power=0.497).

Reoperation data was available for 24/25 (96.00%) ACDF and 18/21 (85.71%) CDA patients. Reoperations occurred in 10/24 (41.67%) ACDF patients and 2/18 (11.11%) CDA patients (p=0.03).

Discussion: CDA patients demonstrated significantly improved arm pain scores and less reoperations than ACDF at 20 years. The arthroplasty device proved to withstand 20 years of motion in all patients, as shown by the lack of index site reoperations, while offering continued radiculopathy relief.

7

Development Of An Automated Segmentation Algorithm In Patients With Rheumatoid Arthritis: An Explorative Study

***Anna Baukje Veldman, Jifke F. Veenland MSc PhD, Merel C. Goossens BSc, Igor G. Lenting BSc, S.G.A. Noud van Ruremonde BSc, Nicky Sewberath Misser BSc, and Carmen L.A. Vleggeert-Lankamp MD MSc PhD**
INSTITUTION: Leiden University Medical Center

Background: Inflammation in the cervical spine of patients with Rheumatoid Arthritis (RA) can lead to atlantoaxial subluxation (AAS), which may eventually cause compression of the spinal cord. To diagnose AAS early, X-rays can be used. However, manual assessment of X-rays is a time-consuming process with high intra- and interobserver variability. (2) In this study, we trained and evaluated the performance of a novel automated segmentation algorithm for automated segmentation of C1-C2.

Methods: Lateral, neutral X-rays of the cervical spine of 100 patients of the BeSt Trial were used. (1) In order to train and evaluate the algorithm, manual segmentations of vertebra C1 and C2 were performed using ITK-SNAP. The total set was split in 80 images for training, and 20 for testing. For the development of the convolutional neural network (CNN), the segmentations of [1] the vertebral bodies C1 and C2 and [2] the anterior atlanto-dens interval (AADI) were used. To perform automated segmentation, three U-Nets in combination with an Adam optimizer and a Dice loss function were trained and tested.

Results: Two of the exploratively developed algorithms performed automated segmentation of the vertebral bodies C1 and C2 and had a rather high Dice Similarity Coefficient (DSC) of 0.78-0.83 on the test set. However, visual overlap of the output label with the manual label was not accurate in most cases. The third algorithm, a 5-layer U-Net which performed automated segmentation of the AADI, reached a mean DSC of 0.67. While its DSC was low, the visual outputs were very accurate.

Conclusion: The most promising algorithm for this objective was a 5-layer CNN in combination with an Adam optimizer and a Dice loss function, which performed automated segmentation on the AADI. In order to improve training and accuracy of this algorithm, more data and further optimization of the algorithm are needed.

References 2. Seo JW, Lim SH, Jeong JG, Kim YJ, Kim KG, Jeon JY. A deep learning algorithm for automated measurement of vertebral body compression from X-ray images. Sci Rep. 2021 Jul 2;11(1):13732

8

Effect of Intraoperative Tranexamic Acid on Perioperative Massive Hemorrhage Requiring Transfusion in Patients Undergoing Elective Spine Surgery: A Propensity Score-Matched Analysis Using a National Inpatient Database

***Akira Honda, Yoichi Iizuka, Tokue Mieda, Eiji Takasawa, Sho Ishiwata, Yohei Kakuta, Yusuke Tomomatsu, Shunsuke Ito, Kazuhiro Inomata, Hirotaka Chikuda**
INSTITUTION: Gunma University

Objective: This study aimed to examine whether the use of intravenous TXA in elective spine surgery is associated with reduced perioperative massive hemorrhage requiring transfusion.

Methods: We extracted all patients who underwent decompression with or without fusion surgery for the cervical, thoracic, and lumbar spine between April 2012 and March 2019. The primary outcome was the occurrence of massive hemorrhage requiring transfusion, defined as at least 560 mL of blood transfusion within 2 days of spine surgery or the requirement of additional blood transfusion from 3–7 days postoperatively. Secondary outcomes were the occurrence of thrombotic complications (pulmonary embolism, acute coronary syndrome, and stroke) and postoperative hematoma requiring additional surgery.

Results: We identified 83,821 eligible patients, with 9,747 (12%) patients in the TXA group. Overall, massive hemorrhage requiring transfusion occurred in 781 (0.9%) patients. Propensity score matching yielded 8,394 pairs. In the matched cohort, the TXA group had a lower proportion of massive hemorrhage requiring transfusion than the control group (0.7 % 19 vs. 1.1%; p=0.002). There was no significant difference in the occurrence of thrombotic complications and postoperative hematoma requiring additional surgery between both groups. The multivariable regression analysis also showed that the use of TXA was associated with significantly lower proportions of massive hemorrhage requiring transfusion 2 1 (odds ratio, 0.62; 95% confidence interval, 0.43–0.90; p=0.012).

Conclusions: In this analysis using real-world data, TXA use in elective spinal surgery was associated with reduced perioperative massive hemorrhage requiring transfusion without increasing thrombotic complications.

Abbreviations: TXA, tranexamic acid

9

The Fatty Infiltration Into Cervical Paraspinal Muscle as a Predictor of Postoperative Outcomes: a Controlled Study Based on Hybrid Surgery

***Junbo He, ändras till Chen Ding, Tingkui Wu, Chen Ding, Beiyu Wang, Ying Hong, Hao Liu**
INSTITUTION: Dept. Orthopaedic Surgery, West China Hospital

Objective: To evaluate the association of fatty infiltration (FI) of cervical paraspinal muscle(CPM) with postoperative outcomes in patients undergoing hybrid surgery (HS) andanalyze the relationship between FI and cross-sectional area (CSA) of CPM.

Methods: A retrospective analysis was performed on 110 consecutive patients undergoing-continuous 2-level HS. According to Goutallier classification of multifidus FI, thepatients were divided into normal, moderate, and severe groups. Clinical outcomes and radiographic parameters were collected and evaluated for relevant comparisons.

Results: Visible FI was identified in 69.1% of patients (76/110), with a propensity in elderlypatients. No statistically significant differences were presented among the threegroups regarding pre- and postoperative clinical evaluation scores. The cervical lordosis was

significantly higher in the normal group before surgery. Likewise, thesagittal vertical axis (SVA) was significantly higher in the severe group thanthenormal group at the final follow-up. The function spine unit angle and disc angle of arthroplasty levels were significantly lower in the severe group than the normal groupat follow-ups. Moreover, after correction according to vertebral body area, nostatistically significant relationship existed between CSA ratio and FI grade.vertical axis (SVA) was significantly higher in the severe group thanthenormal group at the final follow-up. The function spine unit angle and disc angle of arthroplasty levels were significantly lower in the severe group than the normal groupat follow-ups. Moreover, after correction according to vertebral body area, nostatistically significant relationship existed between CSA ratio and FI grade.

Conclusion: CPM degeneration is common and age-related in patients with cervical discdegenerative disease. There was a significant positive correlation between severe FI of CPM and postoperative sagittal balance disorder, particularly in C2-7 SVAandsegmental alignment of arthroplasty level. Meanwhile, FI of CPMappears to have noimpact on clinical outcomes and reveals small correlations to CSA.

Keywords: Cervical paraspinal muscle; Fatty infiltration; Cross-sectional area; Hybrid surgery

10

Effectiveness of Prophylactic Bilateral C5 Foraminotomy on C5 Palsy Incidence Following Combined Anterior-Posterior Cervical Instrumentation and Decompression Surgery for Degenerative Cervical Spine Diseases

***Barış Peker, Hamisi Mraja, Inas Daadour, Cem Sever, Meltem Gökmen, Halil Gök, Ali Duran, Tunay Sanli, Selhan Karadereler, Meriç Enercan, Azmi Hamzaoğlu. Corrections made**
INSTITUTION: Kagithane State Hospital

Objective: C5 nerve root palsy is a well-known complication after cervical posterior or/and anterior approaches. The aim of this study was to compare the complication rates of C5 palsy after combined anterior and posterior cervical spine surgery with and without C5 foraminotomy.

Method: A retrospective database of patients who underwent combined anterior and posterior cervical instrumentation and decompression by a single surgeon for degenerative cervical spine disease from 2016 through 2021 was reviewed. Pre and postoperative neurological examinations, intra-operative neuromonitoring (IONM) results, radio-imaging studies including MRI, CT, and x-rays were evaluated. All patients with preoperative C5 paresis were excluded.

Results: Two hundred and one patients (89F, 112M) with mean age 56,7 (27-80) and follow-up of 4,2 (2-6) years were included in the study. Bilateral prophylactic C5 foraminotomy was performed in 103 patients with a mean age of 60.9 (39-80) years, and C5 palsy developed in 17 (16.7%) of them postoperatively. C5 palsy (5.1%) developed in 5 of 98 patients with a mean age of 51.4 (27-79) who did not undergo bilateral C5 foraminotomy. IONM recordings were retrospectively investigated in 17 patients who underwent foraminotomy and developed C5 palsy. No reduction in amplitude was observed in any patient. Initial C5 amplitudes were low in 5 patients and increased after decompression and foraminotomy. All 22 C5 palsy patients received physiotherapy, and all of them showed improvement in paresis with a minimum of 4/5 muscle strength and more according to the Oxford Scale in 6 weeks to 9 months.

Conclusion: In our series, the incidence of C5 palsy was higher in patients who received prophylactic bilateral C5 foraminotomy than those who did not. IONM is not predictive for C5 palsy. Double-blind randomized prospective studies should be conducted to support the outcome of our study.

ABSTRACTS

11

The effect of cervical spondylosis on heterotopic ossification after cervical disc replacement

*JHao Liu, Beiyu Wang
INSTITUTION: West China Hospital, Sichuan University

Objective: Heterotopic ossification (HO) is an intractable issue after cervical disc replacement (CDR) that may decrease the segmental mobility and even develop to arthrodesis. This study aimed to identify factors in preoperative cervical spondylosis that affect the HO formation after surgery and explore the impacts of preoperative degeneration on the occurrence of HO in different locations.

Methods: This was a retrospective study of patients who underwent CDR in our center. The degree of preoperative cervical spondylosis was evaluated radiologically, including the intervertebral disc, uncovertebral joints, facet joints and ligaments. The effects of cervical spondylosis on the HO formation after CDR were analyzed according to the location of HO. Multivariate logistic regression was performed to identify the independent factors.

Results: 149 patients with a total of 196 arthroplasty segments were involved in this study. According to the univariate analysis, the significant factors for posterior HO after CDR included the disc height loss, anterior osteophytes, preoperative uncovertebral joint osteophytes and facet joint degeneration. Multivariate analysis identified disc height loss was the only independent factor for posterior HO formation (P=0.009). No significant degenerative factors related to the formation of anterior HO were found neither in univariate analysis nor in multivariate logistic regression.

Conclusion: Preoperative cervical spondylosis predominantly affected the HO formation in the posterior disc space after CDR. In the multiple elements of preoperative cervical spondylosis, the disc height loss was an independent risk factor for posterior HO formation.

Table 2. Univariate analysis of heterotopic ossification of each segment depending on the location at last follow-up.

	AHO			PHO		
	(-) n=151	(+) n=45	*p*	(-) n=114	(+) n=82	*p*
Age	43.93±8.34	42.16±7.68	0.203	42.76±8.20	44.59±8.14	0.236
Sex			0.301			0.908
Male	64	23		51	36	
Female	87	22		63	46	
Follow-up (months)	47.84±21.62	54.82±29.69	0.498	47.48±20.53	52.17±27.64	0.882
Level distribution			0.384			0.309
C3/4	9	3		8	4	
C4/5	35	7		20	22	
C5/6	90	26		68	48	
C6/7	17	9		18	8	
Mean IIL score	0.54	0.49	0.718	0.39	0.71	**0.003***
Mean AO score	0.79	0.96	0.256	0.68	1.04	**0.006***
Mean ES score	0.20	0.22	0.687	0.17	0.26	0.196
Pre-op UJ osteophyte			0.575			**0.045***
Yes	81 (53.6%)	22 (48.9%)		53 (46.5%)	50 (61.0%)	
No	70 (46.4%)	23 (51.1%)		61 (53.5%)	32 (39.0%)	
Facet joint degeneration			0.720			**0.035***
1	117 (77.5%)	36 (80.0%)		95 (83.3%)	58 (70.7%)	
2	34 (22.5%)	9 (20.0%)		19 (16.7%)	24 (29.3%)	
OALL	26 (17.2%)	10 (22.2%)	0.447	21 (18.4%)	15 (18.3%)	0.982
Pre-op LN ossification	28 (18.5%)	4 (8.9%)	0.124	14 (12.3%)	18 (22.0%)	**0.071**
Progression of LN	13 (8.6%)	4 (8.9%)	1.000	8 (7.0%)	9 (11.0%)	0.331
ASD	32 (21.2%)	12 (26.7%)	0.440	17 (14.9%)	27 (32.9%)	0.003*

AHO, anterior heterotopic ossification; PHO, posterior heterotopic ossification; IVD, intervertebral disc; HL, height loss; AO, anterior osteophyte; ES, endplate sclerosis; UJ, uncovertebral joint; OALL, ossification of anterior longitudinal ligament; LN, ligamentum nuchae; post-op, values at 1 week after surgery; ROM, range of motion; ASD, adjacent segment degeneration.
Bold values indicate these values would be included in multivariable logistic regression analysis.
* Significant difference between groups.

12

Effects of endplate coverage and intervertebral height change on heterotopic ossification following cervical disc replacement

***Hao Liu, Beiyu Wang**
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Background: Biomechanical factors including endplate coverage and intervertebral disc height change may be related to heterotopic ossification (HO) formation after cervical disc replacement (CDR). However, there is a dearth of quantitative analysis for endplate coverage, intervertebral height change and their combined effects on HO.

Methods: Patients who underwent single-level or two-level CDR were retrospectively reviewed. Radiological data, including the prosthesis-endplate depth ratio, intervertebral height change, posterior heterotopic ossification (PHO) and angular parameters, were collected. Logistic regression analysis was used to identify the potential risk factors. Receiver operating characteristic curves were plotted and the cutoff values of each potential factors were calculated.

Results: A total of 138 patients with 174 surgical segments were evaluated. Both the prosthesis-endplate depth ratio (P<0.001) and postoperative disc height change (P<0.001) were predictive factors for PHO formation. The area under the curve (AUC) of the prosthesis-endplate depth ratio, disc height change and their combined effects represented by the combined parameter (CP) were 0.728, 0.712 and 0.793, respectively. The risk of PHO significantly increased when the prosthesis-endplate depth ratio < 93.77% (P<0.001, OR=6.909, 95% CI 3.521-13.557), the intervertebral height change ≥ 1.8 mm (P<0.001, OR=5.303, 95% CI 2.592-10.849), or the CP representing the combined effect < 84.88 (P<0.001, OR=10.879, 95% CI 5.142-23.019).

Conclusions: Inadequate endplate coverage and excessive change of intervertebral height are both potential risk factors for the PHO after CDR. The combination of these two factors may exacerbate the non-uniform distribution of stress in the bone-implant interface and promote HO development.

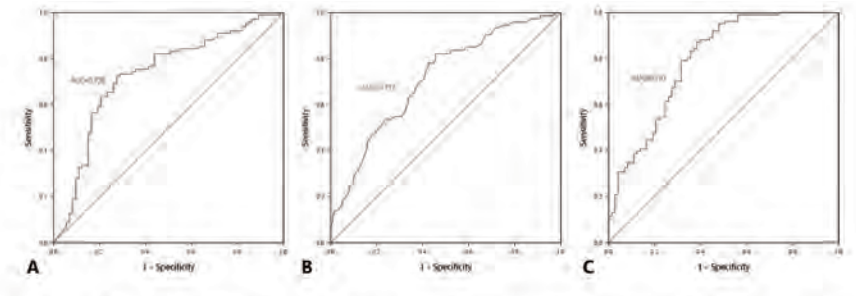

Fig. 1 ROC curve of prosthesis-endplate depth ratio (A), intervertebral height change (B), and CP (C) for the prediction of posterior heterotopic ossification. The AUC are 0.728, 0.712, and 0.793, respectively. ROC curve, receiver operating characteristic curve; CP, combined parameter; AUC, area under the curve.

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MRI evaluation of foraminal changes in the cervical spine with assistance of a novel compression device

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INSTITUTION: Institute of Clinical Sciences

Introduction: Standard supine MRI does not acquire images in a position where most patients with intermittent arm radiculopathy have symptoms. The aim of this study was to test the feasibility of a new compression device and to evaluate image quality and foraminal properties during a Spurling test under MRI acquisition.

Methods: Ten asymptomatic individuals were included. First, the subjects were positioned in the cervical compression device and images were acquired in a relaxed supine position.

Thereafter, we mimicked a Spurling test with the compression device, while repeating the image acquisition. A radiologist measured the blinded investigations evaluating cervical lordosis (C3-C7), foraminal area (oblique sagittal) and foraminal cross-distance (axial). A total of three levels (C4-C7) were measured on the right side on each individual. Measurements were compared between the compressed and relaxed state. Reliability tests for inter- and intraclass correlation were performed.

Results: The device was feasible to use. Images of adequate quality was obtained in all patients. A significant increase (mean 9.4°, $p = 0.013$) in the cervical lordosis and a decreased foraminal cross-distance (mean 32%, $p < 0.001$) was found, during the simulated Spurling test. The foraminal area did not reach a statistically significant change after compression. We had excellent intraobserver reliability and good interrater reliability.

Conclusions: A Spurling test applied during MRI acquisition is feasible with the novel device and provided images of satisfactory quality. We detected increased in cervical lordosis and a shorter foraminal cross distance, indicating the possibility of detecting changes of the foraminal properties.

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High whole-body bone mineral density in ossification of the posterior longitudinal ligament

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INSTITUTION: Hokkaido University

Objective: Recent studies suggested that ossification of the posterior longitudinal ligament (OPLL) is exacerbated by systemic metabolic disturbances, including obesity. However, evidence on the relationship between OPLL and systemic bone metabolism is insufficient. We aimed to investigate whether patients with OPLL develop increased whole-body bone mineral density (BMD).

Methods: In this cross-sectional study, we analyzed whole-body BMD was in symptomatic OPLL patients (OPLL [+]; n = 99) and patients without spinal ligament ossification (OPLL [-]; n = 226) at a single institution in Japan from 2018 to 2022. Subjects were categorized based on sex, age (middle-aged [<70 years] and elderly [≥70 years]), and OPLL type (localized OPLL [OPLL only in the cervical spine] and diffuse OPLL [OPLL in regions including the thoracic spine]). We assessed an association of OPLL with whole-body BMD by multiple regression analysis.

Results: Compared with the OPLL (-) group, the OPLL (+) group of elderly women had significantly higher BMD in all body parts ($P < 0.01$), and the OPLL (+) group of elderly men had significantly higher BMD in all body parts except the ribs, forearm, and head ($P < 0.01$). The factors associated with increased BMD of both the femoral neck (load-bearing bone) and head (non-load-bearing bone) were age, body mass index (BMI), and diffuse OPLL in women and BMI and localized OPLL in men.

Conclusions: Patients with OPLL have increased whole-body BMD, suggesting that an imbalance in systemic bone metabolism rather than focal mechanical irritation could be related with the etiology of OPLL.

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Atlantoaxial stenosis after muscle-preserving selective laminectomy

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INSTITUTION: Tokyo Dental College Ichikawa General Hospital

Objective: This study aimed to clarify risk factors for atlantoaxial stenosis after muscle-preserving selective laminectomy.

Methods: A total of 1205 patients who underwent muscle-preserving selective laminectomy due to cervical disorders were included in this study. Postoperative atlantoaxial stenosis, which needed decompression, appeared in 4 cases, and 30 patients did not have radiological stenosis for more than 10 years after surgery. Twenty healthy volunteers were also used as controls. The radiographic parameters measured were C2-C7 angle, C2-C7 sagittal vertical axis (SVA), C2 slope, C7 slope, C2-C5 angle, C5-C7 angle, C1-C2 angle, and atlantodental interval (ADI).
We measured the anterior-posterior (AP) diameters of the spinal cord (SC) and dural tube (Dura) at C1/C2 with sagittal MRI.

Results: In the cases of atlantoaxial stenosis, the AP of SC and Dura at C1/C2 were smaller preoperatively, and the residual space for SC (SAC) was also smaller. The preoperative ADI was significantly higher in patients with atlantoaxial stenosis, suggesting preoperative instability at C1/C2. Analysis of the ROC curve showed that patients with a preoperative SAC of less than 3.6 mm and an ADI of more than 1.35 mm were more likely to develop postoperative atlantoaxial stenosis.

Conclusions: In the cases of atlantoaxial stenosis after muscle-preserving selective laminectomy, the spinal canal was narrowed at C1/C2 preoperatively, and instability was also observed. When we perform a muscle-preserving selective laminectomy, decompression of C1/C2 is suggested when the SAC at C1/C2 is less than 3.6 mm and the ADI is more than 1.35 mm.

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Brain connectivity markers in degenerative cervical myelopathy patients with depression for predicting the prognosis following decompression surgery

***Yuan Xue, Rui Zhao**
INSTITUTION: Tianjin Medical University General Hospital

Objective: To determine if brain functional connectivity (FC) is associated with the prognosis in depressed degenerative cervical myelopathy patients (DCM) and to investigate the possible brain functional mechanism.

Methods: Resting-state fMRI scans and peripheral blood cell counts from 33 depressed DCM patients, 33 age and gender-matched DCM patients without depression were analyzed. All patients were evaluated using Japanese Orthopedic Association score before and 6 weeks after decompression surgery. JOA recovery rate was calculated to assess the functional recovery for DCM patients. For each participant, seed-based functional connectivity maps based on sub-regions centered on the striatum were computed and compared between groups. Pearson correlations were performed to explore the relationships between clinical measures and brain alterations in depressed DCM patients. To further investigate the relationships between brain alterations and clinical measures in depressed DCM patients, mediation analyses were performed. Flow cytometry was also performed on the three of the 33 depressed DCM patients, and the results were analyzed.

Results: In comparison to patients without depression, DCM patients exhibited lower FC between the dorsal caudate (dC) and the inferior frontal operculum, which is located in the dorsal lateral prefrontal cortex (dlPFC). In depressed DCM patients, the altered dC-dlPFC FC was associated with inflammation as determined by the neutrophils/lymphocyte's ratio and prognosis. Furthermore, the mediation analysis demonstrated that the dC-dlPFC FC mediated the effect of inflammation on prognosis. The outcomes of our three cases followed a similar pattern to these findings

Conclusions: In conclusion, our findings imply that inflammation slowed the functional recovery in depressed DCM patients through the striatal-frontal FC pathway

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Spinal cord MRI signal change at 1 year after cervical decompression surgery is useful for predicting mid-term clinical outcome: an observational study using propensity scores

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INSTITUTION: Department of Orthopaedic Surgery, Shinshu University School of Medicine

Objective: There is little evidence concerning the relationship between magnetic resonance imaging (MRI) T2WI high signal change (T2HSC) at the spinal cord and surgical outcomes for cervical compression myelopathy (CCM).

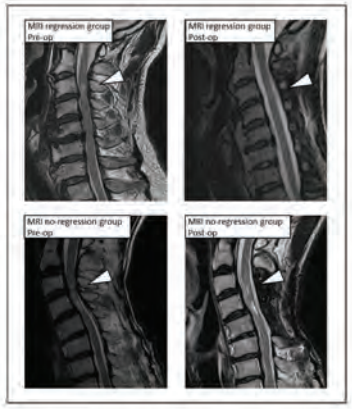
Research question: We examined whether T2HSC regression at one year postsurgery impacts the subsequent prognosis.

Design: Retrospective observational study

Methods: The subjects were 150 CCM patients who underwent surgery. The median age was 68 years (39–87 years) at surgery. Based on spinal MRI at 1 year post-surgery, patients were divided into the following two groups: MRI regression group (Reg. group, with a fading of T2HSC) or no regression group (No-reg. group, with no change in or enlargement of T2HSC). Recovery rates of Japanese Orthopedic Association (JOA) scores at 1, 2, 3 and 5 years postsurgery were compared between groups using a t-test. We adjusted outcome scores for age, sex, diagnosis, and symptom duration by the inverse-probability weighting method using the propensity score. $P < 0.05$ was considered significant.

Results: The recovery rates (mean ± standard error) were as follows: 1 year post-surgery, Reg. group, 44 cases, 49 ± 6%; No-reg. group, 102 cases, 36 ± 4% ($P = 0.087$); at 2 years post-surgery, Reg., 42 cases, 50 ± 6%; No-reg., 91 cases, 37 ± 4% ($P = 0.103$); at 3 years post-surgery, Reg., 33 cases, 51 ± 6%; No-reg., 79 cases, 31 ± 6% ($P = 0.020$); and at 5 years post-surgery, Reg., 21 cases, 62 ± 8%, No-reg., 48 cases, 33 ± 6% ($P = 0.012$).

Discussion: Spinal T2HSC improvements at 1 year post-surgery positively impacted recovery rates starting at 3 years. We recommend confirming spinal MRI at 1 year post-surgery to predict the mid-term outcome for CCM patients.



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Novel and simple test to evaluate the finger dexterity in patients with cervical myelopathy – Finger extension test–

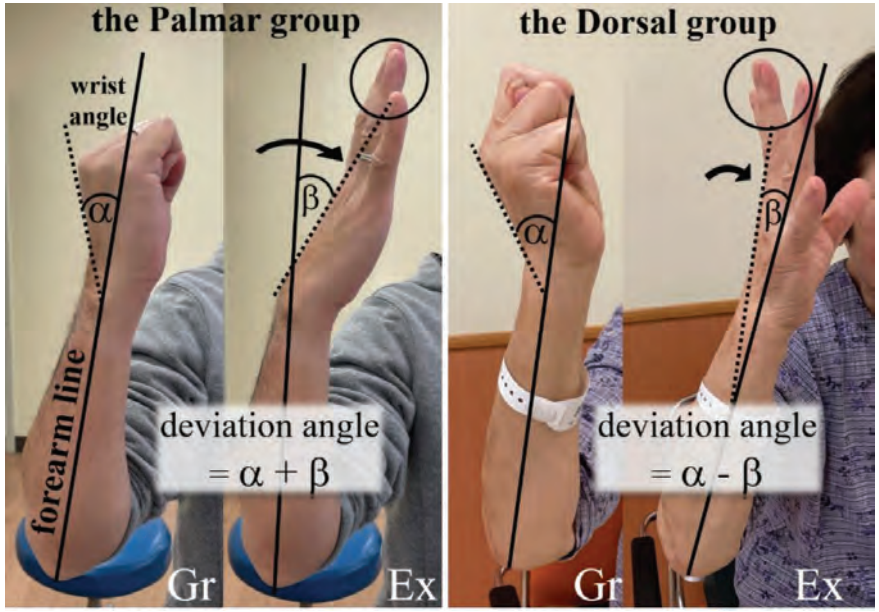
***KAZUYA KITAMURA, Kazuya Kitamura, Naoki Yamaguchi, Atsuto Umei, Haruo Sasaki, Shota Amano, Yohei Kurita, Akimasa Yasuda, Seiji Yamane, Kazuhiro Chiba**
INSTITUTION: Department of Orthopaedic Surgery, National Defense Medical College, Japan

Objective: Patients with cervical spondylotic myelopathy (CSM) often exhibit unintentional wrist flexion to compensate for impaired finger extension. Focusing on this compensatory wrist flexion, we propose Finger Extension Test (FET) to evaluate concisely the severity of CSM.

Methods: Consecutive 33 outpatients (66 hands) with CSM were enrolled. FET procedure: With the forearms kept vertical and supination-pronation neutral in sitting position, patients were asked to grasp and then extend fingers as quickly as possible only once. The angle between the forearm axis (forearm line) and the line aligned to the dorsal surface of the hand was measured as the wrist angle. The difference between the wrist angles in grasp (Gr) and full extension (Ex) was defined as the deviation angle. When finger tips at Ex was positioned palmar or dorsal to the forearm line, hands were grouped into the Palmar (P) group (n=38 hands) or the Dorsal (D) group (n=28 hands). Results of Grip and Release test and JOA sub-scores for finger dexterity (4 points) were compared between the two groups.

Results: The P group had significantly larger deviation angles of the wrist joint (40.2˚ vs 28.8˚, p<0.001) and smaller values of the GR test (19.6 vs 22.3, p=0.002) than the D group. JOA sub-scores were significantly lower in patients with either hand in the P group (2.9, p=0.04 [n=21 patients]) than in those with both hands in the D group (3.6 [n=12 patients])

Conclusion: Simple FET, judging the finger tip position in finger extension, may represent the severity of CSM



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Segmental modified K-line interval on T2-weighted MRI can predict JOA recovery rate after posterior decompression surgery in patients with cervical spondylotic myelopathy

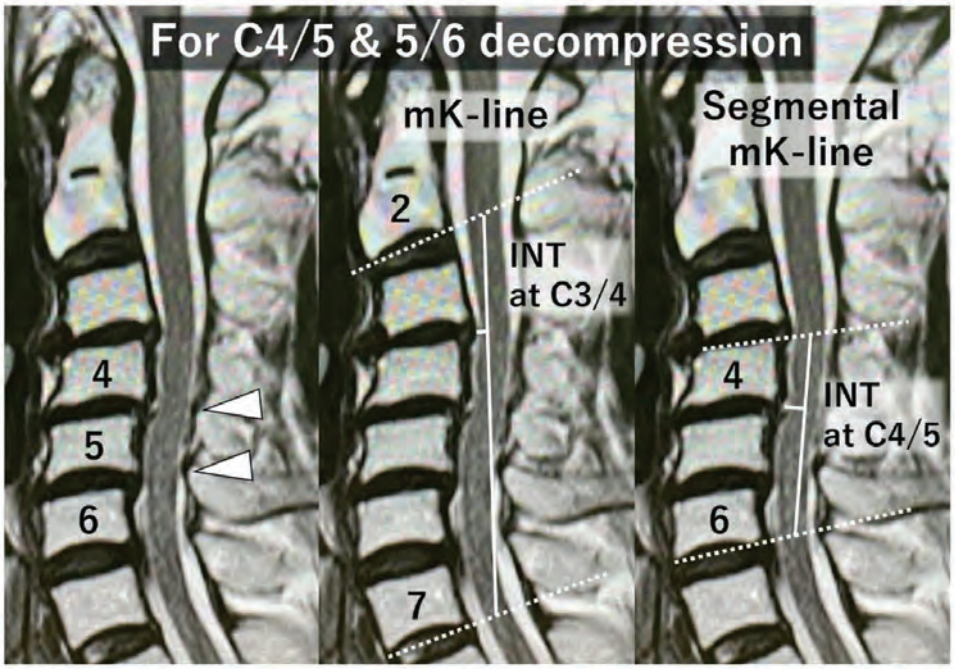
***Naoki Yamaguchi, Kazuya Kitamura, Akimasa Yasuda, Atsuto Umei, Yohei Kurita, Takahiro Ishizaka, Takahiro Nakagawa, Kazuhiro Chiba**
INSTITUTION: Department of Orthopaedic Surgery, National Defense Medical College, Saitama, Japan

Objective: Modified K-line interval (mK-line-INT), which is measured based on C2-7 alignment on sagittal MRI, reportedly predicts insufficient posterior decompression in patients with cervical spondylotic myelopathy (CSM). However, the level where mK-line-INT is measured is not always included in the decompression levels or corresponds to the most stenotic level. This study aimed to propose segmental mK-line (SmK-line) that is drawn within the selected decompression levels, and to investigate the efficacy of SmK-line interval (SmK-line-INT) to predict surgical outcomes.

Methods: SmK-line was defined as the line connecting the midpoints of the spinal cord at the rostral endplate level of the uppermost vertebra and at the caudal endplate level of the lowermost vertebra of the decompressed levels on sagittal MRI. SmK-line-INT was defined as the minimum distance between the anterior compression factor and SmK-line. mK-line-INT, SmK-line-INT, the levels where these INTs were measured, the most stenotic level, and JOA recovery rate [RR] at 1 year postop were investigated in consecutive 62 patients with CSM who underwent posterior decompression.

Results: The percentage of the patients whose INTs were measured at the most stenotic level were 64.5% (mK-line-INT) and 85.5% (SmK-line-INT, p=0.006). Multiple regression analysis revealed that mK-line-INT (p=0.03), age (p=0.01), and SmK-line-INT (p=0.007) were significantly associated with JOA RR. Area under the ROC curve and the cut-off value of these INTs to predict poor JOA RR (< 40%) was 0.568 (p=0.03) and 4.7mm (mK-line-INT) and 0.714 (p=0.01) and 3.4mm (SmK-line-INT), respectively.

Conclusion: SmK-line-INT can predict JOA RR more accurately than mK-line-INT.



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Clinical outcomes of surgical management for mild cervical compressive myelopathy based on minimum clinically important difference

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INSTITUTION: Osaka Medical and Pharmaceutical University

Objective: Cervical compressive myelopathy (CCM), caused by cervical spondylosis or ossification of the posterior longitudinal ligament, is a common neurological disorder in adults worldwide. For patients with moderate and severe CCM, surgical management is recommended. However, the therapeutic management of patients with mild CCM remains controversial. In recent years, there has been a trend toward surgery in the early disease state of CCM, and several studies have examined the outcomes after surgical decompression for mild CCM. Nonetheless, the current knowledge is insufficient to inform patients with mild CCM of the specific surgical effect in clinical setting: whether surgery can provide perceptible improvement of neurological symptoms or not. Hence, the present study aimed to examine the surgical outcomes of mild CCM using the minimum clinically important difference (MCID).

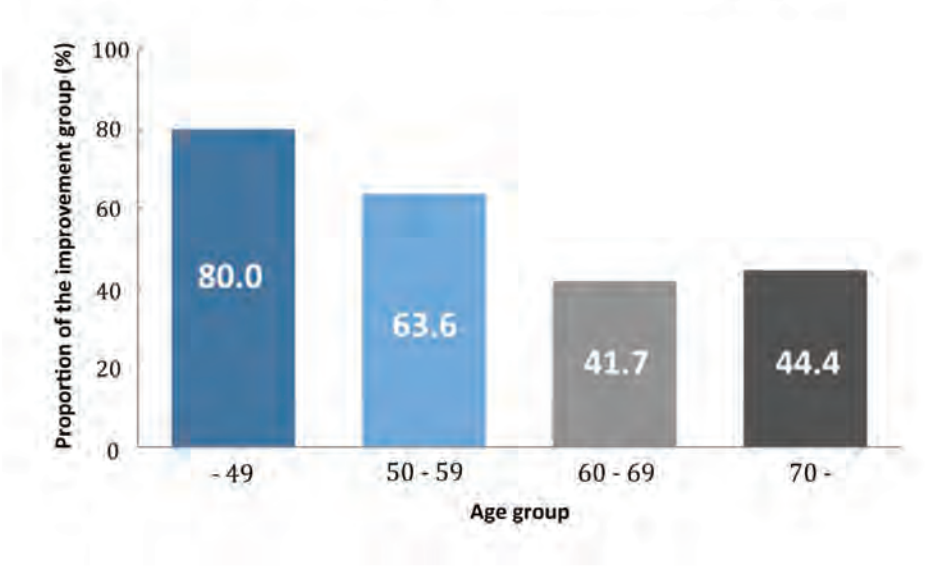
Methods: Patients who underwent surgery for CCM between 2013 and 2021 were retrospectively reviewed. The Japanese Orthopedic Association score (JOA score) was employed as the clinical outcomes, and the MCID was set as 1 point, as previously determined. The patients with the JOA score of ≥14.5 points at baseline were stratified into the mild CCM cohort, which was dichotomized into the improvement group, including the patients with the achieved MCID (JOA score ≥1 point) or with the JOA score of 17 points (full mark) at 1 year postoperatively, and the non-improvement group, including other ones. Demographics, symptomatology, and radiographic variables were compared between the two groups; subsequently, studied using receiver operating characteristic (ROC) curve.

Results: Of 310 patients, 42 were stratified into the mild CCM cohort (mean age, 59.1 years; 64.3% male; the mean JOA score, 15.4 and 16.2 points at preoperatively and 1 year postoperatively, respectively). Twenty-four patients (57.1 %) were assigned to the improvement

group. The improvement group was significantly younger than the nonimprovement group; however, other variables did not differ significantly. The ROC curve analysis revealed that 58 years was the optimal cutoff age for discriminating between the two groups (area under the curve=0.689, P=0.025). The Cochran–Armitage test showed a significant linear trend, with younger age group associated with higher proportion of the improvement group.

Conclusions: In the present study cohort, the majority of patients with mild CCM experienced neurological improvement reaching the MCID after surgery. Further, this study suggests that for younger patients with mild CCM, especially below 60 years, subjective improvement of neurological symptoms can be more expected after surgery. Whereas, for the older patients, surgery becomes more prophylactic significance to halt disease progression

Figure legend: The figure shows proportion of the improvement group by age.



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Long-term results after surgery for degenerative cervical myelopathy

***Tonje Okkenhaug Johansen, Siril Therese Holmberg, Elisabeth Danielsen, Vidar Rao, Øyvind Salvesen, Hege Andresen, Tore Solberg, Carmen L. A. Vleggeert-Lankamp, Sasha Gulati, Øystein P. Nygaard**
INSTITUTION: St. Olav's University Hospital

Background: Degenerative cervical myelopathy (DCM) can cause spinal cord dysfunction. Surgical treatment is considered safe and effective, but long-term results are limited.

Research question: Do the results one year after surgery persist at long-term follow-up?

Design: Observational registry-based study through data from a national registry for spine surgery.

Methods: Patients operated for DCM were approached for long-term follow-up after three to eight years. Primary outcome was change in Neck Disability Index (NDI), secondary outcomes were changes in European Myelopathy Score (EMS), quality of life (EuroQoL EQ5D), numeric rating scales (NRS) for headache, neck pain and arm pain, and perceived benefit of surgery assessed by the Global Perceived Effect scale (GPE) from one year to long-term follow-up.

Results: We included 144 patients operated between January 2013 to June 2018 in two health regions. 123 participants (85.4%) provided PROMs at long-term follow-up. There was no significant change in PROMs from one year to long-term follow-up, including NDI (1.0, 95% CI -2.1 to 4.1, p=0.53), EMS (-0.3, 95% CI -0.7 to 0.1, p=0.09), EQ-5D index score (-0.02, 95% CI -0.09 to 0.05, p=0.51), NRS neck pain (0.3 95% CI -0.2 to 0.9, p=0.22), NRS arm pain (-0.1, 95% CI -0.8 to 0.5, p=0.70), and NRS headache (0.4, 95% CI -0.1 to 0.9, p=0.11). According to GPE assessments, 106/121 patients (87.6%) reported to be stable or improved at long-term follow-up.

Discussion: Long-term follow-up of patients undergoing surgery for DCM demonstrates persistence of statistically significant and clinically meaningful improvement across a wide range of PROMs.

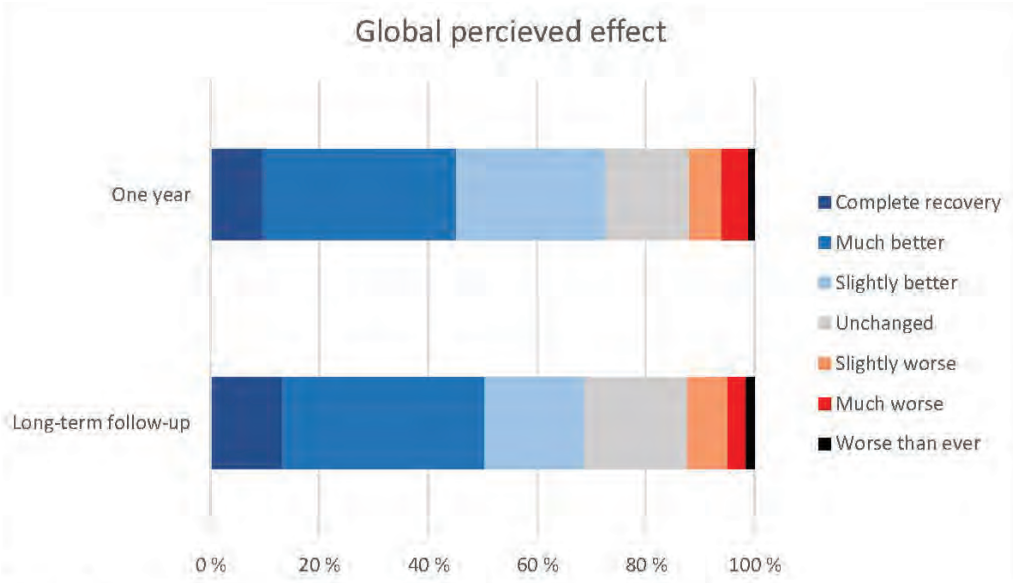

Figure 1
Patients' perceived effect of surgery at one year and long-term follow-up

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Comparison of posterior muscle-preserving selective laminectomy and laminectomy with fusion for treating cervical spondylotic myelopathy: study protocol for a randomized controlled trial

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INSTITUTION: Akademiska Hospital

Background: Cervical Spondylotic Myelopathy (CSM) is the predominant cause of spinal cord dysfunction in the elderly. The patients are often frail and susceptible to complications. Since anterior and posterior fusion techniques have been compared without presenting any superiority the objective of this study is to compare muscle-preserving selective laminectomy with laminectomy and fusion to determine which treatment has the lowest frequency of complications and reoperations.

Methods: This is a multicenter randomized non-inferiority trial with allocation of 300 patients in a ratio of 1:1. The main inclusion criterium is 1-4 levels of CSM in the subaxial spine, C3-C7. The primary endpoint is reoperation for any reason at five years of follow-up. Sample size and power calculation were performed by estimating the reoperation rate after laminectomy to 3.5% and after laminectomy with fusion to 7.4% based on the data from the Swedish spine registry (Swespine). Secondary outcomes are the patient-derived modified JOA score, Neck disability index, European quality of life five dimensions, Visual analog scale for neck- and arm pain, development of kyphosis and, death. Clinical and radiological follow-up is performed at 3, 12, 24 and 60 months after surgery. Data will be analyzed according to the modified intention to treat (mITT) population, defined as randomized patients who are still alive without having left the study after two and five years.

Discussion: The results of the myelopathy randomized controlled (MyRanC) study will improve the clinical practice and surgical treatment regarding CSM.

Trial registration: Clinical trials.gov; NCT04936074

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Looking Back to Move Forward: A Retrospective Study on Risk Factors for Dysphagia in Individuals with Traumatic Cervical Spinal Cord Injury.

***Iris Leister, Iris Meißner, Stephanie Dietmann, Gerrit Hüller, Orpheus Mach, Matthias Vogel, Matthias Ehret, Anita Hausladen, Ludwig Aigner, Doris Maier**
INSTITUTION: BG Trauma Center Murnau

Objective: Among a variety of secondary complications, dysphagia is common among patients with cervical spinal cord injury (SCI) during the acute post-injury phase. Several risk factors for the development of dysphagia after SCI have been postulated including the necessity of mechanical ventilation, tracheostomy, age, spinal surgery via an anterior cervical approach, severity of SCI, and multi-level spinal fusion. The causes and mechanisms of dysphagia are not well understood, and potential contributing factors are being discussed controversially.

Methods: We included data from 407 patients in this retrospective analysis aiming to identify risk factors for dysphagia in individuals who sustained traumatic cervical SCI. Based on literature and clinical experience, candidate explanatory variables were selected from parameters which have been collected as part of standard clinical care. Uni- and multivariate (non-)parametric statistical analyses were conducted to identify risk factors for the development of dysphagia in our defined cohort.

Results: In our study cohort, 92 (22.6 %) presented with dysphagia in the acute / sub-acute post-injury phase. The main risk factors for developing dysphagia are tracheostomy, the necessity of prolonged mechanical ventilation, severity of SCI, and higher neurological level (above C4) of SCI. In contrast to previous literature, an anterior surgical approach, as well as multi-level spinal fusion was not associated with an increased risk in our large cohort. Higher age and tracheostomy are related to a worse disease progression of dysphagia.

Conclusions: Identifying patients at risk early after injury can inform clinical decision-making thereby improving clinical management of dysphagia in individuals with SCI.

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Patient Reported Outcomes after treatment of Subaxial Spine Fractures

***Marcus Björklund, Olof Wolf, Paul Gerdhem, Anna MacDowall**
INSTITUTION: Department of Orthopedics Falu Hospital and Department of Surgical Sciences Uppsala University

Objective: Information about treatment outcomes after subaxial spine fractures (SSF) is sparse. The aim of this study is to present patient reported outcome measures (PROMs) in patients sustaining an SSF.

Methods: This is an observational study on prospectively collected data from the Swedish Fracture Register (SFR). Baseline data includes injury cause, type of trauma, fractureclassification, type of treatment, ankylosis and/or neurological deficit. The Short Musculoskeletal Function Assessment (SMFA) and the European Quality of Life 5 Dimensions (EQ-5D) are sent to the patients at baseline and after one year (1-y). This study was approved by The Swedish Ethical Review Authority.

Results: Between 2015-2021, 2047 patients with SSF were registered in the SFR. PROMs with baseline and 1-y values were available in 299 patients. Baseline epidemiological data did not differ significantly between the PROMs group and the patients without PROMs data except for the proportion of later deceased and neurologic injury (Table 1). EQ-5D decreased from 0.82 (SD±0.29) to 0.67 (SD±0.35), delta-value -0.15 (SD±0.34). EQ-5D health decreased from 80.0 (SD±22.1) to 73.0 (SD±22.8) with a delta-value of -7.1 (SD±26.7). The SMFA Function Index increased from 10.0 (SD±14.6) to 21.1 (SD±22.3), delta-value 11.1 (SD±19.0) and the Bother Index from 8.3 (SD±13.6) to 23.6 (SD±23.0), delta-value 15.3 (SD±21.7).

Conclusion: This study presents self-reported outcomes in patients sustaining a fracture in the subaxial spine. All PROMs were worse at 1y after the fracture. The results indicates that an SSF is a severe injury with major long-term implications for the individual patient.

Table 1: Baseline comparisons between patients with or without available PROMs data

	PROMs available (n=299)	PROMs not available (n=1748)	*P-value*
Age, years, mean ± SD	59.0 ± 17.9	59.4 ± 21.1	0.76
Gender			
Male	207 (69.2%)	1202 (68.8%)	0.87
Female	92 (30.8%)	546 (31.2%)	
Deceased (as of 2021-06-10)	19 (6.4%)	304 (14.9%)	< .00001
Injury mechanism			0.49
Pathologic/Stress fracture	2 (0.7%)	14 (0.8%)	
Traffic	96 (32.1%)	533 (30.5%)	
Fall same level	83 (27.8%)	560 (32.0%)	
Fall from height	68 (22.7%)	358 (20.5%)	
Unspecified fall	13 (4.3%)	97 (5.5%)	
Other cause	27 (9.0%)	116 (6.6%)	
Missing data	10 (3.3%)	70 (4.0%)	
Type of trauma			0.94
High energy	98 (32.8%)	609 (34.8%)	
Low energy	136 (45.5 %)	786 (45.0%)	
Unknown	28 (9.4%)	147 (8.4%)	
Not applicable	2 (0.67%)	14 (0.8%)	
Missing data	35 (11.7%)	192 (11.0%)	
Ankylosis (AS/DISH)			0.07
Yes	44(14.7%)	279 (16.0%)	
No	251 (83.9%)	1463 (83.7%)	
Missing data	4 (1.3%)	6 (0.3%)	
Classification			
AO A	143 (47.8%)	893 (51.1%)	
AO B	45 (15.1%)	242 (13.8%)	
AO C	82 (27.4%)	450 (25.7%)	
Missing data	29 (9.7%)	163 (9.3%)	
Neurologic injury			0.01
None	237 (79.3%)	1359 (77.7%)	
Nerve root	45 (15.1%)	187 (10.7%)	
Complete spinal cord injury	4 (1.3%)	53 (3.0%)	
Incomplete spinal cord injury	10 (3.3%)	110 (6.3%)	
Not possible to assess	3 (1.0%)	39 (2.2%)	
Injured level			0.42
C3	35 (8.5%)	180 (7.3%)	
C4	54 (13.0%)	296 (12.1%)	
C5	67 (16.2%)	493 (20.1%)	
C6	125 (30.2%)	731 (29.8%)	
C7	133 (32.1%)	753 (30.7%)	
Total	414	2453	
Number of injured levels			0.70
1	190 (63.5%)	1105 (63.2%)	
2	104 (34.8%)	594 (34.0%)	
3	4 (1.3%)	35 (2.0%)	
4	1(0.3%)	14 (0.8%)	
Concomitant injury Th1			0.72
Yes	16 (5.4%)	85 (4.9%)	
No	283 (94.6%)	1663 (95.1%)	
Other concomitant fracture			0.66
Yes	69 (23.1%)	424 (24.3%)	
No	230 (76.9%)	1324 (75.7%)	
Primary treatment			0.24
None	28 (9.4%)	234 (13.4%)	
Collar	154 (51.1%)	887 (50.7%)	
Surgical	81 (27.1%)	447 (25.6%)	
Missing data	36 (12.0%)	180 (10.3%)	

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An effective prehospital management after traumatic cervical spinal cord injury can positively influence the neurological as well as the functional outcome

***Christof Wutte (presented by Iris Leister), Iris Leister, Orpheus Mach, Martin Strowitzki, Doris Maier, Lukas Grassner**
INSTITUTION: Traumacenter Murnau

Introduction: There is accumulating evidence of a potential beneficial effect of early surgical intervention on the neurological and functional outcome after traumatic SCI. The emergency medical service (EMS) system in Central Europe is well developed allowing short transportation times between the injury site and the hospital.

This study aimed to investigate the relationship between prehospital management and neurological recovery after SCI

Methods: We performed a retrospective analysis of data from patients who were treated at a Spinal Cord Injury Center. Follow-up data has been collected prospectively as part of the European Multicenter Study about Spinal Cord Injury (EMSCI) registry. We included data acquired between 2004 and 2021. Patients above the age of 18 years, who sustained traumatic SCI without severe concomitant injuries or traumatic brain injury have been included.

Results: We identified 241 patients (196 males), who met inclusion criteria. The main predictor for the neurological outcome was the level of the lesion with significantly worse neurological recovery in individuals who sustained thoracic injuries. Patients with cervical trauma had significantly higher chances to regain function when they have been initially admitted to a specialized center compared to those who were admitted to a regional trauma center and relocated afterwards. The outcome was not associated with the distance between the site of injury and the hospital, due to the well established emergency medical service system.

Conclusions: In case of suspected cervical SCI, a direct transport to a specialized spinal cord injury center should be pursued.

ABSTRACTS

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Implications of statistically significant different regional C1 and C2 bone mineral densities for upper fracture fixation

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INSTITUTION: Medical College of Wisconsin-Neurosurgery

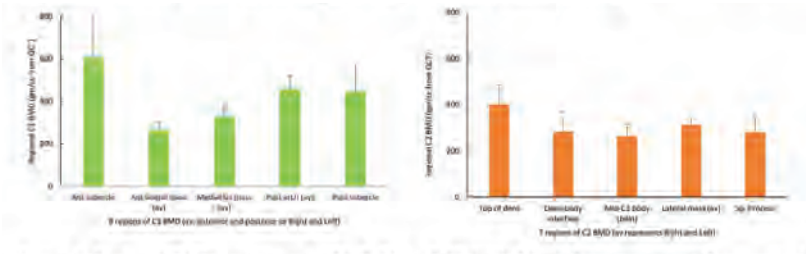
Background: The global population is aging. Elderly patients experience an increased incidence of C1 and C2 fractures, particularly odontoid fractures, due to falls. Surgical stabilization effectiveness depends on screw purchase and local bone strength.

Research Question: Hypothesis: trabecular bone mineral density (BMD), a measure of screw purchase /bone strength, depends on local anatomical regional variations encountered at C1 and C2.

Design and Methods: BMDs of 20 elderly (mean:66-years) human cadaver C1 and C2 were obtained from quantitated Computed Tomography (QCT). Regions for C1: anterior tubercle, bilateral anterior and medial lateral masses, bilateral posterior arches, and posterior tubercle. Regions for C2: odontoid top, base of odontoid-body interface, mid-body, bilateral lateral mass, anterior inferior body near disc, and spinous process. Repeated measure linear-mixed model was used for statistics ($p<0.05$, significance). Tukey's Post Hoc test used to analyze regional BMD variations.

Results: BMD (Figure-1): greatest at C1 anterior tubercle and posterior ring, and least at anterior and medial lateral masses. C2: BMD was greatest at dens top and least in mid-body. Correlation between BMD at dens-vertebral body interface with vertebral body was high (Pearson correlation=0.86). BMD of top of dens was significantly higher ($p<0.05$) than all other regions

Conclusions/Discussion: Regional BMD variations within C1/C2, and C1-to-C2 proved the hypothesis. This may have surgical implications, especially for odontoid fracture fixation with screws as the mid-body has lowest BMD. For posterior arch fracture stabilization with C1-C2 instability using pedicle/pars/lateral mass/ trans-articular screws, regional BMD variations should be considered to optimize screw length to obtain a secure/stable construct.



Legend: Regional BMD variations in C1 (left) and C2 (right) based on quantitated computed tomography images processed using a pe-calibrated phantom of differing bone mineral densities.

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Risk Factors for In-Hospital Mortality in Geriatric Patients with C2 Vertebral Fractures: An Analysis of Concomitant Diagnoses and Treatment Strategies in 10,077 Cases.

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Background: C2 vertebral fractures in elderly patients are a common injury, associated with high mortality rates.

Research question: Is there an association between the type of treatment, comorbidities, concomitant injuries, and procedures with in-hospital mortality?

Design: Nationwide, retrospective cross-sectional study.

Methods: Data were extracted from the German InEK GmbH database covering the years 2019 through 2021. Patients with C2 vertebral fractures, aged 80 years or older, were divided into two groups; surgically treated and non-surgically treated. The association between potential risk factors, including comorbidities, concomitant injuries, and procedures, and in-hospital mortality was analyzed using odds ratios (OR) with 95% confidence intervals (95%CI).

Results: A total of 10,077 C2 vertebral fracture cases were analyzed. The in-hospital mortality rate was 8.4%, with no statistically significant difference in mortality rates between surgically treated (9.4%) and nonsurgically treated patients (7.9%; p=0.103). Comorbidities, such as chronic kidney disease, dementia, and severe motor dysfunction were associated with higher in-hospital mortality. Traumatic brain injuries, C1 and subaxial vertebral fractures, and rib cage fractures, were indicators for in-hospital mortality. 31.5% (N=3,178) of patients were treated surgically, with a mono-segmental screw fixation being the most frequently applied procedure (44.2%). The only procedures associated with a decreased OR were mono-segmental screw-rod fixation (OR=0.74; p=0.044) and the use of intraoperative navigation (OR=0.45; p<0.01).

Discussion: The study highlights the importance of comorbidities and concomitant injuries as risk factors for inhospital mortality in elderly patients. Fixation with a mono-segmental screw-rod system and the use of intraoperative navigation might be associated with a decreased risk. The findings can aid in clinical patient-centered decision-making and complication prevention.

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Degenerative cervical myelopathy: Chronic trauma leads to chronic alterations of Angiopoetin II, an endogenic angiogenetic mediator in CSF. A notice for extended angiogenesis?

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Objective: Aim of this study is to identify alterations of the proangiogenic protein Angiopoetin II (ANG II) in the cerebrospinal fluid (CSF) in patients with chronic spinal cord injury (SCI) compared to a control group.

Methods: Pre- and postoperative patients with DCM (n=49; 21 female; mean age 62.9±11.28) were included. CSF samples were taken pre- and postoperatively. A control group of patients (n=45; 17 female; mean age 61.06±14.54) with abdominal aortic aneurysm (AAA) was established. AAA patients received a CSF drainage preoperatively.. The neurological status of all

participants was evaluated prior surgery (NDI and mJOA). Controls with any neurological deficit or history of neurological diseases were excluded. Samples were examined by ELISA testing. Protein-concentrations of ANG II in CSF (pg/ml) were analyzed.

Results: Both groups did not differ in terms of age and gender distribution. Groups differed regarding their neurological status (mJOA: DCM 10.96±3.1, AAA 17.28±1.26, $p<0.001$; NDI: DCM 40.2±21.1, AAA 6±8.3, $p<0.001$, and in preoperative ANG II concentration: DCM 276±90, AAA 463±240, $p<0.001$). 3 months after surgery ANG II values were almost unaltered in DCM patients, compared to preoperative values (277±65, $p=0.998$). Subgroup correlation analysis of clinical data showed no significant differences in concentrations of ANG II.

Conclusion: In patients with DCM concentrations of ANG II lower than in controls were found pre- and persistent postoperatively. These results correspond probably to immune mediated secondary harm in chronic spinal cord injury. Chronically reduced angiogenetic activity could be a relevant part of DCM pathogenesis and secondary harm mechanisms to the spinal cord.

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Cervical Motion in Elderly

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Background: The term 'physiological motion of the spine' is commonly used although no proper definition exists. Previous work has revealed a consistent sequence of cervical segmental contributions in 80-90% of young healthy individuals. Age has been shown to be associated with a 0.11° decrease of segmental range of motion (sROM) per year, which means 5° decrease in motion of the total subaxial cervical spine every 10 years of ageing. Therefore, it is of interest to study whether this sequence remains present in elderly.

Research Question: The aim is to investigate if the consistent sequence of cervical segmental contributions in young asymptomatic individuals is also present in elderly asymptomatic individuals. Secondary objectives are the assessment of sROM and cervical sagittal alignment.

Design and Methods: Dynamic extension cinematographic recordings of the cervical spine were made in asymptomatic individuals aged 55-70 years old. Individuals without neck pain and severe degenerative changes were included. Two recordings were made in each individual (T1 and T2). Segmental rotation of each individual segment from C4 to C7 were calculated to determine the sequence of segmental contributions. Secondary outcomes were sROM and sagittal alignment.

Results: Ten individuals, with an average age of 61, were included. The predefined normal sequence of motion was found in 10% in T1 and 0% in T2 of individuals. sROM and total ROM were low in all patients. There was no statistically significant correlation between sagittal alignment, degeneration and sROM in the respective segments, nor between cervical lordosis and total ROM.

Discussion: This study shows that ageing is not only associated with a decrease in ROM, but also with a change in motion patterns, as observed in healthy asymptomatic individuals. The altered contribution of the cervical segments during extension appears not to be caused by degeneration and clinical condition.This study shows that ageing is not only associated with a decrease in ROM, but also with a change in motion patterns, as observed in healthy asymptomatic individuals. The altered contribution of the cervical segments during extension appears not to be caused by degeneration and clinical condition.

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Anatomical study of transverse foramen and vertebral artery in subaxial cervical spine for safe pedicle screw insertion

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Background: Cervical pedicle screw (CPS) is technically-demanding procedure, it should pass cervical pedicle, between spinal canal (SC) and transverse foramen (TF). During surgery with lateral X-ray, probe tip passes lateral to SC first, then medial to TF. TF usually exists anterior to the posterior wall of vertebral body (PW). So, the knowledge, how deep TF exists from PW, is important. This study clarifies the distance from PW to TF and vertebral artery(VA) for safe insertion of CPS.

Methods: Consecutive 96 cases' cervical CT angiograms (CTA) were evaluated retrospectively. The age was 72.6±6.2(range 61-85) yrs, and they were 85 male and 11 females. The distance from PW to posterior margin of TF (PW-TF), to posterior margin of contrast medium, equivalent to VA lumen, (PW-VA) were measured with axial section of CTA. The heights for evaluation were subaxial spine, from C3 to C6.

Results: There was no case with VA entering C7 TF, so measurement was for C3-C6. VA enter from right C5 in 5 cases, left C5 in 8 cases (in them, 2 cases were both side), right C4 in 1 case, and left C4 in 1 case. Typical VA entering C6 was in 83 cases. Lack of right VA was in 3 cases and left VA was in 5 cases. PW-TF were 2.7±1.2mm at C3, 3.3±1.3mm at C4, 3.2±1.3mm at C5 and 2.8±1.4 mm at C6. The PW-TF of C4 and C5 were higher than of C3 and C6 with significance. PW-VA were 3.6±1.2mm at C3, 4.2±1.3mm at C4, 4.5±1.6mm at C5, 4.2±1.3mm at C6. From C3 to C5, that increased with significance.

Conclusion: The distance from PW to TF was 3mm and to VA lumen was 4mm, approximately. When screw is proceeded over the distance, there is risk of VA injury. So, when inserting the CPS, it is necessary to confirm that there is no perforation before proceeding. If it is not certain, it is safe to not proceed anteriorly beyond the PW. It is enough strong if the screw bites the cortex of spinal canal. There are individual differences, so preoperative evaluation is mandatory

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Anatomical landmark to reduce surgical invasiveness to the facet joints in posterior exposure of the cervical spine – A cadaveric and clinical study–

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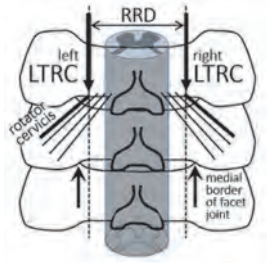
INSTITUTION: Department of Orthopaedic Surgery, National Defense Medical College, Japan

Objective: To identify anatomical landmarks to reduce surgical invasiveness to the facet joint in posterior decompression surgery.

Methods: : (1) The lateral border of tendinous insertion of the rotator cervicis muscle (LTRC), which inserts at the most deep and lateral aspect of the lamina among deep extensor muscles, and the medial border of the facet joint were identified in four cadavers, using a surgical microscope (n=6 joints). Other six facet joints were dissected out to histologically assess the dorsal morphology of the facet joints. (2) Consecutive 30 patients who underwent posterior decompression were involved. Spinal cord width was measured on preop MRI. Intraoperatively, the distance between the bilateral LTRCs was measured and defined as rotator-rotator-distance (RRD). Percentage of the spinal cord width to RRD was calculated.

Results: (1) LTRC was always found slightly medial to the medial border of the bilateral facet joint. The space between LTRC and the medial border of facet joint was macroscopically filled with membranous tissue, instead of a capsule-like fibrous structure. Histologically, the lateral half of the facet joint was covered by the fibrous capsule, however, it was completely missing (n=1) or only a thin fibrous layer was observed in the medial half (n=5). (2) The percentage of the spinal cord width to RRD was 71.1 - 74.3% at each level examined.

Conclusions: LTRC may serve as an anatomical landmark to decide the extent of lateral exposure necessary and sufficient to decompress the spinal cord avoiding unintentional damages to the facet joint.



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Impact of bone-implant gap size on the interfacial osseointegration: an in vivo study

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Objective: To evaluate the impact of bone-implant gap size on the interfacial osseointegrationof cervical disc arthroplasty (CDA) in a rabbit animal model

Methods: A cylindrical (8 mm in diameter with different depth) calvarial bone-implant gapmodel was established to assess the impact of bone-implant gap size on interfacial osseointegration. A series of round-plate implants with different teeth depth (0.5 mm, 1.0 mm, 1.5 mm and 2.0 mm) was specifically designed. A total of 48 NewZealandwhite rabbits were randomly categorized into four groups by the implants theyreceived (0.5 mm: group A, 1.0 mm: group B, 1.5 mm: group C, 2.0 mm: groupD). At 4 th and 12 th week after surgery, animals were sacrificed. Micro-CT, acid fuchsinand methylene blue staining and hematoxylin and eosin (HE) staining were conducted.

Results: At 4th week and 12th week after surgery, both micro-CT and HE staining showed more-new bone formation and larger bone coverage in group A and group Bthan that ingroup C and group D. At 12th week, the bone biometric parameters were significantlysuperior in group C when compared with group D ($p<0.05$). At 12th week, hard tissueslicing demonstrated larger portion of direct contact of new bone to the HAcoatingingroup A and group B.

Conclusion: Bone-implant gap size larger than 1.0 mm negatively affected bone-implant osseointegration between compact bone and HA coated implant surface.

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A novel experimental animal model of delayed palsy after posterior decompression surgery of the cervical spine.

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Background: Posterior shift of the cervical cord was thought to be one of the probable factors causing so called C5 palsy (C5P).

Research Question: Can the structural and functional alterations of cervical roots following posterior decompression be clarified using an animal model?

Design: Basic in vivo research

Methods: Twenty-eight SD rats were divided into Group L (C3-7 laminectomy, N=18) and Group S (sham operation, N=10). The CT myelogram (CTM) was performed before and 3, 10, and 14 days after surgery (Pre, PO3, PO10, PO14, respectively) (Group L, N=5). The 3D-reconstructed images of CTM were created and posterior shift of the cervical cord and the elongation of each anterior rootlet were quantified. Motor evoked potential (MEP) of the deltoid (C5, 6 innervated) and triceps brachii (C7-T1 innervated), mechanical allodynia and grip strength of the forepaw were measured at Pre and PO3, PO7, PO10, and PO14 (Group L: N=8, Group S: N=5). Ultrastructure of the anterior rootlets of C5-8 specimens were examined by TEM.

Results: All anterior rootlets were elongated as the cord gradually shifted posteriorly. The elongation rate of the C6 anterior rootlets was the highest (142% at PO14). The MEP latency of the deltoid was significantly delayed throughout all postoperative time points. However, significant delay in the latency of the triceps brachii was observed only A novel experimental animal model of delayed palsy after posterior decompression surgery of the cervical spine. on PO10. Degenerative change of unmyelinated axons was sporadically observed in the anterior rootlets. Conclusions. Tethering of the anterior rootlets due to posterior cord shift was suggested to be a probable mechanism causing C5P.

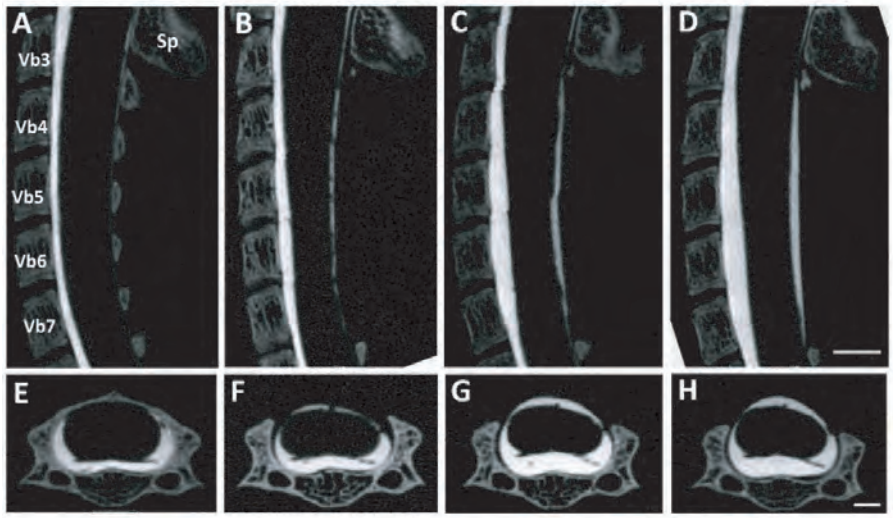

Fig. 1 Sagittal (A-D) and axial (E-G) MPR images of CTM (identical rat). (A, E) Pre and (B, F) PO3, (C, G) PO10, and (D, H) PO14. The scale bars indicate 2 mm (sagittal) and 1 mm (axial). Sp, spinous process of the C2 vertebra; Vb, vertebral body of the cervical spine.

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Spinal glymphatic clearance – a long term (7d) display of spinal perivascular spaces in a mouse model

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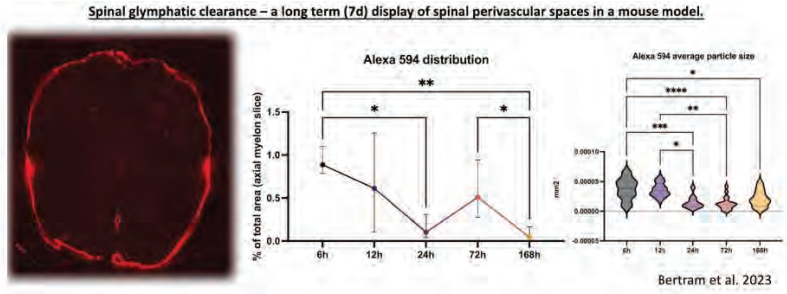
INSTITUTION: Department of Neurosurgery RWTH Aachen University

Background: The circulation within perivascular spaces of the central nervous system (CNS), also known as the "glymphatic system" is enjoying more and more attention. Its potential to transport and clear metabolites as well as drugs into and from neuronal tissue made it an ideal candidate for research in context of neurodegenerative and neuroinflammatory diseases of the brain. However, spinal cords perivascular clearance pathways and dynamics have not yet been properly characterized. Since acute and chronic spinal cord injuries are at least partially driven by an inflammatory component, there is an intrinsic neurosurgical interest to understand spinal cords perivascular clearance dynamics.

Methods: The fluorescence marker Alexa 594 was surgically injected into the cisterna magna of 40 male C57BL/6 mice. Eight animals were euthanized after 6, 12, 24, 72 and 168h respectively and spinal cords dissected for histological analysis. Axial slices were examined via fluorescence microscopy and analyzed using ImageJ version 2.1.0/1.53c to examine tracer distribution. GraphPad Prism v9.4.1 was used for statistical evaluation.

Results: Alexa 594 was found along intramedullary vessels and in the subarachnoid compartment at any given time point. Ordinary one-way ANOVA revealed a significant decrease in stained area of the axial slices over the observed period. A relative decline in stained area comparing 6h (100% ± 63) vs. 24h (15% ± 13;p<.05) 6h vs. 168h (19% ± 32; p<.01) and 72h (80% ± 100) vs 168h (0<.05) as shown by Tukey-test for multiple comparisons, suggests a polynomial function of clearance. The average size of fluorescent particles found within the myelon decreases significantly between 12 and 24h (3.6 ± 1.2x10-5 vs. 1.5 ± 1.1x10 -5mm2 ; p<.05) after intrathecal injection of Alexa 594 displaying a distribution along smaller-caliber vessels.

Conclusion: We demonstrate a mouse model to perform medium to long-term observation of glymphatic circulation as a basis for comparative studies in pathological conditions. To our knowledge this is the first display of perivascular influx and long term circulation from subarachnoid space into the spinal cord and vice versa. Its role in spinal cord injury can be derived from multiple studies of the brains clearance but must be investigated further.



ABSTRACTS

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Evaluation of Bone Mineral Density of Vertebral Body in the Cervical Spine

***Shingo Aoyama, Hiroshi Miyamoto+, Terumasa Ikeda, Nobuhito Nango++, Masao Akagi + Kobe Rosai Hospital ++ RATOC SYSTEM ENGINEERING CO., LTD**
INSTITUTION: KINDAI UNIVERSITY HOSPITAL

Background: Osteoporosis is the cause of vertebral body and proximal femur fractures. The quantitative examination is performed by dual-energy X-ray absorptiometry (DEXA) and computed tomography (CT). Since osteoporosis increases the risk of postoperative adjacent segmental fracture, it is important to evaluate the bone mineral density (BMD) before surgery. It has been reported that the BMD of the cervical spine is different from that of the thoracolumbar spine, but there are few reports about BMD of the cervical and the upper thoracic spine.

Design: Preoperative cervical spine CT were collected from 28 subjects (Male: 18 cases/Female: 10 cases/ Average age: 69.8 years old) who suffered the cervical spine disease at our institute. 3D trabecular bone structure measurement software (TRI/3D-BON-FCS: RATOC SYSTEM ENGINEERING CO., LTD) was used for the evaluation. Measurements were performed on the cervical (C3～7) and upper thoracic (Th1～4) vertebral bodies. Evaluation items were BV/TV (%), cancellous bone volume BMD: vBMD (mg/cm3) and V*m space (mm3) which are numerical indexes of osteoporosis. We evaluated the measured value in each vertebral body and the correlation with YAM value of femoral neck measured before surgery.

Results: BV/TV, vBMD and V*m space of the cervical and the thoracic spine varied at each level. BV/TV and vBMD were highest at C4, and followed by C5, C3, C6 and C7. V*m space was the lowest at C4, followed by C5, C3, C6, and C7. In the thoracic spine, BV/TV and vBMD were maximum and V*m space was minimum at Th1. Th2,3 and Th4 were tended to decrease each values. There was a strong positive correlation between BV/TV, vBMD and the YAM value at C3 and positive correlation at C4,5,6,7. In addition, a negative correlation was observed for V*m space in all cervical vertebrae. In the thoracic spine, there were strong positive correlation at Th3, 4 and a positive correlation at Th1, 2.

Discussion: In the past studies, the cervical spine BMD were high values in C4, 5 and lower values in C3,6 compared to C4,5, and the lowest values in C7. This study showed the same tendency and the thoracic spine BMD tended to decrease toward the caudal side. Since there is a correlation between the femoral YAM value and the cervical and the upper thoracic vertebrae bone density, preoperative DEXA and cervical vBDM evaluation may predict the risk of adjacent segmental fractures in cervicothoracic fusion surgery.

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Traslational dynamism allows higher transfer load even after graft shortening, with less plate stress avoiding failure: a combined biomechanical study with FEM and essays in an ACCF model

***Javier Melchor Duart Clemente, Carlos Atienza Vicente**
INSTITUTION: Valencia General Hospital

Background: Cervical plates stabilizes vertebrae after anterior decompressive procedures; nevertheless, its stabilizing property may negatively affect load transfer if stiffness is too much. On the other hand, there is concern about load transfer after graft shortening, as the contact between vertebral plate and graft may be suboptimal

Research Question: Do traslational dynamic plates transfer more load than static ones independently of implant material or design?

Design: Biomechanical study comparing load transfer and plate stress with a same plate design working either with static or dynamic mechanism.

Methdos: This biomechanical study consists of both a Finite Elemente Model (FEM) as well as biomechanical essays.

A FEM is a computer-generated design; in this case, ANSYS 10 software was used combining both geometrical and mechanical properties of human cervical vertebrae. After developing and validating the cervical FEM, a C6 corpectomy model with plate reconstruction was developed and tested.
For the biomechanical study, a simulation of one Functional Vertebral Unit (FVU: two adjacent vertebrae together with the intervertebral disc between them) was simulated with polyethylene blocks for the vertebrae and with plastic materials similar to disc`s rigidity. With an INSTROM tensile testing machine, flexocompression force was applied at 0.42mm/s under controlled displacement (following ISO12189: 2008 guidelines), and rigidity and displacement between plate and polyethylene were recorded.

Resalts: As can be seen with the Von Misses equivalent tensions, when the plate is working under static configuration most of the load goes through the plate, overloading it, while only a small proportion of the load goes through the graft. On the other hand, when the plate is in dynamic configuration the load is distributed not only on the plate but also and mainly through the graft.

After simulated shortening of the graft, in static situation the load transmitted from C5 to C7 hardly any at all goes through the graft, overloading the plate. Whilst when the plate is dynamic, there is maintenance of contact between the vertebral plates and the bone graft, allowing load transmission.

Discussion: Traslational dynamic plates enable more load transmission through the graft both in inmediate postoperative scenario and after graft shortening, contrarily to the same plate working in static configuration, which is overloaded specially after graft shortening. Dynamic plates should be used to foster bony fusion and to avoid plate overloading, which could lead to construct failure and/or plate breakage due to excessive tensions.

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Electromyographic analysis of mechanical load scenarios of the cervicothoracic junction: First in-vivo study to evaluate the potential decrease of myofascial dehiscences following posterior cervicothoracic fusion

***Sebastian Decker, Heiko Koller, Emmanouil Liodakis, Stephan Sehmisch, Sonja Körner, Bennet Mathis Schröder**
INSTITUTION: Hannover Medical School - Department of Trauma Surgery

Objective: Soft tissue complications following cervicothoracic fusion surgery occur frequently. Postoperative myofascial dehiscence (PMD) can cause disability and pain. This study aimed to analyze how much mechanical stress daily activities postoperatively exert on the posterior muscles and fascia after cervicothoracic fusion surgery.

Methods: Surface electromyography (EMG) was applied next to the upper thoracic spine at the trapezius muscle. Volunteers performed 22 different daily activities, such as tooth brushing or. During the exercises, the electromyographic activity was measured. For each volunteer, root mean square (RMS) values were determined. All exercises were then repeated with the use of a clavicular bandage to unload the shoulder and cervicothoracic muscles. Afterwards the rankings were statistically compared interindividually.

Results: Among the different tasks significant differences in regard to the RMS-values were noted. For instance, horizontal positions caused significantly lower muscle activation compared to all other exercises ($p \leq 0.001$). Notably, no relevant electromyographic differences were detected between the tasks with and without a clavicular bandage. Relevant results are presented in table 1.

Conclusions: This in-vivo electromyographic analysis of cervicothoracic muscle activity demonstrates that myofascial strain differs among various daily activities. Data indicate that postoperative mobilization protocols and behavioral instructions may have the potential to reduce the biomechanical load and consequently the risk of PMD and therefore may reduce the risk for surgical wound-related complications, disability, and need for revision surgery.

Ranking	Activity	Mean RMS- value (µV) without clavicular bandage	Mean RMS- value (µV) with clavicular bandage	p- value
1	Taking on and off a T-shirt	18.23	18.44	0.793
2	Taking on and off trousers	17.82	18.12	0.672
3	Lifting a 5 kg weight	15.85	16.62	0.438
4	Walking with swinging arms	15.32	11.78	0.001
5	Standing up from supine position	14.91	16.67	0.114
6	Standing up gentle from supine position	14.12	12.91	0.217
7	Using knife and fork	13.80	14.76	0.243
8	Touching the back of the neck	13.64	13.94	0.806
9	Taking a 500 ml water bottle from the bed stand	13.62	14.71	0.260
10	Standing up from a chair and sitting down again	13.08	11.73	0.201
11	Tying shoes	12.92	14.19	0.324
12	Brushing teeth	12.01	11.92	0.920
13	Coughing	11.42	8.30	0.011
14	Passive mobilization out of bed	11.01	12.28	0.236
15	Shoulder abduction up to 90°	10.98	9.76	0.275
16	Putting on an apron	10.85	12.16	0.314
17	Shoulder anteversion up to 90°	9.51	9.96	0.716
18	Opening and closing a water bottle	9.39	11.60	0.020
19	Prone position	5.41	4.10	0.018
20	Right lateral position	3.87	4.26	0.536
21	Left lateral position	3.58	3.35	0.780
22	Supine position	1.55	1.32	0.445

Figure 1: RMS values with and without the use of a clavicular bandage.

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Interbody fusion device in the treatment of cervicobrachial syndrome; a prospective 5-year follow up extension study of porous titanium cervical cages

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Background: 3D-printed titanium has been introduced as an alternative implant technology for anterior cervical discectomy and fusion (ACDF) using an interbody cage. The porous titanium cage design is intended to facilitate spinal fusion, but the contemporary scientific literature lacks conclusive long-term clinical and radiological data.

Research Question: Evaluation of Neck Disability Index (NDI) and fusion status at the 5-year time point compared to the 12-month time point from the previously performed EFFECT trial on porous titanium cervical cages.

Study Design: The study is designed as a prospective consecutive follow up of 49 subjects, previously enrolled in the EFFECT trial, to evaluate safety and efficacy with 5 years post-operative followup. At the five-year follow-up, 31 patients were included for final analyses.

Methods: The primary objective was the evaluation of NDI at five years after surgery. The secondary objective was to examine fusion, clinical results, safety and complication rate. Fusion and subsidence were measured at the five years post-operative time-point, using flexionextension radiograph. Clinical results were determined from Patient Reported Outcome Measures being VAS arm, VAS neck, EQ-5D and the Likert perceived recovery.

Results: The fusion rate increased to 100% at five years compared to 91.5% at 12 months at the index level, while the cervical spine demonstrated physiological motion of on average 40.4° at five years (C2-C7 RoM). The segmental lordosis at the treated segment yielded 4°. None of the evaluated cages experienced AP-migration greater than 1 mm at final follow-up. At five years, an average subsidence of 1.4 mm was determined in comparison to 1.2 mm at 12 months. Clinical data were not yet analyzed at the moment of writing the abstract.

Conclusions: 3-D printed porous titanium implants reveal promising fusion results after five years. Furthermore, the study demonstratesthatsingle level anterior cervical fusion can be achieved without additional plating. To supplement the radiological result, long-term clinical success and analysis of patient-reported outcomes is required, and will follow

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When to Initiate Post-Operative Physical Therapy in Multilevel Posterior Cervical- Thoracic Fusions?

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INSTITUTION: Ascension Texas Spine and Scoliosis

Background: The role of Physical Therapy (PT) in patients undergoing surgery for cervical spondylotic myelopathy is understudied and not well understood

Research Question: When should neck strengthening exercise be initiated after multilevel posterior cervical-thoracic fusions

Design: Retrospective study

Methods: Chart reviews were conducted on patients who underwent a ≥3 level posterior cervico-thoracic fusion with caudal levels as C7 and T1/T2. Prescription and completion of physical therapy (PT) were study inclusion criteria

Results: 105 patients were included in the study and were divided into two cohorts: those that initiated PT ≤ 6 weeks post-op and those who initiated PT > 6 weeks post-op. 58 patients were included in the Early PT cohort, and 47 were included in the Late PT cohort. Demographically, the Early PT and Late PT cohorts were similar in age (62.8 vs 61.1 years) and predominantly female (64.5% vs. 67.6%). No significant difference was reported between the groups in body mass index, with a mean of 30.7 for Early PT and 31.2 for Late PT. While both cohorts

showed improvement in radiographic parameters and patient reported outcomes at 2 years post-op, there were significant differences in level of improvement between the two groups. The Early PT group had a comparatively better % improvement (2wk vs. 2 years postop) in cervical lordosis (25.2% vs 14.2%); mean T1 slope (-5.6% vs. -2.6%); and mean C2-C7 sagittal plumbline (-15.2% vs -11.7%). Patients who started PT ≤ 6 weeks post-op also reported greater visual analog scale % improvement 61.9% vs 41% and oswestry disability index % improvement 46.3% vs. 29.6% at 2 years post-op

Discussion: Patients who underwent a three or more-level posterior cervico-thoracic fusion and started PT at or before 6 weeks post-op exhibited greater radiographic and patient reported outcomes benefits than those starting PT more than 6 weeks post-op. The results of this study support the early initiation of neck strengthening PT in most uncomplicated post-cervical fusion adult patients.

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What Effect Does T1 Slope Have on Sagittal Balance and the Relationship with Caudal End of Three or More Level Posterior Cervical Fusions?

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Background: Extending posterior cervical fusions into the upper thoracic spine for degenerative cervical pathologies has been thought to reduce rates of pseudoarthrosis and distal junctional kyphosis, leading to overall improved clinical outcomes

Research Question: Investigate the effect of T1 slope on post-operative Sagittal Vertical Axis (SVA) and whether extension of posterior cervical fusions into the upper thoracic spine (T1/T2 caudal levels) provides improved sagittal balance in comparison to C7 caudal level

ABSTRACTS

Design: Retrospective study

Methods: A database of 327 patients from seven different centers who underwent a three or more-level posterior cervical fusion was created. Two cohorts were created based on fusion caudal level: C7 or T1/T2. The cohorts were then divided again into two subgroups, high T1 slope (>25°) and low T1 slope (≤25°)

Results: 224 patients were included in the C7 caudal and 103 were included in the T1/T2 caudal cohort. The C7 cohort was 55% female, with a mean age of 61±12 yrs. The T1/T2 cohort was 44% female with a mean age of 63.1±12.6 yrs. Mean BMI of the C7 was 28.9±6.8, and 29.1±5.8 in the T1/T2 cohort. Mean SVA was significantly higher in patients with high T1 slopes as compared to patients with Low T1 slopes across all time intervals. The 25th percentile SVA of High T1 slopes were greater than the median SVA values of Low T1 slopes at all intervals. For both the high and low T1 slope cohorts, patients with a caudal T1/T2 had higher SVA values than their C7 counterparts at all intervals despite maintenance of cervical lordosis, however these differences were not statistically significant

Conclusion: Increased sagittal imbalance was higher in patients with >25° T1 slope ranging across preoperative to 24 months postoperative. Extension of the posterior cervical fusion to T1 or T2 did not improve sagittal balance in patients with high T1 slopes. The results of this study do not support routinely extending posterior cervical fusions into T1 or T2 to improve postoperative sagittal balance.

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Radiographic predictors of subaxial subluxation after atlantoaxial fusion

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Background: Subaxial subluxation (SAS) can develop after surgery despite atlantoaxial fusion with the optimal C1-C2 angle.

Research Question: To clarify preoperative radiographic predictors associated with the development of SAS after atlantoaxial fusion for atlantoaxial instability (AAI).

completion of physical therapy (PT) were study inclusion criteria

Design: Retrospective study

Methods: Patients who underwent surgery for AAI with a minimum five-year follow-up and control participants were included. Radiographic parameters were measured. We focused on the angular contribution ratio in the upper cervical spine to the whole cervical lordosis, and the C2/T1-slope ratio was defined as the ratio of C2 slope (C2S) to T1 slope (T1S).

Results: Twenty-seven patients (SAS=11, no-SAS=16; mean age, 60.7 years old; mean follow-up duration, 6.8 years) and 23 demographically matched control participants were enrolled. The SAS onset was at 4.7 postoperative years. Preoperatively, the O-C2 angle, C2-C7 lordosis, and T1S were comparable between the SAS, no-SAS, and control groups. The preoperative C2S and C2/T1-slope ratio were smaller in the SAS group than in the no-SAS or control group (C2S, 11.0° vs. 18.4° vs. 18.7°; C2/T1-slope ratio, 0.49 vs. 0.77 vs. 0.78, $P<0.05$).
The receiver-operating characteristic curve analysis demonstrated that the C2/T1-slope ratio had higher specificity and similar sensitivity as a predictor of postoperative SAS than C2S (specificity 0.90 vs. 0.87; sensitivity 0.73 vs. 0.73). The estimated cut-off values of the C2S and C2/T1-slope ratio were 14° and 0.58, respectively.

Discussion: The preoperative C2/T1-slope ratio was closely associated with postoperative SAS. Patients with a C2/T1-slope ratio <0.58 were at a high risk of SAS after atlantoaxial fusion.

ABSTRACTS

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The characteristics of cervical extensor muscles in dropped head syndrome

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Background: The pathophysiology of dropped head syndrome (DHS) is unknown. Although it is believed that neck extensor muscles atrophy may be a cause of DHS, there have been no reports of measuring the area of the neck extensor muscles.

Research Question: Is the extensors muscle atrophy in the cervical spine a cause of DHS?

Design: Retrospective study

Methods: Twenty patients with DHS (all female, mean age of 73.7 years) were enrolled. The multifidus, semispinalis cervicis, semispinalis capitis, and group of splenius capitis and splenius cervicis at each intervertebral level (C2/3-C6/7) were measured using the volume analyzer SYNAPSE VINCENT ® (Fujifilm Medical Corporation) in the horizontal section of the MRI, Twenty patients with cervical spondylotic myelopathy in whom gender and age matched (all female, mean age of 73.9 years) were selected as controls (group C). The results were compared between DHS group (group D) and group C. In addition, the percentage of fatty infiltration of the extensor muscles was measured on histograms and was compared between the groups.

Results: The semispinalis cervicis of group D was significantly larger at the C2/3 to C4/5 and C6/7 heights compared to group C. The group of splenius capitis and splenius cervicis were significantly larger at all height respectively. There were no significant differences among the other muscles. The area of the extensor muscles of group D was significantly larger than that of group C at the C2/3 and C3/4 levels. However, there was no significant difference in the percentage of fatty infiltration between the groups.

Discussion: The present study has indicated, for the first time, that cervical extensor muscles are not atrophic but hypertrophic at the semispinalis cervicis, group of splenius capitis, and splenius cervicis using the area measurement of MRI. Also, it has been revealed that increase of the area of the extensor muscles was not affected by the fatty infiltration because the percentage did not differ. Therefore, extensor muscle atrophy may not be a trigger of DHS, and other pathologies such as neurogenic, myogenic, and structural, should be investigated as a cause of DHS.

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Preoperative Optimization of Modifiable Patient-Related Factors Reduces the Risk of Distal Junctional Kyphosis (DJK): A Virtual Analysis of a Novel Multicenter Complex Adult Cervical Deformity Database

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Background: Potentially modifiable patient-related factors have not been well studied in complex adult cervical deformity (ACD) surgery, especially in the context of distal junctional kyphosis (DJK).

Research Question: Modifiable baseline patient-related factors may predict increased virtual risk of DJK after complex ACD surgery.

DESIGN: Retrospective, single-center

METHODS: Complex ACD patients with baseline (BL) data were included, excluding those indicated for DJK revision. Virtual risk of DJK was assessed per Passias et al. BL-only factors: 1) prior diagnosis of diabetes, hypertension, or depression 2) presence of BL neurological impairment 3) BL C2-T3 >31^0). BL data correlating to a virtual risk was assessed via backstep logistic regression. CIT determined thresholds for significant factors. Means comparison assessed differences in BL patient-reported outcomes and frailty [Edmonton, Adult Cervical Frailty Index (ACFI)] in patients considered Optimized (Opt) vs not (nOpt).

RESULTS: 52 ACD patients were included (60.4±15.4, sex: 68.8% F). Virtual analysis revealed 30.8% of patients were predicted to suffer DJK by 2Y. Logistic regression revealed significant demographic, nutritional and metabolic factors predictive of DJK were: BMI <18.5 or >30, bone health per total spine DEXA T-score < 1.1, HgA1C > 7.0%, ESR > 15.7 mm/hr, INR > 0.9, Albumin > 4.2 g/dL, Hematocrit > 41.7% (model p=.010). CIT analysis revealed that optimization of a minimum of 3 variables was associated was protective against development of DJK [.727 (.591-.895), p=.003]. Of the total cohort, 73.1% were considered Opt.

DISCUSSION: Through virtual risk analysis, we demonstrate that empiric modifiable metabolic and nutritional factors, as well as pre-operative bone health, are significantly associated with predicted risk of distal junctional kyphosis by 2Y. As such, surgeons should consider reduction of >3 risk factors pre-operatively to reduce complications in complex adult cervical deformity patients.

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Impact of intervertebral foramen area after cervical spinal correction surgery

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Introduction: Laminoplasty enables sufficient decompression in multi-segmental cervical spondylotic myelopathy (CSM). However, CSM with kyphosis may lead to poor surgical outcomes by interfering with posterior shifting of the spinal cord. In such case, corrective fixation using cervical pedicle screw (CPS) is selected. In the other hand C5 nerve palsy is a troublesome complication in surgery for cervical myelopathy. However, the precise mechanism is still unclear. The purpose of study was to investigate the effect of correction surgery by CPS for intervertebral foramen.

Methods: Forty-five patients who underwent correction surgery using CPS (25 male.20 female, a mean of 73 years old) were enrolled in the present study. 87 fusion level (174 foramen) were evaluated foraminal area (FA), head-caudal diameter and anteroposterior diameter in CT reconstruction image at preoperation(pre-op) and final follow-up (FU). C2/7 angle and local angle were measured in XP. We statistically evaluated the change of FA and diameter between pre-op and FU. Correlations between local correction angle and FA, diameter were further evaluated.

Results: Postoperative FA was 28.6mm2 at pre-op and 30.7mm2 at FU (p,0.004). C2/7 were -3.3/3.3 degree and local angle were -0.01/ 0.43 degree (pre-op/ FU). Diameter of head/-caudal and antero-posterior were 7.9 and 3.8 mm2at pre-op, 8.3 and 3.8mm2 at FU. The correlation between corrected local angle and FA was significantly negative correlation (p,0.03). Furthermore, the anteroposterior diameter of the foramina after correction by CPS showed a significant negative correlation. The foramina decreased when the local angle was corrected by 10 degrees or more, and significantly narrowed (15%) in 15 degrees or more.

Discussion: When we are going to plan cervical correction surgery for dropped head syndrome or cervical myelopathy with kyphosis, it is necessary to avoid corrective angle 10 degree at each level.

ABSTRACTS

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High cervical fixed severe kyphosis in adult cases with Down syndrome

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Background: Although the number of adult patients with Down syndrome has increased, there are no coherent reports on the surgical treatment of its high cervical kyphosis. We report our clinical results of surgical treatment for this intractable deformity.

Materials & Methods: Consecutive six adult Down syndrome patients with severe heigh cervical kyphosis who were operated on from 2014 to 2020. Age at surgery: 20-48 years (avr. 28.8 years), common skeletal abnormality: os odontoideum and steep slope of the C1/2 facet joint. Preoperative symptoms: difficulty in raising the upper limbs, non-ambulatory or severe gait disturbance due to myelopathy/ataxia. All cases underwent occipito-cervical corrective fusion. Post-operative follow-up period: 24 -60 months (avr. 42.3 months). Perioperative complications, bony union, and correction status were examined. JOA scoring for neurologic evaluation could not be utilized because of their poor communication.

Results: Solid bony union was obtained in all cases. Average C0-C2 correction angle was 27 degrees. Four non-ambulatory patients became to walk independently postoperatively. Five patients who could not raise their upper extremities were able to raise them after surgery. Postoperative major complications; DJK developed in two patients and required caudal extension of fixation. Allodynia and infection occurred in one patient, respectively.

Discussion & Conclusions: Although these surgeries are technically demanding, even non-ambulatory patients can be expected to improve sufficiently.
Intra-articular dissection in C1/2 facet joint was the key procedure for realignment in most cases. Preoperative data on sagittal alignment and balance were obtained only from sitting radiographs due to severe paralysis, making it difficult to compare the results with already-known sagittal morphologic studies using standing radiographs. Further discussion will be required on this issue.

Figure: Typical preoperative radiograph

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Can Thoracic Inlet Angle Be Used as a Substitute for T1 Slope?

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Background: T1 slope is an important radiographic parameter of sagittal spinal balance for surgical planning. However, the T1 superior endplate can be difficult to visualize on radiographs due to overlying anatomical structures.

Research Question: This study aimed to investigate the usefulness of preoperative TIA for predicting the development of kyphotic deformity after cervical laminoplasty.

Design: Retrospective observational study

Methods: The authors retrospectively extracted data for patients with cervical myelopathy who underwent cervical laminoplasty with a minimum 2-year followup. Patients were divided into 2 groups according to the occurrence of postoperative cervical kyphosis. The T1S was measured on a standing radiograph. The TIA is defined as the angle formed by a line from the center of the T1 upper endplate vertical to the T1 upper endplate and a line connecting the center of the T1 upper endplate and the upper end of the sternum. The TIA was evaluated by MRI in a supine position. We examined the correlation analysis between the preoperative T1S and TIA.

Results: A total of 98 patients were enrolled (mean age 73.7 years; 41.8% female). Postoperative kyphosis occurred in 11 patients (11.2%). In the kyphosis group, both preoperative T1S and TIA were smaller compared with the nonkyphosis group (T1S, 23.5° ± 14.5° vs. 30.3° ± 9.1°, P = 0.03; TIA, 76.1° ± 10.2° vs. 81.8° ± 8.3°, P = 0.04). There was a positive correlation between the preoperative T1S and TIA (correlation coefficient, r = 0.43; P < 0.001).

Discussion: The preoperative TIA showed similar accuracy and reliability as a predictor of postoperative kyphosis compared with the preoperative T1S. The preoperative TIA can be used as a substitute to estimate the T1S when the superior endplate of T1 is not well visualized.

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Efficacy and safety of oblique posterior endplate resection for wider decompression (trumpet shaped decompression) during anterior cervical discectomy and fusion

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Objective: Oblique resection of the posterior endplate (trumpet shaped decompression [TSD]) during ACDF could widen the workspace, enabling removal of lesions behind the vertebral body. The study was conducted to evaluate the efficacy and safety of oblique posterior endplate resection for wider decompression.

Methods: Three-hundred and thirty-three patients who underwent ACDF for the treatment of cervical myelopathy/radiculopathy and were followed up for ≥1 year were retrospectively reviewed. Patients who underwent TSD during ACDF (TSD group) and those who underwent surgery without TSD (non-TSD group) were compared.

Results: In the TSD group, 28.2±5.5% of the endplate was resected, and 26.0±6.1% of the region behind the vertebral body could be visualized via the TSD technique. The resection angle was 26.9±5.9°. The fusion rate assessed on the basis of interspinous motion, intra-graft bone bridging, and extra-graft bone bridging did not significantly differ between the two groups. Furthermore, there were no significant intergroup differences in subsidence. The patient-reported outcome measures at 1-year follow-up were not also significantly different between the groups.

Discusssions: TSD widened the workspace during ACDF, and 26% of the region posterior to the vertebral body could be accessed using this technique. The construct stability was not adversely affected by TSD as demonstrated by the similar fusion and subsidence rates among the patients who underwent TSD and those who did not. Therefore, TSD can be safely applied during ACDF when compressive lesions extend behind vertebral body and are not limited to the disc space, enabling adequate decompression without disrupting the construct stability.

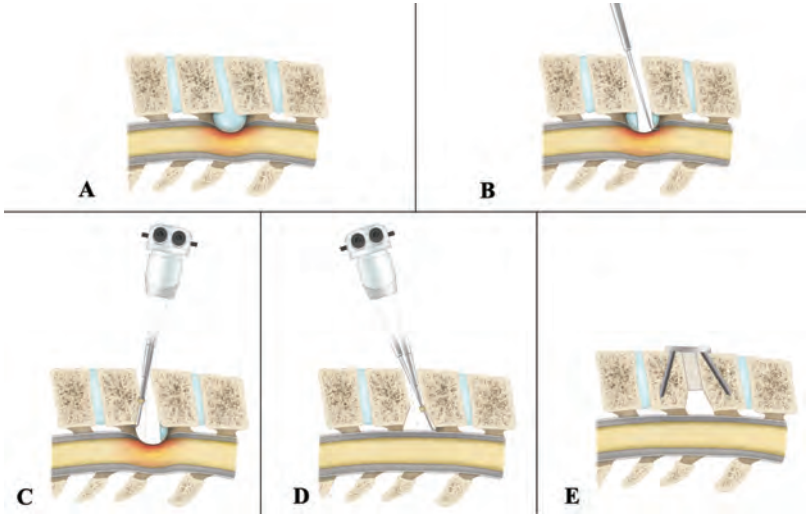

Figure 1. Technical description of TSD. (a) TSD is indicated when the location of compressive lesions, including herniated disc, spur, or ossification of the posterior longitudinal ligament, is not confined within the disc space but extends cranially or caudally and is located at the posterior aspect of the vertebral body. (b) Complete discectomy is performed in a usual manner. The location of the compressive lesion is confirmed via palpation using a micro-curette. (c) After tilting of the microscope caudally to visualize the upper endplate of the caudal vertebra, the posterior one-third of the endplate is resected using a high-speed burr. The compressive lesion is removed using a microcurette and Kerrison punch. (d) The same procedures are performed for the lower endplate of the cranial vertebra after tilting the microscope cranially. (e) The interbody spacer should be located anteriorly, where the endplate is preserved. An anterior cervical plate is then applied.

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Tissue discrimination by bioelectrical impedance during PLL resection in anterior decompression surgery for treatment of cervical spondylotic myelopathy

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Objective: The electrical properties of biological tissues differ depending on their physical properties. This study aimed to explore if bioelectrical impedance (modulus and phase) would discriminate tissues relevant to resection of the posterior longitudinal ligament (PLL) in anterior cervical decompression surgery.

Methods: PLL resection via an anterior approach was performed on the C4/5 segments in six mini-pigs. The bioelectrical impedance measurements were performed for two tissue groups (annulus fibrosus, endplate cartilage, sub-endplate cortical bone, and PLL; PLL, dura mater, spinal cord, and nerve root) using a novel probe and a precision inductance-capacitance-resistance meter. For each group, impedance was analyzed in terms of modulus and phase along a broad spectrum of frequencies (200-3000 kHz) using a nonparametric statistical analysis (Kruskal-Wallis).

Results: The analysis showed a clear difference among the tissues. The modulus and phase show the same changing trend with frequency and present lower values at higher frequencies. Among annulus fibrosus, endplate cartilage, sub-endplate cortical bone, and PLL, it was possible to discriminate each tissue at every frequency point, considering the phase ($p < 0.05$), while this was not always the case (i.e., annulus fibrosus vs PLL at frequency of 200 kHz, 400 kHz, and 3000 kHz, $p > 0.05$) for modulus. Among PLL, dura mater, spinal cord, and nerve root, for every comparison, a statistically significant difference was reported in the modulus, phase, or both ($p < 0.05$).

Conclusions: The results indicated the potential of bioelectrical impedance to provide real-time tissue differentiation and enhance safe PLL resection in anterior cervical decompression surgery, particularly in robot-assisted minimally invasive surgery (RMIS).

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Segmental slope is a predictor of fusion rate in single level anterior cervical discectomy and fusion

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Objective: To explore preoperative segmental slope as a predictor of fusion rate after single-level anterior cervical discectomy and fusion (ACDF).

Methods: Data of consecutive patients with single-level cervical spondylosis who underwent ACDF between 2011 and January 2019 were retrospectively reviewed. Preoperative parameters including baseline characteristics, segment slope, T1 slope, range of motion, intervertebral disk height, and bone density were evaluated. Data were analyzed using Student's t-test, Mann–Whitney U test, $\chi 2$ test, Fisher's exact test, multivariate logistic regression analysis, and receiver operating characteristic curve.

Results: In total, 253 patients were selected. The mean follow-up was 32.1 months (range 24-99 months). Male sex, body mass index, preoperative segment slope, T1 slope, operative levels, and osteoporosis or osteopenia were associated with non-fusion at an early stage after surgery. However, no statistically significant difference was observed at the last follow-up. Multivariate logistic regression analysis revealed that the preoperative segment slope was an independent predictor for non-fusion at 3, 6, and 12 months postoperatively. Osteoporosis or osteopenia was an independent predictor of non-fusion at 6 and 12 months postoperatively. The area under the curve was 0.874 at 3 months ($p<0.001$, cutoff value 10.21°), 0.888 at 6 months ($p<0.001$, cutoff value 14.56°), and 0.825 at 12 months ($p<0.001$, cutoff value 21.08°).

Conclusions: Preoperative segment slope can be used as a predictor of early fusion rate after single-level ACDF. We determined detailed cutoff values . This study may help surgeons take measures to promote early fusion in advance.

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Effect of preoperative segmental range of motion on patient outcomes in cervical disc arthroplasty

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Background: The current cervical disc arthroplasty (CDA) indication criteria, based onthepreoperative segmental ROM, comprises a wide range of variability. This study aims to investigate whether the patients with preoperatively limited or excessive segmental ROM are suitable candidates for arthroplasty

Methods: This was a retrospective study of patients who underwent CDA between January 2008and October 2018 in our hospital. They were divided into the small-ROM(≤5.5°) andthe large-ROM (> 12.5°) groups according to preoperatively index-level ROM. Clinical outcomes, including the JOA, NDI, and VAS scores, were evaluated. Radiological parameters, including cervical lordosis, disc angle (DA), global andsegmental ROM, disc height (DH), and complications

Results: There were 64 patients in the small-ROM and 62 in the large-ROMgroup. There weremore patients diagnosed with cervical spondylosis in the small-ROMthan inthelarge-ROM group. Patients in both groups had significantly improved JOA, NDI, andVAS scores after surgery. Patients in the small-ROM group had dramatic postoperative increase in cervical lordosis, global and segmental ROM. However, there was a paradoxical postoperative decrease in global and segmental ROMinthelarge-ROM group postoperatively. Patients in the small-ROMgroup had lower preoperative DH, and a higher rate of postoperative HO.Patients in the small-ROMgroup had lower preoperative DH, and a higher rate of postoperative HO.

Conclusion: Patients with preoperatively limited segmental ROM had severe HO, and

achievedsimilar postoperative clinical outcomes as patients with preoperatively excessivesegmental ROM. Patients with preoperatively limited segmental ROMshowedapostoperative increase in segmental mobility, which decreased in patients withpreoperatively excessive segmental ROM.

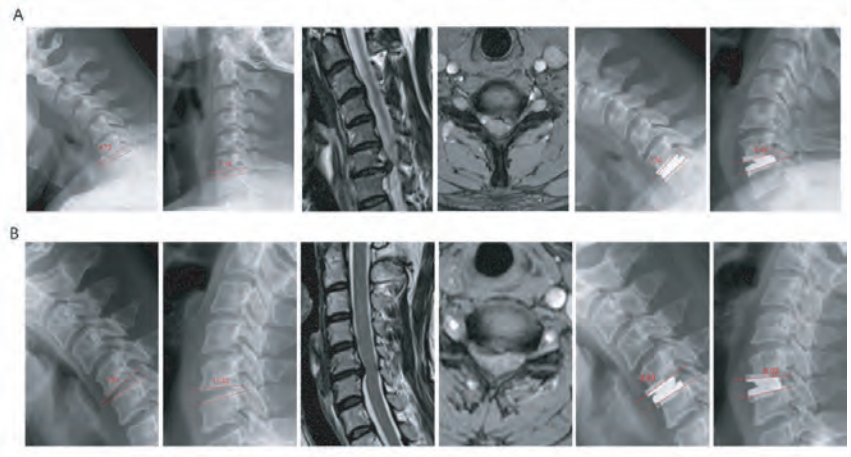

Fig. 1 A. A patient underwent CDA at C6/7 using Prestige-LP discs in the small-ROMgroup. Preoperative segmental ROM was measured at 3.48° using lateral flexion-extension X-rays. Preoperative MRI demonstrated disc herniation at C6/7. X-rays at 50 months follow-up showing increased segmental mobility (ROM=9.50°) at the arthroplasty segment. B. A patient in the large-ROM group underwent CDAat C5/6 using Prestige-LP discs. Preoperative segmental ROM was measured at 17.19°using lateral flexion-extension X-rays, and MRI showed disc herniation at C5/6. TheX-rays recorded at 50 months follow-up showing decreased segmental mobility(ROM = 11.45°) at the arthroplasty segment.

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Cervical disc arthroplasty versus anterior cervical discectomy and fusion for the treatment of single-level disc degenerative disease with preoperative reversible kyphosis

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INSTITUTION: West China Hospital, Sichuan University

Objective: The purpose of the study was to compare the clinical and radiological outcomes of single level CDA and single-level anterior cervical discectomy and fusion (ACDF) inthe patient with preoperative reversible kyphosis.

Methods: From 2014–2018, patients who underwent single-level CDA and single-level ACDFwere consecutively reviewed. The Japanese Orthopedic Association score, NeckDisability Index and VAS were used to evaluate clinical outcomes. Range of motion(ROM), C2-7 Cobb angle, functional spinal unit (FSU) angle, and heterotopicossification (HO) were assessed.

Results: Thirty-eight CDA patients (a mean follow-up of 39.8 months) and 42 ACDF patients (37.6 months) with preoperative reversible kyphosis were included. Both groups hadsignificant improvements in clinical outcomes, without statistically significant differences. After surgery, both groups had a significant increase in C2-7 angle andFSU without significant inter-group differences. At the last follow-up, the C2-7 ROMwas preserved in both groups. The segmental ROM of CDA group decreased mildlyfrom 8.3◦ preoperatively to 5.1◦ finally, whereas the segmental ROMof ACDFgroup decreased significantly to nearly zero. 60.5 % (23/38) patients in CDAgroupdeveloped HO with 9 levels of grade III and 3 levels of grade IV.

Conclusions: For the patients with single-level disc degenerative disease and preoperativereversible kyphosis, both CDA and ACDF achieved satisfactory and comparableclinical results. CDA was non-inferior to ACDF regarding the radiological outcomes of cervical alignment. Patients in CDA group had a relatively high incidence of HOformation.

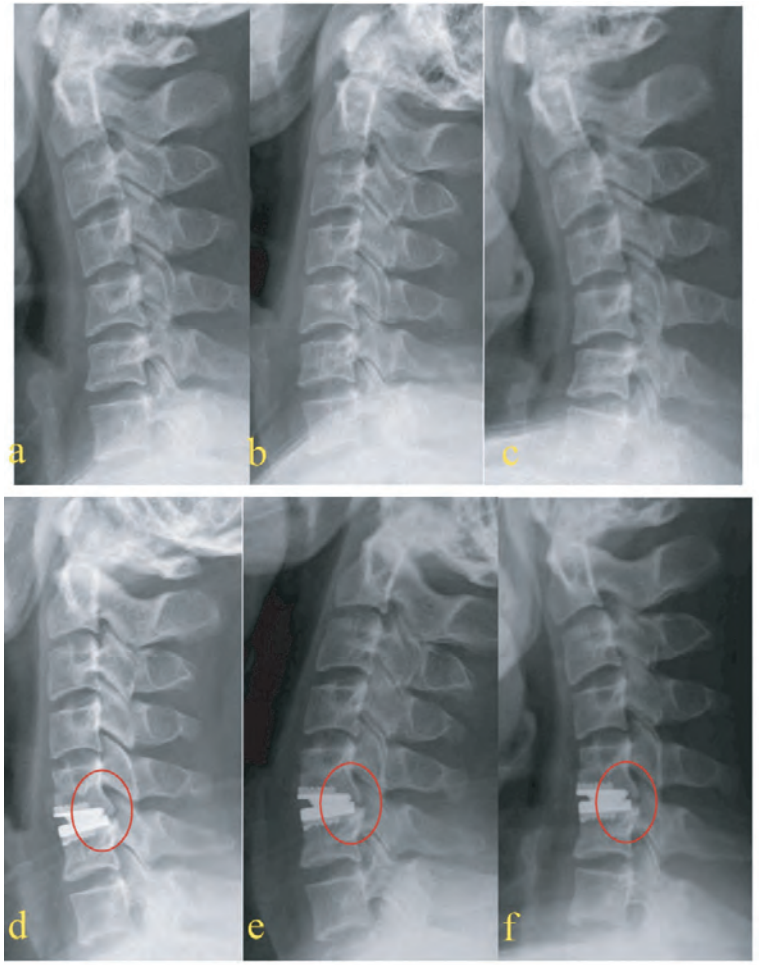

Fig. 1. Case presentation. a, b, c: preoperative neutral, extension and flexion X-rays; d, e, f: neutral, extension and flexion X-rays at 5-year follow-up; red circle indicatedthegrade III HO foramtion.

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Noninferiority of posterior versus anterior cervical surgery: 2-year results (FACET)

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INSTITUTION: Universitair Medisch Centrum Groningen (UMCG)

Background: Posterior foraminotomy (posterior surgery) is a valid alternative to anterior discectomy with fusion (anterior surgery) as surgical treatment of cervical radiculopathy, but quality of evidence is limited.

Methods: This multicenter, randomized, noninferiority trial assessed patients with single-level cervical radiculopathy in 9 Dutch hospitals. Primary outcomes were success ratio (Odom criteria) and decrease in arm pain (visual analogue scale), with a 10% noninferiority margin. Secondary outcomes were neck pain, disability, workability, quality of life, treatment satisfaction, complications, and reoperation. Generalized linear mixed effects modelling was applied.

Results: From January 2016 to May 2020, 265 patients were randomized (132 posterior vs. 133 anterior). Twenty-five patients did not have the allocated intervention, mostly due to symptom improvement. At 2 years follow-up, primary outcome data were available for 236 patients (97%). Predicted proportions of successful outcome were 0.81 after posterior and 0.74 after anterior surgery (difference, -0.06 percentage points; one-sided 95% CI, -0.02), indicating noninferiority of posterior surgery. Between-group difference in arm pain as well as decrease in arm pain were -2.7 (one-sided 95% CI, 7.4) and 1.5 (one-sided 95% CI, 8.2), both confirming posterior noninferiority. Secondary outcomes demonstrated only small betweengroup differences. Reoperations (%) occurred in 9 (8) patients after posterior and 7 (6) after anterior surgery.

Conclusions: This trial demonstrates that, after 2-year follow-up, posterior surgery was noninferior to anterior surgery regarding success rate and arm pain reduction in patients with cervical radiculopathy. Netherlands Trial Register Identifier: NTR5536.

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Short-term neck pain after posterior foraminotomy compared with anterior discectomy with fusion for cervical foraminal radiculopathy – A secondary analysis of the FACET randomized controlled trial

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Background: Short-term neck pain after posterior cervical foraminotomy (posterior surgery) compared with anterior cervical discectomy with fusion (anterior surgery) treating cervical radiculopathy has only been assessed once, retrospectively, to our knowledge. The aim of this study was to prospectively evaluate the course of neck pain for 6 weeks after both treatments.

Methods: This is a secondary analysis of the multicenter Foraminotomy ACDF Cost-Effectiveness Trial (FACET), conducted from January 2016 to May 2020. Of 389 patients who had single-level, 1-sided cervical radiculopathy and were screened for eligibility, 265 were randomly assigned to undergo posterior surgery (n = 132) or anterior surgery (n = 133). The primary outcome of the present analysis was neck pain, assessed weekly for 6 weeks using the visual analog scale (VAS), on a scale of 0 to 100. The secondary outcomes were arm pain , neck disability, work ability, quality of life, treatment satisfaction, motor and sensory changes, and hospital length of stay. Data were analyzed with mixed model analysis in intention-to-treat samples using 2- sided 95% confidence intervals (CIs).

Results: In the first postoperative week, the mean VAS for neck pain was 56.2 mm (95% CI, 51.7 to 60.8 mm) after posterior surgery and 46.7 mm (95% CI, 42.2 to 51.2 mm) after anterior surgery. The mean between-group difference was 9.5 mm (95% CI, 3.3 to 15.7 mm), which gradually decreased to 2.3 mm (95% CI, -3.6 to 8.1 mm) at postoperative week 6. As of postoperative week 5, there was no significant difference between groups. Responder analyses confirmed this result. Secondary outcomes were similar between groups.

Conclusions: Insight into the course of neck pain during the first 6 weeks after posterior compared with anterior surgery is provided. Despite initially more neck pain after posterior surgery, patients swiftly improved and, as of postoperative week 5, results similar to those after anterior surgery were observed. Our findings attribute to improved patient counseling and enhanced shared decision-making between physicians and patients with cervical radiculopathy, where more neck pain in the first postoperative weeks should be balanced against the benefits of posterior surgery.

Accepted for publication Journal of Bone and Joint Surgery

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Patient selection for endoscopic posterior cervical foraminotomy vs anterior cervical discectomy and fusion

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Introduction: The study aimed to report our initial experience of implementing a posterior endoscopic cervical foraminotomy and sequestrectomy in a Neurosurgery department at University Hospital in Capitol of central European country

Methods: Patients requiring endoscopic PCF are selected according to preoperative diagnosis based on the established indications and contra-indications (inclusion and exclusion criteria) for such surgery.

Inclusive criteria: single level cervical radiculopathy due to unilateral "soft" disk herniation or foraminal stenosis

Exclusion criteria: instability; predominantly axial neck pain; symptoms due to central disc pathology; kyphotic deformity; excessive ventral diseases

Patients undergo MRI 24-48 hours after surgery to confirm radiological outcome. All patients are observed for 12-months duration to evaluate the degree of regression of the root pain syndrome assessed on Visual Analog Score (VAS) of the neck and arm with a comparison of preoperative and postoperative performance. Social adaptation of patients after surgery is assessed using the NDI (Neck Disability Index).

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Results: Our initial single-center experience with small (10+), but fast-growing cohort of patients treated with PCF is similar to recent studies: no significant difference was found between ACDF with PCF in clinical outcomes, early complication rates, and reoperation rates. PCF was just as safe and effective as ACDF in the treatment of cervical radiculopathy. It can avoid Patient selection for endoscopic posterior cervical foraminotomy vs anterior cervical discectomy and fusion ventral approach-related complications, such as postoperative dysphagia, hematoma or implant-based complications. It is a valuable alternative for obese patients with "short neck".

Conclusions: The long term results in a larger patient cohort in our center are yet to be determined, we state the safety and benefit of this procedure in our initial experience. Regarding learning curve, we state that conversion from microsurgery to PCF is easier for surgeon already skilled in traditional microsurgical foraminotomy.

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Anterior Cervical X-shaped-Corpectomy and Fusion vs. Anterior Cervical Corpectomy and Fusion for Two-level Cervical Spondylosis

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INSTITUTION: Department of Orthopedics, West China Hospital, Sichuan University, Sichuan province, China

Objective: The choice of surgical techniques for two-level cervical spondylosis (CS) could be a dilemma, thorough decompression or less adverse events? Anterior cervical X-shaped-corpectomy and fusion (ACXF) was designed to blend strengths of both anterior cervical corpectomy and fusion (ACCF) and anterior cervical discectomy and fusion (ACDF) to provide an alternative surgical option. This study aimed to explore the clinical effect of ACXF in treating two-level CS by comparing to ACCF

Methods: A retrospective study was conducted among patients underwent ACXF or ACCF to treat two-level CS between September 2019 and May 2021. Clinical and radiographical data of all the patients were collected preoperatively and at 3 months, 6 months, and 1 year postoperatively, following by intra- and intergroup analyses

Results: 51 patients were included, 19 underwent ACXF and 32 underwent ACCF. ACXF group has a significant smaller transverse decompression range ($P<0.001$) than ACCF. However, both techniques significantly enlarged spinal canal area ($P<0.01$) and improved clinical outcomes. ACXF group had significantly shorter mean hospital stays (8.21±1.44 vs. 11.94±3.20, $P<0.001$), relatively lower rate of CSF leakage (0/19 vs. 4/32, $P=0.283$) and dysphagia (1/19 vs. 5/32, $P=0.392$) than ACCF group. Two surgeries had similar performance in modifying sagittal alignment and promoting bony fusion. Finally, ACXF achieved significant lower subsidence rates than ACCF at all time points ($P<0.01$).

Conclusion: As the combination of ACCF and ACDF, ACXF showed excellent clinical effects with sufficient decompression range and less adverse events, proved to be an ideal alternative option for two-level CS.

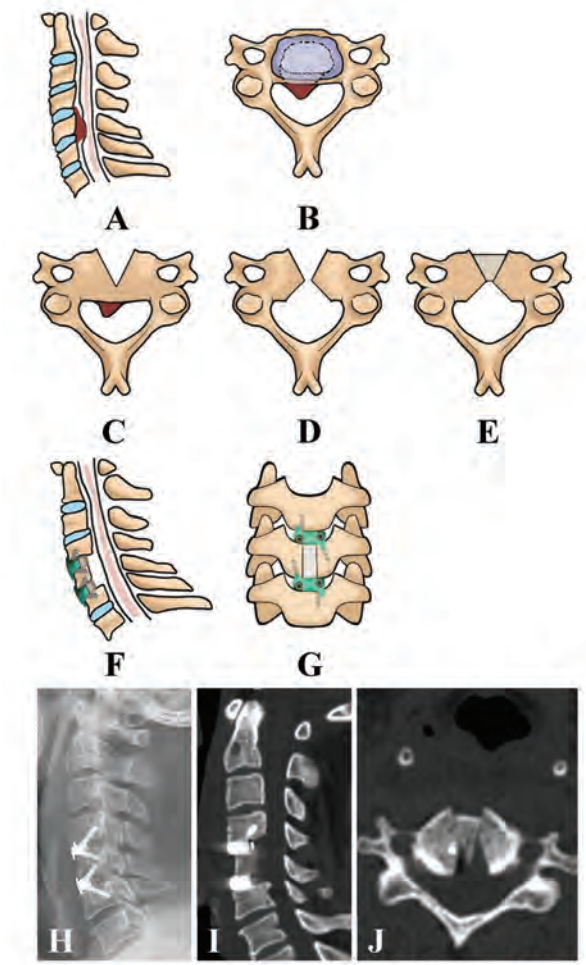

Figure 1. Schematic diagram for ACXF surgery. The osteophyte posterior to the C5 body and C4/5, C5/6 disc herniation (A, B); V-shaped corpectomy after C4/5 and C5/6 discectomy (C); inverted-V-shaped corpectomy and decompression (D); Insertion of the excised and trimmed bone mass (E); Install of double Zero-P VA systems (F, G); Postoperative images of x-ray and CT (H-J).

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Is spinal cord backshift after laminoplasty for degenerative cervical myelopathy correlated to preoperative cervical spine sagittal alignment?

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Objective: Among anterior fusion and laminectomy, laminoplasties are a useful tool to treat cervical myelopathy, but their efficiency in non-lordotic spine is debated. This study aimed to evaluate the spinal cord decompression after French-door laminoplasty for cervical degenerative myelopathy, at each level, according to the preoperative morphology of the cervical spine.

Methods: The anteroposterior diameter of the canal, the anterior and posterior peri-medullary spaces were measured on pre and postoperative MRI for 53 patients. The spinal cord decompression was assessed by measuring the difference between the post and preoperative anterior, posterior and total diameters of the canal. A subgroup analysis according to sagittal morphology (Lordosis, Kyphosis, Straight, Sigmoid) was performed. The relationship between spinal cord backshift and both preoperative C2C7 lordosis and C2C7-SVA distance was also studied.

Results: A significant spinal cord backshift with an increase of the anteroposterior diameter (APD) of the spinal canal, at all levels was found. The mean APD increase was 5.3mm ± 0.2mm ($p<0.001$). The maximal decompression was found at the apex of the lordosis, in C4C5 (APD= +6.0mm) and C5C6 (APD= +6.2mm). The subgroup analysis showed a significant spinal cord backshift at all levels operated on for lordotic spines. No statistical link between spinal cord decompression and C2C7 lordosis or C2C7 SVA distance was found.

Conclusions: Cervical laminoplasty allows spinal cord backshift and circumferential decompression regardless of the preoperative cervical spine shape. The technic seems accurate for lordotic spine with no statistical link between cervical lordosis and spinal cord decompression.

ABSTRACTS

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Trends in Cervical Laminoplasty and 30-Day Postoperative Complications, 2008-2017

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Background: In this decade, surgical techniques of cervical laminoplasty have been refined, while the elderly population grows worldwide. Such changes could affect the incidence and details of postoperative complications.

Research Question: To investigate the recent 10-year trends and 30-day postoperative complications in laminoplasty.

Design: Retrospective multi-institutional study.

Methods: Patients who underwent laminoplasty for cervical spondylotic myelopathy (CSM) or ossification of the posterior longitudinal ligament were enrolled. The primary outcome was the occurrence of all-cause 30-day complications. Trends were investigated and compared in the early (2008-2012) and late (2013-2017) periods.

Results: Among 1095 patients (mean age, 66 years), 542 and 553 patients were treated in the early and late periods, respectively. In the late period, patients were older (65 years vs. 68 years) and open-door laminoplasty (50% vs. 69%) was the preferred procedure, while %CSM (77% vs. 78%) and the perioperative JOA scores were similar to the early period. The preservation rate of the posterior muscle-ligament complex attached to the C2/C7-spinous process (C2, 89% vs. 93%; C7, 62% vs. 85%) increased and the number of laminoplasty levels (3.7 vs. 3.1) decreased. While the 30-day complication rate remained stable (3.9% vs. 3.4%), C5 palsy tended to decrease (2.4% vs. 0.9%, P=0.059). Infection-related complications increased (0.6% vs. 1.8%, P=0.017).

Discussion: From 2008 to 2017, there have been trends toward increasing age at surgery and surgeons' preference for refined open-door laminoplasty. The 30-day complication rate remained stable, but the details have changed: the C5 palsy rate halved, while the infection-related complications increased by three-fold.

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The application of three-dimensional printed patient-specific drilling templates for expansive open-door laminoplasty: a single-center, prospective randomized controlled study

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INSTITUTION: West China Hospital, Sichuan Universityt

Objective: To validate the efficacy of three-dimensional (3D) printed patient-specific drilling templates withthe function of locating and depth control for expansive open-door laminoplasty (EOLP).

Methods: A single-center, prospective randomized controlled study was conducted on the patients whounderwent unilateral EOLP from August 2019 to December 2020. The 3D printed patient-specific drilling template was used in the template group. All the EOLP were performed by a senior surgeon and a junior surgeon.

Results: 37 patients with 12-month follow-up were analyzed. The VAS scores were significantly lower inthe template group at 12 months postoperatively (P<0.05). The anteroposterior diameter, Pavlov's ratio and Open angle were all higher in the template group than those in the control group at 3days and 12 months postoperatively (P<0.05).

The satisfaction of the trough position on both sides and incomplete fracture rate on the hinge side were higher in the template group based on the CTscans taken 3 days after surgery (P<0.05). To the junior surgeon, the satisfaction and the incomplete fracture rate were significantly higher in the template group compared with those inthe control group (P<0.05).

Conclusion: The application of 3D printed patient-specific drilling templates with the function of locating anddepth control for EOLP could improve the outcome of neck pain relief and expand the decompression. It can also improve the satisfaction of the trough position on the open-door side and the hinge side and decrease the complete fracture rate on the hinge side, especially for the junior surgeon.

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Does segmental cervical instability drive the lordosis loss after laminoplasty in patients with cervical spondylotic myelopathy?

***Takuya Obo, Takashi Fujishiro,Masahiro Mizutani,Atsushi Nakano,Yoshiharu Nakaya,Sachio Hayama,Yoshitada Usami,Masashi Neo**
INSTITUTION: Osaka Medical and Pharmaceutical University

Background/ Context: Kyphotic deformity following loss of cervical lordosis after cervical 3 laminoplasty (CLP) leads to unfavorable neurological recovery due to insufficient indirect 4 decompression effect of the spinal cord. Existing literature have described that segmental cervical 5 instability is a contraindication for CLP because it is a potential risk factor for kyphotic changes after 6 surgery; however, this has never been confirmed in any clinical studies.

Purpose: To establish the relationship between segmental cervical instability and loss of cervical 8 lordosis after CLP in patients with cervical spondylotic myelopathy (CSM)

Study design/Setting: A retrospective studyStudy design/Setting: A retrospective

studyStudy design/Setting: A retrospective study

Outcome measures: Cervical radiographic measurements including C2-C7 lordosis

(C2-7 angle), cervical sagittal vertical axis (cSVA), C7 slope, flexion range of motion (fROM) and extension ROM (eROM) were assessed using neutral and flexion-extension views. Segmental cervical instability was classified into anterolisthesis (AL) of ≥2 mm displacement, retrolisthesis (RL) of ≥2 mm displacement, and translational instability (TI) of ≥3 mm translational motion. The amount of C2–7 angle loss at the follow-up period compared to the preoperative measurements was defined as cervical lordosis loss (CLL). Clinical outcomes were assessed using the recovery rate of the Japanese Orthopedic Association score (JOA-RR).

Methods: : We enrolled patients who underwent CLP for CSM with a follow-up period of ≥1 year. CLL was compared among patients with and without segmental cervical instability. Further, multiple linear regression model for CLL was built for the evaluation with adjustment of the reported risks, including Does segmental cervical instability drive the lordosis loss after laminoplasty in patients with cervical spondylotic myelopathy? cSVA, C7 slope, fROM, eROM, and patient age together with AL, RL, and TI, as independent variables. The JOA-RR was also compared between patients with and without segmental cervical instability

Results: A total of 138 patients (mean age, 68.7 years; 65.9% male) were included in the analysis. AL, RL, and TI were found in 12 (8.7%), 33 (23.9%), and 16 (11.6%) patients, respectively. Comparisons among the groups showed that AL led to greater CLL; however, RL and TI did not. Multiple linear regression analysis revealed that greater CLL is significantly associated with greater fROM and smaller eROM (regression coefficient [β]=0.328, 95% confidence interval [CI]: 0.178-0.478, P<0.001; β=−0.372, 95% CI: -0.591 to -0.153, P=0.001, respectively). However, there were no significant statistical associations in the AL, RL, and TI. Whereas, patients with AL tended to exhibit lower JOA RR than those without AL (37.8% vs. 52.0%, P=0.108).

Conclusions: Segmental cervical instability is not the definitive driver for loss of cervical lordosis after CLP in patients with CSM; thus, is not a contraindication in and of itself. However, it is necessary to consider the indications for CLP, according to individual cases of patients with AL on baseline radiograph, which is a sign of poor neurological recovery.

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Impact of the preoperative cervical range of motion on C5 palsy after cervical laminoplasty

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INSTITUTION: Osaka Medical and Pharmaceutical University

Background: Cervical laminoplasty (CLP) is an established technique, but the risk of C5 palsy (C5P) after surgery has not been resolved.

Research Question: To investigate the effect of preoperative cervical spine range of motion on the development of C5 paralysis after CLP.

Design: Retrospective radiological analysis

Methods: 210 patients (134 males and 76 females, mean age 67.7 years) who underwent CLP at our hospital were included in the study. CLP was performed with a double-door technique using a suture anchor, and MRI was performed in all postoperative patients. Patient demographic data, operative time, number of CLP, cervical alignment, decompression width and the diameter of posterior shift of the cord were measured from postoperative MRI and were used as parameters to study. C2-7 Cobb angle, sagittal vertical axis (SVA), C7 slope, and preoperative range of motion (ROM) were examined, and compared between the C5P and non-C5P groups.

Results: C5P occurred in 10 patients (10/210, 4.8%). Larger BMI and smaller preoperative ROM were significant in the C5P group than non-C5P one. Logistic regression analysis showed that preoperative ROM was significantly related to C5P ($P<0.05$, OR: 0.94). No significant differences were found in other parameters.

Conclusion: C5P is known to occur more frequently in patients with foraminal stenosis, and it has been suggested that it may anchor the nerve root. A small preoperative range of motion makes it difficult to adjust the foramen because of lack of the mobility, which may be a risk factor to the development of C5 palsy. Conclusion: Cervical preoperative ROM is involved in C5 palsy, and preoperative range of motion training may be a preventive measure for C5 palsy.

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Clinical Association between Preoperative Nutritional Status and Postoperative Cervical Kyphosis after Laminoplasty in Geriatric Patients with Cervical Spondylotic Myelopathy

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INSTITUTION: Gunma university

Background: Among geriatric patients, a low nutritional status is associated with postoperative medical complications in spine surgery.

Research Question: To determine the association of preoperative malnutrition with an increased risk of cervical kyphosis after laminoplasty in geriatric patients with cervical spondylotic myelopathy.

Design: Retrospective study.

Methods: Patients (≥65 years old) who underwent laminoplasty were included Malnutrition was defined as a geriatric nutritional risk index <98 before surgery. The C2-C7 angle and the global alignment parameters were analyzed on standing radiographs. The postoperative kyphosis was defined as a C2–C7 angle <0° during a 2-year follow-up.

Results: Ninety patients without preoperative kyphotic alignment were enrolled (mean age, 73.5 years old; 41.1% female). Twenty-one patients (23.3%) had malnutrition status (74.2 years old). Preoperatively, the global alignment parameters were comparable between the malnutrition and normal nutrition groups with no significant difference in the C2-C7 angle (15.1° vs. 15.2°). At 2 years postoperatively, the malnutrition group showed a lower C2-C7 angle than the normal nutrition group (9.3° vs. 15.8°, P=0.03). Postoperative kyphosis was more prevalent in the malnutrition group (33.3% vs. 7.2%, P=0.005). The preoperative malnutrition and C2-C7 angle were independent predictors of postoperative kyphosis. The predictive C2-C7 angles differed by preoperative nutritional status (malnutrition group, 11°; normal nutrition group, 7°).

Discussion: Among geriatric patients, preoperative malnutrition was closely associated with the increased occurrence of post-laminoplasty cervical kyphosis. Our results underscore the importance of preoperative nutritional assessment and management in geriatric populations undergoing cervical spine surgery, as malnutrition is a perioperative modifiable risk factor.

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Importance of predicting alignment aggravation for indication of cervical laminoplasty in patients with kyphosis

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INSTITUTION: Okayama Saiseikai General Hospital

Objective: Cervical laminoplasty is generally not indicated in patients with kyphosis because of poor outcomes, and postoperative alignment aggravation may be one of the causes. This study investigated whether alignment aggravation resulted in poor outcomes, and risk factors for alignment aggravation are examined to establish more refined indication in patients with kyphosis.

Methods: Clinico-radiological outcomes of 106 consecutive patients, who had undergone C2-7 laminoplasty were analyzed. Surgical outcomes were assessed, and sagittal parameters were measured on radiographs. Patients were assigned to two groups: kyphosis (n=32) and lordosis (n=74) groups.

Results: Multivariate analyses revealed that among surgical outcomes, axial pain was significantly frequent in kyphosis group, compared to lordosis group (OR, 17.470; 95% CI, 1.708– 178.655; P=0.016). Moreover, axial pain was significantly associated with alignment loss >0° only in kyphosis group (p=0.010) but not in lordosis group. Greater value of ROM during flexion minus that during extension (Flex-Ext ROM) had a significant correlation to C2-C7 angle change (r=-0.565, P=0.001), and was identified as a risk factor for alignment loss >0° in kyphosis group. Receiver operating characteristic curve analysis indicated a Flex -Ext ROM cutoff value of 0.7° for predicting alignment loss >0° in kyphosis group (sensitivity: 77%, specificity: 84%)

Conclusions: Our study showed the importance of predicting alignment aggravation when considering the indication of laminoplasty in patients with kyphosis. Therefore, the current finding of a Flex-Ext ROM >0.7° for predicting alignment loss >0° could contribute to establishing more refined indication of laminoplasty in patients with kyphosis.

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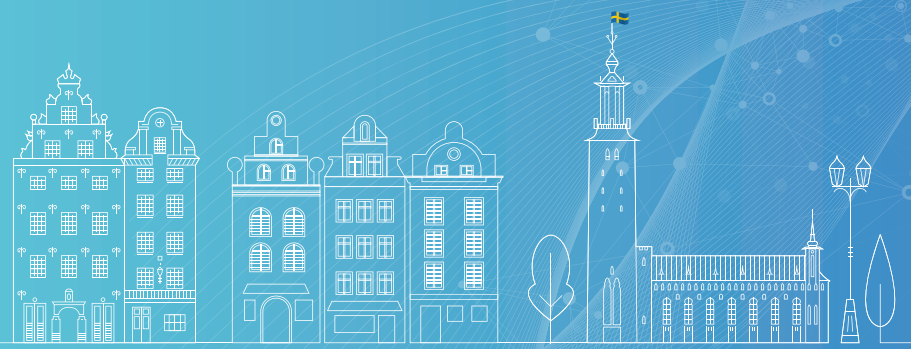

Efficacy of posterior foraminotomy in patients with monoradicular syndrome of the cervical spine

Kubetskyi Yuliy, Kosimshoev Murodzhon

FSI "Federal Center of Neurosurgery", the Ministry of Health, Novosibirsk, Russia 630087, Novosibirsk, Nemirovich-Danchenko street, 132/1 +7 (383) 349-83-22.

Introduction

Operations on degenerative conditions of the cervical spine are arguably among the most successfully performed in all of spinal surgery. For example, decompressive procedures for cervical radiculopathy, whether performed either anteriorly or posteriorly, enjoy approximately 90% or more good to excellent outcomes in many series.

Objective: to evaluate the effectiveness of posterior foraminotomy in patients with monoradicular syndrome of the cervical spine.

Material and methods: The study included 13 patients with monoradicular syndrome of the cervical spine operated in the period from March 2013 to November 2022. Of these, there were 7 men (53.8%) and 6 women (46.2%) aged 33 to 62 years.

Inclusion criteria: unilateral posterolateral soft herniated disc, unilateral radicular symptoms and unsuccessful outcome of conservative treatment for 6 weeks.

VAS, NDI were evaluated. Radiography, CT, and MRI of the spine were performed before treatment and in the early postoperative period, as well as during a control examination. The average follow-up time was 3.5 years.

Conclusion

1. With posterior foraminotomy, regression of the radicular pain syndrome is achieved, improving the quality of life of patients with monoradicular syndrome of the cervical spine.

2. Posterior foraminotomy is an effective surgical option for the removal of a "soft" hernia of the cervical spine, which, along with the use of microsurgical techniques, ensures the achievement of excellent and good treatment results.

Type of interventions	N
Posterior foraminotomy: C5-C6 – 1 C6-C7 – 4 C7-Th1 – 5	10
endoscopic foraminotomy: C6-C7 – 1 C7-Th1 – 2	3
F – up 3.5 years	
❑ VAS: 6.7/7 (5;7) 1.4/1 (1;2)	
❑ NDI 40.0±4 10.2±1.5.	
❑ Intraoperative blood loss was 64.8 ± 24.3 ml	
❑ the duration of the operation was 90.0±30.1 min	

Clinical and radiographic impact of increased signal intensity of spinal cord at the vertebral body level in patients with cervical myelopathy

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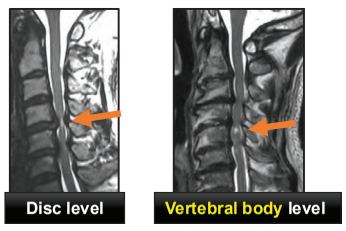
Introduction

- Increased signal intensity (ISI) was often seen on cervical MRI of the patients with cervical compressive myelopathy
- ISI grade correlated with surgical outcomes of cervical compressive myelopathy
- ISI is usually seen at disc level, and sometimes seen at vertebral body level as below



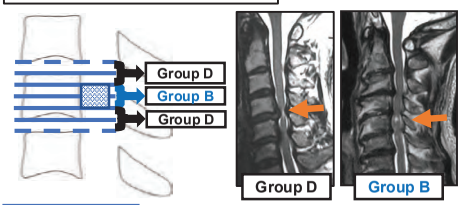
Purpose of this study

This study aimed to investigate the significance of ISI level or position among cervical compressive myelopathy patients

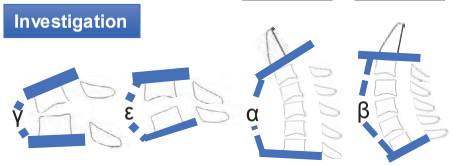
Materials (2013-18)

- **135 cases** (95 M, 40 F, Average age; 69.3)
- Compressive cervical myelopathy with **ISI**

Location of ISI and grouping

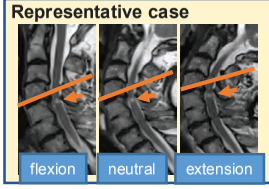


Investigation



Local and C2-7 kyphosis in flexion, lordosis in extension and range of motion(ROM) were calculated.

Representative case



Spinal cord was withdrawn by 3-7mm to cranial side from extension to flexion

Reid JD. J Neurosurg Psychiat 1960

Results	Group D	Group B	*P* Value
Prevalence	109 (80.7%)	26 (19.3%)	
Age	69.2±11.3	69.6±10.1	0.89
Sex	Male:75 (68.8%)	Male:20 (76.9%)	0.47
Local ROM	9.8±5.7	**15.3±4.8**	<0.001
Local angle			
at flexion	-5.1±8.6	**-11.2±6.9**	<0.001
at neutral	2.6±7.2	**-1.8±5.1**	<0.001
at extension	5.1±7.3	3.8±4.0	0.12
C2-7 ROM	38.8±15.6	41.5±12.1	0.52
C2-7 angle			
at flexion	-16.1±16.1	**-25.1±9.4**	0.003
at neutral	9.8±15.1	**5.1±7.6**	0.031
at extension	22.4±13.6	**16.2±9.2**	0.009

Conclusion

- The prevalence of ISI at the vertebral body level was seen in 19.3% of all patients with ISI.
- ISI at the vertebral body level showed more local ROM and more local kyphosis at flexion.
- The spinal cord in group B could be retracted from the vertebral body to the disc level in flexion, and subsequently compressed or stretched. This idea differs from the conventional pincer-mechanism concept.

POSTERS

Surgical results and complications of posterior decompression & fusion surgery for K-line (-) and/or huge (occupying ratio > 50%) ossification of posterior longitudinal ligament in cervical spine

Yasutsugu Yukawa, Y Mihara, F Kato Spine center, Nagoya Kyoritsu Hospital, Nagoya, **Japan**

OPLL (ossification of posterior longitudinal ligament)

- Incidence rate: 3% (1.8-4.1%)
- Surgical treatment is the only accepted treatment of symptomatic OPLL

Surgical approach for C-OPLL

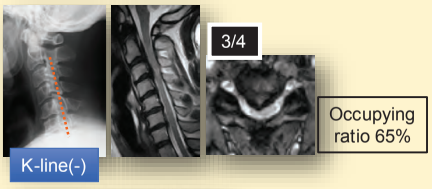
- Anterior procedure
  - Corpectomy & fusion resection or floating of OPLL
- Posterior procedure
  - Laminoplasty
  - Laminectomy(plasty) & fusion
- Antero-Posterior procedure

Materials (2007-2022)

- Cervical OPLL **28 cases** (14 M, 14 F) who underwent posterior decompression and fusion
- Average age 60.5
- K-line (-) : 13 cases
- Huge OPLL (occupying ratio > 50%): 24 cases
- Average occupying ratio of OPLL : 56.4%
- Followed up > 6months

Results	
Surgical time	213 min
Blood loss	169 ml
Decompression levels	4.7
Fusion levels	3.3
JOA preope / postope	10.2 → 13.2
improvement rate	45.3%
Alignment	0.6 kyphotic → 6.2 lordotic

Case presentation: 47y Male, JOA score=8
U/E & L/E numbness and weakness

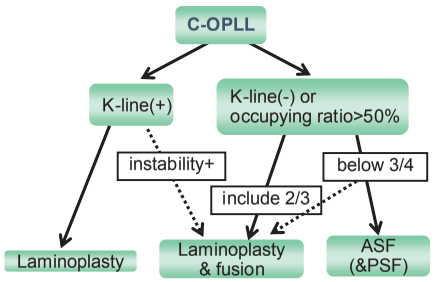


C2-7 laminoplasty,
C2-5 PSF
JOA score=14
(RR= 67%)

Complications

- Dura tear : 1 case
- Postoperative infection: 1 case
- C5 palsy : 2 case

Surgical strategy



Conclusion

- Surgical option for cervical OPLL should be decided in terms of neurological assessment, imaging study and patient' general condition comprehensively
- Posterior decompression & fusion provided relatively good clinical outcomes and less number of complications in cases with K-line(-) / huge OPLL occupation (>50-60%)

The Federal State-Financed Institution
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics
of the RF Ministry of healthcare

ILIZAROV CENTER

Mucopolysaccharidosis-related spinal stenosis

Olga Sergeenko, Polina Ochirova, Alexander Burtsev, Alexey Evsyukov

Materials: 15 patients, age 6-16 years, time 2012-2022

MPS types: 8 patients with MPS IVA, 1 with MPS 1H, 2 with 1HS, 4 with MPS VI

Purpose: To evaluate the results of the decompression with screw fixation in MPS-related spinal stenosis

Results (mean)

Preop mJOA	Preop 6-minute walk test (m)	Follow-up	Final mJOA	Final 6-minute walk test (m)
10 (8-14)	210 (10-420)	5 years (3 weeks-10 years)	13 (4-17)	208 (0-400)

Treatment

Cervical laminectomy with/without FMD + occipitospondylodesis N=13

N=2 ↑ ↓ N=4

Thoraco-lumbar screw fixation with decompression N=7

Complications: N=4:

1) Mayfield clamp skull fracture - 1
2) Non-fusion - 1
3) Neurological deterioration – 2 (died 3 weeks and 4.5 years after surgery)

Fatal outcome: N= 3

1) 3 weeks after cervical surgery – heart failure
2) 4.5 years after cervical surgery – pneumonia
3) 6 month after thoraco-lumbar surgery – brain edema

MPS IVA
9 y.o . boy

Conclusions

Spinal stenosis with myelopathy are usual for MPS patients, and predominantly affected upper cervical spine and thoraco-lumbar level

Surgical tactic determines individually, but screw fixation allows for wide decompression, showed good clinical results and strongly recommended in cases of atlanto-axial instability

Double insurance C1-2 fixation using an aiming device and an intraoperative CT navigation system

Masashi Neo, Takashi Fujishiro, Yoshiharu Nakaya, Sachio Hayama, Yoshitada Usami, Hiromichi Hirai, Katsuhiro Miyake, Yuki Yamamoto

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Introduction

Double insurance C1-2 fixation (The connection of Magerl screw and a C1 lateral mass screw (LMS), A Goel, *Surg. Neurology*, 2007) provides strong fixation and high bony fusion rate. However, this technique has not been popular perhaps because it is difficult to insert two screws into a small C1 lateral mass.

We have performed this technique using an original aiming device for Magerl screw and an intraoperative CT-navigation system for C1LMS.

Technique

1. A guide wire for Magerl screw is inserted using our original aiming device, bilaterally if possible. (Figure 1, M Neo et al, *J Neurosurg* 2002, M Neo et al, *Spine* 2005)
2. Intraoperative CT is taken to check the position of the guide wire(s), and the image data are transferred to the navigation system. (Figure 2)
3. C1 LMS is inserted avoiding the guide wire under navigation. (Figure 3)
4. The Magerl screw is then inserted after drilling and tapping along the guide wire. (Figure 4)
5. The Magerl screw and C1 LMS are connected, followed by bone graft.

Figure 1: Original aiming device

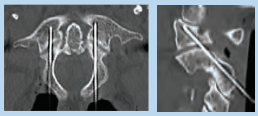
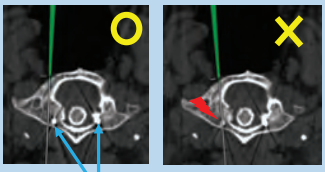


Figure 2



Guide wires Figure 3

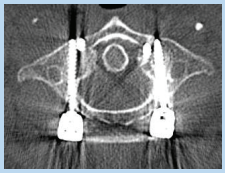


Figure 4

Results

Seven patients were successfully treated with this method. No complication was encountered. Bony fusion was confirmed within 1 year using CT, in six of them. (Figure 5, Table 1)

Figure 5: Bony fusion

Table 1

Age	Sex	Laterality	C1LMN	Bone Graft	Bony fusion confirmed by CT
83	M	L	(+)	Iliac bone span	(+)@1y
72	M	B	(+)	Iliac bone span	(+)@1y
84	M	B	(-)	Iliac bone span	(+)@1y
86	F	B	(+)	Iliac bone span	(+)@1y
76	M	B	(+)	Iliac bone chips	(+)@1y
64	F	B	(-)	Iliac bone span	No postop CT yet @7m
79	F	B	(+)	Local bone chips	(+)@3m

B: bilateral, L: left

Conclusion

With this technique, early bony fusion of C1-2 is surely obtained even in elderly patients with C1 laminectomy (LMN).

Improved Ceramic Spacer in Double Door Cervical Laminoplasty

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COI: none

Contact: taoya@seagreen.ocn.ne.jp

Background

- Cervical laminoplasty (CLP) is widely performed…
  - –double door (French door) or open door
  - –using spacer, anchor, plate, or without material (only suture to muscle)

- even ceramic spacers, so many shapes…

From PENTAX's catalog

- Our method:
  - – Double door, using ceramic spacer
  - – Spacer is fixed with 8 or ∞ shape tying filament

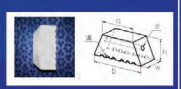
- Spacers in market don't fit for our method

Purpose of study

- Evaluate the usefulness of ceramic spacer fit for our method

Materials and methods

- Modified spacer with notch
  - –catch filament during tying



- Intraoperative image

- Analysis
  - –Consecutive CLP cases since 2017
  - –31 cases, 86 laminae (mean 2.8 / case)
  - –Age: 68.9 ± 9.96yrs
  - –Dislocation, lamina opening, bone fusion
  - –Cost

Results

- Follow up: 19.9±12.8 mos
- No dislocation (0%)
- Handling: quite easy

Just postop.

9mos

- Bone fusion at hinge
  - –CT after 6mos in 20 cases, 53 laminae
  - –51.5 / 53 laminae (97.2%, 103 / 106 hinges)
  - –Maintain opening in all laminae
- Cost (per one lamina, excluding surgical fee)

Method	Cost (JPY)	Details
Kiuta/Miyasaki method	almost 0	Filament is not calculated
CP	174,600	Double door : 37,800 (plate)+68,800×2 (screws)
	243,400	Open door : 37,800 (plate)+68,800×3 (screws)
Ceramic spacer (fixed with Quick through)	33,800	31,800 (spacer)+2,000 (filament)

10,000 JPY = 74.6 USD = 67.9 EUR = 768.5 SEK (24 Apr 2023)

Conclusion

- This new spacer can be fixed stiffly, maintain lamina opened and produce bone fusion.
- It is also cost-effective.
- It is useful in cervical laminoplasty.

POSTERS

Three-Column Osteotomy for the Surgical Treatment of Dropped Head Syndrome Due to the Cervicothoracic-Upper Thoracic Proximal Junctional Failures Following Adult Spinal Deformity Surgery: Radiologic and Clinical Outcomes

Baris PEKER, Ali EVREN, Hamisi MRAJA, Halil GOK, Cem SEVER, Tunay SANLI, Meric ENERCAN, Selhan KARADERELER, Azmi HAMZOGLU.
Scoliosis-Spine Center ISTANBUL

INTRODUCTION

Severe proximal junctional failures (PJF) following adult spinal deformity surgery can result in Dropped head syndrome (DHS) is characterized by severe kyphotic deformity at the cervicothoracic-upper thoracic (CT-UT) spine.

Severe kyphotic deformity causes significant sagittal imbalance, horizontal gaze difficulty and chin-on chest deformity. Surgical treatment of the severe kyphotic deformity requires three-column osteotomies (3CO) for correction.

The aim of this study is to analyze the efficacy and safety of three-column osteotomies in the management of dropped head syndrome due to severe CT-UT PJFs

MATERIALS & METHODS

13 (6M, 7F) patients who had undergone revision surgery with 3CO for dropped head syndrome were included. These patients had undergone their primary adult spinal deformity surgeries at different centers and were admitted to our clinic for revisions.

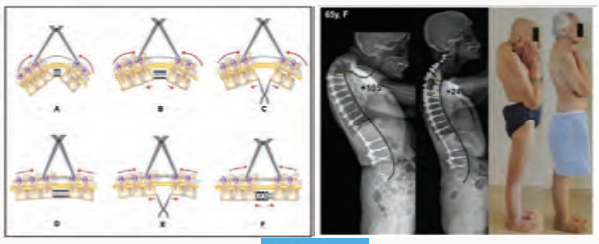
Pre-revision, post-revision, and f/up whole spine standing x-rays were evaluated for cervical and global sagittal alignment parameters. Clinical assessment was done with ODI.

RESULTS

The mean age was 42 (18-79) years and the mean f/up was 5 (2-15) years. 3COs were performed between T2-T4 levels. 3 patients had PSO, 2 patients had Bone-disc-bone resection and 8 patients had PVCR for deformity correction.

Preop mean local kyphosis angle of 66° improved to 14° (79%). All global and cervical sagittal alignment parameters improved postoperatively. Gradual anterior column lengthening technique following PVCR provides proper sagittal alignment restoration both regionally and globally and also avoids iatrogenic neurologic deficit by preventing dural bucking.

7 patients who had preop neurologic deficits had at least one-grade improvement at the final f/up. The most common complication was dural tears in 3 patients (23%) during PVCR. ODI decreased from 63 to 17. Solid fusion was achieved in all patients.



CONCLUSIONS

Three-column osteotomy enabled significant correction of severe proximal junctional failures causing kyphotic and rigid deformity, improved neurological deficit and provided proper global and regional sagittal alignment.

Anterior column lengthening at the level of osteotomy following PVCR procedure enables greater and safer deformity correction.

CONFLICTS OF INTEREST

1. Author: Baris Peker (NA)
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4. Author: Halil Gok (NA)
5. Author: Cem Sever (NA)
6. Author: Tunay Sanli (NA)
7. Author: Meric Enercan (NA)
8. Author: Selhan Karadereler (NA)
9. Author: Azmi Hamzaoglu (Medtronic Consultant)

REFERENCE

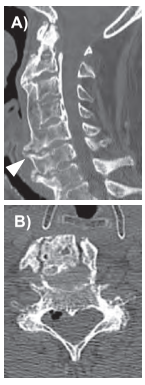
1. A. D. Sharan, D. Kaye, W. M. S. C. Malveaux, and K. D. Riew, "Dropped head syndrome: Etiology and management," J. Am. Acad. Orthop. Surg., vol. 20, no. 12, pp. 766–774, 2012, doi: 10.5435/JAAOS-20-12-766.
2. M. Enercan, C. Ozturk, S. Kahraman, M. Sarier, A. Hamzaoglu, and A. Alanay, "Osteotomies/spinal column resections in adult deformity," Eur. Spine J., vol. 22, no. SUPPL.2, pp. 254–264, 2013, doi: 10.1007/s00586-012-2313-0.
3. K. Hashimoto, H. Miyamoto, T. Ikeda, and M. Akagi, "Radiologic features of dropped head syndrome in the overall sagittal alignment of the spine," Eur. Spine J., vol. 27, no. 2, pp. 467–474, 2018, doi: 10.1007/s00586-017-5186-4.
4. H. Miyamoto, K. Hashimoto, T. Ikeda, and M. Akagi, "Effect of correction surgery for cervical kyphosis on compensatory mechanisms in overall spinopelvic sagittal alignment," Eur. Spine J., vol. 26, no. 9, pp. 2380–2385, 2017, doi: 10.1007/s00586-017-5106-7.
5. D. H. Lee, J. K. Ha, J. H. Chung, C. J. Hwang, C. S. Lee, and J. H. Cho, "A retrospective study to reveal the effect of surgical correction of cervical kyphosis on thoraco-lumbo-pelvic sagittal alignment," Eur. Spine J., vol. 25, no. 7, pp. 2286–2293, 2016, doi: 10.1007/s00586-016-4392-9.

Ten years after surgery for Diffuse idiopathic skeletal hyperostosis with dysphagia

Atsuhiko Hirasawa (Nagakute / JP), Mitsuhiro Kamiya (Kasugai / JP), Nobunori Takahashi (Nagakute / JP)

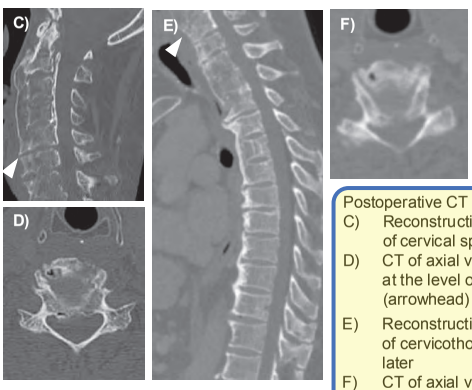
Background and Research question:
Diffuse idiopathic skeletal hyperostosis (DISH) in the cervical spine is a common entity but rarely causes dysphagia, dyspnea, and dysphonia. Some cases have been undergone anterior osteotomy without fusion via anterior cervical approach in order to relief of such symptoms.. But the long-term postoperative courses are unknown well. We report one of the cases.

Case
A 59-year-old male patient had a complaint of progressive difficulty swallowing for a few months. A cervical X-ray and computerized tomography (CT) scan were taken afterward, which showed DISH at the C2-7 level. He then had esophageal endoscopy and swallowing video fluorography to rule out other dysphagia-related disorders.



The patient underwent anterior osteotomy without fusion via anterior cervical approach with significant relief of dysphagia postoperatively.
Two years after surgery, there was a mild feeling of snagging, but no recurrence of difficulty swallowing was observed. CT scan showed no recurrence of ossification growing. After that, there were no visits to our hospital.
Ten years later, CT scans were taken at the time of consultation at other departments did not show an increase in osteophytes. It was also confirmed that food intake could be performed without complaints of difficulty swallowing.

Preoperative CT images of this case.
A) Reconstruction CT of sagittal view of cervical spine
B) CT of axial view of cervical spine at the level of C5/6 (arrowhead)



Postoperative CT images of this case.
C) Reconstruction CT of sagittal view of cervical spine 2 years later
D) CT of axial view of cervical spine at the level of C5/6 2 years later (arrowhead)
E) Reconstruction CT of sagittal view of cervicothoracic spine 10 years later
F) CT of axial view of cervical spine at the level of C5/6 10 years later (arrowhead).

Discussion:
It reported that one of causes of ligament ossification is dynamic factor, but it has been shown that the progression of increased ossification may be stopped without fusion surgery by removing the front line of ossification.

Postoperative C4 radiculopathy may result in axial pain after cervical laminoplasty

Kaho Yasuda, Yoshitada Usami, Sachio Hayama, Yoshihiro Nakaya, Takashi Fujishiro, Masashi Neo
Department of Orthopedic Surgery, Osaka Medical and Pharmaceutical University, Japan

Introduction

Axial pain, the pain from the neck to shoulder, after cervical laminoplasty is a common complication. Although it has been suggested that the posterior muscle plays a pivotal role in axial pain, the pathogenesis has not been fully elucidated. This study suggested that postoperative axial pain may be involved in postoperative C4 radiculopathy, which is caused by a pathomechanism similar to that of C5 palsy.

Case

A 48-year-old woman presented with numbness in her right upper extremity and hand clumsiness. Radiographic examination revealed a spontaneous fusion between C2 and C3. Magnetic resonance imaging (MRI) revealed cervical canal stenosis in C5-C6 and C6-C7 (Fig. 1). Computed tomography (CT) revealed segmental ossification of the posterior longitudinal ligament (OPLL) at C3-Th1. The patient was diagnosed with cervical myelopathy with OPLL. And patient underwent C4-C6 double-door laminoplasty with laminotomy of the caudal C3 and cranial C7, and decompressing from C3-C4 to C6-C7. Immediately after the surgery, the patient's preoperative upper extremity symptoms improved.

On the second postoperative day, hypoesthesia on the left side of the wound and neck pain predominantly on the left side were observed(Fig. 2). However, paralysis of the upper extremities was not observed. The severity of pain on the left and right sides were seven and two, respectively, on the 11-point numerical rating scale (NRS).

Postoperative MRI showed the posterior shift of the cord (Fig. 3a) and the slight left C3-C4 foraminal stenosis (Fig. 3b). We suspected C4 nerve root involvement as the site of the pain and hypoesthesia was localized to a region of the left C4 dermatome. Then, a left C4 nerve root block was performed using 1.0 mL of 1% mepivacaine hydrochloride on the eighth postoperative day (Fig. 4).The left side neck pain improved from seven to two on the NRS immediately after the root block and did not worsen thereafter.

Fig1

Fig2

Fig3

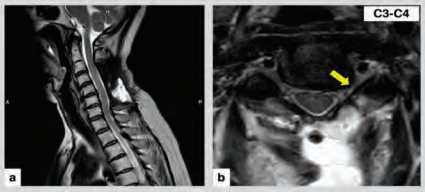
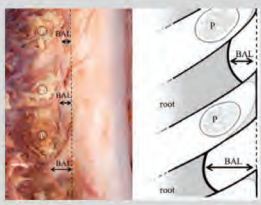


Fig4



Discussion

Usami et al. studied nerve root anatomy to clarify the cause of C5 palsy, another unresolved complication after CLP. They demonstrated that the C3, C4 and C5 nerve roots are likely vulnerable to traction when the spinal cord shifts posteriorly after CLP, compared with the C6, C7, and C8 nerve roots. This is because cranial cervical nerve roots are anchored at a nearer point to the dural sac than caudal ones(Fig. 4). They concluded that these anatomical characteristics are possible reasons why C5 palsy is more common than C6, C7, and C8 palsy. They also suggested that the C4 root may be paralyzed after CLP, resulting in neck pain. However, the symptoms are indistinguishable from postoperative wound pain because C4 radiculopathy presents with pain in the axial cervical to interscapular regions without muscle weakness. Most of the postoperative axial pain resolves gradually within one year, similar to that of C5 palsy, which supports the hypothesis that the tethering effect of the C4 nerve root is involved in axial pain after CLP.

Conclusion

If the postoperative axial pain exhibits laterality or late-onset, there may be C4 radiculopathy caused by tethering of the nerve root with posterior shift of the spinal cord. In those cases, we suggest C4 nerve root block may be effective.

Do the T1 slope and the C2/7 lordosis angle change after L4/5 posterior interbody fusion ?

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GUNMA SPINE CENTER, HARUNASO HOSPITAL

Purpose

To investigate that how the T1 slope and the C2/7 lordosis angle change after L4/5 posterior interbody fusion.

Materials and Methods

47cases (Since 2010, 70 consecutive cases of L4/5 posterior interbody fusion performed by the same surgeon, in which 47 cases had preoperative and 2-year postoperative standing whole-spine lateral XP* data.)

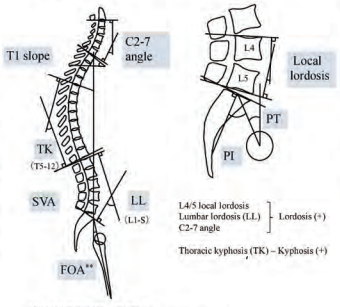
* XP was taken in the clavicle position with horizontal view against the mirror.

Parameters We measured these parameters pre op. and post op. 2 years.

(Using the standing whole spine lateral XP*, each parameter was measured twice and the mean values were taken and compared them by t-test.)

Variables

Sex	Male 14 cases, Female 33 cases	
Age	65±12 y.o.	(27-85)
Disease	Disc disorder	3 cases
	Lumbar canal stenosis	44 cases
	(including 30 cases of L4 degenerative spondylolisthesis)	
Operation	PLIF	2 cases
	TLIF	45 cases
Operation time	108±26 min.	(67-204)
Blood loss	339±122ml	(110-620)



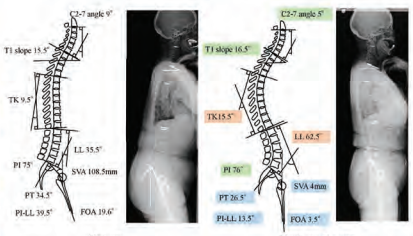
**FOA(Femoral Obliquity Angle):
Subjects were 36/47 (77%) who were measurable the FOA.

Results

Parameters	Pre op.	Post op.2 y.	P value
T1 slope (°)	21.2 ± 8.9	22.0 ± 8.7	P=0.37
C2-7 angle (°)	5.8 ± 12.7	5.3 ± 12.3	P=0.65
Local lordosis (°)	11.9 ± 5.9	17.5 ± 5.8	P<0.01
LL (°)	38.8 ± 11.4	45.7 ± 10.9	P<0.01
PI (°)	52.4 ± 10.6	52.8 ± 10.9	P=0.40
PT(°)	24.1 ± 9.2	19.9 ± 9.1	P<0.01
SVA (mm)	37.9 ± 46.0	23.9 ± 40.2	P<0.05
TK (°)	27.5 ± 12.5	30.7 ± 11.5	P<0.01
FOA (°)	8.6 ± 5.4	6.2 ± 4.1	P<0.01
PI-LL (°)	13.6 ± 14.0	7.4 ± 11.6	P<0.01

increase decrease n.s. n.s. (no significant difference)

A representative case, 78 y.o. female.



Pre op. Post op. 2 years.

Discussion

The T1 slope and the C2-7 lordosis angle did not change after L4/5 posterior interbody fusion. On the other hand, the spinal sagittal alignment had changed. LL and TK increased, and PT, SVA, FOA decreased after the surgery.

Assuming that the postoperative spinal alignment would be an approximates natural physiological state, decreasing of lumbar lordosis and forward leaning posture caused by preoperative L4/5 local pathology might be compensated by increasing posterior pelvic tilt, leg flexion and thoracic extension so that the C2-7 angle and the T1 slope would be maintained.

Changes of the spinal sagittal alignment caused by L4/5 disorder are mostly compensated without changes of the cervical spine alignment.

conclusion

The T1 slope and the C2-7 lordosis angle did not change after L4/5 posterior interbody fusion.

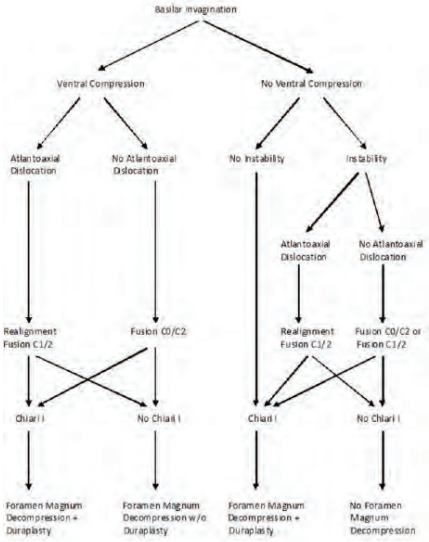
Treatment of Basilar Invagination

Jörg Klekamp, Asklepios Klinikum Bad Abbach, Germany

Material

82 patients (age 40±18 years (9 to 75 years)
Follow Up 57±55 months
77 presented with Chiari I malformation

Fig. 1 – Treatment Algorithm



Treatment

Chiari I malformation, no ventral compression, no instability
33 patients: foramen magnum decompression w/o fusion

Ventral compression and/or C1/2 instability
49 patients: posterior realignment + C1/2 fusion
(44/49 Chiari I: foramen magnum decompression on top)

Fig. 2 w/o Fusion

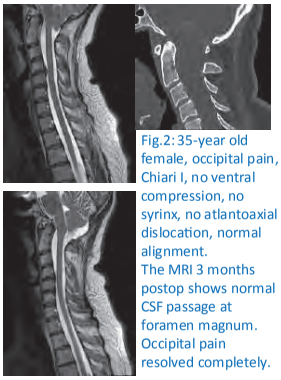


Fig.2: 35-year old female, occipital pain, Chiari I, no ventral compression, no syrinx, no atlantoaxial dislocation, normal alignment.
The MRI 3 months postop shows normal CSF passage at foramen magnum. Occipital pain resolved completely.

Fig.3 continued
Six months after revision with foramen magnum decompression and duraplasty syrinx reduced with posterior shifting of the medulla. Symptoms improved, nausea resolved leading to weight increase of 5kg .

Fig. 3 with Fusion

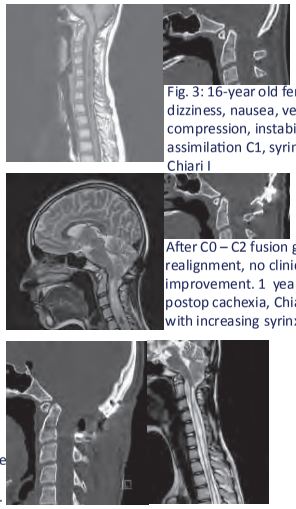


Fig. 3: 16-year old female, dizziness, nausea, ventral compression, instability, assimilation C1, syrinx, no Chiari I

After C0 – C2 fusion good realignment, no clinical improvement. 1 year postop cachexia, Chiari I with increasing syrinx.

Short-Term Results (3 Months)

79% symptomatic improvement w/o C1/2 fusion

73% symptomatic improvement with C1/2 fusion

Long-Term Results

10 Year Progression-Free Survival:
83% w/o C1/2 fusion
81% with C1/2 fusion

Conclusions

40.2% of 82 patients with basilar invagination characterized by absence of ventral compression, atlantoaxial dislocation or signs of craniocervical instability required a posterior decompression only. The remainder underwent C1/2 fusion with posterior realignment. A concomitant Chiari I malformation was managed by additional foramen magnum decompression with duraplasty. Favorable short- and long-term results were almost identical for the fusion and non-fusion group with this algorithm.

ACDF with cervical uncinectomy for cervical radiculopathy with foraminal stenosis

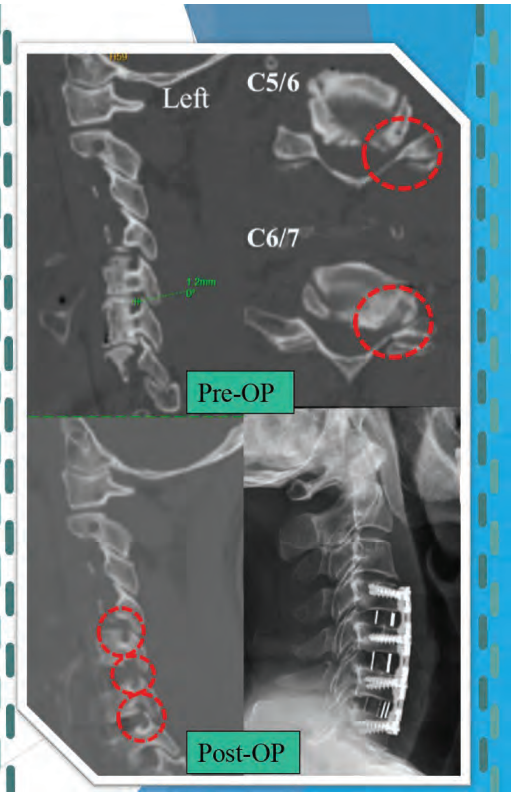
Hao Zhang ZengFeng Guo
The People's Hospital of Longhua. Shenzhen

Objective: This study aims to describe the technique for ACDF with incomplete or complete uncinectomy for the management of cervical radiculopathy due to foraminal stenosis.

Methods: We retrospectively collected clinical and radiological data from June 2018 to June 2021. A total of 20 patients (30 segments) were included. In total, 30 disc levels were investigated. The mean follow-up duration was 6.1 months(range: 4.5-19.2 months). The neck disability index (NDI) and Visual Analog Scale scores(VAS) for neck pain before surgery and at final follow-up were used to evaluate the clinical results. The occurrence of surgical complications, surgical time, and blood loss volume were also investigated.

Results: The mean VAS scores before surgery and at final follow-up were 6.6, 1.5, respectively. The mean NDI before surgery was 0.38 and 0.08 at the final follow-up. The scores decreased significantly at the final follow-up ($p<0.01$).The mean surgical time and the mean blood loss volume were 125 mins and 10 ml, respectively. There were significant improvements at final follow-up. All of patients were decompressed completely, and had a good to excellent outcome.

Conclusions: The results in the present study were consistent with previous reports of ACDF with uncinectomy for cervical foraminotomy, especially when severe osseous foraminal stenosis accompanies other pathologies that require an anterior approach to the cervical spine. Despite completely decompressed the nerve due to bony foraminal stenosis, this technique did well in the short-term, although longer-term follow-up is required.



POSTERS

Dynamic CT imaging of the cervical spine in patients with atlantoaxial instability

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The People's Hospital of Longhua. Shenzhen

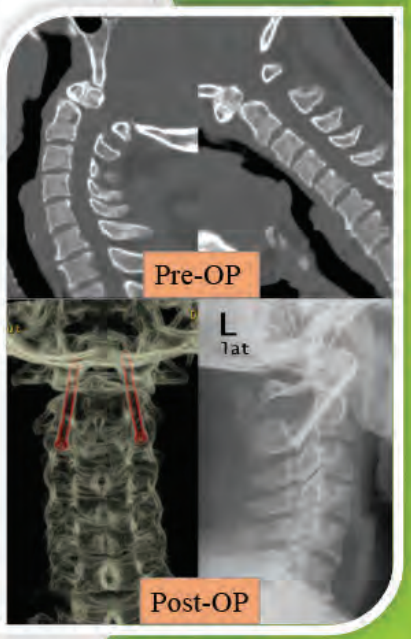
Abstract

Objective: We proposed to evaluate more details of the facetal alignment and the implications of mal-alignment of facets by dynamic CT imaging of the cervical spine in patients with atlantoaxial instability.

Methods: This retrospective study included 16 patients (9 males, 7 females) with or without atlantoaxial instability. Radiography and CT were performed with the neck in the neutral position, flexed and extended position. MR imaging was performed in the neutral position in all patients. Atlanto-dental interval (ADI), dynamic change of the facet joints congruence were taken.

Results: In this study, dynamic CT was performed for 16 patients. Of 7 patients were diagnosed atlantoaxial instability, 8 cases combined with Os Odontoideum , 5 cases associated with basilar invagination. Posterior instrumentation and fusion at only the C1–2 level was performed in 9 patients. Whereas C1–2-level fixation and fusion using Margel's technique was performed in 2 patients with anomalous VA, and occipitocervical fusion combined with transoral anterior decompression was performed in 5 patients with basilar invagination. Another one patient with bilateral partial bony avulsion fracture of transverse atlantal ligament, without atlantoaxial instability, received conservative treatment. All these patients have good and excellent improvement after treatment at the following-up.

Conclusions: The alignment of the upper cervical spine may change significantly according to the neck position. Dynamic computerized tomography scan can provide usefully more detailed information to the diagnosis and the management of atlantoaxial instability.



Decompression of the spinal canal in subaxial cervical spine by the posterior unilateral approach - over the top hemilaminectomy. Results after two years of an ongoing study

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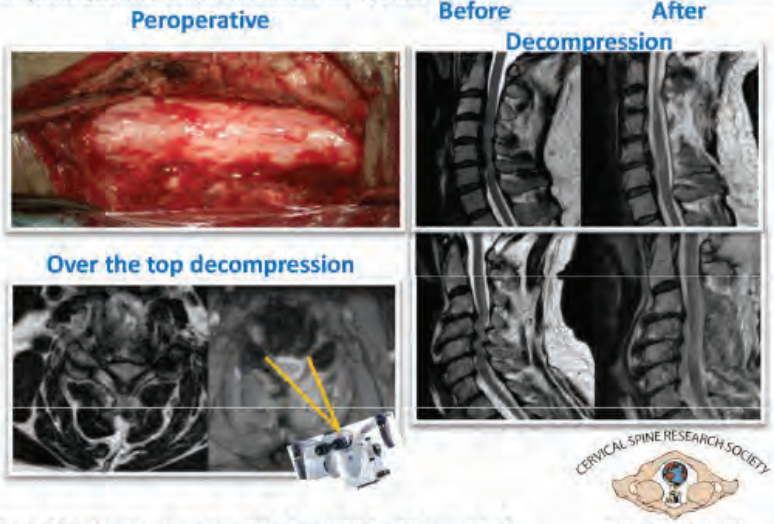
- **Methods:** In our study 15 patients underwent over the top cervical spine decompression. Spinal canal cross-sectional areas (CSA) in all decompressed levels before and after surgery were compared as well as cervical lordosis (Cobb angle).
- **Results:** Mean spinal canal CSA value for the one segment **before** decompression was on average **85,3mm²** , **after** decompression **172,7 mm²** . An **average increase** of the CSA before and after OP by **87,4mm²** . Mean CSA of the myelopathic segment was 55,4 mm² . After 12 month of follow-up the Cobb angle C2-7 did not exceed changes of 3.5° on average. On dynamic X-Ray images, there was no instability, 87% of patients clinically improved.
- **Conclusion:** Over the top cervical spine decompression is an elegant safety method, partially sparing the physiology of the cervical spine.



38th CSRS-Europe Annual Meeting, Stockholm, Sweden 31 May 2023 - 02 Jun 2023

CERVICAL SPINE RESEARCH SOCIETY
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Recurrence of atlantoaxial subluxation after optimal closed reduction of subacute atlantoaxial rotatory fixation: a case report and literature review.

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Masato Tanakai[1], Yasuhito Tanaka[1]
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Objective

- Most of acute atlantoaxial rotatory fixation (AARF) cases can be treated successfully with conservative treatment.
- Some cases rarely develop serious instability and require surgical treatment.
- We report a case of recurrence of atlantoaxial subluxation (AAS) after closed reduction of subacute AARF.

Case material

8 -year-old girl
Past History： None

Falling down

⇩ 2 mos.

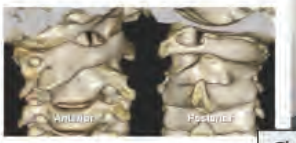
referral to our dept. & **Glisson neck traction**

⇩ failed

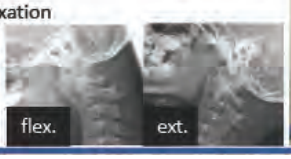
closed reduction & a **halo-vest** fixation

⇩ 2 mos.

axial rotatory displacement improved, but **AAS recurrence**



Closed reduction
Halo-vest



Result

op.

release between C1/2 facet joint using an osteotome

intra-articular bony bridge between C1/2 facet joint

3 yrs.

posterior fusion with autogenous bone graft

Discussion

- ✓ A motion preserving conservative therapy for AARF is a topic.[1)]
  ⇨ **Severe rotation and facet deformity** might be limitation.
- ✓ To evaluate asymmetrical facet deformity on CT[2)] and soft tissue injury on MRI is important.[3)]
- ✓ Posterior **C1/2 intra-articular release**[4)] was the key to reduce deformity successfully in these cases.

Reference

1) Ishii K, et al. Spine, 2011, 2) Fielding JW, et al. JBJS Am, 1977
3) Krakenes J, et al. Neuroradiology, 2002
4) Shimizu T, et al. Seikeigeka (in Japanese), 2013

COI disclosure : None

Is the fusion order of the cranial and caudal levels different in two-level anterior cervical discectomy and fusion for cervical spondylopathy?

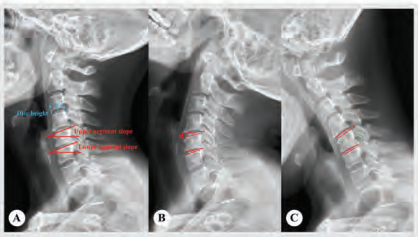
Xia-Qing Sheng, MD, Yang Meng, MD, PhD, Hao Liu, MD, PhD | West China Hospital, Sichuan University

Introduction

Study design. Retrospective study.
Objective. This study aimed to compare the fusion order between the cranial and caudal levels in two-level anterior cervical discectomy and fusion (ACDF) with a zero-profile device in the treatment of cervical spondylopathy.
Summary of Background. Fusion is the standard used to judge the success of ACDF. However, the fusion order in two-level ACDF remains uncertain. The mechanical environment of different levels is different, which may affect the fusion rate or fusion order.

Materials and Methods

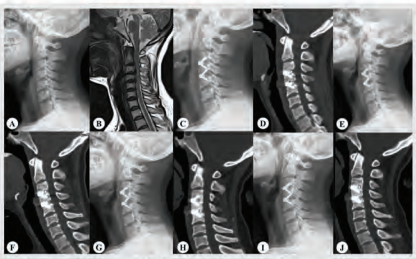
From 2014 to 2019, data of consecutive patients with two-level cervical disc degenerative disease who underwent ACDF were retrospectively reviewed. Radiological assessments were based on the range of motion of the fusion level, segment slope, and disc height, and complications were assessed. And logistic regression analysis were used.



(A) Disc height is calculated as (a+b+c)/3. The segment slope is defined as the angle between the horizontal line and the extension line of the upper endplate of the middle (or caudal) vertebral body. (B)(C) Range of motion is calculated as d–e.

Results

In total, 118 patients were enrolled. The respective fusion rates of the cranial and caudal levels were 26.27% and 10.17% ($p<0.05$) at 3 months, 58.47% and 42.37% ($p<0.05$) at 6 months, 86.44% and 82.20% ($p>0.05$) at 1 year, and 92.37% and 89.83% ($p>0.05$) at the last follow-up. Multivariate logistic regression analysis indicated the preoperative segmental slope and cranial level were independent risk factors for non-fusion. The adjacent segment degeneration (ASD) and subsidence rates were comparable between the two levels.



A 49-year-old woman. (A, B) Degeneration and compression at the C3/4 and C4/5 levels. (C, D) Two suitable prostheses placed at those levels. (E, F) Three-month postoperative, a growing bridge only at the cranial level. (G, H) Fusion of only the cranial level at 6 months postoperatively. (I, J) At 2 years postoperatively, only the cranial level completed fusion.

Conclusions

The caudal level had a slower fusion process than the cranial level. A higher preoperative segment slope was a risk factor of fusion. However, the subsidence and ASD rate were comparable between the caudal and cranial levels in two-level ACDF.

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POSTERS

INSTRUMENTED POSTERIOR OCCIPITO-CERVICAL FUSION SURGERY WITH AUTOLOGOUS TRICORTICAL ILIAC CREST GRAFT FIXED WITH MINIPLATES.

Guillermo Martín Quintero, Óscar Godino Martínez, Andreu Gabarrós Canals
Department of Neurosurgery, Bellvitge University Hospital. Barcelona, Spain

OBJECTIVES

To detail the experience in instrumented posterior **occipito-cervical fusion** (OCF) surgery with **autologous tricortical iliac crest graft** fixed with **malleable miniplates**.

METHODS

We performed a **clinico-radiological analysis of 3 patients** who underwent instrumented OCF, completed with an autologous tricortical iliac crest graft fixed to the occipital bone and to the lamina/spinous process of C2 with malleable miniplates and screws.

- A 59-year-old female with **occipito-cervical junction congenital malformation** with clinical basilar impression. She underwent endoscopic odontoidectomy and posterior descompression with OCF with occipital plate, translaminar C2 screws and iliac crest graft (Fig.1).
- A 25-year-old male affected by disseminated Tuberculosis with **severe occipito-atlantal tuberculous osteomyelitis** (OM) and associated instability. Initial conservative management with corset and antituberculous drugs was chosen. The patient had a good clinical evolution, but due to persistence of radiological instability, OCF (occipital plate, C2 bilateral pedicle screws) with iliac crest graft was performed.

Fig.1 Intraoperative detail of the iliac crest graft fixed with 4 miniplates to occipital bone and C2 lamina.

- A 51-year-old male admitted due to retropharyngeal abscess with subsequent **occipito-cervical OM** with radiological instability. The patient needed and emergent drainage of the abscess by ENT. Once recovered, we carried out an OCF (Occiput-C1-C2-C3 instrumentation) with iliac crest graft.

RESULTS

Subsequent follow-up was carried out in the immediate postoperative period, one month, 6 months and annually

In all cases, **graft integrity was observed with bone fusion** between the occipito-C2 segment, analyzed by computed tomography and dynamic radiographs (Fig.2). **No surgical complications** were detected either at the fusion site or at the graft extraction site, during the immediate postoperative period or during outpatient follow-up.

Fig.2 CT scan and dynamic X-ray demonstrating graft integrity and fusion of the segment at 1 year postop.

CONCLUSIONS

Regarding the classical techniques used in occipito-cervical fusion using wires/cables[1,2], we believe that autologous tricortical iliac crest graft fixed with malleable miniplates may be a **valid and technically simpler alternative to** obtain **segment fusion**.

References:: 1 Wertheim SB, Buhlman L. Occipitocervical fusion. Indications, technique, and long-term results in thirteen patients. *J Bone Joint Surg Am.* 1987;69(6): 833-836
2 McAfee PC, et al. Fusion of the occiputto the upper cervical spine. A review of 37 cases. *Spine.* 1991;16(10): S490-S494.

Posterior Two-Step Distraction and Reduction for Basilar Invagination with Atlantoaxial Dislocation: A Novel Technique for Precise Control of Reduction Degree Without Traction

Xia-Qing Sheng, MD, Yang Meng, MD, PhD, Hao Liu, MD, PhD | West China Hospital, Sichuan University

Introduction

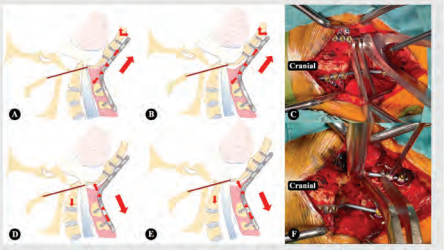
Objective. The pathological changes of basilar invagination (BI) and atlantoaxial dislocation (AAD) include vertical and horizontal dislocations. Current surgical techniques have difficulty accurately controlling the degree of reduction in these two directions and often require preoperative traction, which increases patients' pain, hospital stay, and medical cost. This study aimed to introduce a novel technique for accurately reducing horizontal and vertical dislocation without preoperative traction and report the radiological and clinical outcomes

Materials and Methods

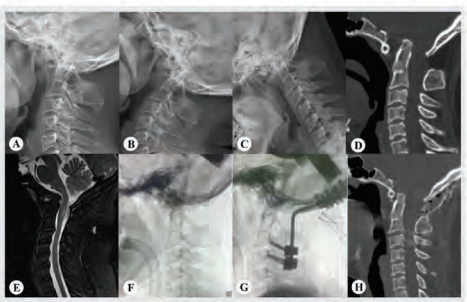
From 2010 to 2020, patients with BI and AAD underwent posterior two-step distraction and reduction (TSDR) and occipitocervical fixation. Radiological examination was used to evaluate the reduction degree (RD) and compression. Japanese Orthopedic Association (JOA) score was used to evaluate clinical outcome.

Results

A total of 55 patients with BI and AAD underwent TSDR and occipitocervical fusion. The clinical symptoms of 98.2% of them improved. JOA score increased significantly after the operation. Appropriate (50%≤RD< 80%) or satisfactory (RD≥80%) horizontal reduction was achieved in 92.7% of patients, and 90.9% obtained appropriate or satisfactory vertical reduction. Thirty-one patients did not undergo preoperative skull traction. There was no significant difference in radiological outcomes or JOA scores between the traction- and non-traction groups. However, the length of hospital stay in the traction group was longer than that in the non-traction group.



Two-step distraction reduction technique in the posterior approach. (A - B) Horizontal and partial vertical reduction were achieved by distraction between the rod holder and the occipital screw. (C) Intraoperative pictures of the first step. (D - E) Vertical reduction was achieved by distraction between the rod holder and the C2 lateral mass screw. (F) Intraoperative pictures of the second step.



A 43-year-old male complained of neck pain, weakness, and paraesthesia for 1 year. (A - C) X-ray and (D) sagittal reconstructed CT scan showed basilar invagination (BI) with atlantoaxial dislocation (AAD). (E) MRI showed compression of the cervical spinal cord, and the cervicomedullary angle (CMA) was 119.7°. (F - G) Intraoperative fluoroscopy showed that the effect of vertical and horizontal reduction was satisfactory. (H) Postoperative sagittal reconstructed CT scan confirmed that horizontal and vertical reductions were achieved after TSDR and occipitocervical fixation.

Conclusions

TSDR enables horizontal and vertical reduction. It is a safe, simple, and effective technique for patients with BI and AAD. Despite the absence of preoperative skull traction, the degree of reduction and clinical outcomes were satisfactory.

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Anterior column reconstruction with integrated plate-spacer in conjunction with conventional anterior plate: A New Technique in the Management of Cervical Spine Trauma

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North Bristol NHS Trust

Introduction

Surgical management of unstable subaxial cervical spine injuries typically involves anterior cage and plate fixation, occasionally augmented with posterior fixation. We describe the use of an integrated plate-spacer in combination with a plate, as a viable and stable construct in the management of unstable cervical injuries

Method

This was a single institution, retrospective case series between 2021-2023 for patients managed with this technique. We identified 12 patients who underwent an anterior fixation for their subaxial cervical spine trauma with an insertion of an integrated plate-spacer. In all cases the Globus MIS coalition spacer and Providence plate was used. The surgeries were performed by 5 Neurosurgical Consultants. Injury pattern, surgical technique and outcomes were analysed.

Surgical Procedure

All the procedures were performed by a consultant neurosurgeon. All anterior surgeries were single level surgeries. A standard anterior cervical discectomy was performed followed by fusion using the globus MIS coalition spacer under fluoroscopic guidance. This was followed by the application of a Providence plate. The posterior instrumented fixation methods were not standardised but left to the discretion of the surgeon based on the patient's pathology.

Figure 1. Globus MIS Coalition spacer

Results

Demographics

12 patients (11M, 1F) were identified with a mean age of 51 years at the time of presentation. Baseline function was recorded using the Rockwell frailty score with a mean of 1.8.

The mechanism of injury for the cases have been recorded in the table B; these included several causes of falls from significant height or speed. 3 patients were involved in a significant road traffic accident with only one patient sustaining injury from a low impact injury (falling from standing). The most common level of injury was at C6/7 (7 patients), followed by C5/6 (2) and C4/5 (2) with just 1 case at C3/4.

Results

Treatment

We additionally evaluated our patients using the AO classification of sub axial spine injuries; 7 patients sustained cervical translational injuries with the rest having significant tension band injuries. All patients had a SLICS score equal or greater than 5, indicating the need for operative intervention. 9 patients underwent anterior surgery only and 3 underwent a combined anterior and posterior fixation. Aside from one outlier (patient 7), the rest of the patients underwent surgery within 9 days from injury with a mean time to surgery of 2.18 days.

11 patients were managed in a hard collar post-operatively; in our institution we routinely use Aspen collars for a period of 6 weeks.

Follow up

In terms of follow up, 10 patients underwent post-operative imaging either in the form of a weight-bearing cervical x-ray (with anterior and lateral views) or CT of their cervical spine. Radiological evidence of bony fusion was reported in 3 cases; this included one patient with a single level anterior fusion only and two patients with additional posterior instrumented fusion. In the rest of the cases there were no radiographic evidence of failure.

Table 1: Injuries and Treatment for cases described

Patient No.	Mechanism of Injury	Level of Injury	AO Classification	Subaxial Injury Classification Scale (SLICS)	Anterior fixation level	Posterior fixation
1	Fall	C 6/7	C, F4, N0, M3	6	C6/7	C5-T1 fusion
2	Fall	C 6/7	C, F4, N2	6	C6/7	Nil
3	Road traffic accident	C3/4	B3, N4	8	C3/4	Nil
4	Fall	C4/5	B3, N3	9	C4/5	Nil
5	Fall	C6/7	B3, N3, M2	9	C6/7	Nil
6	Fall	C5/6	C, F4, N2	8	C5/6	Nil
7	Fall	C5/6	C, F4, N3	10	C5/6	C4-6 posterior decompression and lateral mass screws
8	Surfing	C6/7	B2, BL, F4, N1	5	C6/7	C6-T1 instrumented fusion
9	Road traffic accident	C6/7	B3 N0	8	C6/7	Nil
10	Road traffic accident	C6/7	C, F4, N0, M2	7	No	Nil
11	Fall	C6/7	C, BL, F4, N3	10	Yes	Nil
12	Fall	C4/5	C, BL, F4, N0	6	Yes	Nil

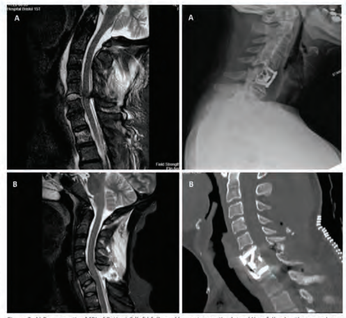

Figure 2: A) Pre-operative MRI of Patient 6 (left) followed by post operative lateral Xray following the procedure (right) B) Pre-operative MRI of Patient 8 (left) followed by post operative CT following the procedure (right)

Outcomes

There were no post-operative complications documented for the cases seen either during admission or at their follow up appointments. 8 patients received follow up reviews following their discharge with an average follow up of 153 days (5 months) overall.

Of the four who did not receive follow up at our institution, 1 patient died during their admission, 1 patient had ongoing care in their country of origin (Germany) and the remaining two cases were discharged to their local hospital. No patients were reported to have suffered late failure of instrumentation or required revision surgery. The one reported mortality in our series was due to concurrent traumatic brain injury and unrelated to their cervical spine surgery

Discussion

Our case series demonstrates how integrated plate-spacers with anterior plating can be used to manage unstable subaxial cervical spine injuries. We found that this technique provided good neurological decompression as well as spinal stability. There were three instances whereby further posterior instrumented fixation was required; first in the case of a fracture associated with ankylosing spondylitis, and the latter two, to facilitate the operative reduction of perched facet dislocations.

Discussion

The question of optimal surgical approaches in cervical spine trauma remains a topic of hot debate with proponents for anterior, posterior and circumferential approaches. Various factors influence the decision for one over the other including pattern of injury, comorbidities, surgeon's training and local institutional practice[1]. Supporters of the anterior approach have demonstrated the clinical advantages such as reduced operative time and thereby blood loss, along with less wound complications[1]. The management of subaxial flexion-distraction injuries were reviewed by Jack et.al[2] through their retrospective cohort study. Overall, only 7% required revision within 30 days in the form of posterior fixation. Furthermore, improved stabilisation has been seen with anterior over posterior approaches in isolated cervical facet fractures[3].

There is biomechanical evidence to suggest that anchored cervical interbody spacers are effective even in high grade flexion distraction injuries but further evaluation is needed to assess the overall strength with the addition of a plate[4]. Theoretical advantages include the addition of compressive lag forces to prevent over-distraction of the segment, and possible avoidance of posterior instrumentation in some cases.

References

1. Sethy SS, Goyal N, Ahuja K, Ifthekar S, Mittal S, Yadav G, Venkata Sudhakar P, Sarkar B, Kandwal P. Conundrum in surgical management of three-column injuries in sub-axial cervical spine: a systematic review and meta-analysis. European Spine Journal. 2022 Feb 1:1-0.
2. Kepler CK, Vaccaro AR, Chen E, Patel AA, Ahn H, Nassr A, Shaffrey CI, Harrop J, Schroeder GD, Agarwala A, Dvorak MF. Treatment of isolated cervical facet fractures: a systematic review. Journal of Neurosurgery: Spine. 2016 Feb 1;24(2):347-54.
3. Jack A, Hardy-St-Pierre G, Wilson M, Choy G, Fox R, Nataraj A. Anterior surgical fixation for cervical spine flexion-distraction injuries. World neurosurgery. 2017 May 1;101:365-71.
4. Wojewnik B, Ghanayem AJ, Tsitsopoulos PP, Voronov LI, Potluri T, Havey RM, Zelenakova J, Patel AA, Carandang G, Patwardhan AG. Biomechanical evaluation of a low profile, anchored cervical interbody spacer device in the setting of progressive flexion-distraction injury of the cervical spine. European Spine Journal. 2013 Jan;22:135-41.

3D Navigation is useful for posterior cervical foraminotomy, especially of the lower cervical spine

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Disclosure Statement of Financial Interest

The authors DO NOT have a financial interest or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation

Introduction

- Unilateral monosegmental radiculopathy, caused by foraminal soft disc nerve root compression, can be safely and effectively treated with posterior cervical foraminotomy (PCF).[1,2]
- Intraoperative fluoroscopy is the most widely used method for level localization, but the quality of images decreases in the lower cervical spine as the neck and shoulder contribute more tissue to the X-ray beam.[3]
- 3D navigation is a technology that uses X-rays to collect a data set that can be converted into three-dimensional images.[4]
- Therefore, 3D navigation has been found to have advantages over fluoroscopy in terms of surgery time, reduced length of stay, radiation exposure and complication rates.[5]
- To our knowledge, no studies have investigated the impact of the orientation advantage of 3D navigation on surgery time, length of hospital stay, and neurological outcomes in the context of upper versus lower cervical spine.

Material And Methods

- In this retrospective observational study, we analyzed a total of 45 patients (mean age 54 ± 9 years, mean BMI 29 ± 7, 22 females and 23 males) who underwent PCF using intraoperative 3D navigation (O-armTM System, Medtronic) between 08/2017 and 04/2022.
- Two-tailed t-tests were used for simple difference comparison of preoperative, postoperative and follow-up (FU, 48 ± 28 days) values for neck pain (visual analogue scale, VAS), radicular pain (VAS) and paresis (muscle strength according to Janda).
- The developments of neurological outcome parameters within the subgroups (C2-C6 and C6-T1) were analyzed by one-way ANOVA.

Figure 1

Figure 1 Patient positioning

Figure 2

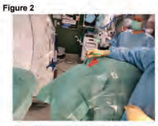

Figure 2 Navigated level localization

Figure 3

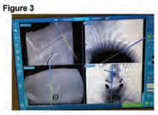

Figure 3 Monitoring view of level localization

Figure 4

Figure 4 Skin incision

Table 1

	overall		C3-C6		C6-T1		C3-C6 vs. C6-T1
	male	female	male	female	male	female	p value
Gender	23	22	11	14	10	7	.5303
	mean	sd	mean	sd	mean	sd	p value
Age (years)	54	8.809	56	9.911	52	9.289	.3027
BMI	29	6.735	28	5.268	31	8.386	.1848
	n	%	n	%	n	%	
Diabetes	6	13.3	3	12.0	3	17.6	.6720
High Blood Pressure	21	46.7	9	36.0	10	58.8	.2092
Nicotine addiction	25	55.6	12	48.0	10	58.8	.5430
Depression	5	11.1	2	8.0	3	17.6	.3795
	mean	sd	mean	sd	mean	sd	p value
Neck pain preop (VAS)	7	2.350	8	2.255	7	2.732	.9414
Radicular pain preop (VAS)	7	2.222	8	1.809	8	2.419	.8549
Paresis preop (Janda)	4	1.107	4	0.9574	4	1.263	**.0313**

Table 1 Baseline characteristics showing demographic, major comorbidities, clinical findings and hospitalization data. Sd = standard deviation. Preop = preoperative. VAS = visual analogue scale. Janda = muscle strength according to Janda scale. Min = minutes.

Figure 5

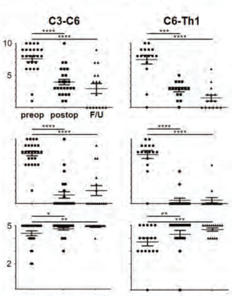

Figure 5 Analysis of postoperative neurological outcome within each subgroup. Neck pain: Preop = preoperative. Postop = postoperative at discharge. F/U = Follow-up. VAS = visual analogue scale. Janda = muscle strength according to Janda scale.

Table 2

	C3-C6		C6-T1		C3-C6 vs. C6-T1
	mean	sd	mean	sd	p value
Time of Surgery (min)	88	24,06	89	26,46	.9848
Length of Stay (days)	6	3,004	6	3,976	.9533
	mean	sd	mean	sd	p value
Neck pain postp (VAS)	4	2,131	3	1,291	.0986
Neck pain F/U (VAS)	3	3,087	1	1,767	.3119
Radicular pain postop (VAS)	1	2,495	1	1,414	.2177
Radicular pain F/U (VAS)	2	3,098	1	1,598	.1183
Paresis postop (Janda)	4,8	0,5228	4,3	1,263	.1255
Paresis F/U (Janda)	4,9	0,2582	4,7	0,488	.1686

Table 2 Level-dependent hospitalization data and postoperative neurological outcome between both subgroups. Sd = standard deviation. Postop = postoperative at discharge. F/U = Follow-up. VAS = visual analogue scale. Janda = muscle strength according to Janda scale.

Results

- Baseline characteristics do not differ significantly except for the extent of paresis (C3-C6: 4,4; C6-T1: 3,7), as shown in table 1.
- In both subgroups, neck pain decreased significantly compared to the preoperative values (Fig. 5, C3-C6: **** $p < .0001$; C6-Th1: *** $p = .0003$, **** $p < .0001$).
- The same improvement applied to the radicular pain (Fig. 5, C3-C6 and C6-Th1: **** $p < .0001$) and paresis (Fig. 5, C3-C6: * $p = .0179$, ** $p = .0015$; C6-Th1: ** $p = .0023$, *** $p = .0003$).
- As shown in table 2, we could neither detect any significant group differences concerning the hospitalization data nor at the time of discharge and follow-up for each neurological parameter (all $p > .0986$).
- 81,3 % of the patients had an intraoperative blood loss of less than 100 ml.
- Mean time of surgery was 92 minutes (± 28) with 6 days (± 3) as the mean length of stay.
- All surgery levels were identified correctly.
- Anterior revision surgery was performed in 3 patients because disc herniation could not be completely removed from dorsal.

Conclusion

- Intraoperative 3D navigation was successfully used for PCF in our patient cohort, resulting in significant symptom relief.
- Especially during procedures on the lower cervical spine and cervicothoracic junction, 3D navigation simplified orientation and thus ensures an equivalent outcome as on the upper cervical spine.

References:
[1]Dodwad SJ et al.: Posterior Cervical Foraminotomy: Indications, Technique, and Outcomes. Clin Spine Surg. 2016 Jun
[2]Bono CM et al.: An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. Spine J. 2011 Jan
[3]Truong VT et al.: Enhanced Visualization of the Cervical Vertebra during Intraoperative Fluoroscopy Using a Shoulder Traction Device. Asian Spine J. 2020 Aug
[4]Tonetti J et al.: Role of 3D intraoperative imaging in orthopedic and trauma surgery. Orthop Traumatol Surg Res. 2020 Feb
[5]Kimaz S et al.: Intraoperative image guidance for cervical spine surgery. Ann Transl Med. 2021 Jan

C1-2 Fusion for Facet Arthritis - Neck Pain and Functional Changes

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Abstract

GOAL

The study is aimed to describe a local Australian case series on the surgical management of atlantoaxial osteoarthritis (AAOA) and its effect on pain reduction and functional disability.

METHODS

The case series retrospectively follows 23 patients who have undergone C1-2 fusion surgery for AAOA pain by a single surgeon. Its primary outcomes measured the change in the visual analogue scale (VAS), neck disability index (NDI), and Roland-Morris neck pain and disability scores (RMNPDS) postoperatively relative to preoperatively. Secondary outcomes included complications, revision surgery, duration of hospital stay, radiographical evidence of fusion, and patient satisfaction. Mean follow-up time was 37 months.

RESULTS

Statistical significance was achieved upon data analysis with all primary outcomes. Patients demonstrated a mean post-operative reduction of 27%, 5.25 points, and 5.6 points across the NDI, RMNPDS, VAS, respectively. Radiographical evidence was also demonstrated on postoperative CT for all followed-up patients. However, the procedure did have a complication rate of approximately 8.7% and 2 patients opted not to undergo the procedure again for the same condition.

CONCLUSION

These results are consistent with the current literature and show that C1-2 fusion surgery is efficacious for reducing intractable AAOA pain and functional disability but should be considered in the context of potential complications and patient satisfaction.

Introduction

Atlantoaxial osteoarthritis (AAOA) represents a well-documented entity and often misdiagnosed cause of severe neck pain in elderly populations [2][3][4]. Its prevalence increases with age, ranging from 5.4% to 18.2% but does not always become symptomatic [5]. It presents clinically with unilateral neck pain that frequently radiates to the occiput and parietal skull. The joint is often tender to palpation and pain and is usually exacerbated by slight rotations of the head, resulting in a markedly limited range of motion. Stiffness in the shoulders and finger paresthesia may also occur. [2][3][4][6][7]. A major differential diagnosis is occipital neuralgia (ON), which is typically characterized by pain and dysesthesia in the occipital nerves. AAOA is often hard to distinguish from ON [2][3], and both can also occur simultaneously as AAOA can cause ON, albeit rarely [8]. Other differential diagnoses include "myelopathic/quadriplegia, migraines, cluster headaches, infection and tumours." [8]

Although studies have demonstrated mixed evidence for their benefits, the initial management of AAOA is conservative. There are numerous non-operative therapy modalities, including physiotherapy, non-steroidal anti-inflammatory drugs (NSAIDs), steroid injections, occipital nerve blocks and radiofrequency ablation [3][9][10][11]. The general progression to operative management is the development of intractable neck pain despite an adequate trial of these conservative therapies.

C1-2 arthrodesis was first reported by Gallie in 1939, using posterior wiring as their approach [12]. Since then, multiple different techniques have been developed and modified with higher success and lower complication rates. The two most popular modern techniques currently are the Magerl and Harms/Goel approaches [13]. The Magerl technique uses trans-articular screw fixation of the lateral mass whereas the Harms/Goel method utilises polyaxial screws and rods into the lateral mass and pars interarticularis. They have both been shown in the literature to provide symptomatic control for AAOA and their use can vary based on different surgeons' preferences [13][14].

There has been a limited collection of case series and meta-analyses published regarding patients with AAOA that have undergone surgical management. A large proportion of older papers usually involved much smaller sample sizes and outdated fixation techniques or consisted of heterogenous sample groups inclusive of non-AAOA pathologies [16]. A portion of the current research also focuses on fusion rates, complication risks, and/or pain reduction as their main primary outcomes [16, 17, 18]. Patient-reported outcomes and the impact of atlantoaxial fusion surgery on functional disability is less researched, and this study intends to compare a local Australian case series with currently available data.

Methodology

PATIENT SELECTION

Data was prospectively collected from a consecutive series of 23 patients, operated on between 2007 and 2021 by the senior author (R.F.), inclusion criteria consisted of all patients with C1-2 osteoarthritis receiving atlantoaxial fusion surgery, >18 years of age, radiographic evidence of atlantoaxial osteoarthritis, and history of intractable neck pain failing or no longer responding to non-operative management. Exclusion criteria consisted of patients with instability secondary to cancer, trauma (fractures or dislocations), or congenital abnormalities/malformations. Patients with rheumatoid and septic arthritis were excluded, as well as those with previous atlantoaxial surgery.

CLINICAL PARAMETERS AND DATA COLLECTION

Patients were required to fill out a Neck Disability Index (NDI), Visual Analogue Scale (VAS) for pain, and Roland-Morris Neck Pain & Disability Score (RMNPDS) prior to surgery. The primary outcomes assessed were changes to NDI, VAS, and RMNPDS postoperatively compared to preoperatively. Follow-up for all patients was performed retrospectively via phone calls over a 2-month period and/or gathered from patient files. Mean follow-up time was 37 months.

Patient demographics and predictor variables were gathered and included age, sex, ASA score, smoking status, osteoporosis, depression, and previous subaxial cervical surgery.

Secondary outcomes assessed were complications, revision surgery, duration of stay, radiographical evidence of fusion, and patient satisfaction. Data for these parameters were also gathered from patient files and confirmed on phone calls. Patient satisfaction was assessed by asking if the patient would undergo the procedure again for the same condition; CT was performed prior to surgery and 6 months after. It was reviewed by the senior author and compared to assess for bony trabeculae bridging across the C1-2 joint indicative of fusion.

STATISTICAL ANALYSES AND METHODS

Changes in pain and disability scores were analysed for 23 participants who have undergone cervical spine fusion and calculated as the difference between the post- and pre-fusion scores.

Baseline characteristics (Table 1) and summary of pain and disability scores (Table 2) included frequencies for categorical variables and mean with SD and median with IQR for continuous variables. Change in pain and depression scores (VAS, NDI and RMNPDS) was calculated as the difference between the post-fusion score and the pre-fusion score. Paired t-tests were used to determine if there was a significant change in the mean pain scores.

Univariate linear regression was used to assess the relationship between the change score and the predictor variables (depression, previous surgery, age, ASA score, sex, and smoking status). Results are presented as the difference in the mean scores with a 95% confidence interval. Statistical significance was assessed using univariate Wald tests with a p-value less than 0.05 considered significant.

Results

Table 1: Demographics

Variable	Class/Statistic	Total (n=23)	Variable	Class/Statistic	Total (n=23)
ASA	2	8 (35%)	Osteoporosis	No	21 (91%)
	3	15 (65%)		Yes	2 (8.7%)
Age	IV	23	Previous Surgery	No	21 (91%)
				Yes	2 (8.7%)
	Mean (SD)	74 (7)	Sex	Male	16 (70%)
	Median (IQR)	75 (70, 78)		Female	7 (30%)
Depression	No	19 (83%)	Smoker	Never	14 (61%)
	Yes	4 (17%)		Ex-smoker	7 (30%)
Fusion Type	Harms	13 (56%)		Smoker	2 (8.7%)
	Magerl	1 (4.3%)			
Months Since Surgery	N	23			
	Mean (SD)	37 (42)			
	Median (IQR)	30 (13, 48)			

Table 2: Summary of pain and disability scores

Variable	Class/Statistic	Pre-Fusion	Post-Fusion	Change	p-value
NDI	N	22	20	20	
	Mean (SD)	9.42 (5.16)	0.55 (0.17)	-0.27 (0.15)	<.0001
	Median (IQR)	0.39 (0.28, 0.54)	0.16 (0.02, 0.21)	-0.27 (-0.34, -0.15)	
RMNPDS	N	22	21	26	0.0001
	Mean (SD)	9.77 (5.91)	4.71 (6.04)	-5.25 (4.95)	
	Median (IQR)	8.50 (5.00, 12.00)	1.00 (0.00, 8.00)	-4.50 (-7.00, -2.50)	
VAS	N	22	21	20	<.0001
	Mean (SD)	7.82 (1.50)	2.43 (2.71)	-5.60 (3.17)	
	Median (IQR)	8.00 (7.00, 9.00)	1.00 (0.00, 5.00)	-6.00 (-8.00, -4.00)	

A total of 23 patients with available demographical data and predictor variables were enrolled for analysis (Table 1). 3 patients were lost to follow-up, 2 of which had pre-operative pain, disability scores, and a CT. The last patient had a post-operative VAS, RMNPDS, and 6-month CT recorded but no NDI and pre-operative scores.

Demographics and Predictor Variables (Table 1)

The mean age at surgery was 74 with a standard deviation (SD) of 7 (total range: 50 to 85). The median age was 75 and the interquartile range (IQR) was 70 to 78. 15 of the patients (65%) were female compared to 8 males (35%). The ASA scores were also divided into 15 patients (65%) having a score of 3, and 8 patients (35%) having a score of 2. The mean follow-up time was 37 months but held an SD of 40 (total range: 6 to 185 months) and the median follow-up time was 40 months with an IQR of 10 to 58 months. Almost all patients (22/86%) utilized a Harms fixation technique and only 1 patient (4%) was operated on using Magerl's. 4 patients (17%) had a current diagnosis of depression and were receiving medical treatment, whilst 19 (83%) did not. Only 2 patients (9%) had a previous or current diagnosis of osteoporosis and similarly, only 2 patients (9%) had undergone previous subaxial cervical surgery. 2 patients (9%) were current smokers, 7 (30%) were ex-smokers and 14 (61%) had never smoked in their life.

The predictor variables did not display any statistical significance except for the 'sex' category. Males had a mean VAS score of 3.560 points higher than females ($p=0.0032$), a mean NDI of 0.172 points higher ($p=0.0234$), and a mean RMNPDS of 4.125 points higher ($p=0.0431$).

Primary Outcomes (Table 2)

Mean and median NDI, RMNPDS, and VAS scores were compared pre- and post-fusion to highlight the differences between the two groups (Table 2). Paired t-tests showed a statistically significant improvement of each score pre- and post-fusion. The NDI had a mean and median reduction of 0.27 points (or 27%) with a standard deviation of 0.19 ($p<0.0001$) and IQR of -0.34 to -0.19. The RMNPDS had a mean reduction of 5.25 points and an SD of 4.85 ($p<0.0001$). It had a median reduction of 4.5 points and an IQR of -7.00 to -2.50. The VAS had a mean reduction of 5.6 points and an SD of 3.17 ($p<0.0001$). It had a median reduction of 6 points and an IQR of -8.0 to -4.0 points.

Secondary Outcomes

The secondary outcomes of the patient group were recorded. None of the patients required revision surgery and the duration of hospital stay ranged from 2 to 5 days, with 2, 12, 5, and 3 patients staying for those respective lengths. 1 patient developed an intraoperative complication and was required to stay longer which will be discussed in the next section. 19/20s of followed-up patients showed radiographical evidence of fusion on CT after 6 months. 16 patients (78%) stated that they would be willing to undergo the surgery again, whilst 2 (9%) declined due to resulting increased pain or neck stiffness and occipital dysesthesia.

Discussion

AAOA is a well-established cause of neck pain and disability. It often remains asymptomatic despite its high radiological prevalence from 5.4% in the sixth decade of life to 18.2% in the ninth decade [5]. Symptomatic lateral AAOA has previously been reported to occur in about 4% of a population with pre-existing spinal degeneration or peripheral osteoarthritis [3]. The mean age of 74 among the patients enrolled in our study is highly congruent with this data, and whilst parameters of pre-existing spinal degeneration or peripheral osteoarthritis were not formally recorded, 2 patients (~9%) did had previous subaxial surgery.

AAOA is often hard to diagnose and does not always respond to conservative therapies, despite there being some evidence for their use [19, 20]. Research on fusion surgery for AAOA is limited and tends to focus on pain reduction, fusion rates, and radiographical changes. However, some studies assess patient function and disability by utilising patient-reported questionnaires such as the NDI, VAS, Numeric Pain Rating Scale (NRS), and Patient Acceptable Symptom State (PASS). Many of these studies demonstrate an improvement in these outcomes post-operatively. [12, 21]

These results are aligned with the data from this case series, which demonstrate statistically significant and large improvements in VAS and NDI scores. The same improvement is seen in the RMNPDS, but the use of the RMNPDS should be discussed. Whilst the RMDQ was designed and has evidence supporting its use for lower back pain assessment [23], its application to neck pain and disability is yet to be outlined in the literature. Given its proven efficacy for lower back pain, it was used as an additional measure of patient-reported outcomes to complement the VAS and NDI, and results should be interpreted within that context.

A recent study by Yin et. al. [16] remarked that whilst the literature demonstrated efficacy for operative interventions, they were not ideal for the collection of patient-reported outcomes such as the NDI. They expressed concerns that factors such as existing comorbidities can confound the results, given the subjective nature of the questionnaires. Whilst it should be acknowledged, developing co-morbidities post-operatively that confound the reported outcomes would likely generate poorer post-operative scores. Despite this, the analysis still highlighted a statistically significant improvement. To reduce the impact of this variable, future studies with a strict follow-up period should be conducted.

They also noted issues that sections of the questionnaire could be deemed invalid. An example of this is the 'driving' section of the NDI, where patients would often mistakenly attribute difficulties with driving postoperatively to neck stiffness instead of pain. This was also observed within our study wherein many patients needed to be reminded upon phone assessment to judge the section based purely on neck pain, instead than stiffness. Another issue we noticed was that patients who did not drive prior to, or following the surgery would have the entire section marked as invalid, which ultimately could result in a lower score compared to a patient with the same presentation that did drive.

A common observation reported by patients was the limitation in rotational range of motion following surgery. This was described to impact upon their daily functioning but significantly less severely than the AAOA pain. Another observation reported by 3 patients (13%) was the development of occipital dysesthesia following fusion surgery. For one of the patients, it caused such discomfort that they refused to have the surgery again for the same condition. The majority of patients (18 out of 20) opted that they would have the surgery again for the same condition though. This is congruent with a study by Stulik et. al., in which patients reported the rotational restriction but accepted it as a condition for relief from their neck pain and disability [22]. It should be noted that there is a paucity of information on occipital dysesthesia following fixation surgery and could be expanded on in further studies.

Our case series displays C1-2 fusion surgery to be an efficacious and effective treatment for AAOA pain that is non-responsive to adequate courses of conservative therapies. It is worth noting that the literature generally reports low rates of minor complications associated with the procedure and this has been theorised to be largely due to experienced surgeons performing C1-2 arthrodesis [13, 15]. Our overall complication rates were quite low at about ~8.7%. However, both the patients in our case series developed quite significant complications of myocardial infarction and PRES. Whilst this is highly unlikely to be due to the surgeon's experience, it demonstrates that the procedure can carry some significant risk to the patient and should be considered prior to undertaking.

Our study's main limitations lie within the relatively small sample size and long mean follow-up time. Whilst still analysing one of the larger case series on C1-2 fusion for AAOA, smaller sample sizes result in wide confidence intervals and underpowered analyses. The predictor variable results should be also interpreted cautiously due to sparse data. Only 4 patients had depression, 2 had previous surgery and 2 were smokers. This results in highly influential observations that may not be reflected in the population of interest. A soft confounder within the predictor variables is the imbalance of females (15) to males (8) in the study. The males demonstrated statistically significantly worse scores on VAS, NDI and RMNPDS, scoring higher by 3.560, 0.172, and 4.121 respectively. In addition to this, depression has been shown to be a cause of increased pain and poorer daily function in patient-reported outcomes [24]. Whilst not statistically significant in this study, it could be mentioned that two of the patients with depression reported much poorer outcomes compared to the patients without.

Complications

The overall complication rates were low (~10%). Two patients developed relatively significant complications resulting from the procedure, with one having a myocardial infarction and another developing posterior reversible encephalopathy. The first patient required an extended hospital stay (6+ days), being transferred under the care of a cardiologist following surgery. The second patient was readmitted within 30 days to the hospital under the care of a neurologist. Both patients made full recoveries.

Conclusion

C1-2 fusion surgery for intractable AAOA pain demonstrated a statistically significant reduction in both pain and disability. However, the procedure does have a small risk of morbidity (<10%), and not all patients were satisfied with the results. The progression to fusion surgery should be strongly considered within that context.

References

1. Swartz, E. E., Floyd, R. T., & Cendoma, M. (2005). *Cervical spine functional anatomy and the biomechanics of injury due to compressive loading.* Journal of athletic training. Retrieved April 30, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1250253/
2. Ehni, G., & Benner, B. (1984). Occipital neuralgia and the C1–2 arthrosis syndrome. *Journal of Neurosurgery*, *61*(5), 961–965. https://doi.org/10.3171/jns.1984.61.5.0961
3. Adogwa, O., Buchowski, J. M., Sellaturai, J. A., Shirley, M. A., Theologis, A. A., Lin, E., CrewCrew, T., Peters, C., & Riew, K. D. (2020). Improvements in neck pain and disability following C1-C2 posterior cervical instrumentation and fusion for Atlanto-axial osteoarthritis. *World Neurosurgery*, *139*. https://doi.org/10.1016/j.wneu.2020.04.051
4. Hala, J. T., & Hardin, J. G. (1987). Atlantoaxial (C1-C2) facet joint osteoarthritis: A distinctive clinical syndrome. *Arthritis & Rheumatism*, *30*(5), 577–582. https://doi.org/10.1002/art.1780300514
5. Zapletal, J., & de Valois, J. C. (1997). Radiologic prevalence of advanced lateral C1-C2 osteoarthritis. *Spine*, *22*(21), 2513–2518. https://doi.org/10.1097/00007632-199711010-00009
6. Schaeren, S., & Jeanneret, B. (2005). Atlantoaxial osteoarthritis: Case series and review of the literature. *European Spine Journal*, *14*(5), 501–506. https://doi.org/10.1007/s00586-004-0856-4
7. Harata, S., Tohno, S., & Kawaguchi, T. (1982). Osteoarthritis of the Atlanto-axial joint. *International Orthopaedics*, *5*(4), 277–282. https://doi.org/10.1007/bf00270189
8. Sherry, M. F., Guha, D., Mohanty, C., & Tator, C. H. (2015). Occipital neuralgia secondary to unilateral atlantoaxial osteoarthritis: Case report and review of the literature. *Surgical Neurology International*, *6*(1), 186. https://doi.org/10.4103/2152-7806.172253
9. Akuli, C. M., Hooten, W. M., Sanders, R. A., Watson, J. C., Moeschler, S. M., Gazelka, H. M., Fowler, B. C., Elrinpe, J. L., Qu, W., & Lamer, T. J. (2017). Outcomes of C1-2 joint injections. *Journal of Pain Research*, *Volume 10*, 2283–2289. https://doi.org/10.2147/jpr.s144255
10. Bogduk, N., & Govind, J. (2009). Cervicogenic headache: An assessment of the evidence on clinical diagnosis, invasive tests, and treatment. *The Lancet Neurology*, *8*(10), 959–968. https://doi.org/10.1016/s1474-4422(09)70209-1
11. Haldeman, S., & Dagenais, S. (2001). Cervicogenic headaches. *The Spine Journal*, *1*(1), 31–46. https://doi.org/10.1016/s1529-9430(01)00024-9
12. Gallie, W. E. (1939). Fractures and dislocations of the cervical spine. *The American Journal of Surgery*, *46*(3), 495–499. https://doi.org/10.1016/s0002-9610(39)90310-0
13. Kreinbrink, P. S., Telera, T. F., Lotti, M., Jeszensky, D., Haschtmann, D., Porchet, F., & Mannion, A. F. (2012). Patient-rated outcome after atlantoaxial (C1-C2) fusion: More than a decade of evaluation of 2-year outcomes in 126 patients. *European Spine Journal*, *3*(C12), 3620–3630. https://doi.org/10.1007/s00586-021-06959-1
14. Elliott, R. E., Tanweer, O., Boah, A., Morsi, A., Ma, T., Frempong-Boadu, A., & Smith, M. L. (2014). Outcome comparison of atlantoaxial fusion with transarticular screws and screw-rod constructs. *Journal of Spinal Disorders & Techniques*, *27*(1), 11–28. https://doi.org/10.1097/bsd.0b013e318277fe19
15. Elliott, R. E., Tanweer, O., Smith, M. L., & Frempong-Boadu, A. (2013). Outcomes of fusion for lateral atlantoaxial osteoarthritis: Meta-analysis and review of literature. *World Neurosurgery*, *80*(6). https://doi.org/10.1016/j.wneu.2012.08.018
16. Yin, M., Ding, P., Liu, S., Ma, J., & Ma, W. (2022). Research progress of atlantoaxial osteoarthritis: A narrative literature review. *World Neurosurgery*, *160*. https://doi.org/10.1016/j.wneu.2022.01.081
17. GHANAVATI, A., L. E. V. A. N. D. E. R. J., LEVENTHAL, M. A. R. V. I. N., & BOHLMAN, H. E. N. R. Y. H. (1996). Osteoarthrosis of the atlanto-axial joints. long-term follow-up after treatment with Arthrodesis*?. *The Journal of Bone & Joint Surgery*, *78*(9), 1300–7. https://doi.org/10.2106/00004623-199609000-00002
18. Kukilo, T. R., Riew, K. D., Dvorkowski, L. R., Wein, D. S., Schroeder, T. M., & Gilula, L. A. (2006). Management of recalcitrant osteoarthritis of the Atlanto-axial joint. *Orthopedics*, *29*(7), 633–638. https://doi.org/10.3928/0147-7447-20060701-06
19. Mehnert, M. J., & Freedman, M. K. (2013). Update on the role of 2-joint injection and radiofrequency neurotomy for cervicogenic headache. *PM&R*, *5*(3), 222–227. https://doi.org/10.1016/j.pmrj.2013.01.001
20. Holm, W., Chua, N. H., & Vissers, K. C. (2010). Long-term pain relief in patients with cervicogenic headaches after pulsed radiofrequency application into the lateral atlantoaxial (C1-2) joint using an anterolateral approach. *Pain Practice*, *10*(4), 267–271. https://doi.org/10.1111/j.1533-2500.2010.00366.x
21. Kang, D. G., Lehman, R. A., Wagner, S. C., Peters, C., & Riew, K. D. (2017). Outcomes following arthrodesis for Atlanto-axial osteoarthritis. *Spine*, *42*(5). https://doi.org/10.1097/brs.0000000000001783
22. Stulik, J., Rama, M., & Kryl, J. (2012). Operační léčba atlantoaxiální artrózy (AAOA): prospektivní studie 27 pacientů [Surgical treatment for atlantoaxial osteoarthritis (AAOA): a prospective study of twenty-seven patients]. Acta chirurgiae orthopaedicae et traumatologiae Cechoslovaca, *79*(1), 31–36.
23. Burbridge, C., Randall, J. A., Abraham, L., & Bush, E. N. (2020). Measuring the impact of chronic low back pain on everyday functioning: Content validity of the Roland Morris Disability questionnaire. *Journal of Patient-Reported Outcomes*, *4*(1). https://doi.org/10.1186/s41687-020-00234-5
24. Bay, M. J., Robinson, R. L., Katzo, W., & Kravetz, K. (2003). Depression and pain comorbidity. *Archives of Internal Medicine*, *163*(20), 2433. https://doi.org/10.1001/archinte.163.20.2433

Percutaneous 3D image-guided navigated C1 ring osteosynthesis: initial single center experience

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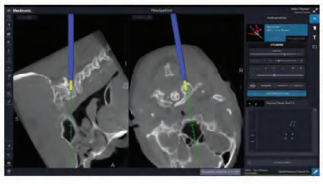
INTRODUCTION

The classical surgical management of unstable C1 fracture by atlanto-axial fusion impacts motion and function. Open surgery can also affect wound healing and duration of hospital stay. We present our initial experience in a modified procedure in unstable C1 fractures – Percutaneous navigated procedure for isolated C1 ring osteosynthesis.

MATERIALS & METHODS

The patients were in prone position in a Mayfield carbon headholder. The navigation frame was placed on the head holder. An intraoperative, 3D image navigation system was used for the 1,5 cm skin incision on both sides and the optimal placement of C1 screws. A transverse rod was then placed connecting the two screws under the fascia. The patients were prospectively evaluated in terms of their clinical, functional, and radiological outcomes with a follow-up of 6 months.

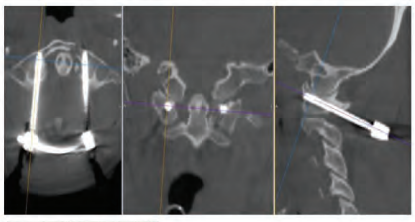


RESULTS

A total of 4 screws were placed in two patients by this technique with a mean follow up of 6 months. The mean duration of surgery was 123 minutes and the average blood loss was 20 mL. The patients were discharged from the hospital within two days after the surgery. The intraoperative O-arm scan and follow-up CT showed correct placement of screws and wound healing. There were no complication regarding the atlanto-axial stability. Patients returned to their occupation within 2 months.

CONCLUSIONS

Percutaneous isolated C1 ring osteosynthesis allows a motion-preserving option in unstable C1 fractures. This percutaneous navigated technique can safely compete most commonly used surgical procedures. This mini-invasive method reduce the blood loss during the surgery, hospital stay and preserve the functional status.



FURTHER INFORMATION
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CONFLICT OF INTEREST: none

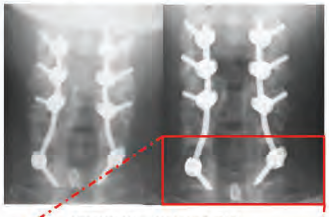
POSTERS

Factors related to implant failure in posterior cervical fusion

Tokue Mieda[1]
Yoichi Iizuka[1] Eiji Takasawa[1] Sho Ishiwata[1] Akira Honda[1] Masatoshi Ono[2] Masatake Ino[2] Naofumi Toda[2] Keisuke Fueki[2] Takachika Shimizu[2] Hirotaka Chikuda[1]
1) Department of Orthopaedic Surgery, Gunma University Graduate School of Medicine, Maebashi, Japan 2)Department of Orthopedic Surgery, Gunma Spine Center, Harunaso Hospital, Takasaki, Gunma, Japan

Background

Postoperation　Postoperation at 3months



Bilateral screw loosening at C7

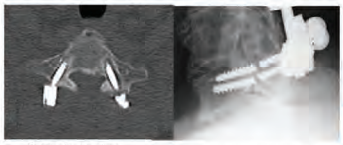
Objectives

The purpose of this study was to investigate factors associated with postoperative screw breakage and loosening (implant failure) after posterior cervical spine fusion surgery.

Methods

2011～2019年:posterior cervical fusion surgery(68cases)
↓
UIV:C2orC3
LIV:C7orT1～3
Followed up for at least 12 months

61cases
Male:44, Femal:17, Mean age at surgery:59.2years



Screw loosening
→Clear Zone≧1mm　Screw Brakeage
Nagashima et al., J Clin Neurosci., 2019

Implant failure(＋)→ GroupF
Implant failure(－)→ GroupNF

Radiographic assessments

①C6screw	⑤T1slope
②Screw malposition	⑥C2-C7SVA
③Transverse fixator	⑦C2-C7angle
④LIV(C7 or T1～3)	⑧Range of motion(ROM)

53 patients without C6 screw insertion (C6skipping group)
↓ similar study limited to the C6skipping group
GroupC6F and GroupC6NF

Results

UIV/LIV

UIV	LIV	GroupF (n=14)	GroupNF (n=47)
C2	C7	7	9
	T1	1	20
	T2	1	2
	T3	0	1
C3	C7	5	11
	T1	0	4
	T2	0	0
	T3	0	0

GroupF:all failures occurred at LIV

All cases (Univariate analysis)	GroupF (n=14)	GroupNF (n=47)	p
Age(years)	54.4±12.4[a]	60.6±11.2[a]	0.085*
Sex(Male/Female)	9/5	35/12	0.506**
Diagnosis (CSM/OPLL/others)	5/8/1	20/23/4	0.865**
C6screw, n(%)	1(7.1)	7(14.9)	0.668**
Malposition, n(%)	5(35.7)	20(42.6)	0.762**
Transverse fixator,n(%)	6(42.9)	11(23.4)	0.184**
LIV(C7/T1～3)	12/2	20/27	0.006**
Preoperative C2-C7ROM(°)	30.0±9.7	32.6±15.0	0.550
Preoperative C2-C7Cobb angle(°)	-5.9±14.5	-2.3±14.3	0.416
Follow up C2-C7Cobb angle(°)	-4.5±11.2	-0.3±10.4	0.196
Preoperative C2-C7SVA(mm)	22.5±8.6	28.4±15.0	0.668
Follow up C2-C7SVA(mm)	29.9±15.2	37.5±15.7	0.115
Preoperative T1slope(°)	20.1±11.6	21.2±11.0	0.791
Follow up T1slope(°)	21.8±12.6	26.6±10.1	0.221

[a] Mean±SD　* t-test　** chi-squared test　*** Fisher exact probability test

C6 skipping group (Univariate analysis)	GropuC6F (n=13)	GroupC6NF (n=40)	p
Age(years)	54.8±11.5[a]	61.0±12.4[a]	0.124*
Sex(Male/Female)	9/4	30/10	0.725**
Diagnosis (CSM/OPLL/others)	5/7/1	16/21/3	0.995***
Malposition, n(%)	5(38.5)	18(45)	0.679**
Transverse fixator, n(%)	6(46.2)	10(25)	0.149**
LIV(C7/T1～3),n(%)	11(84.6)	18(45)	0.023***

[a] Mean±SD　* t-test　** chi-squared test　*** Fisher exact probability test

Logistic regression analysis

All cases	Odds ratio	95%CI	p
LIV positon	11.1	1.5-80.3	0.017

C6 skipping group	Odds ratio	95%CI	p
LIV position	7.6	1.0-55.0	0.046

Discussion

- The incidence of C7 pedicle screws failure was significantly lower in the cases with concomitant C6 or T1 pedicle screws compared with that in the cases without the concomitant insertion of C6 or T1 pedicle screws　*Nagashima et al., J Clin Neurosci., 2019*
- Risk factors for implant failure at LIV　①Ending at C7　②Skipping screw insertion at proximal vertebra adjacent to LIV　③Postoperative C2-C7SVA(>40mm)　*Okamoto et al., World Neurosurg., 2021*

This study→The fixation with screw insertion ending at C7 might lead to failure.

Conclusion

Factors associated with failure in posterior cervical fusion surgery were examined, and fixation with screw insertion up to C7 might lead to failure.

Were There Relationship between Ankylosis in the Occipito-Cervical-Junction, Thoracic Kyphosis, and C2 High Riding VA in Patients with Ankylosing Spondylitis ?

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East Maebashi Orhopedic Hospital, Japan, Gothenburg University, Umea University, Uppsala University, Dept. of Surgical Science, Sweden, Hospital Universitari Dexeus, Barcelona, Spain

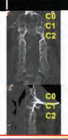
CSRS-ES May 31- June 2 2023, Stockholm Sweden

- Disclosure - I have not received anything of value from or own stock in a commercial company or institution related directly or indirectly to the subject of this presentation.

Introduction

Ankylosing spondylitis (AS) affects the axial skeleton and leads to progressive ankylosis of all spinal segments.

Furthermore, **hyper thoracic kyphosis** caused a **hyper cervical lordosis** that because patients has to get the horizontal gaze.



Objective

1. To present the radiographical features of the **Occipito-Atlanto-Axial (OAA) joint** in **AS** patients using a novel measure, ***the X-angle***.
2. To describe the correlation between ankylosed **OAA joint** and **thoracic kyphosis(TK)** and **HRVA**.

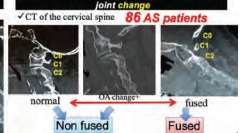
Materials : Patient's profile

86 *AS patients* who underwent **the posterior fixation surgery for cervical fracture** using SWESPINE registry

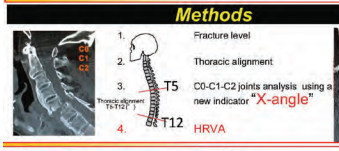
Gender : male 67, female 19
Age at surgery : 69.2 ± 11.8 (40 – 94) yrs.
Retrospective study

2 Groups due to C0-C1 & C1-C2 joint change

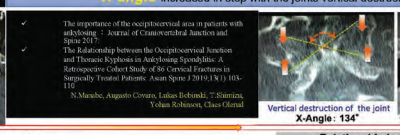
✓CT of the cervical spine　**86 AS patients**



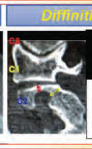
Methods



X-angle increased in step with the joints vertical destruction.



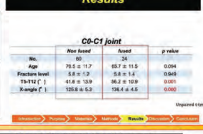
Diffinition of HRVA



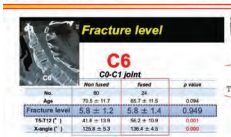
Isthmus height<5mm
Internal height<2mm

Risk of Vertebral Artery Injury: A Comparison between C2 Subarticular Segmental and C1-2 Transarticular Screws

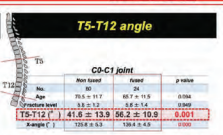
Results



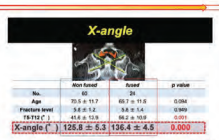
Fracture level



T5-T12 angle

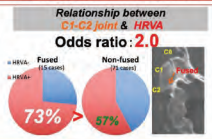


X-angle

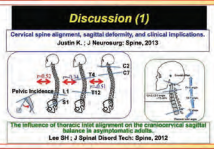


Relationship between C1-C2 joint & HRVA

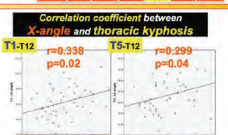
Odds ratio : 2.0



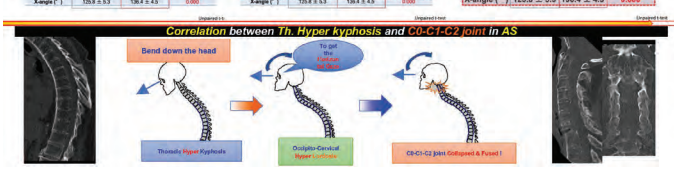
Discussion (1)



Correlation coefficient between X-angle and thoracic kyphosis

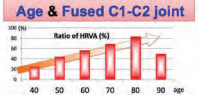


Correlation between Th. Hyper kyphosis and C0-C1-C2 joint in AS



Discussion (2)

HRVA was related to Age & Fused C1-C2 joint



Discussion (3)

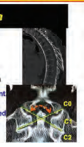
- **RA** was risk factor for **HRVA**.

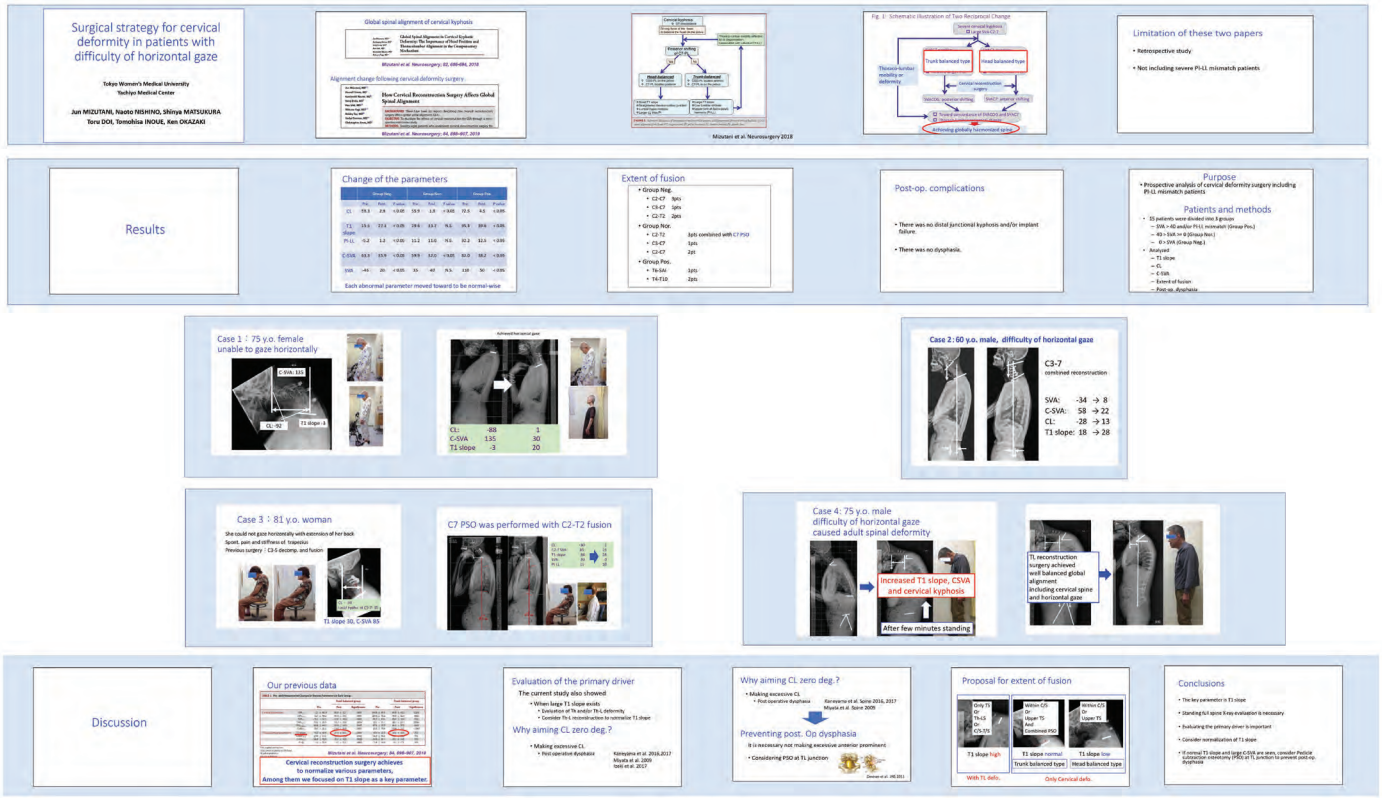
Is Rheumatoid Arthritis a Risk Factor for a High-Riding Vertebral Artery? Miyata M., Neo M.: Spine, 2008

- **HRVA** will be caused C0-C1-C2 joint changes .

Conclusion

1. **Thoracic hyper-kyphosis** was related to the degenerative change of the **C0-C1-C2 joint** in patients with AS.
2. The **X-angle** was found to be a reliable tool to evaluate the osteoarthritis of the **C0-C1-C2 joint**.
3. **HRVA** was related to **Age** & **fused C1-C2 joint**.





Dropped Head Syndrome: A Treatment Strategy and Surgical Intervention

Hiroshi Miyamoto[1], Terumasa Ikeda[2], Shingo Aoyama[2], Kensuke Toriumi[2], Masao Akagi[2]

1. Dept. of Orthopaedic Surg., Kobe Rosai Hospital, Kobe, Japan 2. Dept. of Orthopaedic Surg., Kindai University Hospital, Osaka-Sayama, Japan

Objective. The pathology of dropped head syndrome (DHS) is diverse, and reports of surgery for DHS are scarce. We aimed to describe surgery for DHS and to investigate the surgical outcomes thereof.

Methods. We enrolled 40 consecutive patients (six males and 34 females; average age at surgery, 72.0 years) with DHS who underwent correction surgeries at a single institute. Short fusion (SF), with the extent of fixation mainly at the cervical region, was performed for 27 patients; long fusion (LF), involving the cervical and thoracic spine, for 13. Clinical and radiological outcomes were investigated, and factors analyzed using the Japanese Orthopedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ).

Results. All patients were able to gaze horizontally at the follow-up. Instances of five transient C5 palsy results, and five distal junctional kyphosis results were found, but no revisions were reported due to recurrence. Patients whose T1 slope-20° was smaller than the C2–7 angle postoperatively exhibited better clinical outcomes in the three domains of the JOACMEQ, regardless of the extent of fixation,

Conclusion. For cases where the T1 slope is relatively small, and approximately 10° of cervical lordosis is predicted to be obtained postoperatively, SF is appropriate. Alternatively, for cases with higher T1 slope, obtaining a cervical lordosis over 20° has a risk of post-operative complications. For such cases, it is an option to perform an LF involving the cervical and thoracic spine.

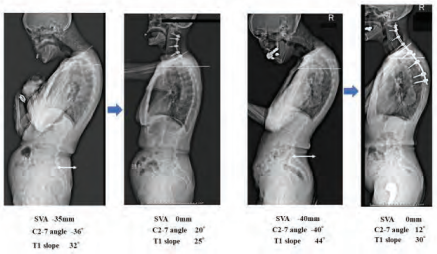


Figure Legend Left side. 76 years old female. Pre-operative T1 slope was 32 degrees. We aimed to obtain cervical lordosis bigger than 32 minus 20 degrees. Short fusion was performed, and 20 degree cervical lordosis was obtained. Right side. 69 years old female. Pre-operative T1 slope was higher (44 degrees). Long fusion was performed to obtain moderate cervical lordosis (12 degrees) and smaller T1 slope (30 degrees) aiming to be compatible with the formula; cervical lordosis over T1 slope minus 20 degrees. In both cases, SVA became zero after surgery.

POSTERS

Morphologic Characteristics of Subaxial Cervical Spine for Pedicle Screw placement (CPS) insertion base on Computer Tomography Analysis

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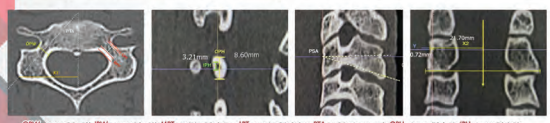
Surawit Visuthisakchai, MD, Buddhachinaraj hospital, Phitsanulok

Background and Rationale

Cervical pedicle screw has higher pull out strength and cyclic load to failure comparing to lateral mass screw. However, cervical pedicle insertion is a technical demanding procedure and has potential risk of injury to vertebral artery or neurological structures. Only two studies reporting the cervical morphology of Thai population. The aim was to study the cervical spine morphology including pedicle thickness and to identify an optimal entry point for the screw in each level.

Methods

- A retrospective observational study
- A total of eighty CT image series of cervical spine done in Bhudchinnaraj hospital from 10th February, 2019 to 20th October, 2021
- Inclusion criteria: Age was from twenty to sixty years old
- Exclusion criteria are any evidence of previous operated cervical spine found in CT-image, evidence of cervical spine fracture, facet arthrosis with Pathria grade > 2 and evidence of abnormal lytic or sclerotic lesion found in CT-image
- The image was processed into multiplanar reconstruction image for measuring the cervical spine morphology and identifying optimal entry point.
- The target point for cervical pedicle screw insertion was clarify in associated with lateral vertebral notch of cervical spine. The name of of insertion point is S-S point.

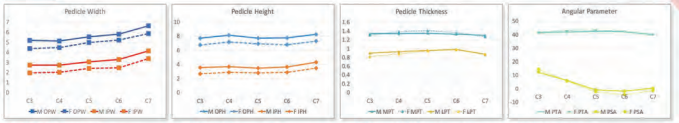


OPW = Outer pedicle width, IPW = Inner pedicle width, MPT = Medial pedicle thickness, LPT = Lateral pedicle thickness, PTA = Pedicle transverse angle, OPH = Outer pedicle height, IPH = Inner pedicle height, PSA = Pedicle sagittal angleOptimal entry point: Medio-lateral distance equal to X2-X1 and Supero-inferior distance equal to Y relative to lateral vertebral notch

Conclusion

This study demonstrate the feasibility of pedicle screw insertion in Thai population without pedicle violation with caution in female patients. Preoperative MD-CT scan should be done in every patients to prevent devastating complications. The S-S point may the optional for cervical pedicle screw insertion point. Further research needed to validate the optimal entry point found in this study.

Result



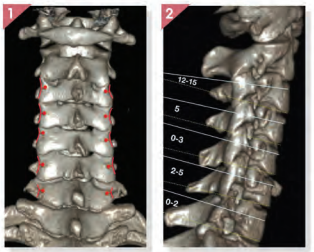
Pedicle width parameter
- The mean of IPW and OPW are in ascending order from C3 to C7 level.
- The mean of OPW of C3 and C4 are less than 4.5 mm in female group. Therefore, 3.5 mm pedicle screw may be unable to be inserted at C3 and C4 level in some female patient.

Pedicle height parameter
- The mean of OPH and IPH are relatively constant and higher than the mean of the width dimension.

Pedicle cortical thickness parameter
- The mean of MPT are constantly higher than 1 mm, while the mean of LPT are less than 1 mm.
- Suggesting that the guide probe should direct toward the medial pedicle cortex to minimize risk of pedicle violation.

Angular parameter
- The mean of PTA are relatively constant with the mean range from 40 to 43 degrees.
- PSA at C3 and C4 level, they tend to be upward inclination relatively to their endplate, while others tend to downward inclination.
- No difference among gender, according to the angular parameters.

Discussion



Optimal entry point (1)

- Medial to the lateral vertebral notch with the mean value range from 1.8-2.6 mm except in C3 level which is about 1.3–1.6 mm.
- Below to the lateral vertebral notch about 0.26 – 1.2 mm with the exception for C4 level which is above the lateral vertebral notch about 0.05 – 0.27 mm.
- No difference among gender, according to the optimal entry point.

Screw trajectory (2)

- Angle medially about 40-43 degrees in all sub-axial cervical level.
- Angle upward at C3 (12-15 degrees) and C4 (5 degrees)
- Angle neutral to downward at C5 (0-3 degrees) and C7 (0-2 degrees)
- Angle downward at C6 (2-5 degrees)

Percutaneous navigated screw implantation for C2 fractures: the two technique adaptation according to Magerl and Judet

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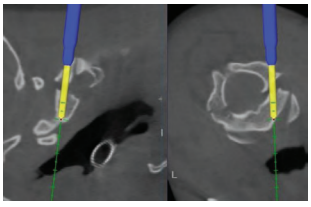
CERVICAL SPINE RESEARCH SOCIETY EUROPE

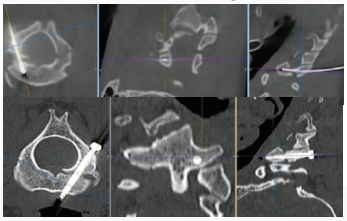
INTRODUCTION

It is advantageous to implement some of the common techniques used in C2 fractures in a mini-invasive manner. This shortens the hospital stay, reduces the risks of wound healing, bleeding, reduces paravertebral muscle trauma due to the percutanoeus approach and the consumption of analgesics.



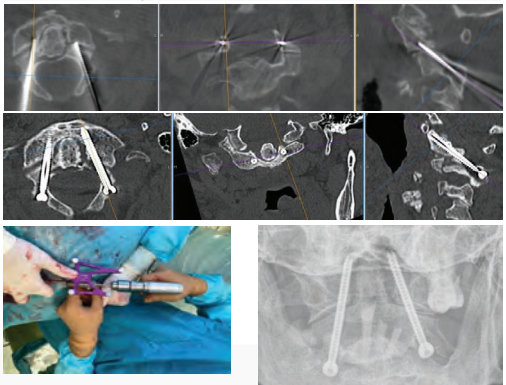
RESULTS

The operating time of both techniques lasted less than 1 hour with a blood loss less than 50 ml in seven operated patients by now at our department.
Navigation accuracy when comparing screenshots of the planned screw trajectory during pre-drilling and the real position of the Kirschner wire and the screws from the intraoperative 3D scan was in all cases <1mm.
Patients were discharged on the 2nd postoperative day with the obligation to wear a soft collar. An outpatient check-up with a CT scan was performed 6 and 12 weeks after the surgery when we were able to state bone healing.



CONCLUSIONS

We state the safety of the method used in the small group of our patients .The final effect of the treatment encourages the wider use of this technique.



MATERIALS & METHODS

We present our initial experience using the percutaneous navigated approach by two techniques: the unilateral approach according to Judet at Hangman's fracture and the implantation of two C1 / 2 transarticular screws according to Magerl. In both cases, we use the pronation position with the head fixed in carbon Mayfield on which the navigation reference is also attached. We carry out a reference scan with mobile intraoperative 3D imaging system, navigate the soft tissue dilatation through a 1 cm skin incision and pre-drill in the planned trajectory into which we insert Kirschner wire.
We perform a control 3D scan followed by implantation of the cannulated screw. We use a semi-threaded tightening bicortical screw for the Judet technique compared to full-thread screws for the Magerl technique. The final assessment is then performed by an intraoperative 3D scan.

FURTHER INFORMATION
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CONFLICT OF INTEREST: none

Percutaneous navigated transpedicular instrumentation in subaxial cervical spine: early single-center experience

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INTRODUCTION

Transpedicular (TPD) screw placement in cervical spine is a demanding procedure biomechanically superior to massa lateralis screws. The advent of intraoperative 3D imaging with neuronavigation (NN) established the safe use of TPD trajectory in cervical spine.

In various cases there is no dorsal decompression needed, in our consideration these patients are well suitable for a minimal invasive approach. In our initial single-center study we report our initial experience with percutaneous approach for TPD screw placement.

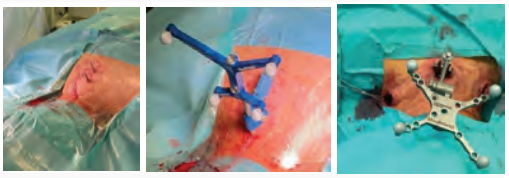
MATERIALS & METHODS

Inclusion criteria for the study was the indication for dorsal cervical instrumentation without need for decompression e.g., after ventral surgery. We use the pronation position with the head fixed in carbon Mayfield on which the navigation reference is also attached. In lower cervical spine the reference frame is fixed on the spinous process. We carry out a reference scan with mobile intraoperative 3D-imaging device, navigate the soft tissue dilatation through a small skin incision and pre-drill in the planned TPD trajectory into which we insert Kirschner wire. We perform a control 3D scan followed by navigated implantation of the cannulated screws. The final assessment with implanted rods is then performed by an intraoperative 3D scan.

RESULTS

Our actual cohort contains 6 cases with 32 percutaneously implanted TPD screws in subaxial cervical spine. There was no neurovascular injury. Navigation accuracy when comparing screenshots of the planned screw trajectory during pre-drilling and the real position of the Kirschner wire and the screws from the intraoperative 3D scan was in all cases <1mm.

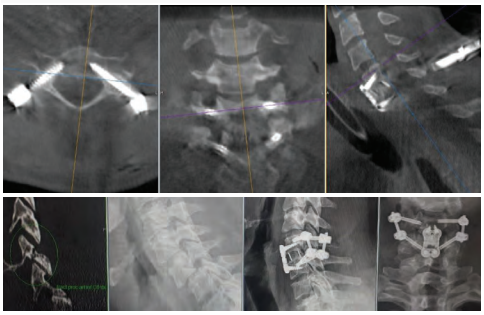
Patients were discharged on the 2nd postoperative day. An outpatient check-up with a radiograph was performed 6 and 12 weeks after the surgery when we were able to state intact implanted construct and unproblematic wound healing.



CONCLUSIONS

We state the safety and benefit of percutaneous implantation of TPD screws in subaxial cervical spine. Intraoperative 3D-imaging with neuronavigation is enabling safer procedure with less tissue exposition.

Due to superior biomechanical nature of TPD trajectory there is legitimate consideration about lowering the number of involved levels.



FURTHER INFORMATION
benedikt1@gmail.com

CONFLICT OF INTEREST: none

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