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<th>Wednesday, 22 May</th>
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<th>Friday, 24 May</th>
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<td>08:15–08:30</td>
<td>Welcome address</td>
<td>08:30–09:30</td>
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<td>08:30–09:30</td>
<td>Mario Boni Grant nominated oral presentations</td>
<td>Value, pain management and outcomes in cervical spine conservative treatment</td>
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<td>09:30–10:30</td>
<td>Degenerative cervical spine</td>
<td>Cervical deformity and sagittal balance</td>
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<td>11:00–11:45</td>
<td>Round table session 1</td>
<td>Presidential lecture 1</td>
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<td>11:45–12:15</td>
<td>Presidential lecture 1</td>
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<td>12:30–13:30</td>
<td>Industry lunch symposia</td>
<td>Industry lunch symposia</td>
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<td>14:00–15:00</td>
<td>Trauma of the cervical spine</td>
<td>Tumours, infections and surgical outcome in the cervical spine</td>
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<td>15:00–16:30</td>
<td>Debate session 1</td>
<td>Debate session 2</td>
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<td>16:00–16:30</td>
<td>Mario Boni Grant nominated ePosters</td>
<td>Invited guest lecture 2</td>
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<tr>
<td>16:30–17:00</td>
<td>Preview of future meetings</td>
<td>My worst complication</td>
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<tr>
<td>17:00–17:30</td>
<td>Invited guest lecture 1</td>
<td>Invited guest lecture 1</td>
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<td>17:30–18:30</td>
<td>CSRS–Europe general assembly members only</td>
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From 18:00
Welcome reception
Barceló Aran Mantegna Hotel

From 19:30
Social evening
Terrazza Caﬀarelli

Key
- Invited speaker session
- Scientific programme
- CSRS–Europe meeting (members only)
- Industry session
- Social programme
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Organisation and imprint

Venue
Barceló Aran Mantegna
Via Andrea Mantegna, 130
00147 Rome (IT)

Hosting society
Cervical Spine Research Society–Europe
www.csrs-e.org

Conference chairs
Francesco C. Tamburrelli
Orthopedic Spine Surgeon
Catholic University of Rome
Rome (IT)

Conference co-chair
Carmen Vleggeert-Lankamp
Neurosurgeon
Leiden University Medical Centre
Leiden (NL)

Programme committee
Ronald Bartels (Nijmegen/NL)
Michael Mayer (Vogtareuth/DE)
Carmen Vleggeert-Lankamp (Leiden/NL)

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Conventus Congressmanagement & Marketing GmbH
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Circulation 300
Editorial deadline 6 May 2019

Conference website
www.csrs-europe-congress.com
CSRS–Europe committee members

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Björn Zoëga
(Stockholm/SE)

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(Vogtareuth/DE)

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(Paris/FR)

Programme Committee
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(Nijmegen/NL)

Trustees & Bylaws Committee
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(London/GB)

Philippe Bancel
(Paris/FR)

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(Barcelona/ES)

Mauro Costaglioli
(Cagliari/IT)

Carmen Vleggeert-Lankamp
(Leiden/NL)

Francesco C. Tamburrelli
(Rome/IT)

Mario Boni Award Liaison Officer
Claes Olerud
(Uppsala/SE)
Welcome note of the conference chairs

Dear colleagues, dear friends,

It is a great pleasure for us to welcome you to the 35th Annual Meeting of the Cervical Spine Research Society-Europe from 22–24 May in Rome.

This year the meeting returns to Italy in the sign of the continuity that began many decades ago in our country when, in 1983, the society was founded. Since then, many unforgettable colleagues have contributed making great a society specifically dedicated to a highly specialized sector such as the cervical spine.

The congress, as usual, will deal with all the aspects of the cervical spine pathologies even if the main theme of the 35th meeting is focused on the fractures of the sub-axial cervical spine.

The numerous requests for participation, with high-level scientific contributions, are surely the most important guarantee for the success of the meeting. Unfortunately, it was impossible to give all participants the opportunity to present the fruits of their research; nevertheless, the willingness to present a poster must be considered a great opportunity to share their results with the most experienced surgeons in the field.

According to a widely tested model, also this year, debates for and against on important issues will enliven the discussion and stimulate the interest of the audience.

Once again, the annual meeting of our society will be an incredible opportunity for those who want to improve their skills, update their knowledge and share information with experts.

The congress will be held in Rome, one of the most fascinating cities in the world, whose history spans over two thousand years. Also known as the Eternal City and Caput Mundi, the city, unique for the immense beauty of the imperial ruins and the beauty of the Roman Baroque, has been the landmark of the classical world, inspiring and influencing writers, architects and painters who came in Rome from all over the world. A city that always remains in the hearts of the visitors. Even a few hours after the meeting can be enough to bring home incredible memories of the city.

Thank you very much to the faculty that offers us this incredible opportunity, and thanks to all the participants with the hope that they can enjoy an unforgettable meeting.

Francesco C. Tamburrelli       Mauro Costaglioli
Conference chairs and local hosts of CSRS-Europe 2019

Carmen Vleggeert-Lankamp
Conference chair of CSRS-Europe 2019
Invited guest lecture

Friday, 24 May • 16:00–16:30
Health and diseases in the digital era
Luca Pani (Miami, FL/US)

Luca Pani is Professor of Clinical Psychiatry at the Department of Psychiatry and Behavioral Sciences, University of Miami, and Professor of Pharmacology and Clinical Pharmacology, University of Modena and Reggio Emilia, in Italy. He is also VP for Regulatory Strategy and Market Access Innovation at VeraSci in Durham, NC and the Chief Scientific Officer for EDRA Publishing in Milan, Italy and Inpeco SA, Total Lab Automation in Lugano, Switzerland.

As the former Director General of the Italian Medicines Agency (AIFA, 2011-2016) and former member of the CHMP and SAWP for EMA in London (2010-2017), he has been recognized worldwide as an expert in regulatory science with particular emphasis on health technology assessment linked with novel strategies for the reimbursement of precision medicines.

In his roles he negotiated the world first gene therapy (Strimvelis®) and implemented very advanced Managed Entry Agreements linked to regulatory validated registries for real life data follow-up and further evaluations based on advanced bioinformatics principles.

His current interests lie in virtual reality assessment tools to detect early signs of mental disorders and designing decision tree algorithms to price drugs under conditions of uncertainty by using clinical and sensor generated data to continuously populate the unknown variabilities of effectiveness and by linking them to outcome values.

He is the author of over one hundred and seventy scientific publications covering both pre-clinical, clinical as well as regulatory topics, he is the editor and author of several volumes and a writer of successful leisure literature. He has attended over 1,200 conferences, seminars, workshops and national and international roundtables as an invited speaker.
Kyung-Soo Suk was born in Seoul, Korea on August 29th, 1964. He graduated from Yonsei University College of Medicine in 1990. He trained internship and orthopedic residency from 1990-1995 in Yonsei University Hospital. And he served his military service for three years as a military surgeon and a captain. After the military service he experienced spine fellowship for two years in Yonsei University Hospital under the guidance of Prof. Nam-Hyun Kim and Hwan-Mo Lee. And he went to the Johns Hopkins Medical Institute in Baltimore, US for further study of spine as a clinical and research fellow of Prof. John P Kostuik for one year. Now he is working at the Gangnam Severance Hospital in Yonsei University College of Medicine as a professor, chairman of orthopedic surgery and medical director of spine hospital. He performs 400 cervical spine surgeries annually. His first participation in CSRS meeting was in 2000 meeting held in Charleston. His research interest is degenerative cervical spinal disease, cervical myelopathy, OPLL and cervical deformity. He is an associate member of CSRS and founding member of CSRS-AP. Now he is the President of CSRS-AP.
Dr. Vaccaro graduated Summa Cum Laude from Boston College in 1983 with a B.S. in Biology. He received his M.D. degree from Georgetown University School of Medicine where he was promoted with “Distinction” He earned membership in the Alpha Omega Alpha (AOA) Honor Society and graduated with honors in 1987. He completed a year of Surgical Internship at Cedars-Sinai Medical Center in Los Angeles, CA and his Orthopaedic Surgery Residency was at Thomas Jefferson University where he graduated in 1992. Dr. Vaccaro completed a Spine Fellowship at the University of San Diego, CA. He earned a PhD in 2007 in the field of Spinal Trauma and an MBA at the Fox school of business at Temple University in Philadelphia in 2015 where he received the Dean’s certificate of excellence.

Dr. Vaccaro is the Richard H. Rothman Professor and Chairman of Orthopaedic Surgery and Professor of Neurosurgery at the Sidney Kimmel Medical College at Thomas Jefferson University in Philadelphia, Pennsylvania. He was the recipient of the Leon Wiltse award given for excellence in leadership and clinical research for spine care by the North American Spine Society (NASS) and is the past President of the American Spinal Injury Association and current President of the Association for Collaborative Spine Research.

He has over 610 peer reviewed and 200 non-peer reviewed publications. He has published over 330 book chapters and is the editor of over 46 textbooks and co-editor of OKU-Spine I and editor of OKU-8. Dr. Vaccaro is the Co-Director of the Regional Spinal Cord Injury Center of the Delaware Valley and Co-Chief of Spine Surgery and the Spine Fellowship program at the Sidney Kimmel Medical College at Thomas Jefferson University where he instructs current fellows and residents in the diagnosis and treatment of various spinal problems and disorders.
18:00–19:30  ePoster exhibition
Foyer

P1–P7  Biomechanics and basic science  p. 95
P8–P24  Cervical deformity and sagittal balance  p. 95
P25–P35  Complications – epidemiology, diagnosis and imaging  p. 97
P36–P59  Degenerative cervical spine  p. 98
P60–P64  Motion preservation  p. 100
P65–P72  Trauma of the subaxial cervical spine  p. 100
P73–P86  Trauma of the upper cervical spine  p. 101
P87–P99  Tumors and infections  p. 102
P100–P128  Value and outcomes in cervical spine surgery  p. 103

18:00–19:30  Welcome reception
Foyer
08:00–18:30  ePoster exhibition
Foyer
see page 95 ff.

08:15–08:30  Welcome address
Auditorium
By the local conference chairs and the president of the CSRS–Europe

08:30–09:30  Lecture session 1
Auditorium
Mario Boni Grant nominated oral presentations
Chairs Claes Olerud (Uppsala/SE), Francesco C. Tamburrelli (Rome/IT)

08:30  Maintaining range of motion after cervical arthroplasty does not prevent adjacent segment degeneration
Xiaoyu Yang (Leiden/NL), Roland Donk (Mill/NL), Mark Arts (The Hague/NL)
Hisse Arnts (Amsterdam/NL), Joris Walraevens (Heverlee/BE)
Zhiwei Zhai (Leiden/NL), Bart Depreitere (Leuven/BE)
Ronald Bartels (Nijmegen/NL), Carmen Vleggeert-Lankamp (Leiden/NL)

08:36  Is upper cervical involvement in female patients with RA associated with neck pain, dysfunction and QOL?
Kazuto Miura (Nagaoka, Niigata/JP), Osamu Morita (Nagaoka/JP)
Toru Hirano, Kei Watanabe, Naoki Kondo, Jun-ichi Fujisawa (Niigata/JP)
Tadamasa Hanyu, Takahiro Netsu (Nagaoka/JP), Naoto Endo (Niigata/JP)

08:42  Intraoperative neuromonitoring for ossification of posterior longitudinal ligament in nationwide prospective multicenter study
Go Yoshida, Yukihiro Matsuyama, Hiroki Ushirozako (Hamamatsu/JP)
Shiro Imagama (Nagoya/JP), Shigenori Kawabata (Tokyo/JP)

08:48  Degenerative cervical myelopathy – chronic trauma leads to alterations of endogenic inflammatory and angiogenetic mediator concentrations in CSF
Christian Blume, Hans Clusmann, Lars Ove Brandenburg, Matthias Geiger
Marguerite Mueller, Christian Andreas Müller (Aachen/DE)

08:54  Minimal clinically important difference and substantial clinical benefit using PROMIS CAT in cervical spine surgery
Michael Steinhaus (New York, NY/US), Benjamin Khechen (Chicago, IL/US)
Daniel Stein, Thomas Ross, Jingyan Yang (New York, NY/US)
Kern Singh (Chicago, IL/US), Todd J. Albert, Darren Lebl, Russel Huang
Harvinder Sandhu, Bernard Rawlins, Frank Schwab, Virginie Lafage
Han Jo Kim, Sravisht Iyer (New York, NY/US)
09:00   Neuropathic pain after spinal cord injury relieves in CCL21 knockout (plt) mouse through decreasing of M1 type microglia/macrophage and inflammatory cytokines at the injured site and lumbar enlargement
   Hideaki Nakajima, Kazuya Honjoh, Shuji Watanabe
   Akihiko Matsumine (Fukui/JP)

09:06   Discussion

09:30–10:30 Lecture session 2
   Auditorium   Degenerative cervical spine
   Chairs   Carmen L. A. Vleggeert-Lankamp (Leiden/NL), Giuseppe Costanzo (Rome/IT)

09:30   Radiological outcomes following hyperlordotic cage insertion in anterior cervical discectomy and fusion
   Dianna Li, Katherine Poulgrain, Andrew Kam (Westmead/AU)

09:35   Is right side anterior cervical approach a risk factor of recurrent nerve injury? From the point of the frequency of aortic arch anomaly
   Takeshi Aoyama, Naoshi Obara (Sapporo/JP)

09:40   Posterior foraminotomy versus anterior decompression and fusion in patients with cervical degenerative disc disease with radiculopathy – 5-year outcome from a national spine register
   Anna MacDowall (Uppsala/SE), Robert Heary (Newark, NJ/US)
   Marek Holy (Rebro/SE), Claes Olerud (Uppsala/SE)

09:45   Disc height narrowing does not affect the intervertebral stability in cervical spondylolisthesis – analysis of CT and X-rays of 101 spondylolisthesis patients
   Ryoma Aoyama, Tateru Shiraishi, Ken Ninomiya
   Satoshi Nori (Ichikawa-shi/JP), Junichi Yamane (Musashimurayama/JP)
   Kazuya Kitamura (Yokohama/JP), Satoshi Suzuki (Tokyo/JP)

09:50   Discussion

10:00   Morphological changes in the intervertebral disc post trauma – Any impact of preexisting segment degeneration?
   Ingrid Sitte, Miranda Klosterhuber, Richard Andreas Lindtnner
   Sabrina Barbara Neururer (Innsbruck/AT), Anton Kathrein (Zams/AT)
### Scientific Programme  | Thursday, 23 May

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Programme</th>
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| 10:05 | Adjacent segment pathology after cervical laminoplasty  
Shino Mori, Ko Ikuta, Takaomi Kobayashi, Ryohei Yano, Kensuke Hotta  
Keigo Masuda, Takahiro Kitamura, Hideyuki Senba  
Satoshi Shidahara (Karatsu-city, Saga/JP) |
| 10:10 | The spinal cord “back shift” concept in posterior decompression and stabilization in lordosis for cervical spondylotic myelopathy – favorable clinical outcomes  
Vincenzo Denaro, Gianluca Vadalà, Alberto Corrado Di Martino  
Rocco Papalia (Rome/IT) |
| 10:15 | Clinical feature of the revision cases due to symptomatic adjacent segment degeneration after the anterior cervical decompression and fusion surgery  
Atsuomi Aiba, Macondo Mochizuki, Ryo Kadota (Numazu, Shizuoka/JP)  
Takeo Furuya (Chiba/JP), Masao Koda (Tsukuba/JP) |
| 10:20 | Discussion |
| 10:30–11:00 | Industrial and ePoster exhibition and coffee break |
| Foyer |  |
| 11:00–11:45 | Round table session 1  
An intriguing case on subaxial trauma  
With Philippe Bancel (Paris/FR) as moderator and Dominique Rothenfluh (Oxford/GB) and Heiko Koller (Vogtareuth/DE) as discussants. |
| Auditorium |  |
| 11:45–12:15 | Presidential lecture 1  
by the president of the CSRS–AP  
Björn Zoëga (Stockholm/SE)  
Direct internal fixation for atlas fracture and Surgical treatment of cervical sagittal malalignment  
Suk Kyung-Soo (Seoul/KR) |
12:30–13:30  Industry lunch symposia  
Space 1, 4A+B, 4C+D  
see page 34

13:30–14:00  Industrial and ePoster exhibition and lunch break  
Foyer

14:00–15:00  Lecture session 3  
Auditorium  
Chairs  
Øystein Nygaard (Trondheim/NO), Mauro Costaglioli (Cagliari/IT)

14:00  
A dynamic multi-segmental finite element model of rear-impact cervical whiplash – Role of spine morphological variations and head inertial properties on segmental rotations  
Jamie Baisden (Milwaukee, WI/US), Jobin Daniels (Madras/IN)  
Narayan Yoganandan (Milwaukee, WI/US), Gurunarhan Kumar (Madras/IN)

14:05  
Comparison of surgical results of C-arm versus O-arm in C1-2 transarticular screw fixation  
Keiji Wada, Ryo Tamaki, Osamu Satoh, Ken Okazaki (Tokyo/JP)

14:10  
Time course of respiratory dysfunction in the cervical spinal cord injury without bony injury – respiratory function restore around 12 weeks after injury  
Chikara Ushiku, Kota Suda, Satoko Harmon, Matsumoto Miki Komatsu (Bibai/JP), Masahiko Takahata Norimasa Iwasaki (Sapporo/JP), Akio Minami (Bibai/JP)

14:15  
Relationship between the timing of reduction for cervical spine dislocations and neurological recovery  
Hisakazu Shitozawa, Yasuo Ito, Takeshi Kikuchi (Kobe/JP)

14:20  
Discussion

14:30  
Clinical outcomes of acute cervical spinal cord injury depending on the timing of surgery  
Tae Young Kwon, Kyung Jin Song, Jong Hyun Ko Hyung Jik Kim (Jeonju-si, Jeollabuk-do/KR)
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<tr>
<th>Time</th>
<th>Session Title</th>
<th>Presenters</th>
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<td>14:35</td>
<td>The effect of rod pattern and multiple screw-rod constructs for surgical</td>
<td>Sebastian Hartmann, Claudius Thomé, Werner Schmölz, Raphael Gmeiner</td>
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<td>stabilization of the 3-column destabilized cervical spine – presentation of</td>
<td>Anto Abramovic, Anja Tschugg (Innsbruck/AT), Heiko Koller (Vogtareuth/DE)</td>
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<td>biomechanical analysis and clinical rationale</td>
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<td>14:40</td>
<td>Type II odontoid fracture in elderly patients treated conservatively – Is bony</td>
<td>Giorgio Lofrese (Cesena/IT), Federico De Iure (Bologna/IT), Antonio Musio (Ferrara/IT), Francesco</td>
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<td>union the goal?</td>
<td>Cultrera, Roberto Donati (Cesena/IT), Antonio Martucci (Bologna/IT), Pasquale De Bonis (Ferrara/IT)</td>
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<td>14:45</td>
<td>Crowned dens – normal finding in old people, radiological degenerative sign</td>
<td>Carlos Villas, Mariana Elorz, Matías Alfonso, Rafael Llombart, Jesús Payo-Ollero, Jorge</td>
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<td>or clinical syndrome? Reflection on four cases and a prevalence study on</td>
<td>Gómez, Alvaro Suárez, Jesús Dámaso Aquerreta (Pamplona/ES)</td>
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<td>843 patients</td>
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<td>14:50</td>
<td>Discussion</td>
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<td>15:00</td>
<td>Debate session 1</td>
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<td>Cervical spondylodesis – With or without navigation?</td>
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<td>Auditorium</td>
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<td>Johannes Schroeder (Osnabruck/DE) will try to convince you that navigation</td>
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<td>is helpful and necessary and Antonio Raco (Rome/IT) will defend his view</td>
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<td>that cervical surgery can be performed without navigation. André Jackowski</td>
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<td>(Birmingham/GB) moderates the discussion.</td>
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<td>15:30</td>
<td>Industrial and ePoster exhibition and Coffee break</td>
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<td>16:00</td>
<td>Mario Boni Grant nominated ePosters</td>
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<td>Chairs</td>
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<td>Carlo Logroscino, Vincenzo Denaro (Rome/IT)</td>
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<td>16:00</td>
<td>Surgical navigation technology using a combination of augmented and virtual</td>
<td>Gustav Burström, Oscar Persson, Erik Edström, Adrian Elmi Terander (Stockholm/SE)</td>
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<td>reality for minimally invasive spine surgery</td>
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16:04 O24  Another solution in order to increase accuracy of cervical pedicle screw placement – a new aiming probe for CPS
Kota Suda, Satoko Matsumoto, Miki Komatsu, Masahiro Ota
Takeru Tsujimoto, Mitsuru Asukai, Yoshihiro Utsunomiya, Yasuaki Tojo
Akio Minami (Bibai/JP)

16:08 O25  Intramedullary tumors of the cervical spine
Jörg Klekamp (Quakenbrück/DE)

16:12 O26  Surgical site infection after cervical laminoplasty using hydroxyapatite spacer
Takafumi Inoue (Takeo City, Saga/JP)

16:16 O27  Randomized, placebo-controlled, double-blinded trial of granulocyte colony stimulating factor-mediated neuroprotection for acute spinal cord injury
Masao Koda (Tsukuba, Chiba/JP), Masashi Yamazaki (Chiba, Tsukuba/JP)
Seiji Ohtori, Hideki Hanaoka (Chiba/JP)

16:20  Discussion

16:30–16:50  Preview upon future CSRS annual meetings Europe and Asia Pacific
Auditorium

16:50–17:00  CSRS – Europe Research Grant
Auditorium
Medtronic
Further Together
Presentation of the research proposal that was awarded with the CSRS–Europe research Grant, that was sponsored by Medtronic

17:00–17:30  Invited guest lecture 1
Auditorium
Chair Francesco C. Tamburrelli (Rome/IT)
Cervical spine trauma – sharing 20 years of mistakes and complications
Federico De lure (Bologna/IT)

17:30–18:30  CSRS Europe general assembly
Auditorium
for CSRS–Europe members only

19:30–23:59  Social evening
Terrazza Caffarelli
see page 38
<table>
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<tr>
<th>Time</th>
<th>Event</th>
<th>Details</th>
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<td>08:30–16:00</td>
<td>ePoster exhibition</td>
<td>see page 95 ff.</td>
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<tr>
<td>08:30–09:30</td>
<td>Lecture session 4</td>
<td><strong>Value, pain management and outcomes in cervical spine conservative treatment</strong>&lt;br&gt;Chairs Andrés Combalia (Barcelona/ES), Massimo Balsano (Vicenza/IT)</td>
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<td>08:30</td>
<td>The role of non-rigid cervical collar in pain relief and functional restoration after whiplash injury – a systematic review and pooled analysis of randomized controlled trials</td>
<td>Luca Ricciardi (Rome/IT; Jacksonville, FL/US), Vito Stifano, Filippo Maria Polli, Luca Proietti, Andrea Perna, Alessandro Olivi, Francesco C. Tamburrelli, Carmelo Lucio Sturiale (Rome/IT)</td>
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<tr>
<td>08:35</td>
<td>The Odom’s criteria validated at last – a clinimetric evaluation in cervical spine surgery.</td>
<td>Anne Broekema, Rob Molenberg, Jos Kuijlen, Rob Groen, Michiel Reneman, Remko Soer (Groningen/NL)</td>
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<td>08:40</td>
<td>Combination of 10-s Grip and Release test and 10-s Step test can distinguish thoracic myelopathy from cervical myelopathy</td>
<td>Yasutsugu Yukawa, Hiroshi Hashizume, Akihito Minamide, Hiroshi Iwasaki, Shunji Tsutsui, Masanari Takami, Motohiro Okada, Hiroshi Yamada (Wakayama/JP)</td>
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<tr>
<td>08:50</td>
<td>Discussion</td>
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<td>09:00</td>
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</table>
09:00 The neurological deficits patterns of cervical radiculopathies which were misdiagnosed as peripheral nerve entrapment diseases

Tomohiko Hasegawa, Yu Yamato, Daisuke Togawa, Go Yoshida
Tomohiro Banno, Hideyuki Arima, Shin Oe, Takao Omura
Yukihiro Matsuyama (Hamamatsu/JP)

09:05 The corticospinal reserve – reversible reorganization of motor area and excitability in degenerative cervical myelopathy

Anna Zdunczyk, Leona Kawelke, Thomas Picht, Peter Vajkoczy (Berlin/DE)

09:10 The three sagittal morphotypes that define the normative cervical spine

Sohrab Virk, Renaud Lafage, Jonathan Elysee, Todd J. Albert
Lawrence G Lenke, Frank Schwab, Virginie Lafage (New York, NY/US)


Kais Abu Nahleh, Hassan Allouch, Mootaz Shousha, Mohammed Alhashash Heinrich Böhm (Bad Berka/DE)

09:20 Discussion

09:30–10:30 Lecture session 5
Auditorium Cervical deformity and sagittal balance
Chairs Óscar L. Alves (Porto/PT), Giosuè Gargiulo (Turin/IT)

09:30 A comparison of cervical disc arthroplasty and anterior cervical discectomy and fusion in patients with two-level cervical degenerative disc disease: 5-year follow-up results

Gao Xinlin (Chengdu/CN)

09:35 Cervical and spinal sagittal alignment deviation in the general elderly population – a Japanese cohort survey randomly sampled from a basic resident registry

Masashi Uehara, Jun Takahashi, Shota Ikegami, Ryosuke Tokida Hikaru Nishimura (Matsumoto/JP), Noriko Sakai (Obuse/JP) Hiroyuki Kato (Matsumoto/JP)
09:40  O39  The clinical relevance of the cervical disc prosthesis – combining clinical results of two RCTs  
Caroline Goedmakers (Leiden/NL), Ronald Bartels  
Roland Donk (Nijmegen/NL), Mark Arts (The Hague/NL), Erik van Zwet  
Carmen Vleggeert-Lankamp (Leiden/NL)

09:45  O40  Is C1/2 fusion required for all patients with Chiari I Malformation or basilar invagination?  
Jörg Klekamp (Quakenbrück/DE)

09:50  Discussion

10:00  O41  Does a disruption of the C2 extensor muscle insertions affect post-operative cervical alignment in cervical laminoplasty?  
Ko Ikuta, Shino Mori (Karatsu-city/JP)

10:05  O42  The impact of cervical sagittal imbalance on laminoplasty indicated to patients with cervical myelopathy  
Minori Kato (Osaka/JP)

10:10  O43  The impact of the multifidus muscle swelling on C5 palsy after cervical laminoplasty  
Yoshitada Usami, Yoshiharu Nakaya, Sachio Hayama,  
Atsushi Nakano (Takatsuki/JP), Mutsumi Ohue (Kishiwada/JP)  
Masashi Neo (Takatsuki/JP)

10:15  O44  Biomechanical effects on intermediate segment of noncontiguous hybrid surgery with cervical disc arthroplasty and anterior cervical discectomy and fusion – a finite element analysis  
Tingkui Wu, Beiyu Wang, Hao Liu, Xin Rong, Yang Meng (Chengdu/CN)

10:20  O45  The characteristic of cervical sagittal alignment in patients with chronic low back pain  
Hideyuki Arima, Yu Yamato (Hamamatsu/JP), Koichi Sato (Tokyo/JP)  
Ryu Shiba (Shizuoka/JP), Yoshihiro Uchida (Shimizu-cho/JP)  
Toshiyuki Tsuruta (Ogi/JP), Kanehisa Hashiguchi (Kagoshima/JP)  
Hajime Hamamoto (Shizuoka/JP), Eiichiro Watanabe (Fuji/JP)  
Koaru Yamanaka (Shizuoka/JP),kokai Nomura (Fujieda/JP)  
Yukihiro Matsuyama (Hamamatsu/JP)

10:25  Discussion
10:30–11:00  Industrial and ePoster exhibition and coffee break
Foyer

11:00–11:45  Round table session 2
Auditorium  Spinal cord lesion – treatment and timing

A remarkable case on spinal cord lesion. Ronald Bartels (Nijmegen/NL) will present a case and Cedric Barrey (Lyon/FR), Anna MacDowall (Uppsala/SE) and Roberto Assietti (Milan/IT) will give their comments.

11:45–12:15  Presidential lecture 2
Auditorium  by the president of CSRS–US
Chair Björn Zoëga (Stockholm/SE)

Cervical spine trauma current concepts
Alexander R. Vaccaro (Philadelphia, PA/US)

12:15–12:20  Preview upon future CSRS–US 2019 annual meeting
Auditorium

12:20–12:25  Fellowships of CSRS–AP
Auditorium

Presentation of travel fellowships of CSRS–AP

12:30–13:30  Industry lunch symposia
Space 1, 4A+B, 4C+D
see page 35

13:30–14:00  Industrial and ePoster exhibition and lunch break
Foyer

14:00–15:00  Lecture session 6
Auditorium  Tumours, infections and surgical outcome in the cervical spine
Chairs Ronald Bartels (Nijmegen/NL), Massimiliano Visocchi (Milan/IT)

14:00  Anterior cervical corpectomy and reconstruction using titanium implants in the surgical treatment of cervical spondylodiscitis – long term results
Mohammed Alhashash, Reza Bahrami, Mootaz Shousha Heinrich Böhm (Bad Berka/DE)
14:05 Feasibility of the far lateral suboccipital approach to the retroodontoid region – How much bone removal is needed?
Gergely Bodon (Esslingen a. N./DE), Kristof Kiraly (Budapest/HU)
Bernhard Hirt (Tübingen/DE), Heiko Koller (Vogtareuth/DE)

14:10 Risk factor of surgical site infection (SSI) in cervical spine surgery: importance of perioperative hygienic status
Naosuke Nagata, Shuichi Kaneyama, Masatoshi Sumi, Koichi Kasahara
Aritetsu Kanemura, Hiroaki Hirata, Masaaki Ito (Kobe/JP)

14:15 Patterns of short-term and long-term surgical outcomes and prognostic factors for cervical ossification of the posterior longitudinal ligament between anterior cervical corpectomy and fusion and posterior laminoplasty
Bong Ju Moon (Gwangju/KR), Dong Ah Shin, Seong Yi, Yoon Ha
Keung Nyun Kim, Do Heum Yoon (Seoul/KR), Jung-Kil Lee (Gwangju/KR)

14:20 Discussion

14:30 Trends in posterior cervical fusion in the United States from 2000-2016
Michael Safaee (San Francisco, CA/US), Katherine Corso, Jill Ruppenkamp
Ann Menzie (Raynham, MA/US), Christopher Ames (San Francisco, CA/US)

14:35 Increasing surgical invasiveness relative to frailty status in cervical deformity surgery – a risk benefit analysis
Peter Passias, Avery Brown, Cole Bortz, Katherine Pierce, Haddy Alas
Bassel Diebo, Renaud Lafage, Virginie Lafage (New York, NY/US)
Christopher Ames (San Francisco, CA/US)
Douglas Burton (Kansas City, KS/US), Neel Anand (Los Angeles, CA/US)
Robert Hart (Seattle, WA/US), Gregory Mundis (San Diego, CA/US)
Brian Neuman (Baltimore, MD/US), Breton Line (Denver, CO/US)
Christopher Shaffrey (Charlottesville, VA/US), Eric Klineberg (Davis, CA/US)
Justin Smith (Charlottesville, VA/US), Frank Schwab (New York, NY/US)
Shay Bess (Denver, CO/US)

14:40 Does prophylactic foraminotomy reduce the occurrence of postoperative C5 palsy in reconstruction surgery using cervical pedicle screw?
Terumasa Ikeda, Hiroshi Miyamoto, Masao Akagi (Osaka/JP)
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<td>Cortical breach detection in spine surgery – Novel use of diffuse reflectance spectroscopy</td>
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<td><strong>Jarich Spliethoff</strong> (Eindhoven/NL), <strong>Benno H. W. Hendricks</strong> (Delft/NL)</td>
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<td>Minimal invasive surgery in the cervical spine</td>
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<td><strong>Michael Mayer</strong> (Vogtareuth/DE) says “No”, <strong>Bernhard Meyer</strong> (Munich/DE) says “Yes” and <strong>Carmen Vleggeert-Lankamp</strong> (Leiden/NL) moderates the discussion.</td>
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<td><strong>Mauro Costaglioli</strong> (Cagliari/IT)</td>
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<td>Health and diseases in the digital era</td>
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<td><strong>Luca Pani</strong> (Miami, FL/US)</td>
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<td><strong>Gergely Bodon</strong> (Esslingen/DE), <strong>Carmen Vleggeert-Lankamp</strong> (Leiden/NL) <strong>Óscar Alves</strong> (Porto/PT)</td>
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<td>The Mario Boni awards awards for best oral presentation and best ePoster presentation will be announced.</td>
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<td>17:15–17:30</td>
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Awards
The winner of the Mario Boni Award (oral paper) will be rewarded 1,000 EUR.
The winner of the Mario Boni Award (ePoster) will be rewarded 500 EUR.

Badge
Please wear your name badge during all conference events, including the networking activities.

Certification
The conference has been accredited by the European Accreditation Council for Continuing Medical Education (EACCME®) with 11 European CME credits (ECMEC®s).
23 May – 6 points, 24 May – 5 points

For certification you must provide proof of attendance. Therefore please scan your badge at the check-in desk on-site every day at the conference. Certificates of attendance will be sent to you via e-mail after the conference.

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Please take a few moments to fill out the evaluation form to help us refine and improve our programme. You will receive the evaluation form via e-mail after the conference.

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Please see www.csrs-europe-congress.com.

Online programme
For current detailed information regarding the scientific programme please have a look at our session planner at http://programm.conventus.de/csrs2019. Compose your individual programme and review it at any time on your way.

Opening hours
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Experience the latest innovations at stand #7.
Registration
Registration for the conference is required.

On-site fee from 15 May
Delegate 790 EUR
Trainee* 520 EUR

Day tickets
Delegate 50 EUR 350 EUR 350 EUR
Trainee* 40 EUR 230 EUR 230 EUR

Welcome reception, 22 May free for registered delegates
Welcome reception acc. person, 22 May 30 EUR
Social evening, 23 May 95 EUR

* Please provide a confirmation of status when registering on-site.

The registration fee includes
• Admission to all scientific sessions and access to our industrial exhibition
• Welcome reception
• Congress materials (final programme and abstracts, name badge, bag etc.)
• Refreshments as indicated in the programme

Wi-Fi access
Wi-Fi is available for free throughout the whole conference area.
Login: CSRS_Europe
Password: 2019_Rome
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MATTER

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General hints for authors and presenters

Submission of a presentation/Technical information
Your Presentation should be prepared as PDF or PowerPoint (Office 2016) with 16:9 aspect ratio. For video- and audiofiles, please use standard formats (AVI, WMV, MPG) and bring these as separate files to the speakers’ ready room. When using videos, please re-member to include the required Codec. The use of personal notebooks is possible upon agreement. Please provide an adapter for HDMI (VGA) if necessary.

In the lecture hall, you will find a lectern with a laptop and presenter with laserpointer. A technical assistant will support you.

Should you wish to use non-digital equipment, please contact us in advance.

Display of name and countdown in projection
Your name will be displayed on top of your presentation. Please consider to leave space (ca. 1/10 height at the top of your presentation). A Countdown will be displayed on the bottom right corner.

Presentation upload
There will be a media check-in for uploading your presentation. Please hand in your presentation a day before, but not later than 2 hours before your timeslot in the media check-in. To hand in your presentation, please use a medi-um with USB connection, which is not protected via software.
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Providence Medical Technology
# Welcome note of the conference chairs

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**Zimmer Biomet Cervical Solutions: Addressing the Pathology with the Right Product**

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Join us at booth #5 and discover our Cervical Procedural Solutions!
12:30–13:30 Lunch symposium by K2M*
Space 1
Cervical tumour and trauma, how I manage the most challenging cases

Moderator
Pier Paolo Mura (Rome/IT)

Faculty
Roberto Assietti (Milan/IT), Matthew Crocker (London/GB)

Faculty present two case summaries each, with goal of discussing anterior and posterior surgical techniques for the treatment of tumour and trauma cases in the cervical spine.

12:30–13:30 Lunch symposium by Medtronic International Trading Sarl
Space 4C+D
Addressing complex posterior cervical spine surgeries: The challenges and how to overcome them

12:30 Introduction

12:35 What do I do to avoid complications in complex posterior cervical spine surgeries?
Neil Buxton (Saint Helens/GB)

13:00 How can navigation and intra-operative imaging facilitate posterior cervical fusion surgery
Martin Gehrchen (Copenhagen/DK)

12:30–13:30 Lunch symposium by Providence Medical Technology*
Space 4A+B
One small leap for posterior cervical fusion

12:30 Introduction

12:40 Minimally invasive posterior cervical fusion with DTRAX® (GL-DTRAX Spinal System)
Dr. Óscar L. Alves (Porto/PT)

13:10 Discussion

* Lunch will be served.
Industry lunch symposia • Friday, 24 May

12:30–13:30 Lunch symposium by Depuy Synthes
Space 4A+B
Johnson & Johnson Medical Devices Companies*
Complex cervical reconstruction

12:30 Current concepts for post cervical deformity C0-T1
Chris Ames (San Francisco, CA/US)

13:00 Advances in cervical deformity treatment – what the latest research tells us
Heiko Koller (Vogtareuth/DE)

12:30–13:30 Lunch symposium by Globus Medical*
Space 1
Advanced posterior cervical fixation with robotics navigation

Speakers
Christopher D. Chaput (San Antonino, TX/US)
Laura B. Flawn (San Antonino, TX/US)

12:30–13:30 Lunch symposium by NuVasive*
Space 4C+D
The goals and challenges of degenerative and complex cervical spine surgery

12:30 Introduction – What alignment goals we should take in account when planning cervical surgery
Ronald Bartels (Nijmegen/NL)

12:40 Case-based discussion – Anterior approach demonstrating planning, surgical strategy, intraoperative evaluation and outcome

Presenter
Ronald Bartels (Nijmegen/NL)
Discussants
Ronald Bartels (Nijmegen/NL), Pedro Berjano (Milan, IT)

13:00 Case-based discussion – Global evaluation in a chin-on-chest deformity case. The importance of evaluating the cervical but also the subcervical spine for the planning and execution

Presenter
Pedro Berjano (Milan, IT)
Discussants
Ronald Bartels (Nijmegen/NL), Pedro Berjano (Milan, IT)

13:20 Take-home messages

* Lunch will be served.
We support spine surgeons with durable, reliable products and partner services for safe procedures and outstanding clinical outcomes since the early 80’s. Our philosophy of sharing expertise with healthcare professionals and patients allows us to develop innovative implant and instrument systems that help to preserve stability and stabilize the cervical and thoracolumbar spine.

K2M Group Holdings, Inc. is a global leader of complex spine and minimally invasive solutions focused on achieving three-dimensional Total Body Balance™. Since its inception, K2M has designed, developed and commercialized innovative complex spine and minimally invasive spine technologies and techniques used by spine surgeons to treat some of the most complicated spinal pathologies.

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German Spine Congress

14th Annual Meeting of the German Spine Society

28–30 November 2019
Munich

www.dwg-kongress.de
Social and cultural programme

Welcome Reception

Enjoy the first evening with your colleagues, friends, and exhibitors full of networking possibilities with snacks and refreshments.

Date  22 May 2019  
Time  from 18:00  
Location  Barceló Aran Mantegna  
Via Andrea Mantegna 130  
00147 Rome  
Fee  inclusive

Social Evening

We would like to invite you to join a memorable social evening at the “Terrazza Caffarelli” in Rome. This exclusive location offers one of the most fascinating panoramic views in Rome overlooking the artistic, urban and architectural wonders of the Capital City.

Date  23 May 2018  
Time  from 19:30  
Location  Terrazza Caffarelli  
Piazzale Caffarelli 4  
00186 Rome  
Website  www.terrazzacaffarelli.it/en  
Fee  95 EUR  
Transportation  Please be aware that there will no central shuttle service to the location. For information how to get to the Terrazza Caffarelli, please refer to the check-in desk.
35th ANNUAL MEETING
CERVICAL SPINE RESEARCH SOCIETY EUROPE

22–24 MAY 2019 Rome

ABSTRACTS

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O1
Maintaining range of motion after cervical arthroplasty does not prevent adjacent segment degeneration

Xiaoyu Yang¹, Roland Donk², Mark Arts³, Hisse Arnts⁴, Joris Walraevens⁵, Zhiwei Zhai⁶, Bart Depreitere⁷, Ronald Bartels⁸, Carmen Vleggeert-Lankamp¹

¹Leiden University Medical Centre, Neurosurgery, Leiden, Netherlands
²Via Sana Clinics, Orthopaedic Surgery, Mill, Netherlands
³The Hague Medical Centre, Neurosurgery, The Hague, Netherlands
⁴Academic Medical Centre, Neurosurgery, Amsterdam, Netherlands
⁵KU Leuven, Herleve, Belgium
⁶Leiden University Medical Centre, Radiology, Leiden, Netherlands
⁷University Hospitals Leuven, Neurosurgery, Leuven, Belgium
⁸Radboud University Medical Centre, Neurosurgery, Nijmegen, Netherlands

Question: Many previous research reported that adjacent segment degeneration (ASD) was prevented in patients with cervical arthroplasty by means of maintaining range of motion (ROM) and restoring disc height. However, baseline information of ASD and progression of ASD were rarely reported, and methods to assess ROM are insufficiently precise in most studies. This study aims to investigate the correlation between ASD and ROM.

Methods: Patients that underwent anterior discectomy for cervical radiculopathy due to a herniating disc were analyzed for segmental and global cervical ROM and the presence of ASD, both preoperatively, 12 and 24 months postoperatively. 253 patients were included in two randomized, double-blinded trials (RCT) comparing anterior cervical discectomy with arthroplasty (ACDA), anterior cervical discectomy with intervertebral cage (ACDF), or anterior cervical discectomy without intervertebral cage (ACD) for one level disc herniation. ROM was defined by a custom developed image analysis tool. ASD was defined by decrease in disc height and anterior osteophyte formation on X-rays. Clinical outcome was evaluated by means of the Neck Disability Index (NDI).

Results: Two-year postoperatively, the ACDA group had a higher ROM at the index level and a larger global cervical ROM than the other two groups. The incidence of ASD was comparable in the three groups though, being circa 34% at baseline, and circa 58% at 2-year follow-up. Likewise, ASD progression was comparable in the three treatment arms. No correlation was demonstrated between ROM and ASD, and neither was there a correlation between ROM and NDI or ASD and NDI.

Conclusions: ROM is better preserved in the patients that were subjected to arthroplasty, however, this did not result in less ASD, nor in better clinical outcome. Although follow-up of two-year may be too short to draw firm conclusions, data tend to indicate that the clinical relevance of persisting ROM at the target level is absent.
O2
Is upper cervical involvement in female patients with RA associated with neck pain, dysfunction and QOL?
Kazuto Miura1,2, Osamu Morita1, Toru Hirano2, Kei Watanabe2, Naoki Kondo3, Jun-ichi Fujisawa1, Tadamasa Hanyu3, Takahiro Netsu1, Naoto Endo2
1Nagaoka Red Cross Hospital, Spine and Spinal Cord Surgery, Nagaoka, Japan
2Niigata University, Orthopedic Surgery, Niigata, Japan
3Nagaoka Red Cross Hospital, Rheumatology, Nagaoka, Japan

Question: The most important indications for surgery in the presence of cervical spine involvement in rheumatoid arthritis (RA) are resistant pain and neurological deficits. On the other hand, patients with cervical spine subluxation are often asymptomatic in clinical experience. The aim of this study is to investigate the relationship between upper cervical lesions and neck pain, cervical dysfunction and quality of life (QOL) in female patients with RA.

Methods: We enrolled 1047 female RA patients in this cross-sectional study. Upper cervical lesion (atlantoaxial subluxation [AS], and vertical subluxation [VS]) were evaluated on plain radiographs. Visual analogue score (VAS) for neck pain, Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ) for neck dysfunction and Short Form-8 (SF-8) for QOL were assessed. One-to-one propensity score matching was performed to control demographic (including age, body mass index (BMI), onset year and age of RA, and disease duration) and clinical (surgical history, Steinbrocker stage, use of corticosteroid, methotrexate (MTX), and biological agent (BIO)) imbalances. Multivariate logistic regression analysis of unadjusted and propensity score-matched cohorts were performed to examine the influence of upper cervical lesions.

Results: The propensity score-matching procedure yielded scores of 146 pairs of matched patients with upper cervical lesions and without those. The multivariate analysis of propensity score-matched population found upper cervical lesions to show no significant association with any of the outcome analyzed, including neck pain (p=0.448), cervical dysfunction (p=0.336) and QOL (p=0.092-0.933).

Conclusions: For female RA patients, upper cervical lesions were not associated with neck pain, cervical dysfunction and QOL.

O3
Intraoperative neuromonitoring for ossification of posterior longitudinal ligament in nationwide prospective multicenter study
Go Yoshida1, Yukihiro Matsuyama1, Hiroki Ushirozako1, Shiro Imagama2, Shigenori Kawabata3
1Hamamatsu University School of Medicine, Orthopaedic surgery, Hamamatsu, Japan
2Nagoya University, Orthopedic Surgery, Nagoya, Japan
3Tokyo Medical and Dental University, Orthopedic Surgery, Tokyo, Japan

Question: Surgical treatment for cervical/thoracic ossification of posterior longitudinal ligament (OPLL) is one of the most challenging spinal procedures because of high neurological complication rate. Intraoperative spinal neuromonitoring (IOMN) may have a role in identifying and preventing neural damage for high risk spine surgery.
Methods: We prospectively analyzed the incidence of neurological deterioration and details of IOMN alert, and clarified how to prevent neural damage in case of IOMN alert in OPLL surgery from 2010 to 2016. The surgical techniques used for cervical OPLL were posterior laminoplasty/laminectomy with fusion, or anterior cervical discectomy/corpectomy and fusion, and those used for thoracic OPLL were posterior decompression and fusion. Tc(E)-MEPs were monitored under uniform monitoring conditions at 16 hospitals.

Results: OPLL surgeries were consisted of 622 cervical OPLL and 249 thoracic OPLL. Totally, TP, FP, TN, FN and rescue cases of Tc-MEPs were 7, 33, 550, 0 and 20 in cervical OPLL and 30, 28, 170, 1 and 20 in thoracic OPLL, respectively. Alarm and neurological deficit rate were 6.3% and 1.1% in cervical OPLL, and 20.1% and 12.0% in thoracic OPLL, respectively. In cervical OPLL, 61.5% of the alerts occurred during lamina opening for laminoplasty. Among these patients, 73.3% were rescued by suspension surgery, irrigation, or additional decompression/foraminotomy. However, suspension surgery in corpectomy cases were mostly ineffective. In thoracic OPLL, 54.0% of alerts occurred during posterior decompression for OPLL. For these patients, suspension surgery and steroid injection after the alarm were also ineffective. However, posture change, bilateral rodding, or additional dekyphosis after alarm were effective.

Conclusions: This study indicates totally 58.4% rescue cases by Tc-MEPs. Although neurological deficit of OPLL was high, appropriate intervention for protecting spinal cord and blood supply immediately after IOMN alert was effective even in high risk OPLL surgery.

O4

Degenerative cervical myelopathy – chronic trauma leads to alterations of endogenic inflammatory and angiogenetic mediator concentrations in CSF

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Question: Endogenous immune mediated reactions of inflammation and angiogenesis is a component of the secondary injury of the spinal cord in patients with degenerative cervical myelopathy. Aim of this study is to detect and identify the alteration of certain mediators in the cerebro-spinal fluid (CSF) in patients with chronic spinal cord injury (SCI) compared control group.
Methods: Patients with DCM (n=28; 14 female; mean age 62.3±10.8) and indication for surgery were included. CSF samples were taken preoperatively. A control group of patients (n=38; 13 female; mean age 65.0±15.0), with abdominal aortic aneurysm (AAA), requiring surgery was established. Patients of this group received a CSF drainage for intrathecal pressure monitoring, samples were taken preoperatively. The neurological status of patients and controls was evaluated prior surgery including NDI and mJOA. Controls with any neurological deficit or history of neurological diseases were excluded. Samples were examined via ELISA tests. Protein-concentrations of inflammatory and angiogenic factors were measured in CSF pg/ml: Angiopoietin-2, VEGF-A and C (Vascular Endothelial Growth Factor), RANTES (Regulated And Normal T cell Expressed and Secreted), Interleukin (IL) 1 beta and IL 8.

Results: Patients and controls did not differ in terms of age and gender distribution. The groups clearly distinguished in their neurological status (mJOA: DCM 10.8±3.3, AAA 17.3±1.2, p

Conclusions: Proangiogenetic mechanisms (Angiopoetin 2 and IL-8) were significantly reduced in patients with DCM. Comparable with known angiogenetic reactions in SCI, however these immune mediated reactions seem to be suppressed over a longer period of time in chronic SCI. Furthermore Angiopoetin 2 alterations are associated with the clinical severity of DCM.

05
Minimal clinically important difference and substantial clinical benefit using PROMIS CAT in cervical spine surgery

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Question: PROMIS allows for improved psychometric properties with reduced questionnaire burden through computer adaptive testing (CAT). The purpose of this study is to establish minimal clinically important difference (MCID) and substantial clinical benefit (SCB) thresholds for PROMIS use in patients with cervical spine pathology

Methods: Adult patients undergoing cervical spine surgery at a single institution between 2016-2018 were prospectively enrolled. Patients completed questionnaires (SF-36, NDI, VAS arm/neck, and PROMIS PI, PF) preoperatively and at 6 months postoperatively. MCID was calculated using distribution-based and SCB using anchor-based methods. The Health Transition Item of the SF-36 was utilized as an anchor with the cut-off values chosen using receiver operating characteristic (ROC) curve analysis.
Results: There were 139 patients meeting inclusion criteria, with a mean age of 56.4 years and diagnoses of myelopathy (n=36), radiculopathy (n=48) and myeloradiculopathy (n=49). There were significant improvements in PROMIS PF, PROMIS PI, NDI, and SF-36 MCS and PCS pre- to post-operatively (p <0.001). The test-retest reliability of all tests was excellent (ICCs = 0.87-0.94). Using these values, we calculated the standard error of measurement (SEM) and MCID for all tests. PROMIS, SF-36 and NDI scores were all correlated with our anchor question (|r| = 0.34-0.48, p<0.001). MCIDs were 8.5 (NDI), 11.1 (SF-36 PCS), 9.7 (SF-36 MCS), 4.9 (PROMIS PI), and 4.5 (PROMIS PF). SCB was 13 (NDI), 24 (SF-36 PCS), 11.8 (SF-36 MCS), 6.85 (PROMIS PI), 6.75 (PROMIS PF). MCIDs were greater than the SEM for all measures.

Conclusions: We report an MCID of 4.9 for the PROMIS PI and 4.5 for PF. SCB threshold for PI and PF was closer to 6.8. These data support the use of PROMIS in cervical spine patients and support the use of the CATs as a method to reduce questionnaire burden. Lastly, our results provide important reference as PROMIS reporting becomes more widespread in the literature.

O6
Neuropathic pain after spinal cord injury relieves in CCL21 knockout (plt) mouse through decreasing of M1 type microglia/macrophage and inflammatory cytokines at the injured site and lumbar enlargement
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¹Faculty of Medical Sciences University of Fukui, Department of Orthopaedics and Rehabilitation Medicine, Fukui, Japan

Question: Activated microglia are thought to contribute to neuropathic pain symptoms through their release of modulators of neuronal excitability. In this study, spinal cord injury (SCI) models by using mutant (plt) mice that have deficient CCL19/CCL21 (microglia-activating factor) expression, we assessed the post-SCI chronic neuropathic pain and the expression of microglia/macrophage (M/M) and inflammatory cytokines in the injured site and lumbar enlargement.

Methods: C57BL/6 and plt mice were subjected to SCI at T9-T10 level. EGFP+ bone marrow cells were obtained from C57BL/6-transgenic mouse. Behavioral and sensory testing were recorded at times indicated post-SCI. To evaluate the expression of M1 and M2 types M/M, immunohistochemistry (CD11b, iNOS, CD206), flow cytometry analysis and western blotting (TNF-α, IFN-γ, IL-4) were performed.

Results: SCI-induced hypersensitivities to mechanical and thermal stimulation relieved in plt mice. CD11b positive cells increased from 4 days up to more than 14 days post injury in both mice. In the results of immunohistochemistry and flow cytometry analysis, the phenotype of M/M was M1 type-dominant in both mice at the lesion site and lumbar enlargement. The decrease of M1 type M/M was seen in plt mice compared with wild type, while the number of M2 type M/M was not different in both mice. The expression of TNF-α and IFN-γ was decreased in plt mice and that of IL-4 was not different in both mice.
Conclusions: CCL21 is reported as chemokine to recruit M1 type M/M and induce allodynia by microglia activation. The suppression of inflammatory cytokines by decreasing the number of M1 type M/M in the injured site and lumbar enlargement was associated with reduction in inhibitory scar tissue/cavity formation in the subacute/chronic phase, and the provision of a permissive environment for reduction of neuropathic pain.

O23
Surgical navigation technology using a combination of augmented and virtual reality for minimally invasive spine surgery
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Question: To evaluate whether an augmented reality surgical navigation [ARSN] system with automatic instrument tracking, yielding feedback of instrument position in relation to deep anatomy, is feasible and accurate for pedicle cannulation.

Background: Minimally invasive spine surgery [MISS] has the possibility of reducing the length of hospital stays, and reducing blood loss and infection rates compared to open surgery. However, it limits the view for the surgeon, leading to an increased use of ionizing radiation during surgery.

Design: Cadaveric animal laboratory study

Methods: A hybrid OR equipped with a robotic C-arm with integrated optical cameras for augmented reality instrument navigation was used. In two pig cadavers, cone beam computed tomography [CBCT] scans were performed and pedicle screw insertions were planned. In total, 78 insertions were performed. Technical accuracy was assessed on post-insertion CBCTs by measuring the distance between the navigated device and the corresponding pre-planned path. Drilling and hammering into the pedicle were also compared. An independent reviewer assessed a simulated clinical accuracy according to Gertzbein.

Results: The technical accuracy was 1.7 ± 1.0 mm at bone entry point (Figure 1). Angular deviation was 1.7 ± 1.7° in the axial and 1.6 ± 1.2° in the sagittal plane. There was no difference in accuracy between hammering and drilling. The clinical accuracy was 97.4-100% depending on the screw size considered for placement. No ionizing radiation was used during navigation.

Conclusions/Discussion: The addition of instrument tracking to ARSN improves feedback on deep anatomical structures and facilitates accurate navigation, with close to 100% accuracy, while abolishing staff radiation exposure. Further studies will be needed to confirm our initial results in human subjects.

Figure 1
O24
Another solution in order to increase accuracy of cervical pedicle screw placement – a new aiming probe for CPS
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Question: Cervical pedicle screw (CPS) malposition has high risk of neurovascular injury. In order to increase accuracy, many systems such as navigation systems using CT or O-arm and template systems have been developed, however, there are limitations in cost or preparation time. The first author developed a new aiming probe for accurate CPS placement. The purpose of this study is to estimate the accuracy of CPS placement using this probe and to compare to that of navigation system or template system.

Methods: A patent probe is designed to aim at the safety zone of the pedicle in order to avoid the spinal canal and transverse foramen. CPSs were inserted into C3, C4, C5, and C6 pedicles using this aiming probe and fluoroscopy. Screw misplacement was evaluated with postoperative CT and classified as either screw exposure (under 50% of the screw diameter outside of the pedicle) or pedicle perforation (over 50% of the screw diameter).

Results: From 2015 to 2018, 68 consecutive cervical trauma cases treated with posterior instrumentation using CPS and LMS. There are 70 male and 8 female, and the average age is 67 years old (from 17 to 90 years). A total of 79 CPSs were inserted into pedicle safely using this probe. Postoperative CT demonstrated that 3 screws (3.8%) showed «screw exposure» and 0 screws (0%) showed «pedicle perforation». There was no neurovascular complication in all cases.

Conclusions: The reported CPS malposition rate is from 3.5 to 11.1% in O-arm navigation system studies and from 2.5 to 4.5% in template system studies. That accuracy is quite high, however, O-arm is extremely expensive and template system need long time. This probe has an equivalent accuracy to navigation or template systems and advantages of low cost and without loss of time, which are favorable for emergency surgery such as trauma cases.

O25
Intramedullary tumors of the cervical spine
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Question: Intramedullary tumors are rare benign lesions in the overwhelming majority. Radiation and chemotherapy are of limited value. Early surgery is considered as treatment of choice. This study provides data on surgical morbidity and long-term results.

Methods: All spinal cord pathologies have been entered into a spinal cord register since 1991. 60 intramedullary tumors of the cervical cord were operated by the author. Apart from tumor resection rates data on permanent surgical morbidity and progression-free survival were determined. Clinical data were classified according to McCormick.
Results: There were 31 ependymomas, 11 angioblastomas, 9 astrocytomas, 5 cavernomas, 2 gangiogliomas, 1 dermoid cyst and 1 metastasis. 93% were removed completely while the remainder underwent subtotal resections (4 astrocytomas grades II or III). Permanent morbidity was determined as 9.4%. 96.6% kept their preoperative McCormick grade after rehabilitation, while 3.4% lost one grade with surgery permanently. 54 patients were able to walk before surgery. Of these, one patient lost his walking capacity permanently. Among patients undergoing a complete tumor resection no adjuvant therapy was required. Overall, progression-free survival for 10 years was observed for 80% of all patients. Tumor recurrences were observed after incomplete resections and in patients with von Hippel Lindau disease (VHL).

Conclusions: Compared to intramedullary tumors of the thoracic spine, cervical intramedullary tumors can be removed completely with lower morbidity. All histologies except some astrocytomas grades II or III were amenable to complete resection. Therefore, surgery should be recommended as soon as these tumors become symptomatic.

O26
Surgical site infection after cervical laminoplasty using hydroxyapatite spacer
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Question: Surgical site infection (SSI) is an important complication in spinal surgery that leads to significant morbidity; however SSI cases after cervical laminoplasty have been rarely reported. Especially those of including superficial SSI have never been reported. The object of this study was to analyze the incidence of SSI after cervical laminoplasty.

Methods: We analyzed a consecutive cohort of 453 adult patients who underwent spinous process splitting cervical laminoplasty using ceramic spacer by a same surgeon from October 2006 to December 2018. Antibiotics (cefazolin, CEZ) administered at operation day and post-operative day 1. The epidural drainage tube was removed at post-operative day 2. SSI was based on the CDC criteria and was clinically reviewed. We analyzed age, gender, treated lamina, operation time, the amount of intraoperative bleeding and post-operative drainage, comorbid disorder, isolated pathogens, reoperation, and hospitalization day. The statistical analysis was performed with Mann-Whitney U test and chi-square test, and differences with P<0.05 was considered significant.

Results: From a total of 453 patients, 18 developed SSI (4.0%) including 2 deep SSI (0.4%). Pathogens were only isolated in two of deep SSI (MRSA, Serratia marcescer) and one of superficial SSI (Serratia marcescer). Debridement was required two in both SSI groups respectively. Removal of the spacer was required only in deep SSI group. The patient age, gender, treated lamina, operation time, the amount of intraoperative bleeding and postoperative drainage observed for SSI group were not significantly different from those for non-SSI group. SSI was only associated with prolonged hospitalization.

Conclusions: An infection rate of 4.0% implied that SSI after cervical laminoplasty is not rare. SSI was only associated with prolonged hospitalization.
Randomized, placebo-controlled, double-blinded trial of granulocyte colony stimulating factor-mediated neuroprotection for acute spinal cord injury

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\textbf{Question:} Granulocyte Colony Stimulating Factor (G-CSF) is generally used for neutropenia. Our experimental studies revealed that G-CSF promoted neurological recovery after SCI via various mechanisms. Next we moved to early phase of clinical trials. In a phase 1/2a trial, no adverse events were observed. Next, we conducted a non-randomized, non-blinded, comparative trial, which suggested the efficacy of G-CSF for promoting neurological recovery. We are now performing a phase 3 trial to confirm G-CSF treatment efficacy for acute SCI.

\textbf{Methods:} The current trial includes cervical SCI (AIS B/C) within 48 hours after injury. Patients are re-assessed for neurological status at 48 hours after injury, and those whose palsy is AIS B/C are enrolled. Patients are randomly assigned to G-CSF and placebo groups. The G-CSF group is administered 400 μg/m\textsuperscript{2}/d×5d of G-CSF in normal saline via intravenous infusion for 5 consecutive days. The placebo group is similarly administered a placebo. Allocation is concealed between blinded evaluators of efficacy/safety and those for laboratory data, as G-CSF markedly increases white blood cell counts that can reveal patient treatment. Efficacy and safety is evaluated by blinded observer. Our primary endpoint is changes in ASIA motor scores from baseline to 3 months. Each group includes 44 patients (88 total patients). Our protocol was approved by the Pharmaceuticals and Medical Device Agency and this trial is funded by the Center for Clinical Trials, Japan Medical Association.

\textbf{Results:} All the patients (total 88 cases) had been enrolled to the current trial. Results of the current trial will be disclosed after the 1-year follow-up of all the patients.

\textbf{Conclusions:} G-CSF is one of possible candidates for novel therapeutic agents for SCI.
Figure 1

**Trial design**

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SCI
<table>
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<th>Examination•Informed Consent</th>
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<tr>
<td>Neurological Evaluation</td>
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<td>Enrollment•Randomization</td>
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**G-CSF**
- 44 cases

**Placebo**
- 44 cases

Evaluation at 1, 3, 6, 12 months

Administration
- 400μg/m² × 5 days
- DIV

Within 48 hours
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**Legend**
- Blue: G-CSF
- Red: Placebo
O7
Radiological outcomes following hyperlordotic cage insertion in anterior cervical discectomy and fusion
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Question: Cervical alignment is associated with myelopathy and quality of life. Kyphosis correlates with increased neck pain and poor post operative neurological outcomes. Anterior cervical discectomy and fusion (ACDF) aims to decompress neural structures and optimise cervical alignment. This study examines the quantitative impact of the hyperlordotic 15° ACDF cage on cervical alignment. If post operative radiographical parameters are improved to a greater extent than the standard cage, its wider utilisation can be statistically justified, and its impact on disability scores further explored.

Methods: A retrospective analysis of radiographical parameters of cervical alignment was conducted in 80 consecutive ACDF patients from two institutions between 2013 and 2017. 40 received 15° cages, 40 received standard cages. Pre and post-operative Cobb angles and C2-7 sagittal vertical axis (SVA) were generated from radiographical imaging utilising the Surgimap program. Changes in lordosis and SVA were compared within and between groups, and the significance of the change evaluated using the student t-test.

Results: In both groups, post-operative device level, segmental, and global Cobb angles were superior to pre-operative values (p<0.05), especially among patients with pre-operative kyphosis (p<0.05). Trends suggested greater changes in lordosis in the 15° group, but they did not reach statistical significance (p=0.06-0.23). However, subgroup analyses indicated greater device level Cobb angle change in patients less than 65yo (p<0.049), and those with pre-operative lordosis (p<0.003). Neither standard nor hyperlordotic cages significantly improved SVA in this study.

Conclusions: Hyperlordotic and standard cages both improve cervical lordosis segmentally and globally. Hyperlordotic cages were not shown to be statistically superior to standard cages in this study. Prospective studies featuring consistent imaging modalities are necessary to further delineate their utility.

O8
Is right side anterior cervical approach a risk factor of recurrent nerve injury? – from the point of the frequency of aortic arch anomaly
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Question: There is still controversy between right- and left-side anterior cervical approach. Although right-side approach is easier for right-handed surgeon, it is postulated that right-side approach has higher risk of recurrent laryngeal nerve (RLN) palsy, since the frequency of non-RLN is higher in right-side. RLN originates from vagus nerve, turns at subclavian artery in right side or aortic arch in left side, and ascends to larynx. Though in the aberrant origin of right subclavian artery (AORSA), the right-side LN is non-RLN. The safety of right-side anterior cervical approach is discussed from the point of AORSA.
Methods: Consecutive 534 cases 3D-CT angiography (3D-CTA) of aortic arch were analyzed retrospectively. The purposes of taking CTA were dissection aneurysms, vascular disorder in lower extremity, coronary artery, etc. They were 336 male and 198 female, age range was 0-92yrs (69.5±12.5yrs). The types of aortic arch were divided using Adachi, Williams and Nakagawa classification.

Results: They were type A in 447 cases (84%), type B in 70 cases (13%), type C in 11 cases (2.1%). These relatively usual types account for 528 cases (99%). Type M, mirror image of type A, were in 2 cases (0.37%). Type G, the AORSA with both sides carotid artery originates separately, was in 1 case (0.19%). And type H, the AORSA with bilateral carotid arteries originates as common trunk, were in 3 cases (0.56%). In short, AORSA were 4 in 534 cases (0.74%).

Conclusions: The frequencies of AORSA and non-RLN are equivalent since the report that all non-RLN accompany AORSA. This study suggests the frequency of non-RLN is rare as 0.74%. Right-side approach is still attractive method. Although rare, preoperative diagnosis of AORSA could be beneficial. Chest X-ray is useless, the finding of artery situating posterior to esophagus in CT is characteristic of AORSA. Though contrast-enhanced CT is excessive, it can be an option to enlarge area to caudal in routine preoperative CT for cervical surgery.

O9
Posterior foraminotomy versus anterior decompression and fusion in patients with cervical degenerative disc disease with radiculopathy – 5-Year outcome from a national spine register
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3 Department of Orthopedics, rebro University Hospital, Rebro, Sweden

Question: The long-term efficacy of posterior foraminotomy compared with anterior cervical decompression and fusion (ACDF) for the treatment of degenerative disc disease with radiculopathy has not been previously investigated in a population-based setting.

Methods: All patients in a national register from January 1, 2006 until November 15, 2017, with cervical degenerative disc disease and radiculopathy, were assessed. Using propensity score matching, patients treated with posterior foraminotomy were compared with those undergoing ACDF. The primary outcome measure was the Neck Disability Index (NDI) with a minimal clinically important difference defined as >15%. Secondary outcomes were assessed with additional patient reported outcomes measures (PROMs).

Results: A total of 4,368 patients (2,136/2,232 women/men) met the inclusion criteria. Posterior foraminotomy was performed in 647 patients and 3,721 patients underwent ACDF. After meticulous propensity score matching, 567 patients with a mean age of 54 years remained in each group. Both groups had substantial decreases in their NDI scores; however, after 5 years, there was not a significant difference (2.4%; 95% CI, -4.3 to 9.0; P=0.48) between the groups. There were no significant differences between the groups in EQ-5D or numeric rating scale (NRS) for neck and arm pain.
Conclusions: In patients with cervical degenerative disc disease and radiculopathy, both groups demonstrated clinical improvements, at 5-year follow-up, which were comparable and did not achieve a clinically important difference from one another. This study design obtains population-based results, which are generalizable.

Figure 1

O10
Disc height narrowing does not affect the intervertebral stability in cervical spondylolisthesis: Analysis of CT and X-rays of 101 spondylolisthesis patients
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4Keio University, Department of Orthopaedics, Tokyo, Japan

Question: The concept of degenerative cascade in lumbar spondylolisthesis was broadly recognized, and vertebral body is thought to be stabilized by disc height narrowing. However, degenerative cascade in cervical spondylolisthesis is not fully understood. The purpose of this study is to examine whether the cervical disc height narrowing causes the stability of the intervertebral space in cervical spondylolisthesis.

Methods: This study was conducted to analyze cervical X-rays and CT-mylography of 731 patients with cervical spine disorders between 2008 and 2013. We defined cervical spondylolisthesis as antero-posterior vertebral slipping of more than 2mm identified on lateral X-rays in
neutral position or sagittal CT. On lateral X-rays, considered parameters were neck alignment, C2-7 angle, range of flexion-extension neck motions (ROM), C2-7 sagittal vertical axis (SVA) and change of translation in flexion-extension from neutral position. Anterior translation was defined to be plus value in anterior spondylolisthesis, while posterior translation was defined plus value in posterior spondylolisthesis. On sagittal CT, we classified disc height at slipped level into 5 grades. High disc height grade indicates more narrowed disc height.

**Results:** Anterior and posterior spondylolisthesis was detected in 81 disc levels and 43 disc levels respectively. The change of translation in flexion-extension examined according to the disc height grade, and results are on figure 1. The change of translation was not statistically different among groups of 5 disc height grades. There was no statistical significant difference in neck alignment, C2-7 angle, ROM, C2-7 SVA and mean age among groups of 5 disc height grades.

**Conclusions:** From the results of this study, disc height narrowing did not affect the change of translation in flexion and extension at slipped level. Disc height narrowing was difficult to contribute the stability in cervical spondylolisthesis.

**Figure 1**

![Figure 1](image)

O11
Morphological changes in the intervertebral disc post trauma – Any impact of preexisting segment degeneration?

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**Question:** In the first 24 hours post intervertebral disc (IVD) trauma, up to 75% cell death has been reported. The aim of the study was to assess histological changes and cell-death over a time period of up to one year after trauma, with particular regard to the impact of preexisting degeneration grades.
Methods: 111 anterior portions of IVDs of the cervical spine were studied histologically by light microscopy and ultrastructurally by transmission electron microscopy (TEM). The group was investigated with regard to two parameters: fracture mechanism (compression vs. rotation fractures) and degeneration grade (low vs. high). Disc architecture (e.g. ruptures) was studied histologically. Cell morphology was examined ultrastructurally to quantify cell-death, healthy and balloon cells. According to ultrastructural observations, two time-groups (up to 6 days vs. later) were established. Statistical analyses (SPSS) were carried out within the time-groups.

Results: Histological changes were obvious in the annulus fibrosus where ruptures with haematoma were replaced by granulation tissue. Significantly higher cell numbers per mm² were found in highly degenerated segments after compression fractures (time group 2) than in all other investigated groups. Necrotic cell death was obvious with significant differences in time group 1 (acute trauma) comparing both degeneration groups according to compression and rotation fractures. Apoptosis was significant higher in low degenerated segments after compression fractures. No difference was found between groups after the sixth day (time group 2). Cell-death (mean 44% for all groups) remained high after day 6 post-trauma.

Conclusions: Interestingly, alterations post trauma of the different cell morphologies according to low and high degenerated discs were only present in the early phase after trauma (up to 6 days), but not later on.

Figure 1:
Figure 2

Histological Investigations in compression trauma

Histological Investigations in less compression (rotation) Trauma

Time group 1: 0-6 days post trauma. Time group 2: 7 days-1 year post trauma.
Figure 3

Statistical analysis undertaken in the different time groups

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<td>ns</td>
<td>oAF: P&lt;0.001</td>
<td>ns</td>
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<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>NP: P=ns</td>
<td></td>
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<td>balloon cells</td>
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<td>ns</td>
<td>ns</td>
<td>ns</td>
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<td>Total cell death</td>
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<td>ns</td>
<td>oAF: P&lt;0.028</td>
<td>ns</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>iAF: P&lt;0.015</td>
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<tr>
<td>total cell count</td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

Figure 4

Healthy, Necrosis, Chondroptosis, Apoptosis, Balloon
O12
Adjacent segment pathology after cervical laminoplasty
Shino Mori¹, Ko Ikuta¹, Takaomi Kobayashi², Ryoei Yano³, Kensuke Hotta¹, Keigo Masuda¹
Takahiro Kitamura¹, Hideyuki Senba¹, Satoshi Shidahara¹
¹Karatsu Red Cross Hospital, Karatsu-city, Saga, Japan

Question: In cervical spine surgery, it is generally supposed that adjacent segment pathology (ASP) is an important problem associated with fusion surgery. In contrast, there is a consensus that cervical laminoplasty (CLP) is a motion preservation surgery. Consequently, there had been only a few case reports of ASP after CLP. The aim of this study was to evaluate the prevalence and clinical features of ASP after CLP.

Methods: Seventy-four patients of cervical myelopathy, who underwent CLP and could be followed for minimum 2 years after surgery, were retrospectively reviewed. The ASP was assessed using a radiographical grading system described by Hilibrand et al. We evaluated radiological findings on standing lateral radiographs and MRI. The postoperative follow-up duration was mean 4.3 years. We conducted a comparative study between patient group with ASP (group-A) and that without ASP (group-C) to evaluate clinical features of ASP after CLP.

Results: The ASP was found in 7 patients (9.5%); 1 patient within 2 years after surgery and 6 patients at over 4 years after surgery. The ASP developed at proximal segment (Oc-C2) in 3 patients and at distal adjacent segment in 6 patients. There were no significant differences between two groups on preoperative demographic details and radiological findings. A significant decrease of cervical ROM with unexpected postoperative interlaminar bony fusions was observed in group-A, postoperatively. In patients with proximal ASP, the C2-7 lordosis decreased and Oc-C2 lordosis increased with significant differences after CLP.

Conclusions: The ASP after CLP might occur more frequently than previously thought. Patients with unexpected interlaminar bony fusions and decrease of cervical ROM after CLP have a higher risk of ASP. The proximal ASP (Oc-C2 level) was connected with increase of Oc-C2 lordosis after surgery, which resulted from compensation for postoperative loss of lordosis at the C2-7. Meanwhile, the relevant factors of distal ASP could not be found in this study.

O13
The spinal cord “back shift” concept in posterior decompression and stabilization in lordosis for cervicalspondylotic myelopathy – avorable clinical outcomes
Vincenzo Denaro¹, Gianluca Vadalà¹, Alberto Corrado Di Martino¹, Rocco Papalia¹
¹Campus Bio-Medico University of Rome, Department of Orthopaedic Surgery, Rome, Italy

Question: Surgical management of patients with multilevelcervicalspondylotic myelopathy (CSM) aims to decompress the spinal cord and restore the normal sagittal alignment. The literature lacks of high level evidences about the best surgical approach. The purpose of this study was to investigate the efficacy of posterior decompression and stabilization in lordosis for multilevel CSM.

Methods: 36 out of 40 patients were clinically assessed at a mean follow-up of 5, 7 years. Outcome measures included EMS, mJOA Score, NDI and SF-12. Patients were asked whether surgery met their expectations and if they would undergo the same surgery again. Bone graft fusion, instrumental failure and cervical curvature were evaluated. Spinal cord back shift was measured and correlation with EMS and mJOA score recovery rate was analyzed.
Results: All scores showed a significative improvement (p < 0.001), except the SF12-MCS (p > 0.05). Ninety percent of patients would undergo the same surgery again. There was no deterioration of the cervical alignment, posterior grafted bones had completely fused and there were no instrument failures. The mean spinal cord back shift was 3.9 mm (range 2.5-4.5 mm). EMS and mJOA recovery rates were significantly correlated with the postoperative posterior cord migration (P < 0.05).

Conclusions: Posterior decompression and stabilization in lordosis is a valuable procedure for patients affected by multilevel CSM, leading to significant clinical improvement thanks to the spinal cord back shift. Postoperative lordotic alignment of the cervical spine is a key factor for successful treatment.

Figure 1

Long-Term Follow-Up

- Satisfied patients
- The initial recovery is maintained over time
- Improved SEP/MEP
- Significant improvement in myelopathy scores
- Functional recovery perceived by the patient is higher than the neuropsychological findings (SEP/MEP)

<table>
<thead>
<tr>
<th>Disease Specific Scores and HRQoL</th>
<th>Mean</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
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<tr>
<td>mJOA</td>
<td>17</td>
<td>14</td>
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<tr>
<td>mNSA</td>
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<td>13</td>
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<tr>
<td>mNMN</td>
<td>20</td>
<td>9.8</td>
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</tr>
<tr>
<td>mFRS</td>
<td>26</td>
<td>16</td>
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<tr>
<td>mPULS</td>
<td>95</td>
<td>91</td>
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</tbody>
</table>

O14
Clinical feature of the revision cases due to symptomatic adjacent segment degeneration after the anterior cervical decompression and fusion surgery
Atsuomi Aiba¹, Macondo Mochizuki¹, Ryo Kadota¹, Takeo Furuya², Masao Koda³
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²Chiba university, Orthopedic Surgery, Chiba, Japan
³Tsukuba University, Orthopedic Surgery, Tsukuba, Japan

Question: We have indicated anterior decompression and fusion surgery for every degenerative cervical spine, usually with myelopathy. Re-worsening due to adjacent segment degeneration/ASD is advocated often as negative side of the anterior cervical fusion surgery. To prevent recurrence due to ASD, we have preferred to indicate multilevel fusion surgery for younger patients with developmental narrow spinal canal, which is not rare in Japanese population. Purpose of this study is to clarify the incidences of revision surgeries due to symptomatic ASD and to examine the validity of our indication of the first surgery.

Methods: Subjects include 248 patients(177male/71female, avg.62.7yo), who underwent anterior decompression and fusion surgery for cervical degenerative disease including 56 OPLL cases in 2007-11. Average fusion segments are 2.0. Average F/U period is 5.4 years. We assessed incidences of revision surgeries due to symptomatic ASD, duration between two surgeries and etiology up to each revision surgery.
Results: In the 248 cases, 11 cases have experienced revision surgeries for symptomatic ASD. Duration between 1st and 2nd surgery is 33-120 (avg. 68) months. Symptomatic segment is C7/T1 in 4 cases, C5/6 in 3 cases, C4/5 in 2 cases and 2 others. Etiology up to the revision surgeries includes CSM/4 cases, C8 root/4 cases and 3 others. For revision surgery, anterior surgery had indicated again except for an OYL case. (table 1)

Conclusions: Incidence of revision surgeries for symptomatic ASD was 4.4% (11/248) in avg. 5.6 years F/U. This frequency, relatively lower than reported literally, represents validity of indication on the 1st surgery, which avoids short fusion for younger developmental narrow canal cases. However, C8 palsy due to C7/T1 ASD recognized considerably in younger patients after multilevel surgery, which should be newly taken account when choosing multilevel surgery for younger cervical spine.

Figure 1

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis &amp; 1st op.</th>
<th>Duration /months</th>
<th>Symptomatic level</th>
<th>Etiology</th>
<th>2nd op.</th>
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<tr>
<td>43</td>
<td>M</td>
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<td>93</td>
<td>7/1</td>
<td>C8</td>
<td>7-1 ant.</td>
</tr>
<tr>
<td>44</td>
<td>M</td>
<td>OMP, 7-6</td>
<td>91</td>
<td>7/1</td>
<td>C8</td>
<td>7-1 ant.</td>
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<tr>
<td>45</td>
<td>M</td>
<td>CSM, 3-6</td>
<td>72</td>
<td>7/1</td>
<td>C8</td>
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</tr>
<tr>
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<td>M</td>
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<td>69</td>
<td>7/1</td>
<td>C8</td>
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</tr>
<tr>
<td>55</td>
<td>F</td>
<td>CSM, 4-5</td>
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<td>5/6</td>
<td>CSM</td>
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<td>4/5</td>
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<td>4-6 ant.</td>
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<tr>
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<td>6/7</td>
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<td>44</td>
<td>5/6</td>
<td>CYL</td>
<td>5-7 pos.</td>
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</table>

O15
A dynamic multi-segmental finite element model of rear-impact cervical whiplash – Role of spine morphological variations and head inertial properties on segmental rotations
Jamie Baisden¹, Jobin Daniels², Narayan Yoganandan¹, Gurunarhan Kumar²
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²Indian Institute of Technology, Dept of Engineering Design, Madras, India

Question: To investigate the role of variations in spine morphology and head inertia properties on cervical spine segmental rotation in rear-impact whiplash loading.

Methods: A multi-segmental (C2-C7) cervical spine finite element model, with its morphology parametrized using mesh morphing, was used to study the influence of disc height, anteroposterior vertebral depth, and segmental size, as well as variations in head mass, moment of inertia, and center of mass locations. The influence of these variations on the characteristic S-curve formation in whiplash response was evaluated using the peak C2-C3 flexion marking the maximum S-curve formation and time taken for the formation of maximum S-curve.

Results: The peak C2-C3 flexion in the S-curve formation was most influenced by disc height and vertebral depth, followed by anteroposterior head center of mass location. The time to maximum S-curve was most influenced by the anteroposterior location of head center of mass and segmental size.
Conclusions: The role of gender-dependent vertebral depth and segmental size may explain the pronounced S-curve formation for females reported in both post-mortem human subjects and volunteer experiments in whiplash type mechanisms of injury; and hence, may help explain why women are clinically more predisposed to whiplash injury than men.

O16
Comparison of surgical results of C-arm versus O-arm in C1-2 transarticular screw fixation
Keiji Wada¹, Ryo Tamaki¹, Osamu Satoh¹, Ken Okazaki¹
¹Tokyo Women’s Medical University, Orthopaedics, Tokyo, Japan

Question: C1–2 transarticular screw (TAS) is technically demanding. Traditionally, C-arm has been used to place TAS. O-arm based navigation system (O-arm) has been implemented to help some of the technical difficulties of screw placement in the upper cervical spine. The purpose of this study is to compare the surgical outcomes of TAS using C-arm and O-arm.

Methods: The present study was conducted in 71 patients who underwent TAS in our hospital between 2006 and 2018. The mean age at surgery was 61 years. Fifty-three patients underwent surgery with C-arm (C-group) and 18 patients with O-arm (O-group). Additional surgery, such as C3-7 laminoplasty (LP), was performed in 8 patients in C-group and 3 patients in O-group. Total of 91 TAS were inserted: 62 in C-group and 29 in O-group. Unilateral and bilateral TAS was performed in 51 and 20 patients, respectively. Operative time, intraoperative bleeding, accuracy of screws, perioperative complications and bone union were evaluated. Screw accuracy was assessed using Neo classification: grade (G) 0: no perforation, G1: perforation<4mm.

Results: The mean operative time was 183 (105–349) min in C-group and 207(116-266) min in O-group. The mean blood loss was 132 (20–382) g in C-group and 360 (20-2684) g in O-group. The operative time without additional surgery was 170 (105-249) min in C-group and 179 (116-266) min in O-group. The mean blood loss without additional surgery was 132(20-382) g in C-group and 163 (20-480) g in O-group. The accuracy of TAS was G0:44, G1:17, G2:3, G3:3 in C-group, and that was G0:28, G1:1 in O-group. Bone union was completed 100% (20/20pts) with bilateral TAS, though 78.7% (37/47pts) with unilateral TAS. Deep wound infection was observed in a case in C-group.

Conclusions: O-arm dramatically improved accuracy of TAS. Bone union rate was 100% with bilateral TAS. Therefore, TAS should be performed with bilateral TAS if O-arm is available.

O17
Time course of respiratory dysfunction in the cervical spinal cord injury without bony injury: respiratory function restore around 12 weeks after injury
Chikara Ushiku¹, Kota Suda¹, Satoko Harmon, Matsumoto¹, Miki Komatsu¹ Masahiko Takahata², Norimasa Iwasaki², Akio Minami²
¹Hokkaido Spinal Cord Injury Center, Orthopaedic Surgery, Bibai, Japan
²Hokkaido University Graduate School of Medicine,, Orthopaedic Surgery, Sapporo, Japan

Question: Cervical spinal cord injury without bony injury (SCIWOB) is a common cervical injury in the elderly population, and is most likely to occur at the C3/4 level. Respiratory dysfunction (RD) related to damage of the spinal respiratory center, which is close to the C4 segment, is one of the greatest challenges to improving activities of daily life in cases of
severe paralysis. We evaluated the time course of RD and motor function in cervical SCIWOBi with a view to selecting effective medical strategies.

**Methods:** We followed 54 patients (49 men, 5 women; mean age 65 years) who were treated for SCIWOBi at our medical center from 2011 to 2014, were evaluated within 72 hours of injury, and were followed at least 12 weeks. Whether treated conservatively or surgically, all patients began respiratory-muscle training the day after admission. The percent vital capacity (%VC), forced expiratory volume in one-second/forced vital-capacity ratio (FEV 1.0%), and American Spinal Injury Association motor score (MS) were recorded at admission and again at weeks 4 and 12. We calculated the %VC rate of change and the MS improvement rate over the entire period.

**Results:** Fifty patients (92.6%) had restrictive ventilatory impairment at admission. The %VC correlated with the upper- and lower-limb MS at admission, and the %VC and upper- and lower-limb MS had improved at weeks 4 and 12 after injury. The %VC rate of change was significantly correlated with the rate of improvement in lower-limb MS throughout the entire period.

**Conclusions:** Lung capacity decreased in SCIWOBi due to respiratory-muscle paralysis and on the same level with upper- and lower-limb motor paralysis. Lung capacity improved as the lower limbs recovered motor function. Respiratory rehabilitation should be continued for at least 12 weeks after SCIWOBi.

O18
Relationship between the timing of reduction for cervical spine dislocations and neurological recovery
Hisakazu Shitozawa1, Yasuo Ito1, Takeshi Kikuchi1
1Kobe Red Cross Hospital, Orthopedics, Kobe, Japan

**Question:** Although many studies have reported that it is desirable to perform reductions for cervical spine dislocation injuries as early as possible, the ideal timing remains unclear. The purpose of this study was to clarify the relationships between the interval from injury to reduction (referred to as “reduction time”) and the neurological prognosis.

**Methods:** A total of 206 patients with cervical spinal cord injury were treated at our hospital from 2007 to 2018. In those patients, there were 54 cases with distractive flexion dislocation according to the Allen classification (42 males, 12 females; average age, 60.0 years). Their ASIA Impairment scale (AIS) grade at the arrival at the hospital ranged from A to D. We evaluated the reduction time and the transition of paralysis after one month from the injury.

**Results:** The distribution of AIS grade at the time of injury was as follows: A, 24 cases; B, 13 cases; C, 8 cases; and D, 9 cases. The mean reduction time was 7.0 hours (range, 2.0 hours to 21 days). Twenty one cases (38.9%) were performed reduction within the determined cut-off value of 6 hours, which included 9 grade A, 4 grade B, 4 grade C and 4 grade D. Among these 21 patients, all 12 patients with initial AIS B, C and D improved significantly by one or more AIS grade. On the other hand, in 18 AIS B, C and D patients whose reduction time was over 6 hours, only 9 patients (50.0%) showed improvement by one or more AIS grade.

**Conclusions:** In our case series, patients with AIS grade B, C and D showed neurological improvement in case the reduction time was less than 6 hours. These results indicate an aiming reduction time and transportation time for the acute treatment. We should make an effort to shorten the reduction time by transferring the patients to a hospital that can perform reduction and diagnose the dislocation injury as soon as possible.
O19
Clinical outcomes of acute cervical spinal cord injury depending on the timing of surgery
Tae Young Kwon¹, Kyung Jin Song², Jong Hyun Ko¹, Hyung Jik Kim¹
¹Chonbuk National University Hospital, Chonbuk National University, Department of Orthopedic Surgery, Jeonju-si, Jeollabuk-do, South Korea

Question: There have been lots of prior studies that show optimal surgical time for acute SCI. Most studies reported that early surgery had better results than late surgery. However, the timing of surgery remains controversial. We tried to evaluate the clinical outcomes of acute cervical spinal cord injury (SCI) depending on the timing of surgery.

Methods: We analyzed patients whose surgery was performed for acute cervical spinal cord injury from 2007 to 2017. We analyzed change in AIS (ASIA Impairment Scale) and ASIA motor subscore depending on the timing of surgery and analyzed the relation of clinical outcomes and age, gender, neurologic level of injury and type of spinal cord syndrome by multivariate analysis. Secondary outcomes were analyzed with complication and mortality.

Results: A total of 154 patients with acute cervical SCI were enrolled. Of these, 49 patients (group A) underwent early surgery (≤24hr), 54 patients (group B) underwent intermediate surgery (24~72hr) and 48 patients (group C) underwent delayed surgery (≥72hr). AIS improvement was shown as 44.8% in group A, 31% and 24.1% in group B and C respectively (A vs B&C; p=0.041). In the multivariate analysis, with steroid administration, the rate of AIS improvement were 33% in early surgery group and 16% in the other group (odds ratio=2.6, p=0.061). Age, gender, and NLI had no relation with AIS statistically. Mortality during hospitalized period was 2 in group A and 1 in group B. The complication rate was 34.6% in group A, 28.5 and 24.4% in group B and C respectively.

Conclusions: Surgery prior to 24 hours after acute cervical SCI could improve clinical outcome.

O20
The effect of rod pattern and multiple screw-rod constructs for surgical stabilization of the 3-column destabilized cervical spine – presentation of biomechanical analysis and clinical rationale
Sebastian Hartmann¹, Claudius Thomé¹, Werner Schmölz², Raphael Gmeiner¹
Anto Abramovic¹, Anja Tschugg¹, Heiko Koller¹
¹Medical University, Neurosurgery, Innsbruck, Austria
²Medical University, Trauma surgery, Innsbruck, Austria

Question: Supplemental posterior cervical instrumentation can improve construct stability after corpectomy procedures (CE), particularly in the 3-column deficient spine. Among standard screw-rod instrumentation using CoCr-rods, advanced constructs including the use of outrigger rods (OGR) and 6-screws/3-rods constructs (6S3R) with additional lamina screws are available (Fig.1). The biomechanical characteristics of each construct are yet to be compared.

Methods: Based on reconstructed human CT-scans, 3-coulmn deficient PVC cervical models were created. The CE-level distances were calculated and reconstructed using titanium mesh cages. Biomechanical testing was performed with the use of different rod materials (Ti vs. CoCr), different rod diameters (3.5 vs. 4.0mm), ± constrained anterior plating, ± cross-links, and the use of different construct pattern. All motion tests were performed in a customized 6-degree of freedom spine tester (2Nm). Stability was expressed in ROM changes (°).
Results: A total of 432 tests were performed. The largest reduction of ROM was noticed for the 6S3R-group, while the addition of an outrigger rod caused moderate advantage (Fig.2). For all simulated 1-, 2- and 3-level CE constructs, the use of CoCr rods initiated a substantial ROM reduction in all planes. The use of 1 cross-link lowered ROM mainly in AR. In the OGR-group, a decreased ROM was recorded for all motion directions compared to the Standard-Group. Differences observed were increased with the number of CE-levels resected and without anterior plating.

Conclusions: A PVC model allows us to benchmark the mechanical effect of different screw-rod construct pattern of the 3-column destabilized spine. The 6S3R-group outperformed all other constructs and might resemble the standard of reference for advanced posterior fixation of 3-column destabilized cervical spine, particularly in multilevel CE. The use of CoCr-rods improves construct endurance in patients with posterior-only instrumentation without anterior plating.

Figure 1

Figure 2
Type II odontoid fracture in elderly patients treated conservatively – Is bony union the goal?
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Antonio Martucci², Pasquale De Bonis³
¹M.Bufalini Hospital, Neurosurgery, Cesena, Italy
²Maggiore “C.A. Pizzardi” Hospital, Spine Surgery, Bologna, Italy
³University Hospital S.Anna, Neurosurgery, Ferrara, Italy

Question: Independently from radiological outcome, hard collar immobilization represent a safe and effective treatment choice when facing type II geriatric odontoid fractures

Methods: 50 geriatric patients with type II odontoid fractures were treated with Aspen/Vista collars. On admission, each patient was assessed assigning ASA score, modified Rankin scale (mRS-pre) and Charlson Comorbidity Index (CCI). 12-15 months after treatment, functional evaluations were performed employing a second modified Rankin scale (mRS-post) together with Neck Disability Index (NDI) and Smiley Webster Pain Scale (SWPS). Radiological outcome was evaluated through dynamic cervical spine x-rays at 3 months and cervical spine CT scans 6 months after treatment. Three different conditions were identified: stable union, stable non-union, unstable nonunion. Surgery was preferred whenever a fracture gap >2 mm, an anteroposterior displacement >5 mm, an odontoid angulation >11° or neurological deficits occurred.

Results: Among the 50 patients, 24 reached a stable union while 26 a stable nonunion. Comparing the two groups, no differences of ASA (p=0.60), CCI (p=0.85) and mRS-pre (p=0.14) were noted. Similarly, no differences of mRS-post (p=0.96), SWPS (p=0.85) and NDI (p=0.51) were observed between patients who reached an osseous fusion and those with a stable fibrous non-union. No effects of age, sex, ASA, mRS-pre, fracture dislocation and radiological outcome were discovered on functional outcome. At logistic regression analysis, female sex and high values of CCI emerged associated with worse NDI.

Conclusions: In geriatric type II odontoid fractures pre-injury clinical status and comorbidities overcome imaging in determining post-treatment level of function. Hard collar immobilization led to a favourable functional outcome whatever a bony union or a fibrous nonunion was obtained.
Crowned dens – normal finding in old people, radiological degenerative sign or clinical syndrome? Reflection on four cases and a prevalence study on 843 patients

Carlos Villas¹, Mariana Elorz², Matías Alfonso¹, Rafael Llombart¹, Jesús Payo-Ollero¹ Jorge Gómez¹, Alvaro Suárez¹, Jesús Dámaso Aquerreta²

¹Clinica Universidad de Navarra, Orthopaedic Surgery and Traumatology Department, Pamplona, Spain
²Clinica Universidad de Navarra, Radiology Division, Pamplona, Spain

Question: Knowledge about the so-called crowned dens syndrome (CDS) is reduced to the seldom published reports on one or a few cases. These authors state that this entity would not be a very rare condition but mentions some doubts on the possibility of being also an eventual radiological finding. The propose of this study was to search a possible distinction of ossifications around the apex of the odontoid process as early as degeneration signs, normal findings in old people and the so-called CDS (Figure 1).
Methods: For this preliminary study, we reviewed retrospectively 843 consecutive CT studies of the upper cervical spine. Four out of these studies were indicated by CDS suspicion, 18 in patients with sub-axial neck pain, 43 in general medical checking in patients with no cervical pain, 144 in studies of the facial bones, 292 in studies of neck structures and cavum and 348 in studies of the brain. Data about age, sex, nuchal pain and fever were taken on every patient as well as the presence of lumpy (Figure 2) or lineal (Figure 3) calcifications in the CT, associated or not to degenerative signs at disc spaces or zygapophyseal joints (Figure 4).

Results: Twenty seven (3.2%) out of the 843 CT scan studies disclose some kind of calcification around the odontoid process. The average age was 80.4 (57 to 98); 59% were men and 41% were women. No patient had fever and only the four under suspicion of having a CDS, complained of suboccipital pain. Two of these patients were finally diagnosed of CDS and 2 had degenerative signs-simple arthritis at C1C2 level. Only two 2 of the 27 patients had chondrocalcinosis in the extremities.

Conclusions: The so-called CDS has to be better defined. Nuchal pain may be caused by C1C2 arthritis and similar images may be found in asymptomatic people over fifty years. This study is the largest study conducted on the prevalence of periodontoid calcifications and will continue in order to better define the options for diagnosis in case of facing patients with suboccipital pain.

Figure 1

Figure 2

Figure 3

Figure 4
O28
The role of non-rigid cervical collar in pain relief and functional restoration after whiplash injury – a systematic review and pooled analysis of randomized controlled trials
Luca Ricciardi\textsuperscript{1,2}, Vito Stifano\textsuperscript{1}, Filippo Maria Polli\textsuperscript{1}, Luca Proietti\textsuperscript{3}, Andrea Perna\textsuperscript{3}
Alessandro Olivi\textsuperscript{1}, Francesco C. Tamburrelli\textsuperscript{3}, Carmelo Lucio Sturiale\textsuperscript{1}
\textsuperscript{1}Fondazione Policlinico Universitario A. Gemelli IRCCS, Istituto di Neurochirurgia, Rome, Italy
\textsuperscript{2}Mayo Clinic, Department of neurosurgery, Jacksonville, FL, United States
\textsuperscript{3}UCSC- A. Gemelli University Hospital Foundation, Division of vertebral surgery, Roma, Italy

Question: Whiplash injury (WI) represents a common diagnosis at every emergency department. Several investigations have been conducted to compare the different medical management for non-surgical cases. Although active-mobilization (PhT) protocols have demonstrated good clinical outcomes, patients’ compliance and PhT service availability are needed. Furthermore, the role of a non-rigid cervical collar (nRCC) for pain management and range of motion (RoM) preservation has not been completely clarified. Accordingly, we designed this systematic review and pooled analysis of randomized control trials to investigate any role of nRCC when PhT protocols are not pursuable.

Methods: We performed a systematic review of the randomized control trials (RTCs), according to PRISMA guidelines, and a pooled analysis in order to investigate the role of the nRCC for pain management, scored through the visual analogue scale (VAS) and the RoM, by comparing the use of a nRCC versus a non-immobilization protocols, regardless the association with physical therapy (PhT). Due to a certain heterogeneity across the RTCs, follow-up times time-range re-setting was necessary in order to pool the data.

Results: A total of 141 papers were reviewed, 6 of them matched the inclusion criteria and were admitted to the final study. Pooled-analysis showed that nRCC does not improve the outcome in term of VAS score and RoM trends along the follow-up. Moreover, VAS and RoM trends seem to further improve at long-term follow-up in non-immobilization associated with PhT group.

Conclusions: This pooled analysis of the available RTCs shows the absence of an advantage using nRCC after a WI. On the contrary, non-immobilization protocols show an overall better trend of pain relief and neck mobility recovery, regardless their association with PhT. Thus, nRCC prescription should be always avoided in WI management.

O29
The Odom’s criteria validated at last – a clinimetric evaluation in cervical spine surgery
Anne Broekema\textsuperscript{1}, Rob Molenberg\textsuperscript{1}, Jos Kuijlen\textsuperscript{1}, Rob Groen\textsuperscript{1}, Michiel Reneman\textsuperscript{1}
Remko Soer\textsuperscript{1}
\textsuperscript{1}University Medical Center Groningen, Neurosurgery, Groningen, Netherlands

Question: The Odom’s criteria are, since 1958, a widely used 4-point rating scale for assessing the clinical outcome after cervical spine surgery. Surprisingly, the Odom’s criteria have never been validated.

Research question: The aim of this study was to investigate the reliability and validity of the Odom’s criteria for the evaluation of surgical procedures of the cervical spine.

Methods: Patients with degenerative cervical spine disease were included. Reliability was assessed with inter-rater and test-retest design using a quadratic weighted Kappa coefficient.
Construct validity was assessed by means of hypothesis testing with related constructs. To evaluate if the Odom’s criteria could act as a global perceived effect (GPE) scale, we assessed concurrent validity by comparing the areas under the curves (AUCs) of the receiver operating characteristic curves (ROCs) with the set of questionnaires.

**Results:** A total of 110 patients were included in the study. Overall inter-rater reliability was $\kappa=0.77$ and the test-retest reliability $\kappa=0.93$. Inter-rater reliability for the radiculopathy patients was $\kappa=0.81$ and for myelopathy patients $\kappa=0.68$. More than 75% of the hypotheses were met. The AUCs showed similar characteristics between the Odom’s criteria and GPE.

**Conclusions:** The Odom’s criteria meet the predefined criteria for reliability and validity. Therefore, the Odom’s criteria may be used to measure surgical outcome after a cervical spine procedure, specifically for patients presenting with radicular symptoms. Results of previous studies that have been deemed less trustworthy, because of the use of the Odom’s criteria, should be reconsidered.

**Methods:** Thirty three thoracic myelopathy (TM) patients and 123 cervical myelopathy (CM) patients, who were diagnosed by clinical symptoms and MR images without other level stenosis, were enrolled. Those cases with neuromuscular diseases of other parts such as lumbar spinal canal stenosis and cases of joint diseases in which it is difficult to appropriately implement Step test are excluded. The test was conducted preoperatively and 1 year after surgery.

**Results:** Their mean age (TM/CM) was $61.8 \pm 14.3/63.3 \pm 12.1$. They included 19 males/14 females in TM group, and 74/49 in CM group. The Step test (TM/CM) was $9.0 \pm 6.2/10.4 \pm 5.9$ preoperatively and improved to $14.0 \pm 5.2/14.0 \pm 5.4$ postoperatively. The G&R test (TM/CM) was $20.3 \pm 4.8/16.3 \pm 6.1$ before surgery and $21.5 \pm 4.0/19.3 \pm 4.9$ after surgery. The average number of Step test and G&R test in 1230 healthy subjects were $19.7 \pm 3.4$ and $21.5 \pm 5.5$.

**Conclusions:** Both TM and CM patients showed marked decrease preoperatively and postoperative increase in Step test. However CM patients alone demonstrated significant decrease of G&R test before surgery and prominent increase after surgery. The combination of Step test and G&R test are useful to diagnose thoracic myelopathy and cervical myelopathy.

**Figure 1**

<table>
<thead>
<tr>
<th></th>
<th>Step test</th>
<th>G&amp;R test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical myelopathy</td>
<td>$9.0 \pm 6.2$</td>
<td>$16.3 \pm 6.1$</td>
</tr>
<tr>
<td>Thoracic myelopathy</td>
<td>$10.4 \pm 5.9$</td>
<td>$20.3 \pm 4.8$</td>
</tr>
<tr>
<td>Healthy subjects</td>
<td>$19.7 \pm 3.4$</td>
<td>$21.5 \pm 5.5$</td>
</tr>
</tbody>
</table>
Blood-spinal cord barrier disruption in patients with degenerative cervical myelopathy

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³RWTH University Aachen, Institute of Anatomy and Cell Biology, Aachen, Germany

Question: Disruption of the blood spinal cord barrier (BSCB) is associated with several acute and neurodegenerative diseases causing secondary injuries to the spinal cord. Aim of this study is to prove the presence of BSCB disruption in patients with degenerative cervical myelopathy (DCM) and give a possible explanation for the onset of secondary injuries.

Methods: Twenty-one patients (mean age 63.3 ± 11.6 years) with DCM were prospectively included. All patients had an indication for neurosurgical decompression. As controls 33 patients (mean age 62.3 ± 15.2 years) with abdominal aortic aneurysm (AAA) and indication for surgery were included. These Patients (AAA) routinely received CSF drainage prior surgery for intraoperative intrathecal pressure monitoring. Samples of CSF and blood serum were taken simultaneously from each participant. All participants underwent neurological examination including mJOA and NDI. Regarding BSCB disruption and intrathecal immunoglobulin (Ig) concentrations the samples were examined for Albumin (mg/dl), IgG (mg/dl), IgA (mg/dl) and IgM (mg/dl). Quotients (CSF/serum) were standardized calculated according to the Reiber diagnostic: QIgG (n x 10-3), QIgA (n x 10-3), QIgM (n x 10-3) and QAlb (n x 10-3) 21. The individual age related references ranges of QAlb for patients and controls were calculated: QAlb = (4 + age/15) × 10–3.

Results: Patients and controls distinguished significantly in their clinical status (mJOA: DCM 10.1±3.1, AAA 17.6±1.2, p=12) and patients with severe clinical status (n=14, mJOA Conclusions: Patients with DCM seem to have an increased permeability and disruption of the BSCB. The severity of BSCB disruption (QAlb) and the diffusion of Ig are related to the clinical status of the patients. Similar to the acute SCI, BSCB disruption could be the initiation for secondary harm of the spinal cord in DCM. Having documented this particular pathomechanism in patients with DCM for the first time, we suggest that this diagnostic tool could be an important addition to surgical decision making in the future.

O32 withdrawn
The neurological deficits patterns of cervical radiculopathies which were misdiagnosed as peripheral nerve entrapment diseases
Tomohiko Hasegawa¹, Yu Yamato¹, Daisuke Togawa¹, Go Yoshida¹, Tomohiro Banno¹
Hideyuki Arima¹, Shin Oe¹, Takao Omura¹, Yukihiro Matsuyama¹
¹Hamamatsu university school of medicine, Orthopaedics, Hamamatsu, Japan

Question: Cervical roots supply fibers to form brachial plexus and branches to individual peripheral nerves. Thus sometimes we encounter difficulties to distinguish cervical radiculopathy from peripheral nerve neuropathy. The purpose of this study was to retrospectively review cases of cervical radiculopathy that were referred to our hospital that were diagnosed as peripheral neuropathy at the previous hospital.

Methods: Retrospective case series. 878 cases who were referred to our department suspected for peripheral neuropathy from 1999 to 2016. All the patients were examined for their neurological symptoms, physical test radiographic examination or MRI and underwent electrophysiological study. The patients with normal conduction velocity (NCV) and abnormal cervical MRI findings correspond to the muscle weakness area were diagnosed as cervical radiculopathy. Finally 39 cases were included in this study. We investigated the diagnosis at previous doctor, clinical symptoms and distribution of the paralyzed muscles in these patients.

Results: Average age was 58 years old. All cases had no neck pain. Distribution of harmed nerve roots were as below, C5: 2 (5%), C5 and 6: 3 (8%), C6: 5 (13%), C7: 3 (8%), C7 and 8: 3 (8%), C8: 24 (62%), T1: 1 (1%). C8 radiculopathies were most frequently misdiagnosed. The diagnoses at previous doctor were shown. Four axillary nerve paralysis in the C5 or C5, 6 combined radiculopathy, one carpal tunnel syndrome in the C6 radiculopathy, two radial nerve paralysis in C7 radiculopathy, three posterior interosseous nerve palsy, 4 ulnar nerve palsy, 4 cubital tunnel syndromes in C8 radiculopathy. C8 palsy showed various distributions of muscle weakness area. In almost C8 radiculopathy patients, muscle weakness area were presented in two or more peripheral nerve areas.

Conclusions: The most common muscle weakness differences between peripheral neuropathy and C8 radiculopathy was present in the muscles innervated by the radius and the median nerve so a detailed evaluation of the muscle strength is required.
O34
The corticospinal reserve – reversible reorganization of motor area and excitability in degenerative cervical myelopathy
Anna Zdunczyk¹, Leona Kawelke¹, Thomas Picht¹, Peter Vajkoczy¹
¹Charité, Department of neurosurgery, Berlin, Germany

Question: We have recently shown a compensatory reorganization of the corticospinal network in patients with degenerative cervical myelopathy which led to the concept of the “corticospinal reserve capacity”. In patients suffering from mild symptoms (JOA>12) and thus preserved reserve an increased motor area due to a higher recruitment of supplementary motor areas (M2) was observed. We now investigated how the status of the reserve impacts postoperative outcome and whether these compensatory changes are reversible.

Methods: 20 patients with a cervical degenerative myelopathy were examined preoperatively and in a 9 months follow up with navigated transcranial magnetic stimulation (nTMS). Based on the initial JOA score two patient groups were established (JOA<12/>12). We determined the resting motor threshold (RMT), recruitment curve (RC), cortical silent period (CSP) and motor area for the FDI muscle.

Results: The RMT showed no difference in the follow up measurement for both groups (p=0.06). Operative decompression let to a reconstitution of motor area size in the severely symptomatic patient group (p=0.03). In patients with preoperatively mild symptoms (JOA>12) and preserved corticospinal reserve no significant change in motor area size was detected. However the compensated increased recruitment of supplementary motor areas and disinhibition diminished after 9 months (M2 area pre/postop p=0.02; CSP pre/postop p=0.03). Patients who clinically didn’t benefit from surgery also didn’t present a reconstitution of corticospinal excitability.

Conclusions: Based on these results, we could detect reversible adaptive mechanisms on the cortical and spinal level, i.e. corticospinal reserve capacity. Changes in these nTMS parameters might therefore serve as a valuable pre-and postoperative tool in these patients.

O35
The three sagittal morphotypes that define the normative cervical spine
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²Columbia University, New York, NY, United States

Question: The alignment of the c-spine allows for forward gaze and the aim of this study was to describe cervical alignment and how it varies amongst asymptomatic volunteers

Methods: We examined cervical/standing radiographs from adult volunteers. We examined volunteers with a previously published normal limit of chin-brow vertical angle (CBVA). A 2-step cluster analysis was used to find natural groups among volunteers. We performed a post hoc ANOVA analysis for a deeper analysis of the differences between groups.

Results: Overall, 84/119 of volunteers met inclusion criteria of CBVA (age: 49.0±17.1 y/d, 73.8% Female, BMI 27.7kg/m2±6.1). We found 3 alignment groups based on cervical curvature and T1S (sillhouette measure >0.6). Group 1 was “kyphotic cervical” [KC] spine (N = 27, C2-C7: -8.6°±7.3, T1S: 17.4°±6.6), group 2 was “Medium Curve” [MC] (N = 43, C2-C7: 8.7°±7.3,
T1S: 26.6°±4.0°), group 3 was “Large Curve” [LC] (N = 14, C2-C7: 21.2°±7.2, T1S: 39.5°±6.4°) (all p<0.001). There was a difference in C0-C2 alignment (17.9° for KC, 12.9° for MC, 10.9° for LC, p = 0.019). These cohorts demonstrated a double compensation: change in C2-C7 to compensate for T1S increase to maintain cSVA (cSVA: 31mm vs 25mm vs 26mm p = 0.174) and reciprocal change in C0-C2 to maintain a horizontal gaze (CBVA: 5.7° vs 2.7° vs 4.6° p = 0.066). Examination of vertebra orientation demonstrated that C4 had a constant orientation vs horizontal (C4S: 23.8 vs 21.5 vs 22.5 p = 0.665). Correlation analysis between C2-C7 and vertebra orientations demonstrated C4 orientation is independent of C2-C7.

Conclusions: These results show cervical alignment is complex with compensation of cervical curvature and C0-C2 for differences in T1S. C4 is constant in terms of orientation and may be the center of rotation of the cervical spine.

O36
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Heinrich Böhm¹
¹Zentralklinik Bad Berka, Department of Spinal Surgery, Bad Berka, Germany

Question: Spinal surgery in Parkinson’s disease (PD) is challenging with high complication rates reported. The aim of this study is to evaluate outcome and complications occurring in cervical spinal surgery in patients with PD.

Methods: Analysis of prospectively collected data of all patients with PD undergoing cervical spine surgery between 1999 and 2018; evaluation of epidemiological, clinical and outcome data as well as complications.

Results: Five female and 16 male patients with PD for 8.3±7.2 years (median Hoehn & Yahr stage: 3) were identified. The Ø age was 71.8 (range 56-83) years; predominant indication for surgery was myelopathy in 9 and radiculopathy in 6 cases. In 10 patients index surgery was performed form anterior and in 9 patients primarily from posterior. In 2 cases an anterior-posterior approach was necessary. 3.2±2.7 (range 1-12) levels were fused. Construct failure in 3 patients led to 6 revisions. Postoperative weaning failure necessitated tracheostomy in 5 cases. Dysphagia in 5 patients required a PEG in 4 cases (of which one was treated by posterior approach only). One patient suffered from esophageal injury. SSI occurred in 2 cases which resulted in multiple revisions in one patient. Overall, 8 patients (38%) needed reoperation after index surgery. Pneumonia complicated the outcome in 4 cases. Mean hospital stay was prolonged in comparison to other patient population with 34±22 (range 3-71) days. At the time of last FU (mean 22.5±28.4, range 1-113 month) 7 patients showed improved neurology while in 1 case deterioration was detected.

Conclusions: Beside increased risk for construct failure after cervical spine surgery in patients with PD the surgeon should be aware and the patient informed of possible deterioration of disease related dysphagia, even after posterior-only approach, and prolonged hospital stay due to weaning failure, pneumonia and SSI with overall increased rate of revision surgeries. In contrast neurologic improvement can be achieved in the majority of patients.
A comparison of cervical disc arthroplasty and anterior cervical discectomy and fusion in patients with two-level cervical degenerative disc disease: 5-year follow-up results

Gao Xinlin¹

¹West China school of medicine, Orthopedics Department, Chengdu, China

**Question:** Present the long-term clinical and radiographic comparison between the Prestige-LP cervical disc replacement and the Zero-p spacer cervical disc fusion in treatment of patients with symptomatic two-level cervical degenerative disease.

**Methods:** 36 patients in the ACDF group and 24 patients in the CDA group were analyzed before surgery and at 1 week, 3, 6, 12, 24 and 60 months after surgery. Clinical assessments included JOA, VAS, and NDI scores. Radiographic assessments included CL, ROM of the total cervical spine, FSU, superior and inferior adjacent segments. Complications including HO and ASD at 5-year follow-up were collected as well.

**Results:** Mean follow-up period was 65.6 months. Both ACDF and CDA groups showed significant clinical improvements in terms of JOA, VAS and NDI (P<.05), but there was no significant difference between groups at the last follow-up period. A significant increase of cervical lordosis (CL) was observed in the CDA group after surgery while significant difference was not observed between groups. ROM of the total cervical spine and FSU were maintained during the follow-up and significant decrease was observed in ACDF group after surgery (P<.05). The ROM of the superior adjacent segment did not show any difference while the ROM of the inferior adjacent segment in the ACDF group was observed a significant increase at 6 months and 1 year after surgery and a significant decrease at the last follow-up period. A total of 8 (33.3%) patients in the CDA group were observed an occurrence of HO. ASD was observed in 2 (8.3%) patients underwent CDA surgery and 8 (22.2%) patients underwent ACDF surgery.

**Conclusions:** Both the use of the Prestige-LP and Zero-P spacer implantations are safe and effective. At 5 years after surgery, CDA with Prestige-LP is superior in terms of ROM of the total cervical spine, FSU and inferior adjacent segment. It also has a relatively low ASD occurrence rate. This procedure may be a suitable choice for the treatment of contiguous two-level CDDD.
Abstracts | Oral presentations

### Table 1. Demographic Information

<table>
<thead>
<tr>
<th>Variable</th>
<th>ACDVF Group (N = 36)</th>
<th>CDA Group (N = 24)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>Mean ± SD</td>
<td>58.6 ± 9.5</td>
<td>54.7 ± 6.8</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>22</td>
<td>15</td>
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<tr>
<td></td>
<td>Female</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Height, cm</td>
<td>Mean ± SD</td>
<td>161.9 ± 7.4</td>
<td>163.8 ± 8.5</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>Mean ± SD</td>
<td>61.1 ± 10.0</td>
<td>64.8 ± 10.5</td>
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<td>Clinical diagnosis, n</td>
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<tr>
<td>Myelopathy</td>
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<td>9</td>
<td></td>
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<tr>
<td>Level implanted, n</td>
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<tr>
<td>C1–C2</td>
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</tr>
<tr>
<td>C3–C4</td>
<td>4</td>
<td>9</td>
<td></td>
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<tr>
<td>Blood loss, mL</td>
<td>Mean ± SD</td>
<td>91.1 ± 100.2</td>
<td>77.8 ± 83.6</td>
</tr>
</tbody>
</table>

ACDF, anterior cervical disectomy and fusion; CDA, cervical disc arthroplasty; SD, standard deviation.

*For continuous variables, P-values are from analysis of variance or Mann–Whitney U test, and for categorical variables, they are from χ² analysis.

### Table 2. Clinical Outcomes

<table>
<thead>
<tr>
<th></th>
<th>ACDVF (N = 36)</th>
<th>CDA (N = 24)</th>
<th>P</th>
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<tbody>
<tr>
<td>VAS scores Preoperative</td>
<td>5.8 ± 3.5</td>
<td>4.8 ± 4.4</td>
<td>0.133</td>
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<tr>
<td>Last follow-up</td>
<td>2.4 ± 2.6</td>
<td>1.9 ± 2.6</td>
<td>0.515</td>
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<tr>
<td></td>
<td>P</td>
<td>&lt;0.001</td>
<td>0.016</td>
</tr>
<tr>
<td>JOA scores Preoperative</td>
<td>9.5 ± 3.5</td>
<td>8.1 ± 2.7</td>
<td>0.419</td>
</tr>
<tr>
<td>Last follow-up</td>
<td>16.0 ± 1.3</td>
<td>14.9 ± 2.4</td>
<td>0.728</td>
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<tr>
<td></td>
<td>P</td>
<td>&lt;0.001</td>
<td>0.006</td>
</tr>
<tr>
<td>NIH scores Preoperative</td>
<td>22.3 ± 17.5</td>
<td>20.3 ± 11.8</td>
<td>0.877</td>
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<tr>
<td>Last follow-up</td>
<td>10.1 ± 7.8</td>
<td>9.6 ± 8.3</td>
<td>0.892</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>&lt;0.001</td>
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</tr>
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</table>

ACDF, anterior cervical disectomy and fusion; CDA, cervical disc arthroplasty; VAS, visual analogue scale; JOA, Japanese Orthopaedic Association; NIH, Neck Disability Index.

*For continuous variables, P-values are from Mann–Whitney U test and for categorical variables, they are from χ² analysis.

### Table 3. Radiographic Outcomes

<table>
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<tr>
<th></th>
<th>Preoperative</th>
<th>1 Week</th>
<th>3 Months</th>
<th>6 Months</th>
<th>1 Year</th>
<th>2 Year</th>
<th>Last Follow-up</th>
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<tr>
<td>CI</td>
<td>ACDVF</td>
<td>90 ± 8.6</td>
<td>115 ± 9.5</td>
<td>112 ± 10.2</td>
<td>117 ± 10.4</td>
<td>104 ± 12.5</td>
<td>10.8 ± 9.6</td>
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<td></td>
<td>CDA</td>
<td>75 ± 10.2</td>
<td>129 ± 12.3</td>
<td>119 ± 12.4</td>
<td>113 ± 8.7</td>
<td>112 ± 10.2</td>
<td>10.7 ± 10.4</td>
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<tr>
<td></td>
<td>P (RMANOVA)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
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<tr>
<td>ROM of C1–C2</td>
<td></td>
<td></td>
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<tr>
<td>ACDVF</td>
<td>44 ± 13.8</td>
<td>31 ± 6.6</td>
<td>34 ± 7.7</td>
<td>32 ± 5.1</td>
<td>31 ± 15.9</td>
<td>31 ± 15.9</td>
<td>38 ± 11.5</td>
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<tr>
<td>CDA</td>
<td>513 ± 14.2</td>
<td>418 ± 12.5</td>
<td>448 ± 13.5</td>
<td>458 ± 16.3</td>
<td>469 ± 12.3</td>
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<tr>
<td>P</td>
<td>0.110</td>
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<tr>
<td>ROM of SSU</td>
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<tr>
<td>ACDVF</td>
<td>224 ± 7.1</td>
<td>22 ± 2.8</td>
<td>41 ± 3.1</td>
<td>40 ± 2.8</td>
<td>23 ± 2.2</td>
<td>3 ± 0.7</td>
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<td>CDA</td>
<td>286 ± 16.3</td>
<td>17 ± 7.6</td>
<td>19 ± 6.3</td>
<td>20 ± 6.8</td>
<td>18 ± 6.6</td>
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<tr>
<td>P</td>
<td>0.002</td>
<td>&lt;0.001</td>
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<tr>
<td>ROM of superior adjacent segment</td>
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<tr>
<td>ACDVF</td>
<td>104 ± 8.1</td>
<td>81 ± 5.2</td>
<td>82 ± 5.6</td>
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<td>CDA</td>
<td>197 ± 9.6</td>
<td>103 ± 4.2</td>
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<tr>
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<tr>
<td>ROM of inferior</td>
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<tr>
<td>ACDVF</td>
<td>7 ± 3.5</td>
<td>7.8 ± 3.4</td>
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<tr>
<td>CDA</td>
<td>8.4 ± 3.2</td>
<td>9.8 ± 3.4</td>
<td>10.2 ± 2.9</td>
<td>10.0 ± 3.6</td>
<td>10.4 ± 9.8</td>
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<tr>
<td>P</td>
<td>0.359</td>
<td>0.270</td>
<td>0.450</td>
<td>0.657</td>
<td>0.303</td>
<td>0.016</td>
<td></td>
</tr>
</tbody>
</table>

CI, cervical lordosis; ACDVF, anterior cervical disectomy and fusion; CDA, cervical disc arthroplasty; ROM, range of motion; SSU, functional spinal unit.

*Significant different from preoperative parameter analysis by paired t-tests.

(Mann–Whitney U test.)
Figure 4

Figure 5

Figure 6
Cervical and spinal sagittal alignment deviation in the general elderly population – a Japanese cohort survey randomly sampled from a basic resident registry
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Noriko Sakai³, Hiroyuki Kato¹
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²Shinshu University Hospital, Rehabilitation Center, Matsumoto, Japan
³New Life Hospital, Orthopaedic Surgery, Obuse, Japan

Question: There are presently no clear benchmarks for such values or those for the cervical spine in the general population. Quality epidemiological studies are needed to establish standards for spinal alignment deviation. In this study of an aged Japanese population, we employed random sampling from the basic resident registry of a rural town for subject selection to determine reference values of sagittal spinal alignment including the cervical spine.

Methods: We established 8 groups based on age (50’s, 60’s, 70’s, and 80’s) and gender after random sampling from the resident registry. A total of 413 people were enrolled. Radiographic parameters of sagittal spinal alignment of the cohort were measured and analyzed. Comparisons between age groups on the basis of 50’s age group reference values were performed using multiple comparisons based on the Dunnett test.

Results: Each spinal alignment parameter stratified by age and gender was presented. Global spinal alignments became more misaligned with age for both genders. Sagittal vertical axis (SVA) forward shift was significantly more frequent in 80’s males and 70’s females, and SVA in 80’s females was a mean of 66 mm forward of that of 50’s females. Forward movement of the cervical spine was especially prominent in men. Cervical protrusion was markedly greater in 60’s males onwards. C2-7 SVA was large at all ages in males, and T1 slope increased from their 60’s. In women, lumbar lordosis and posterior pelvic inclination were noticeable from a younger age than in men. The amount of pelvic tilt misalignment in female subjects was approximately 10 years earlier than their male counterparts.

Conclusions: This first resident cohort of Japanese individuals determined average spinal alignment parameters by age and gender. Spinal balance generally shifts forward as age increases. A forward shift in the upper cervical spine occurs first in men, while lumbopelvic alignment shift occurs first in women.

The clinical relevance of the cervical disc prosthesis – combining clinical results of two RCTs
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Carmen Vleggeert-Lankamp¹
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²Radboud University Medical Center, Neurosurgery, Nijmegen, Netherlands
³The Hague Medical Center, Neurosurgery, The Hague, Netherlands
⁴Leiden University Medical Center, Medical Statistics, Leiden, Netherlands

Question: Is ACDA clinically superior to either ACDF or ACD in the entire group of patients or in a particular subgroup of patients?

Methods: Individual patient data of two prospective, double-blind, randomised clinical trials were combined. Both trials were independently conducted in University Medical Centers in
the Netherlands. Participants were randomly assigned to receive anterior cervical discectomy either followed by placing a prosthesis (ACDA), placing a cage (ACDF) or placing nothing (ACD) in the intervertebral space after the cervical disc space was cleared out. The individual patient data from 109 (X trial) and 142 (X trial) patients were combined: allocating 83 patients to AC, 83 patients to ACDF and 85 patients to ACDA. Both trials included patients with radicular signs and symptoms in one or both arms due to a single level cervical disc herniation with or without an osteophyte. Data was available on 159 patients after two-year follow-up. Neck Disability Index, SF36 and McGill pain score were evaluated during two years post-operatively. An pre-specified subgroup analysis was performed for age, disc height, BMI, smoking and gender; according to the X trial protocol.

Results: The NDI decreased comparably in all treatment arms to circa 50% of baseline value and mean NDI differences varied from 0.4 to 1.1 on a 100 point NDI scale, with confidence intervals never exceeding the 20-point Minimal Clinical Important Difference (MCID). Secondary outcome parameters were comparable too. Subgroup analysis could not demonstrate clinically relevant differences in NDI between treatments after two years.

Conclusions: Combining data of RCTs provides sufficient statistical power to conclude that a difference in clinical outcome between the three groups is absent. Neither is there evidence that a specific subset of patients based on age, BMI, smoking, gender or preoperative disc height of the involved level would benefit more from one of the treatment strategies.

Figure 1
O40
Is C1/2 fusion required for all patients with Chiari I Malformation or basilar invagination?
Jörg Klekamp
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Question: C1/2 fusion has been proposed as standard treatment for Chiari I Malformation (CMI) and basilar invagination (BI). The alignment of C1/2 facettes and the clivus canal angle (CCA) before and after surgery were analyzed as parameters for C1/2 stability and craniocervical sagittal balance.

Methods: All spinal malformations have been entered into a spinal cord register since 1991. The CCA and C1/2 facettes were analyzed in 391 patients with CMI and/or BI. Postoperative results were determined after 3 months and progression-free survival rates calculated with Kaplan-Meier statistics.

Results: In 291 patients with CMI without BI, the CCA was in the normal range (143±11°) in contrast to 12 patients with BI without CMI (122±12°) and 88 patients with CMI+BI (120±15°; p<0.0001). The C1/2 facettes were in normal alignment in 94% in CMI without BI, 58% in BI without CMI and 36% in CMI+BI (p<0.0001). Anterior subluxations of the C1 facette occurred in BI with ventral medullary compression only, posterior subluxations in all groups. In CMI without BI (n=132) and CMI+BI without ventral compression (n=29) posterior decompressions without fusion left the CCA unchanged (-0.4±3° and -0.1±5°, respectively) irrespective of facette orientation. In BI with ventral compression (n=36) decompressions with realignment and fusion increased the CCA from 113±16° by 6±7° on average. Clinical results after 3 months (improved status for 77% in CMI without BI, 86% with CMI+BI after decompression, 79% with BI after decompression plus fusion) and progression-free survival rates for 10 years (91% for CMI without BI, 77% for CMI+BI after decompression and 84% for BI after decompression plus fusion) showed no significant differences.

Conclusions: Patients with CMI without BI and BI without ventral compression do not require C1/2 fusion and can be managed by posterior decompression alone without compromising sagittal balance. Patients with BI and ventral compression should undergo posterior decompression, realignment and fusion.

O41
Does a disruption of the C2 extensor muscle insertions affect post-operative cervical alignment in cervical laminoplasty?
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Question: It has been reported that post-operative loss of cervical lordosis correlated with poor outcomes in cervical laminoplasty (CLP). The aim of this study was to evaluate a connection between a disruption of the C2 extensor muscle insertions and post-operative alignment changes of the cervical spine in CLP.

Methods: A total of 60 patients, who underwent CLP (C3-6 or C4-6) for cervical myelopathy and could be followed for minimum 1 year after surgery, were reviewed. The C2 extensor muscle insertions were dissected and reconstructed in C3-6 CLP and were completely preserved in C4-6 CLP. The patients were distributed into two groups as follows; C3-6 CLP:32 patients (group D) and C4-6 CLP:28 patients (group P). We conducted a comparative study
on the changes of sagittal alignment following each CLP between the two groups. Several radiographic parameters were measured on standing lateral radiographs before surgery and at 1-year FU. In a statistical analysis, t-test and Mann-Whitney U test were used.

**Results:** There were no significant differences between the two groups on baseline data, such as age, gender, ASA-PS grade, BMI and all of radiographic parameters. At 1-year FU, C2 tilt indicated a significant difference (p=0.028) between the two groups and the other parameters demonstrated no significant differences. In group D, C2 tilt increased from 11.9±7.2 to 15.3±8.6, C2-7 Cobb”s angle decreased from 15.4±9.8 to 11.3±10.6 and C2-7 SVA increased from 27.8±14.5 to 31.9±15.3 with statistical differences (p=0.005, 0.001, and 0.007, respectively) after surgery. Meanwhile, the group P showed no significant changes on the cervical alignment following surgery.

**Conclusions:** We found that the disruption of C2 extensor muscle insertions might cause a slight increase of the C2 anteversion and consequently lead to loss of cervical lordosis after CLP. We suggest that the most cephalad laminoplasty level should be the C4 rather than the C3 to preserve the C2 extensor muscle insertions in CLP.

**O42**
The impact of cervical sagittal imbalance on laminoplasty indicated to patients with cervical myelopathy

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**Question:** Recently, some authors have used a regional definition of “cervical SVA (C2-7 SVA)”. However, it is unclear whether the sagittal cervical imbalance that is designated by C2-7 SVA impacts both the clinical status and the surgical outcomes of cervical degenerative diseases including cervical myelopathy. The purpose of this study was to evaluate the influence of C2-7 SVA on laminoplasty for cervical myelopathy.

**Methods:** Patients with cervical myelopathy (n = 110; 39 women, 71 men; mean age, 66.8 years; the follow-up, 2 years) who underwent laminoplasty were included in this study. The relationship between cervical sagittal parameters, including C2–7 SVA, and clinical status was evaluated. The changes in radiographic cervical alignment parameters and clinical status 2 years after surgery were compared between patients with sagittal cervical imbalance (defined as C2–7 SVA ≥35 mm; group A, n = 14) and those without (group B, n = 96). Their clinical status by using the JOA score, the JOACMEQ, the visual analog scale for neck pain and shoulder stiffness, and the SF-36.

**Results:** Preoperatively, the mean C2–7 SVA of all patients was 19.9 mm. C2–7 SVA significantly correlated with C2–7 angle, T1 slope, and thoracic kyphosis, but did not with lumbar and pelvic sagittal parameters (Table 1). C2–7 SVA did not correlate with defined health-related quality of life evaluation scores (VAS, JOACMEQ, and SF-36). Postoperatively, SF-36 PCS and VAS for neck pain got worse in group A (Table 2). Concerning cervical imbalance, the postoperative change of C2–7 SVA did not significantly differ in 2 groups. Patients with a large C2–7 SVA maintained cervical alignment after laminoplasty but experienced severe postoperative neck pain.

**Conclusions:** Our patients with cervical imbalance experienced severe postoperative neck pain (axial pain) even though cervical alignment was maintained after laminoplasty. Laminoplasty alone was not suitable for patients with sagittal cervical imbalance.
The impact of the multifidus muscle swelling on C5 palsy after cervical laminoplasty
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Masashi Neo1
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2Katsuragi Hospital, Kishiwada, Japan

**Question:** Cervical posterior decompression surgery is an established technique that yields good clinical outcomes, but the risk of C5 palsy (C5P) after surgery has not yet been resolved. Previous studies have reported that lateral stretching and postoperative swelling of multifidus muscles may cause stretching of medial branches and cervical nerves. The present study aimed to identify the effects of posterior neck muscle swelling on C5P by evaluating early postoperative MRI.

**Methods:** 218 consecutive C5 nerve roots from 109 patients who underwent laminoplasty were examined. We reviewed the demographics, surgical data, X-ray images, and MRI images of each patient, including the axial cross-sectional area (CSA) of posterior neck muscles. The 109 patients and 218 nerve roots were divided into C5P and non-C5P groups. Each parameter and its
changes were compared between the two groups, examining correlations with C5P. **Results:** In the demographics analysis, existence of OPLL, history of smoking, DM, and preoperative JOA scores were not significantly different between the C5P and non-C5P groups. Only BMI was higher in the C5P group. In terms of surgical and imaging data, numbers of laminoplasty, operating time, laminectomy trough width, accomplishment of C4/5 foraminotomy, C2–C7 Cobb angle, preoperative spinal cord rotation, and posterior shift of the spinal cord were not significantly different in the two groups. Only the multifidus CSA change ratio was significantly higher in the C5P group. Multiple logistic regression analyses revealed that the multifidus CSA change ratio and BMI were significant independent factors. **Conclusions:** Our results indicate that multifidus swelling is associated with C5P through traction of the C5 nerve via medial branches of the cervical dorsal rami. The medial branch is the shortest of the dorsal rami and may have the largest effect by traction force. Therefore, a gentle procedure for deep posterior muscles during surgery is a potential countermeasure for the prevention of C5P.

**O44**
**Biomechanical effects on intermediate segment of noncontiguous hybrid surgery with cervical disc arthroplasty and anterior cervical discectomy and fusion – a finite element analysis**

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**Question:** Cervical degenerative disc disease (CDDD) at two noncontiguous is a special type of multilevel CDDD. No study has examined biomechanical differences between anterior cervical discectomy and fusion (ACDF) and hybrid surgery (HS) constructs for noncontiguous CDDD. Differences in the biomechanical changes between the intermediate and adjacent segments are unknow.

**Methods:** A finite element model of a healthy cervical spine (C2-7) was constructed. Three surgical models were developed: (1) skip-level ACDF at C3/4 and C5/6 (FF), (2) ACDF at C3/4 and cervical disc arthroplasty (CDA) at C5/6 (FA) and (3) CDA at C3/4 and ACDF at C5/6 (AF). A 75N follower load with 1.0N·m moment was applied to the top of the C2 vertebra in the intact model to simulate flexion, extension, lateral bending and axial rotation. Surgical models achieved identical motion angles of the intact model in each direction.

**Results:** The FF model required much higher moments than did the two HS models. In the FF model, the motion contributions of the unfused segments were unevenly increased. The magnitude of the increased motion, facet contact force (FCF) and intradiscal pressure (IDP) in the intermediate segment was larger than those in the supra- or infra-adjacent segments. In the FA and AF models, the motion contributions of the untreated levels were evenly changed, and the intermediate segment did not experience additive motion, FCF or IDP. The segment adjacent to the level of ACDF had greater FCF and IDP than did the segment adjacent to the level of CDA in the two HS constructs.

**Conclusions:** ACDF at two noncontiguous levels substantially alters kinematics, FCF and IDP at the unfused levels, and the intermediate segments exhibit additive motion and forces. HS constructs resulted in less altered biomechanics and kinematics of the untreated levels and showed no additive biomechanical effects on the intermediate segments. However, the effects were associated with the relative location of the ACDF and CDA levels.
Figure 1

![Figure 1](image1)

Figure 2

![Figure 2](image2)

Figure 3

![Figure 3](image3)
Welcome note of the conference chairs

Abstracts | Oral presentations

Figure 4

Figure 5

Figure 6
The characteristic of cervical sagittal alignment in patients with chronic low back pain

Hideyuki Arima¹, Yu Yamato¹, Koichi Sato², Ryu Shiba³, Yoshihiro Uchida⁴, Toshiyuki Tsuruta⁵
Kanehisa Hashiguchi⁶, Hajime Hamamoto⁷, Eichiro Watanabe⁸, Kaoru Yamanaka⁹
Kokai Nomura¹⁰, Yukihiro Matsuyama¹

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²Sato Orthopedic Clinic, Tokyo, Japan
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¹⁰Tanumakaido Orthopedic Clinic, Fujieda, Japan

Question: Difference in postural control has been identified between people with and without chronic low back pain (CLBP). This difference may affect cervical lesion. However, cervical alignment in patients with chronic low back pain has not been previously described. The purpose of this study was to describe cervical alignment and cervical deformity in patients with CLBP.

Methods: Of the patients who visited an orthopedic clinic due to low back pain lasting more than 3 months, 127 cases [average 71 years old (49–91), 48 male and 79 female] who had whole standing spinal screening radiographs were evaluated. (CLBP group) Cervical parameters evaluated included cervical lordosis (CL), C2-C7 sagittal vertical axis (C2-7 SVA), and the T1 slope (T1S) minus the CL (T1S-CL). Cervical deformity was defined as C2-C7 SVA >4 cm, CL<0°, or T1S-CL > 15°. We compared the cervical alignment and prevalence of cervical deformity with that of 127 age and gender matched healthy volunteers (HV group) (average 71 years old (50–91), 48 male 79 female).

Results: The prevalence of cervical deformity was significantly lower in CLBP group than in HV group (26.4% vs. 74.0%, P < 0.01). The mean pelvic incidence was 47.2°vs. 49.1°in CLBP group and HV group, respectively( P = 0.130). The mean cervical lordosis was larger in CLBP group than in HV group (16.2°vs.12.0°, P = 0.004). The mean C2-7 SVA was smaller in CLBP group than in HV group (17.6 mm vs. 25.0 mm, P < 0.001). The mean T1 slope minus cervical lordosis was smaller in CLBP group than in HV group (9.1°vs.19.8°, P < 0.001). The mean EQ-5D was smaller in LBP than in HV (0.73 vs. 0.83, P < 0.001).

Conclusions: This study results suggest that patient with CLBP present better cervical sagittal alignment and lower prevalence of cervical deformity than age and gender matched healthy volunteers, which means that CLBP at least doesn”t impact on cervical lesion negatively.
O46
Anterior cervical corpectomy and reconstruction using titanium implants in the surgical treatment of cervical spondylodiscitis – long term results
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²Zentralklinik Bad Berka, Spine surgery, Bad Berka, Germany

Question: Spinal infections account for 1-7% of pyogenic osteomyelitis. With bony destruction, corpectomy is unavoidable. The use of cages in the presence of infection is still raising the concerns of many surgeons. We evaluated the treatment of cervical spondylodiscitis by means of anterior cervical corpectomy and reconstruction using titanium implants.

Methods: A retrospective analysis of data between 1994 and 2015 in our department revealed 42 patients with cervical spondylodiscitis treated by cervical corpectomy and reconstruction using titanium implants. The clinical, laboratory and radiological parameters were analysed preoperatively, postoperatively and for a minimum of two years after surgery.

Results: There were 20 females and 22 males with a mean age of 72 years. 23 patients had preoperative neurological deficit. One level corpectomy was done in 24, two levels in 15 and three levels in 3 patients. 17 patients had epidural abscess, five patients had an accompanying lumbar infection. The mean operative time was 187 minutes and the mean blood loss was 450 ml. In 20 patients a stand-alone implant was used and in 22 posterior fixations was added. Followed up was for a mean of 38 months. Mean VAS improved from 8 pre-to 3 postoperatively, and the mean NDI from 18 to 10. The mean CRP improved from a mean of 96 preoperatively to a mean of 20 two weeks after. Cervical lordosis improved from 1.3° preoperatively to 6° (p=0.02). Fusion was achieved in 38 patients. In 4 patients, asymptomatic pseudo-arthritis was documented. A single patient had persisting infection around the implant and underwent cage removal. Reoperation in 2 patients due to hematoma, and oesophageal injury

Conclusions: Anterior corpectomy and reconstruction using titanium implants is safe in the treatment of cervical spondylodiscitis with low rate of infection recurrence. Restoration of the sagittal profile and fusion can be successfully achieved. If the implant design permits and with good bone quality, additional fixation could be spared.

O47
Feasibility of the far lateral suboccipital approach to the retroodontoid region – How much bone removal is needed?
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²Semmelweis University Budapest, Laboratory for Applied and Clinical Anatomy, Dept. of Anatomy, Budapest, Hungary
³University of Tübingen, Clinical Anatomy Tübingen, Tübingen, Germany
⁴Klinikum rechts der Isar, Neurosurgery, München, Germany

Question: The posterolateral extradural suboccipital approach can be used to reach the anterior epidural space and the retroodontoid regions. The extent of necessary bone removal was not yet studied. We examined the changes of the horizontal and vertical surgical windows using successive bone removal of the atlas during this approach.

Methods: This anatomical study was done bilaterally on 5 Thiel-fixed human cadavers (mean age 83.7 years, range 74-94 yrs). Vertebral arteries were filled with colored silicon. After a
wide posterolateral suboccipital approach, the C2 nerve root was identified and sacrificed to gain access to the epidural region in all specimens. Our goal was to reach the epidural space and to dissect the dens free of soft tissues from its base to its tip. We measured the surgical window with a) intact C1 posterior arch, b) after a dome formed laminotomy of C1, c) after resection of the unilateral hemiarch of C1, and d) finally after drilling 3mm of the medial aspect of the lateral mass of C1. Steps of the bone removal are shown on Fig.1.

**Results:** Intact spines where characterized by a very narrow surgical window of 6,3± 2,1 mm x 9,7 ± 1,5 mm (horizontal x vertical window) as per the area formed by the dura to C1-lateral mass and C2-lamina to C1-arch distances. The vertical window increased to a 13,0 ± 1,2 mm in case of laminotomy and to 17,3 ± 1,1 mm in case of removal of the ipsilateral C1-posterior arch. Bone removal from the medial aspect of the C1-lateral mass increased horizontal surgical window to 10,3 ± 0,5 mm. The final size of the surgical window was 10,3 ± 0,5 mm x 17,3 ± 1,1 mm (horizontal x vertical window).

**Conclusions:** The surgical window could be increased significantly through bone removal of the atlas vertebra. If only the anterior epidural space or the base of the dens needs to be reached, the dome formed laminotomy allows for an adequate surgical window. The tip of the dens could only be reached if the ipsilateral posterior arch is resected.

**Figure 1**
O48
Risk factor of surgical site infection (SSI) in cervical spine surgery – importance of perioperative hygienic status
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Aritetsu Kanemura\(^1\), Hiroaki Hirata\(^1\), Masaaki Ito\(^1\)
\(^1\)Kobe Rosai Hospital, Orthopaedic Surgery, Kobe, Japan

Question: Surgical site infection (SSI) after cervical spine surgery can result in increased morbidity and mortality. Since patient factors as well as surgical invasion associate with the incidence of SSI, the risk factors should be investigated exhaustively. This study aimed to investigate the risk factors of surgical SSI in cervical spine surgery in both “patient” and “surgery” aspects.

Methods: A total of 388 cases (258 males and 130 females, mean 67.1 y.o.) who underwent cervical spine surgery from 2015 to 2017 was reviewed. The incidence of SSI within 6 months after surgery and the risk factor of the SSI were investigated from the aspect of “patient” and “surgery”.

Results: SSI occurred in 4 cases (3 males and a female, mean 53.8 y.o.). The incidence of SSI was higher in the “patients” with BMI of 30 or more (2/23 cases: 8.7%, control: 0.56%), requiring assistance for daily activity preoperatively (2/58: 3.4%, cont.: 0.6%), cerebral palsy (1/8: 12.5%, cont.: 0.79%), psychological disorder (1/13: 7.7%, cont.: 0.80%), serum level of albumin 3.5mg/dl or less before surgery (2/38: 5.3%, cont.: 0.57%) and 3.0mg/dl or less after surgery (3/90: 3.3%, cont.: 0.34%). In addition, SSI was observed more frequently in the “surgery” with instrumentation (3/114: 2.6%, cont.: 0.37%), 6 or more vertebral levels involved (3/99: 3.0%, cont.: 0.35%), taking more than 180 minutes (4/110: 3.6%, cont.: 0%).

Conclusions: The results of this study demonstrated that obesity (BMI $\geq$ 30), cerebral palsy and psychological disorder increased the incidence of SSI after cervical spine surgery besides nutritional status or surgical invasion. These patients had difficulty in keeping their surgical site clean by themselves, and which can that could be considered as a risk factor of SSI. Therefore, perioperative hygienic status should be tightly taken care around the surgery for cervical spine.

O49
Patterns of short-term and long-term surgical outcomes and prognostic factors for cervical ossification of the posterior longitudinal ligament between anterior cervical corpectomy and fusion and posterior laminoplasty
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Jung-Kil Lee\(^1\)
\(^1\)Chonnam National University Hospital and Medical School, Department of Neurosurgery, Gwangju, South Korea
\(^2\)Yonsei University College of Medicine, Neurosurgery, Seoul, South Korea

Question: During short-term follow-up period, surgical outcomes for cervical ossification of the posterior longitudinal ligament (OPLL) between anterior cervical corpectomy and fusion (ACCF) and laminoplasty (LP) were similar. However, there were several reports that long-term surgical outcomes were superior in the ACCF compared with LP. Therefore the objective of this study is to compare short-term and long-term surgical outcome patterns between ACCF and LP.
LP in patients diagnosed with cervical OPLL and identify factors affecting surgical outcomes.

**Methods:** This study enrolled 70 patients who underwent ACCF and 63 patients who underwent LP between 2005 and 2012. Patterns of surgical outcomes were analyzed in accordance with surgical procedures. Furthermore, these patients were divided into two subgroups on the basis of follow-up duration: the short-term group (less than 48 months) and the long-term group (more than 48 months) group. Occupying ratio, type of OPLL, shape of ossified lesion, cervical sagittal alignment, grade of signal intensity on MRI, and Japanese orthopedic association (JOA) score were examined.

**Results:** Surgical outcomes of ACCF went into reverse at 48 months follow-up period. In short-term group, JOA recovery rate had no difference between ACCF and LP. In long-term group, the ACCF recovery rate (78.5±31.0) was significantly higher than the LP recovery rate (48.4±54.9) (P=0.008). In short-term group, old age (p=0.011), hill shape (p=0.013), and high grade of MRI signal intensity (p=0.040) had negative effects on recovery rate. On the other hand, in long-term group, LP (p=0.021) and a high grade of MR signal intensity (p=0.017) independently and negatively affected recovery rate.

**Conclusions:** Long-term surgical outcomes of ACCF became better than those of LP at more than 48 months follow-up period. Furthermore, high grade MRI signal changes and the LP surgical procedure were independent negative factors for long-term surgical outcomes.

**Figure 1**
### Figure 2

**TABLE 1. Demographics and preoperative variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>ACCF</th>
<th>LP</th>
<th>P</th>
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<tbody>
<tr>
<td>No of Patients</td>
<td>70</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>M : F</td>
<td>50 : 20</td>
<td>48 : 15</td>
<td>0.533</td>
</tr>
<tr>
<td>Age at Surgery (Mean±SD, year)</td>
<td>57.2±9.7</td>
<td>55.3±9.1</td>
<td>0.247</td>
</tr>
<tr>
<td>Follow-up duration (Mean±SD, month)</td>
<td>47.9±16.9</td>
<td>40.4±12.3</td>
<td>0.084*</td>
</tr>
<tr>
<td>Score available for spinal cord (Mean±SD, mm)</td>
<td>6.2±4.7</td>
<td>6.0±4.0</td>
<td>0.392</td>
</tr>
<tr>
<td>Occupying ratio of OPLL (Mean±SD, %)</td>
<td>56.4±10.3</td>
<td>54.8±14.6</td>
<td>0.474</td>
</tr>
<tr>
<td>Preop JOA score (Mean±SD)</td>
<td>11.9±2.6</td>
<td>12.3±2.3</td>
<td>0.384</td>
</tr>
<tr>
<td>JOA Recovery rate (Mean±SD, %)</td>
<td>73.1±32.3</td>
<td>57.5±49.4</td>
<td>0.011*</td>
</tr>
<tr>
<td>Type of OPLL, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>21 (15.7)</td>
<td>21 (15.7)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mixed</td>
<td>10 (7.9)</td>
<td>25 (17.7)</td>
<td></td>
</tr>
<tr>
<td>Segmental</td>
<td>9 (6.9)</td>
<td>16 (11.4)</td>
<td></td>
</tr>
<tr>
<td>Lateralist</td>
<td>31 (22.8)</td>
<td>31 (22.8)</td>
<td></td>
</tr>
<tr>
<td>Shape of ossified fusion, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hill</td>
<td>40 (37.3)</td>
<td>31 (49.2)</td>
<td>0.360</td>
</tr>
<tr>
<td>Platy</td>
<td>20 (18.2)</td>
<td>33 (50.8)</td>
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</tr>
<tr>
<td>Sagittal alignment, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lordotic</td>
<td>17 (24.3)</td>
<td>33 (21.4)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Straight</td>
<td>10 (14.8)</td>
<td>12 (17.2)</td>
<td></td>
</tr>
<tr>
<td>Kyphotic</td>
<td>17 (24.3)</td>
<td>17 (24.3)</td>
<td></td>
</tr>
<tr>
<td>Grade of IS1 on MRI, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>15 (21.4)</td>
<td>14 (22.2)</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>44 (62.9)</td>
<td>24 (31.1)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>11 (15.7)</td>
<td>25 (35.7)</td>
<td></td>
</tr>
</tbody>
</table>

ACCF, anterior cervical competency and fusion; LP, laminectomy; JOA, Japanese Orthopaedic Association; OPLL, ossification of the posterior longitudinal ligament; IS1, increased signal intensity; MRI, magnetic resonance imaging.

*P < 0.05

### Figure 3

**TABLE 2. Relationship between recovery rate and preoperative variables according to surgical approaches**

<table>
<thead>
<tr>
<th>Variable</th>
<th>ACCF</th>
<th>LP</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>30</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>20</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Follow-up duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 4Fms</td>
<td>28</td>
<td>44</td>
<td>0.410</td>
</tr>
<tr>
<td>&gt; 4Fms</td>
<td>42</td>
<td>19</td>
<td>0.008*</td>
</tr>
<tr>
<td>Occupying ratio (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 50</td>
<td>43</td>
<td>35</td>
<td>0.121</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>27</td>
<td>28</td>
<td>0.600</td>
</tr>
<tr>
<td>Shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hill</td>
<td>40</td>
<td>31</td>
<td>0.006*</td>
</tr>
<tr>
<td>Platy</td>
<td>30</td>
<td>22</td>
<td>0.519</td>
</tr>
<tr>
<td>Type of OPLL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>11</td>
<td>21</td>
<td>0.194</td>
</tr>
<tr>
<td>Mixed</td>
<td>19</td>
<td>25</td>
<td>0.083</td>
</tr>
<tr>
<td>Segmental</td>
<td>9</td>
<td>16</td>
<td>0.990</td>
</tr>
<tr>
<td>Lateralist</td>
<td>31</td>
<td>1</td>
<td>0.005*</td>
</tr>
<tr>
<td>Grade of IS1 on MRI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>15</td>
<td>14</td>
<td>0.172</td>
</tr>
<tr>
<td>1</td>
<td>44</td>
<td>24</td>
<td>0.569</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>25</td>
<td>0.777</td>
</tr>
<tr>
<td>Sagittal alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lordotic</td>
<td>17</td>
<td>33</td>
<td>0.388</td>
</tr>
<tr>
<td>Straight</td>
<td>36</td>
<td>29</td>
<td>0.061</td>
</tr>
<tr>
<td>Kyphotic</td>
<td>17</td>
<td>80</td>
<td>0.946</td>
</tr>
</tbody>
</table>

JOA, Japanese Orthopaedic Association; ACCF, anterior cervical competency and fusion; LP, laminectomy; MRI, magnetic resonance imaging.

*P < 0.05
Figure 4

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Relationship between recovery rate and preoperative variables, according to surgical approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JOA Recovery rate</strong></td>
<td><strong>Short-term group (≤ 48 months)</strong></td>
</tr>
<tr>
<td></td>
<td>ACCF</td>
</tr>
<tr>
<td>Gender</td>
<td>N</td>
</tr>
<tr>
<td>Male</td>
<td>19</td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
</tr>
<tr>
<td>Occupying ratio (%)</td>
<td>N</td>
</tr>
<tr>
<td>&lt;50</td>
<td>20</td>
</tr>
<tr>
<td>≥50</td>
<td>8</td>
</tr>
<tr>
<td>Shape</td>
<td>N</td>
</tr>
<tr>
<td>Bulge</td>
<td>16</td>
</tr>
<tr>
<td>Plateau</td>
<td>12</td>
</tr>
<tr>
<td>Type of OPLL</td>
<td>N</td>
</tr>
<tr>
<td>Continuous</td>
<td>5</td>
</tr>
<tr>
<td>Mixed</td>
<td>6</td>
</tr>
<tr>
<td>Segmental</td>
<td>2</td>
</tr>
<tr>
<td>Localized</td>
<td>15</td>
</tr>
<tr>
<td>Grade of ISL on MRI</td>
<td>N</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Sagittal alignment</td>
<td>N</td>
</tr>
<tr>
<td>Lateral</td>
<td>8</td>
</tr>
<tr>
<td>Straight</td>
<td>12</td>
</tr>
<tr>
<td>Kyphotic</td>
<td>8</td>
</tr>
</tbody>
</table>

JOA, Japanese Orthopaedic Association; ACCF, anterior cervical corpectomy and fusion; LP, laminectomy; N, number; OPLL, ossification of the posterior longitudinal ligament; ISL, increased signal intensity; MRI, magnetic resonance imaging.

*P < 0.05

Figure 5

<table>
<thead>
<tr>
<th>TABLE 4</th>
<th>Multiple linear regression analysis of recovery rate according to follow-up period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JOA Recovery rate</strong></td>
<td><strong>Short-term group (≤ 48 months)</strong></td>
</tr>
<tr>
<td></td>
<td>Unstandardized coefficient (B)</td>
</tr>
<tr>
<td>Surgical Approach</td>
<td>-9.933</td>
</tr>
<tr>
<td>Sex</td>
<td>11.682</td>
</tr>
<tr>
<td>Age</td>
<td>-1.385</td>
</tr>
<tr>
<td>Type of OPLL</td>
<td>-6.736</td>
</tr>
<tr>
<td>Alignment</td>
<td>-4.962</td>
</tr>
<tr>
<td>Shape of lesion</td>
<td>-28.002</td>
</tr>
<tr>
<td>MRI grade</td>
<td>-44.761</td>
</tr>
<tr>
<td>Occupying ratio</td>
<td>-3.822</td>
</tr>
<tr>
<td>Preoperative JOA score</td>
<td>1.789</td>
</tr>
</tbody>
</table>

JOA, Japanese Orthopaedic Association; OPLL, ossification of the posterior longitudinal ligament; MRI, magnetic resonance imaging.

*P < 0.05
O50
Michael Safaee1, Katherine Corso2, Jill Ruppenkamp2, Ann Menzie2, Christopher Ames1
1UCSF, Neurological Surgery, San Francisco, CA, United States
2Johnson & Johnson, Raynham, MA, United States

Question: To what extent has the rate of posterior cervical fusion (PCF) increased over the past 16 years and what are the most significant areas of growth?

Methods: Adult patients who underwent PCF from 2000-2016 were identified in the Premier Healthcare Database (PHD) using International Classification of Disease Codes (ICD) 9 and 10. Complexity was defined by concurrent codes within the same admission as index PCF including an osteotomy (PCF+OST), thoracic fusion (PCF+T), anterior cervical fusion (PCF+ACF), or deformity diagnosis (PCF+DEF). Demographics, clinical and hospital characteristics, and healthcare utilization measures were collected. Yearly procedure volumes were projected to the US population using weights based on the American Hospital Association survey data. Rate of PCF procedures were estimated for the overall population undergoing PCF and stratified by age, gender, and surgical complexity.

Results: A total of 60,891 discharges for PCF occurred over the study period. Both the projected volume of patients and the rates of patients undergoing PCF per 100,000 population increased over time. For patients age 65 or older, the compound annual growth rate (CAGR) of PCF was 8.8% with an overall increase of 281% over the study period. Patients age 85 or older had the greatest CAGR (10%) and total growth (361%) over the study period. PCF complexity increased across the study period. The CAGR was 7.9% for PCF alone compared to 19.0% for PCF+T and 15.2% for PCF+DEF, among patients aged 65 or older.

Conclusions: Rates of posterior cervical fusion have increased dramatically over the past 16 years with significant growth among the elderly, particularly over age 85, and among patients with cervical deformity.
Increasing surgical invasiveness relative to frailty status in cervical deformity surgery – a risk benefit analysis

Peter Passias1, Avery Brown1, Cole Bortz1,2, Katherine Pierce1, Haddy Alas1, Bassel Diebo3, Renaud Lafage4, Virginie Lafage4, Christopher Ames5, Douglas Burton6, Neel Anand7, Robert Hart3, Gregory Mundis3, Brian Neuman10, Breton Line11, Christopher Shaffrey12, Eric Klineberg13, Justin Smith12, Frank Schwab4, Shay Bess11, International Spine Study Group (ISSG)11

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2NYU Langone Health, New York, NY, United States
3SUNY Downstate Medical Center, New York, NY, United States
4Hospital for Special Surgery, New York, NY, United States
5University of California San Francisco, San Francisco, CA, United States
6University of Kansas, Kansas City, KS, United States
7Cedars-Sinai Medical Center, Spine Trauma Surgery, Los Angeles, CA, United States
8Swedish Neuroscience Institute, Spine Trauma Surgery, Los Angeles, CA, United States
9Scripps Clinic Torrey Pines, San Diego, CA, United States
10Johns Hopkins University, Baltimore, MD, United States
11Denver International Spine Center, Denver, CO, United States
12University of Virginia, Charlottesville, VA, United States
13University of California Davis, Davis, CA, United States

Question: Investigate the outcomes of CD surgery by frailty status and surgical invasiveness.

Methods: Operative CD(C2-C7 Cobb>10°, CL>10°, cSVA>4cm, CBVA>25°) patients >18yr with surgical and NDI data were included. Invasiveness was calculated using an invasiveness index specific for CD Surgery. Invasiveness scores were calculated within the frail(F,0.3-0.5) and severely frail(SF,>0.5) states. Logistic regression analysis assessed the relationship between increasing invasiveness, no reoperations, and meeting MCID in any HRQL at 1Y. Decision tree analysis assessed thresholds for an invasiveness risk-benefit cutoff point, above which experiencing a reoperation or not reaching MCID were higher.

Results: 159 pts met inclusion criteria. There were 3NF, 34F, and 77SF pts. For all pts, regression analysis found a significant relationship between increasing invasiveness & revision surgery(1.02[1.00-1.03] p=0.03).Within F and SF subgroups, the results were:(1.01[0.99-1.03] p=0.37) and (1.02[1.00-1.04] p=0.045). Defining no reop or meeting MCID for any HRQL at 1Y as a favorable outcome, decision tree analysis established an invasiveness risk-benefit cutoff of 46.8. Pts below this cutoff were 1.75[0.77-3.96](p=0.18) times more likely to meet MCID & no reop. Invasiveness above this cutoff point was a negative predictor,(0.57 [0.25-1.29], p=0.18). For F pts only, risk benefit cutoff was 66.6: (above:3.08[0.73-17.8]p=0.21) vs. below:0.33[0.06-1.88]p=0.21). For SF pts, risk benefit cut-off was 46.8: (above:1.82[0.65-5.06]p=0.25 vs. below:0.55[0.20-1.54]p=0.25).

Conclusions: Increasing invasiveness is associated with increased odds of major complications and reoperations. A risk/benefit cut off for decreasing major complications/reoperations and meeting MCID was found to be 79.3 for NF patients, 111 for F patients, and 53.3 for SF patients. Above these thresholds, increasing invasiveness is associated with increasing the risk of major complications or reoperations and not meeting MCID at 3Y.
Does prophylactic foraminotomy reduce the occurrence of postoperative C5 palsy in reconstruction surgery using cervical pedicle screw?

Terumasa Ikeda¹, Hiroshi Miyamoto¹, Masao Akagi¹

¹Kindai University Hospital, Orthopaedic surgery, Osaka, Japan

**Question:** C5 nerve palsy is an annoying complication in surgery for cervical myelopathy, and the incidence was reported to occur in several percent. However, the precise mechanism is still unclear. Several papers have reported that posterior reconstruction surgery using screw-rod system such as cervical pedicle screw (CPS) causes a higher frequency (12-50%) of postoperative C5 nerve palsy compared with conventional laminoplasty. For preventing the palsy, prophylactic foraminotomy may be performed. However, it is unclear whether the prophylactic foraminotomy at C4/5 reduces the occurrence of postoperative C5 palsy.

**Methods:** Thirty-seven patients who underwent correction surgery using CPS (21 male, 16 female, a mean of 71 years old) were enrolled. For the cases accompanying with preoperative foraminal stenosis at C4/5 on CT image, prophylactic foraminotomy was performed. The patients were divides into two groups; group P (postoperative C5 palsy occurred) and group NP (no palsy). The duration until the palsy was recovered was investigated. Statistical analyze in respect to correction angle of kyphosis, correction of C2-7 angle, the presence of preoperative foraminal stenosis at C4/5 on CT, and the posterior shift of the spinal cord on MRI between two groups was performed.

**Results:** Postoperative C5 palsy occurred in seven patients (18.9%). It took a mean of 2 months for complete recovery. The frequency having the incidence was higher in those with bigger correction angle of kyphosis and the presence of preoperative foraminal stenosis at C4/5 with statistical significance.

**Conclusions:** The prophylactic foraminotomy did not reduce the incidence of postoperative C5 palsy, however, it may reduce the severity of the palsy because it took two months until full recovery. It was also indicated that the bigger kyphosis correction and the presence of preoperative foraminal stenosis are the risk factors of C5 palsy in correction surgery using CPS.
Cortical breach detection in spine surgery – Novel use of diffuse reflectance spectroscopy

Gustav Burström1, Akash Swamy2, Jarich Spliethoff3, Benno H.W. Hendricks2, Oscar Persson1
Erik Edström1, Adrian Elmi Terander1
1Karolinska Institute, Clinical Neuroscience/Neurosurgery, Stockholm, Sweden
2Delft Technical University, Delft, Netherlands
3Philips Research, Eindhoven, Netherlands

**Question:** To evaluate whether diffuse reflectance spectroscopy (DRS), at the tip of surgical instruments, is a feasible technology for cortical breach detection when placing vertebral screws.

**Methods:** Lateral mass and pedicle screws are used in cervical fixation surgery. To avoid misplaced screws that could cause neurovascular damage, a novel technology relying on DRS can be used. This technology can differentiate between different tissues in the human body. If used at the tip of surgical instruments, breach detection could warn the surgeon before placing an inaccurate screw.

**Methods:** Four cadavers were used to place pedicle screws with typical breaches (inferior, medial, lateral, and anterior). DRS measurements were collected in the wavelength range of 400-1600 nm using a spectroscopic system built into the tip of a pedicle probe. DRS data of the vertebral constituents, such as blood, fat and water, along with photon scattering coefficients were analyzed.

**Design:** Cadaveric human laboratory study

**Results:** Four typical pedicle screw breaches were performed. In each case, the technology was able to detect a statistically significant change in fat fraction between cancellous bone, cortical bone, and actualized breach. The mean fat fraction was 58.6 ± 9.5% in cancellous bone, 8.7 ± 13.0% in cortical bone, and 46.5 ± 25.1% when breached. Impending breach could be reliably detected within 3 mm from cortical border.

**Discussion:** Using DRS technology at the tip of surgical instruments, might be used for accurate spinal screw placement by warning the surgeon before breaching the cortical bone. Further studies are needed to evaluate the technology in human subjects.
Biomechanics and basic science

P1 Cervical spine morphology and ligament property variations – a finite element study of their influence on sagittal bending characteristics
Jamie Baisden (Milwaukee, WI/US), Jobin Daniels (Madras/IN)
Narayan Yoganandan (Milwaukee, WI/US), Gurunarhan Kumar (Madras/IN)

P2 Is it possible to place accurate C2 screws without spinal computerized navigation?
Carlos Ribeiro, Rui Reinas, D’jamel Kitumba (Vila Nova de Gaia/PT)
Óscar L. Alves (Porto/PT)

P3 Cervical sagittal balance compensation mechanisms after lower cervical spine total disc replacement (TDR)
Rui Reinas, D’jamel Kitumba (Vila Nova de Gaia/PT), Óscar L. Alves (Porto/PT)

P4 Anatomy of the dens and its implications for fracture treatment – an anatomical and radiological study
Jan Štulík, Petr Nesnídal, Ondřej Naňka, Martin Podhráský, Gabriela Hodasová
Petr Foštík (Prague/CZ), Sohrab Virk (New York, NY/US)

P5 The impact of different artificial disc heights on the facet joint during cervical disc replacement – a finite element study
Xiaofei Wang, Hao Liu, Yang Meng (Chengdu/CN)

P6 3D printed anatomical models of severe cervical deformity – a new tool for surgical planning and intraoperative surgery guidance
Federico De Iure, Michele Cappuccio, Luca Amendola, Maurizio Ortolani
Claudio Belvedere, Alberto Leardini (Bologna/IT)

P7 Teriparatide anabolic therapy as potential treatment of type II dens non-union fractures
Francesco C. Tamburrelli, Enrico Pola (Rome/IT)

Cervical deformity and sagittal balance

P8 Postoperative reciprocal changes in global spinal alignment after occipitospinal fusion and risk factors of horizontal gaze difficulty
Shuichi Kaneyama, Masatoshi Sumi, Koichi Kasahara, Aritetsu Kanemura, Hiroaki Hirata
Masaaki Ito (Kobe/JP)

P9 Impact of cervical kyphosis on the results of selective laminectomy in patients with cervical spondylotic myelopathy
Ken Ninomiya, Ryoma Aoyama, Satoshi Nori (Ichikawa/JP), Junichi Yamane (Tokyo/JP)
Kazuya Kitamura (Yokohama/JP), Seiji Ueda (Kawasaki/JP), Hiraku Hotta
Ukei Anazawa (Ichikawa/JP), Tateru Shiraishi (Tokyo/JP)

P10 Dropped Head syndrome requiring reconstruction surgery after cervical laminoplasty: Report of three cases and review of the literature
Shigeo Ueda, Nobuhiro Sasaki, Tomoaki Fujita, Miyuki Fukuda, Masayuki Kuroda
Hiroaki Manabe, Minoru Hoshimaru (Katano/JP)

P11 The relations with cervical kyphosis change and sagittal global alignment to occur after cervical laminoplasty
Norichika Yoshie, Teruhumi Kokabu, Yuichiro Abe, Yuki Okamura, Yasushi Yanagibashi
Takahiko Hyakumachi (Eniwa/JP)
P12  Morphologic change of the spinal cord according to correction of cervical kyphosis by surgical intervention
Shingo Aoyama, Hiroshi Miyamoto, Terumasa Ikeda, Masao Akagi (Osaka/JP)

P13  Outcomes of correction surgery using cervical pedicle screw for dropped head syndrome
Hiroshi Miyamoto, Terumasa Ikeda, Masao Akagi (Osaka/JP)

P14  Changes in the quality of life of patients operated on for kyphotic deformity of the cervical spine, depending on the parameters of the local sagittal balance of the cervical spine
Vladimir Klimov, Vladislav Kelmakov, Aleksey V. Evguykov, Evgeniy Loparev
Murodzhon Kosimshoev, Evgenia Amelina (Novosibirsk/RU)

P15  Radiographic and clinical outcomes can correlate in cervical deformity correction: a discriminant analysis of HRQL outcomes and correlation with an established morphological classification
Renaud Lafage, Peter Passias, Jingyan Yang (New York, NY/US)
Eric Klineberg (Davis, CA/US), Gregory Mundis (La Jolla, CA/US)
Themistocles Protopsaltis (New York, NY/US), Christopher Shaffrey (Charlottesville, VA/US)
Shay Bess (Denver, CO/US), Han Jo Kim (New York, NY/US)
Christopher Ames (San Francisco, CA/US), Frank Schwab (New York, NY/US)
Justin Smith (Charlottesville, VA/US), Virginie Lafage (New York, NY/US)
International Spine Study Group (ISSG) (Denver, CO/US), Sohrab Virk (New York, NY/US)

P16  Intraoperative alignment goals for severe cervical deformity to achieve optimal improvements in health-related quality of life measures
Sohrab Virk, Peter Passias, Renaud Lafage (New York, NY/US), Eric Klineberg (Davis, CA/US)
Gregory Mundis (La Jolla, CA/US), Themistocles Protopsaltis (New York, NY/US)
Christopher Shaffrey (Charlottesville, VA/US), Shay Bess (Denver, CO/US)
Han Jo Kim (New York, NY/US), Christopher Ames (San Francisco, CA/US)
Frank Schwab (New York, NY/US), Justin Smith (Charlottesville, VA/US)
Virginie Lafage (New York, NY/US)

P17  Upper thoracic versus mid-thoracic lower instrumented endpoints have similar radiographic and clinical outcomes in cervical deformity patients
Han Jo Kim, Mathieu Bannwarth (New York, NY/US), Justin Smith (Charlottesville, VA/US)
Eric Klineberg (Davis, CA/US), Gregory Mundis (La Jolla, CA/US), Themistocles Protopsaltis Jonathan Elysee (New York, NY/US), Shay Bess (Denver, CO/US)
Christopher Shaffrey (Charlottesville, VA/US), Peter Passias
Frank Schwab (New York, NY/US), Christopher Ames (San Francisco, CA/US)
Virginie Lafage (New York, NY/US), International Spine Study Group (ISSG) (Denver, CO/US)

P18  Importance of the sagittal Occipitoaxial alignment in rheumatoid arthritis, clinical outcome and adjacent levels degeneration analysis – a retrospective study on 35 patients treated by Occipitocervical stabilization
Maurizio Genitiempo, Francesco C. Tamburrelli (Rome/IT)

P19  Occipital cervical fixation in pediatric patients under 10 years of age
Osvaldo Mazza, Marco Crostelli, Carlo Iorio, Massimo Mariani, Dario Mascello (Rome/IT)
P20 Comparison of perioperative complications following posterior column osteotomies versus posterior based three column osteotomy for correction of moderate to severe cervical sagittal deformity in 95 patients at single center
Darryl Lau, Cecilia Dalle Ore, Vedat Deviren, Christopher Ames (San Francisco, CA/US)

P21 Neurologic complication rates and utility of intraoperative neuromonitoring in lower cervical and upper thoracic posterior based three column osteotomies for correction of cervical deformity
Darryl Lau, Cecilia Dalle Ore, Vedat Deviren, Christopher Ames (San Francisco, CA/US)

P22 Hybrid fixations for atlantoaxial dislocation or instability
Hao Zhang (ShenZhen city/CN)

P23 Surgical treatment for dropped head syndrome with severe positive imbalance: Report of three cases
Masatake Ino, Takachika Shimizu, Tetsu Tanouchi (Maebashi/JP)

P24 The Impact of the lower instrumented level on outcomes in cervical deformity surgery
Peter Passias, Haddy Alas, Avery Brown, Katherine Pierce, Cole Bortz, Renaud Lafage Virginie Lafage, Bassel Diebo (New York, NY/US)

Complications – epidemiology, diagnosis and imaging

P25 C5 palsy develops relatively often after multilevel anterior or anteroposterior combined surgery in cervical spine

P26 Corticospinal tract function and clinical presentations among various morphologies of ossification of the posterior longitudinal ligament in the cervical spine
Kazuyoshi Nakanishi, Naosuke Kamei, Toshio Nakamae, Yuji Tsuchikawa, Taiki Morisako Takahiro Harada, Nobuo Adachi (Hiroshima/JP)

P27 Analysis of complications of pedicle screw fixation in surgery of the cervical spine
Vladimir Klimov (Novosibirsk/RU), Murodzhon Kosimshoev (Novosibirsk/RU) Aleksey V. Evsyukov (Novosibirsk/RU)

P28 Surgical outcomes for upper cervical lesions in athetoid cerebral palsy patients
Hisanori Mihara, Yasunori Tatara, Takanori Niimura, Tatsuhiro Sekiya, Yohei Ito Atsushi Goda (Yokohama/JP)

P29 Serious complications related to surgical site infection after cervical laminoplasty: a report of two case
Munehisa Koizumi, Yoshinobu Kato, Shinji Isomoto, Kazunori Tanaka Tsuyoshi Yamasaki, Takahiro Mui, Kazuya Sugimoto, Yasuhiro Tanaka (Nara/JP)

P30 Notfall reposition of atlantoaxial dislocation in trauma
Mahmoud Aboelsaad (Düsseldorf/DE)

P31 Percutaneous ultrasonographic observation of the spinal cord in cases of epidural hematoma after cervical laminoplasty
Yoshiharu Nakaya, Atsushi Nakano, Sachio Hayama, Takashi Fujishiro, Toma Yano Masashi Neo (Takatsuki/JP)
P32 Defining an algorithm for treatment of severe cervical deformity using surgeon survey and treatment patterns
Sohrab Virk, Jonathan Elysee (New York, NY/US), Munish Gupta (St. Louis, MS/US)
Eric Klineberg (Davis, CA/US), Frank Schwab, Han Jo Kim (New York, NY/US)
Douglas Burton (Kansas City, KS/US), Peter Passias
Themistocles Protopsaltis (New York, NY/US), Justin Smith (Charlottesville, VA/US)
Christopher Ames (San Francisco, CA/US), Renaud Lafage
Virginie Lafage (New York, NY/US)

P33 The X-ray of upper cervical spine is generally unclear – the computed tomography (CT) doesn’t reflect the weight of head. Therefore, the accurate diagnosis of vertical subluxation (VS) is difficult. Tomosynthes (TOMOS) can be taken in standing position. We investigated the effectiveness of TOMOS for VS.

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1. Preclinical data on file. Data may not be representative of clinical results. TR 9604787

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