

COMMENTARY TO HABILITATION THESIS¹

The process of magnetic resonance (MR) imaging is very complex and is influenced by a large number of factors. Preparation and positioning of the patient, setting up the imaging sequence and the analytical methods used are the basic steps of the whole chain of tasks that are necessary for quality imaging and subsequent interpretation of the output. The present thesis is a compilation of ten scientific articles in which the author deals with the optimization of the cervical spinal cord examination protocol and analytical methods of advanced cervical spinal cord and brain imaging.

MR imaging of the cervical spinal cord is a great challenge. Due to its small size, proximity to bone and artifacts from breathing, swallowing and cerebrospinal fluid flow, it is not an easy task. The author was an active member of an international team that optimized and analysed the examination protocol for quantitative analysis of the cervical spinal cord by different sequences (anatomical, diffusion-weighted, and magnetization transfer), including appropriate patient positioning and scheduling of the examination by the technician. The author has proposed and validated several analytical approaches for the preparation and evaluation of anatomical and diffusion-weighted images of the cervical spinal cord of healthy volunteers, patients with clinically isolated syndrome and multiple sclerosis. One method semi-automatically detects the cervical spinal cord and subsequently distinguishes grey and white matter voxels for which it creates binary masks that can be used for subsequent analyses. Another method uses voxel-based analysis to statistically compare diffusion-weighted images of the cervical spinal cord of two cohorts of subjects (typically healthy versus diseased). Both methods have been used in the analysis of longitudinal data from patients with clinically isolated syndrome in an attempt to find predictors for conversion to definite multiple sclerosis. Such a predictor was found, and its sensitivity and specificity reached high values (93% and 72%, respectively), which are higher than when using the standard McDonald criteria (80% and 53%, respectively). However, there is a need to validate this method in a larger group.

The segmentation of brain structures, whether a coarse division into grey and white matter or a finer division into individual cortical and subcortical structures, is an important and necessary step in many analyses. Also, the detection of pathologies and their segmentation (e.g., necrotic component, enhancing part after contrast agent application, or oedematous part) is crucial especially for modern machine learning methods where large amounts of information need to be processed. Therefore, in addition to the cervical spinal cord segmentation method, the author is also working on machine learning for brain tumour detection and segmentation, where he is currently a member of a grant team working on this problem. The author has contributed to an international publication that uses federated learning methods to perform multicentric learning without the need to transfer image information from health care facility. This approach simplifies the legislative framework of the matter, where it is easier to comply with GDPR and cybersecurity requirements for large multicentric studies.

For a successful study, it is necessary to have optimally acquired data and to use appropriate analytical methods that are least burdened by subjective errors. Although there are major advances in this area, the development of artificial intelligence presents us with new opportunities and challenges in all aspects of radiology, from the patient positioning, image formation, data analysis, to interpretation of results and diagnosis.

¹ The commentary must correspond to standard expectations in the field and must include a brief characteristic of the investigated matter, objectives of the work, employed methodologies, obtained results and, in case of co-authored works, a passage characterising the applicant's contribution in terms of both quality and content.

[1]² KOPŘIVOVÁ, Tereza, Miloš KEŘKOVSKÝ, Tomáš JŮZA, Václav VYBÍHAL, Tomáš ROHAN, Michal KOZUBEK a **Marek DOSTÁL**. Possibilities of Using Multi-b-value Diffusion Magnetic Resonance Imaging for Classification of Brain Lesions. *Academic Radiology* [online]. 2024, 31(1), 261–272. ISSN 1076-6332. Dostupné z: doi:10.1016/j.acra.2023.10.002

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
40 %	40 %	30 %	40 %

[2] COHEN-ADAD, Julien, Eva ALONSO-ORTIZ, Mihael ABRAMOVIC, Carina ARNEITZ, Nicole ATCHESON, Laura BARLOW, Robert L. BARRY, Markus BARTH, Marco BATTISTON, Christian BÜCHEL, Matthew BUDDÉ, Virginie CALLOT, Anna J. E. COMBES, Benjamin DE LEENER, Maxime DESCOTEAUX, Paulo Loureiro DE SOUSA, **Marek DOSTÁL**, Julien DOYON, Adam DVORAK, Falk EIPPERT, Karla R. EPPERSON, Kevin S. EPPERSON, Patrick FREUND, Jürgen FINSTERBUSCH, Alexandru FOIAS, Michela FRATINI, Issei FUKUNAGA, Claudia A. M. Gandini WHEELER-KINGSHOTT, Giancarlo GERMANI, Guillaume GILBERT, Federico GIOVE, Charley GROS, Francesco GRUSSU, Akifumi HAGIWARA, Pierre-Gilles HENRY, Tomáš HORÁK, Masaaki HORI, James JOERS, Kouhei KAMIYA, Haleh KARBASFOROUSHAN, Miloš KEŘKOVSKÝ, Ali KHATIBI, Joo-Won KIM, Nawal KINANY, Hagen KITZLER, Shannon KOLIND, Yazhuo KONG, Petr KUDLIČKA, Paul KUNTKE, Nyoman D. KURNIAWAN, Slawomir KUSMIA, René LABOUNEK, Maria Marcella LAGANÀ, Cornelia LAULE, Christine S. LAW, Christophe LENGLET, Tobias LEUTRITZ, Yaou LIU, Sara LLUFRIU, Sean MACKEY, Eloy MARTINEZ-HERAS, Loan MATTERA, Igor NESTRASIL, Kristin P. O'GRADY, Nico PAPINUTTO, Daniel PAPP, Deborah PARETO, Todd B. PARRISH, Anna PICCHIECCHIO, Ferran PRADOS, Àlex ROVIRA, Marc J. RUITENBERG, Rebecca S. SAMSON, Giovanni SAVINI, Maryam SEIF, Alan C. SEIFERT, Alex K. SMITH, Seth A. SMITH, Zachary A. SMITH, Elisabeth SOLANA, Yuichi SUZUKI, George TACKLEY, Alexandra TINNERMANN, Jan VALOŠEK, Dimitri VAN DE VILLE, Marios C. YIANNAKAS, Kenneth A. WEBER, Nikolaus WEISKOPF, Richard G. WISE, Patrik O. WYSS a Junqian XU. Generic acquisition protocol for quantitative MRI of the spinal cord. *Nature Protocols* [online]. 2021, 16(10), 4611–4632. ISSN 1750-2799. Dostupné z: doi:10.1038/s41596-021-00588-0

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
15 %	5 %	10 %	0 %

[3] COHEN-ADAD, Julien, Eva ALONSO-ORTIZ, Mihael ABRAMOVIC, Carina ARNEITZ, Nicole ATCHESON, Laura BARLOW, Robert L. BARRY, Markus BARTH, Marco BATTISTON, Christian BÜCHEL, Matthew BUDDÉ, Virginie CALLOT, Anna J. E. COMBES, Benjamin DE LEENER, Maxime DESCOTEAUX, Paulo Loureiro DE SOUSA, **Marek DOSTÁL**, Julien DOYON, Adam DVORAK, Falk EIPPERT, Karla R. EPPERSON, Kevin S. EPPERSON, Patrick FREUND, Jürgen FINSTERBUSCH, Alexandru FOIAS, Michela FRATINI, Issei FUKUNAGA, Claudia A. M. GANDINI WHEELER-KINGSHOTT, Giancarlo GERMANI, Guillaume GILBERT, Federico GIOVE, Charley GROS, Francesco GRUSSU, Akifumi HAGIWARA, Pierre-Gilles HENRY, Tomáš HORÁK, Masaaki HORI, James JOERS, Kouhei KAMIYA, Haleh KARBASFOROUSHAN, Miloš KEŘKOVSKÝ, Ali KHATIBI, Joo-Won KIM, Nawal KINANY, Hagen H. KITZLER, Shannon KOLIND, Yazhuo KONG, Petr KUDLIČKA, Paul KUNTKE, Nyoman D. KURNIAWAN, Slawomir KUSMIA, René LABOUNEK, Maria Marcella LAGANÀ, Cornelia LAULE, Christine S. LAW, Christophe LENGLET, Tobias LEUTRITZ, Yaou LIU, Sara LLUFRIU, Sean MACKEY, Eloy MARTINEZ-HERAS, Loan MATTERA, Igor NESTRASIL, Kristin P. O'GRADY, Nico PAPINUTTO, Daniel PAPP, Deborah PARETO, Todd B. PARRISH, Anna PICCHIECCHIO, Ferran PRADOS, Àlex ROVIRA, Marc J. RUITENBERG, Rebecca S. SAMSON, Giovanni SAVINI, Maryam SEIF, Alan C. SEIFERT, Alex K. SMITH, Seth A. SMITH,

² Bibliographic record of a published scientific result, which is part of the habilitation thesis.

Zachary A. SMITH, Elisabeth SOLANA, Y. SUZUKI, George TACKLEY, Alexandra TINNEMANN, Jan VALOŠEK, Dimitri VAN DE VILLE, Marios C. YIANNAKAS, Kenneth A. WEBER II, Nikolaus WEISKOPF, Richard G. WISE, Patrik O. WYSS a Junqian XU. Open-access quantitative MRI data of the spinal cord and reproducibility across participants, sites and manufacturers. *Scientific Data* [online]. 2021, 8(1), 219. ISSN 2052-4463. Dostupné z: doi:10.1038/s41597-021-00941-8

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
15 %	0 %	10 %	0 %

[4] COHEN-ADAD, Julien, Eva ALONSO-ORTIZ, Stephanie ALLEY, Maria Marcella LAGANA, Francesca BAGLIO, Signe Johanna VANNESJO, Haleh KARBASFOROUSHAN, Maryam SEIF, Alan C. SEIFERT, Junqian XU, Joo-Won KIM, René LABOUNEK, Lubomír VOJTÍŠEK, **Marek DOSTÁL**, Jan VALOŠEK, Rebecca S. SAMSON, Francesco GRUSSU, Marco BATTISTON, Claudia A. M. GANDINI WHEELER-KINGSHOTT, Marios C. YIANNAKAS, Guillaume GILBERT, Torben SCHNEIDER, Brian JOHNSON a Ferran PRADOS. Comparison of multicenter MRI protocols for visualizing the spinal cord gray matter. *Magnetic Resonance in Medicine* [online]. 2022, 88(2), 849–859. ISSN 1522-2594. Dostupné z: doi:10.1002/mrm.29249

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
20 %	0 %	15 %	0 %

[5] **DOSTÁL, Marek**, Miloš KEŘKOVSKÝ, Eva KORIŤÁKOVÁ, Eva NĚMCOVÁ, Jakub STULÍK, Monika STAŇKOVÁ a Vladan BERNARD. Analysis of diffusion tensor measurements of the human cervical spinal cord based on semiautomatic segmentation of the white and gray matter. *Journal of magnetic resonance imaging: JMRI* [online]. 2018. ISSN 1522-2586. Dostupné z: doi:10.1002/jmri.26166

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
70 %	10 %	80 %	30 %

[6] **DOSTÁL, Marek**, Miloš KEŘKOVSKÝ, Erik STAFFA, Josef BEDNAŘÍK, Andrea ŠPRLÁKOVÁ-PUKOVÁ a Marek MECHL. Voxelwise analysis of diffusion MRI of cervical spinal cord using tract-based spatial statistics. *Magnetic Resonance Imaging* [online]. 2020 [vid. 2020-07-28]. ISSN 0730-725X. Dostupné z: doi:10.1016/j.mri.2020.07.008

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
80 %	20 %	80 %	50 %

[7] PATI, Sarthak, Ujjwal BAID, Brandon EDWARDS, Micah SHELLER, Shih-Han WANG, G. Anthony REINA, Patrick FOLEY, Alexey GRUZDEV, Deepthi KARKADA, Christos DAVATZIKOS, Chiharu SAKO, Satyam GHODASARA, Michel BILELLO, Suyash MOHAN, Philipp VOLLMUTH, Gianluca BRUGNARA, Chandrakanth J. PREETHA, Felix SAHM, Klaus MAIER-HEIN, Maximilian ZENK, Martin BENDSZUS, Wolfgang WICK, Evan CALABRESE, Jeffrey RUDIE, Javier VILLANUEVA-MEYER, Soonmee CHA, Madhura INGALHALIKAR, Manali JADHAV, Umang PANDEY, Jitender SAINI, John GARRETT, Matthew LARSON, Robert JERAJ, Stuart CURRIE, Russell FROOD, Kavi FATANIA, Raymond Y. HUANG, Ken CHANG, Carmen BALAÑA, Jaume CAPELLADES, Josep PUIG, Johannes TRENKLER, Josef PICHLER, Georg NECKER, Andreas HAUNSCHMIDT, Stephan MECKEL, Gaurav SHUKLA, Spencer LIEM, Gregory S.

ALEXANDER, Joseph LOMBARDO, Joshua D. PALMER, Adam E. FLANDERS, Adam P. DICKER, Haris I. SAIR, Craig K. JONES, Archana VENKATARAMAN, Meirui JIANG, Tiffany Y. SO, Cheng CHEN, Pheng Ann HENG, Qi DOU, Michal KOZUBEK, Filip LUX, Jan MICHÁLEK, Petr MATULA, Miloš KEŘKOVSKÝ, Tereza KOPŘIVOVÁ, **Marek DOSTÁL**, Václav VYBÍHAL, Michael A. VOGELBAUM, J. Ross MITCHELL, Joaquim FARINHAS, Joseph A. MALDJIAN, Chandan Ganesh Bangalore YOGANANDA, Marco C. PINHO, Divya REDDY, James HOLCOMB, Benjamin C. WAGNER, Benjamin M. ELLINGSON, Timothy F. CLOUGHESY, Catalina RAYMOND, Talia OUGHOURLIAN, Akifumi HAGIWARA, Chencai WANG, Minh-Son TO, Sargam BHARDWAJ, Chee CHONG, Marc AGZARIAN, Alexandre Xavier FALCÃO, Samuel B. MARTINS, Bernardo C. A. TEIXEIRA, Flávia SPRENGER, David MENOTTI, Diego R. LUCIO, Pamela LAMONTAGNE, Daniel MARCUS, Benedikt WIESTLER, Florian KOFLER, Ivan EZHOV, Marie METZ, Rajan JAIN, Matthew LEE, Yvonne W. LUI, Richard MCKINLEY, Johannes SLOTBOOM, Piotr RADOJEWSKI, Raphael MEIER, Roland WIEST, Derrick MURCIA, Eric FU, Rourke HAAS, John THOMPSON, David Ryan ORMOND, Chaitra BADVE, Andrew E. SLOAN, Vachan VADMAL, Kristin WAITE, Rivka R. COLEN, Linmin PEI, Murat AK, Ashok SRINIVASAN, J. Rajiv BAPURAJ, Arvind RAO, Nicholas WANG, Ota YOSHIKI, Toshio MORITANI, Sevcan TURK, Joonsang LEE, Snehal PRABHUDESAI, Fanny MORÓN, Jacob MANDEL, Konstantinos KAMNITSAS, Ben GLOCKER, Luke V. M. DIXON, Matthew WILLIAMS, Peter ZAMPAKIS, Vasileios PANAGIOTOPOULOS, Panagiotis TSIGANOS, Sotiris ALEXIOU, Ilias HALIASSOS, Evangelia I. ZACHARAKI, Konstantinos MOUSTAKAS, Christina KALOGEROPOULOU, Dimitrios M. KARDAMAKIS, Yoon Seong CHOI, Seung-Koo LEE, Jong Hee CHANG, Sung Soo AHN, Bing LUO, Laila POISSON, Ning WEN, Pallavi TIWARI, Ruchika VERMA, Rohan BAREJA, Ipsa YADAV, Jonathan CHEN, Neeraj KUMAR, Marion SMITS, Sebastian R. VAN DER VOORT, Ahmed ALAFANDI, Fatih INCEKARA, Maarten M. J. WIJNENGA, Georgios KAPSAS, Renske GAHRMANN, Joost W. SCHOUTEN, Hendrikus J. DUBBINK, Arnaud J. P. E. VINCENT, Martin J. VAN DEN BENT, Pim J. FRENCH, Stefan KLEIN, Yading YUAN, Sonam SHARMA, Tzu-Chi TSENG, Saba ADABI, Simone P. NICLOU, Olivier KEUNEN, Ann-Christin HAU, Martin VALLIÈRES, David FORTIN, Martin LEPAGE, Bennett LANDMAN, Karthik RAMADASS, Kaiwen XU, Silky CHOTAI, Lola B. CHAMBLESS, Akshitkumar MISTRY, Reid C. THOMPSON, Yuriy GUSEV, Krithika BHUVANESHWAR, Anousheh SAYAH, Camelia BENCHEQROUN, Anas BELOUALI, Subha MADHAVAN, Thomas C. BOOTH, Alysha CHELLIAH, Marc MODAT, Haris SHUAIB, Carmen DRAGOS, Aly ABAYAZEED, Kenneth KOLODZIEJ, Michael HILL, Ahmed ABBASSY, Shady GAMAL, Mahmoud MEKHAIMAR, Mohamed QAYATI, Mauricio REYES, Ji Eun PARK, Jihye YUN, Ho Sung KIM, Abhishek MAHAJAN, Mark MUZI, Sean BENSON, Regina G. H. BEETS-TAN, Jonas TEUWEN, Alejandro HERRERA-TRUJILLO, Maria TRUJILLO, William ESCOBAR, Ana ABELLO, Jose BERNAL, Jhon GÓMEZ, Joseph CHOI, Stephen BAEK, Yusung KIM, Heba ISMAEL, Bryan ALLEN, John M. BUATTI, Aikaterini KOTROTSOU, Hongwei LI, Tobias WEISS, Michael WELLER, Andrea BINK, Bertrand POUYMAYOU, Hassan F. SHAYKH, Joel SALTZ, Prateek PRASANNA, Sampurna SHRESTHA, Kartik M. MANI, David PAYNE, Tahsin KURC, Enrique PELAEZ, Heydy FRANCO-MALDONADO, Francis LOAYZA, Sebastian QUEVEDO, Pamela GUEVARA, Esteban TORCHE, Cristobal MENDOZA, Franco VERA, Elvis RÍOS, Eduardo LÓPEZ, Sergio A. VELASTIN, Godwin OGBOLE, Mayowa SONEYE, Dotun OYEKUNLE, Olubunmi ODAFE-OYIBOTHA, Babatunde OSOBU, Mustapha SHU'AIBU, Adeleye DORCAS, Farouk DAKO, Amber L. SIMPSON, Mohammad HAMGHALAM, Jacob J. PEOPLES, Ricky HU, Anh TRAN, Danielle CUTLER, Fabio Y. MORAES, Michael A. BOSS, James GIMPEL, Deepak Kattil VEETTIL, Kendall SCHMIDT, Brian BIALECKI, Sailaja MARELLA, Cynthia PRICE, Lisa CIMINO, Charles APGAR, Prashant SHAH, Bjoern MENZE, Jill S. BARNHOLTZ-SLOAN, Jason MARTIN a Spyridon BAKAS. Federated learning enables big data for rare cancer boundary detection. Nature Communications [online]. 2022, 13, 7346. ISSN 2041-1723. Dostupné z: doi:10.1038/s41467-022-33407-5

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
15 %	0 %	7.5 %	0 %

[8] KEŘKOVSKÝ, Miloš, Jakub STULÍK, Ivana OBHLÍDALOVÁ, Petra PRAKSOVÁ, Josef BEDNARIK, **Marek DOSTAL**, Matyáš KUHN, Andrea SPRLÁKOVÁ a Marek MECHL. State-of-the-Art MRI Techniques for Multiple Sclerosis. Česká a slovenská neurologie a neurochirurgie [online]. 2017, 80/113, 647–659. Dostupné z: doi:10.14735/amcsnn2017647

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
15 %	0 %	15 %	10 %

[9] **DOSTÁL, Marek**, Miloš KEŘKOVSKÝ, Jakub STULÍK, Josef BEDNAŘÍK, Petra PRAKSOVÁ, Monika HULOVÁ, Yvonne BENEŠOVÁ, Eva KORITÁKOVÁ, Andrea ŠPRLÁKOVÁ-PUKOVÁ a Marek MECHL. MR Diffusion Properties of Cervical Spinal Cord as a Predictor of Progression to Multiple Sclerosis in Patients with Clinically Isolated Syndrome. Journal of Neuroimaging [online]. 2021, 31(1), 108–114. ISSN 1552-6569. Dostupné z: doi:https://doi.org/10.1111/jon.12808

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
30 %	20 %	50 %	30 %

[10] STULÍK, Jakub, Miloš KEŘKOVSKÝ, Matyáš KUHN, Monika SVOBODOVÁ, Yvonne BENEŠOVÁ, Josef BEDNAŘÍK, Andrea ŠPRLÁKOVÁ-PUKOVÁ, Marek MECHL a **Marek DOSTÁL**. Evaluating Magnetic Resonance Diffusion Properties Together with Brain Volumetry May Predict Progression to Multiple Sclerosis. Academic Radiology [online]. 2022 [vid. 2022-06-14]. ISSN 1076-6332. Dostupné z: doi:10.1016/j.acra.2021.12.015

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30 %	30 %	40 %	40 %