

N E W S

OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN

SERIES OF BIOLOGICAL AND MEDICAL

ISSN 2224-5308

Volume 2, Number 326 (2018), 5 – 11

S. K. Akshulakov¹, V. A. Byvalcev², K. Lumenta³, T. T. Kerymbaev¹,
V. G. Aleynikov¹, Y. A. Urumbaev¹, A. B. Sansyzbaev¹

¹JSC "National Center of Neurosurgery", Astana, Kazakhstan,

²Road Clinical Hospital at the station. Irkutsk-Passenger OJSC Russian Railways, Russia,

³University clinic in Munich, Germany.

E-mail: byval75vadim@yandex.ru, raim@rambler.ru, neurochirurgie.kb@klinikum-muenchen.de,
kerimbaev_t@mail.ru, doctor.aleynikov@gmail.com, yermeku@rambler.ru, aybol_87@mail.ru

NEW TECHNOLOGIES IN SPINAL NEUROSURGERY. ANALYSIS OF EARLY RESULTS OF THE USE OF FUNCTIONAL DISKS IN PATIENTS WITH DEGENERATIVE DISEASES OF THE CERVICAL SPINE

Abstract. *Introduction.* The technique of implantation of functional disks for surgical treatment of patients with degenerative diseases of the cervical spine was developed in the early 2000s. To date, the literature reflects the results of treatment, but in Kazakhstan this technology was not used until 2016.

Purpose of the study. Conducting an analysis of clinical outcomes and instrumental data using the technique of implantation of functional disks in patients with one-, two-level degenerative lesions of intervertebral discs of the cervical spine.

Materials and methods. The study included 10 patients who underwent replacement of the affected segment of the cervical spine with a functional disk in the conditions of spinal neurosurgery and pathology of the peripheral nervous system department of the National Center of Neurosurgery JSC, Astana. Dynamic observation and complex clinical and instrumental evaluation of the results of treatment were evaluated within 12 months after the operation.

Results and discussion. After performing the discectomy and replacing the affected level with a functional disc, all patients had a decrease in the severity of the pain syndrome according to the VAS and an improvement in the quality of life according to the Oswestry index. According to the instrumental survey methods, the mobility of the affected segment is determined, without the formation of degeneration in an adjacent level. Restoration of regional cervical lordosis was also noted. Complications were observed in one case, the incoming paresis of the recurrent nerve developed.

The conclusion. The technique of replacement of the affected segment in the cervical region with a functional disc has a high clinical efficiency, which is confirmed by a significant decrease in the severity of the pain syndrome according to the VAS, an improvement in the quality of life of patients according to the Oswestry index, and a low number of postoperative complications. Also, the described method of surgical treatment of patients with degenerative diseases of the cervical region allows to restore the sagittal profile and reduce the load on the adjacent vertebral-motor segment with a low probability of formation of degeneration of the adjacent disc.

Key words: cervical spine, degenerative diseases, functional disc, arthroplasty.

Introduction. The negative spine disease is the progressive dehydration and fibrosis of the pulpous nucleus of the intervertebral disc. These changes lead to loss of elasticity, height loss of disc, formation of bone spurs, cracking of the pulpous nucleus and protrusion of the nucleus [1]. Progression of the disease leads to instability in the anterior axis of the spine, which causes a pain syndrome. Radiculopathic pains

occur when the corresponding nerve root is compressed. Also, in this case, there may be impaired sensitivity, a decrease in tendon reflexes and paresis. With compression on the spinal cord, there is a myelopathic syndrome manifested by increased reflexes, clonus, impaired motility, gait and balance [2, 3, 5]. In cases of failure of conservative treatment methods, surgical intervention involving discectomy and segment stabilization (ACDF: anterior cervical discectomy with fusion) is resorted to. Despite the success of this treatment technique, there are some described cases when this technique significantly accelerates degeneration in adjacent segments of the vertebrae [2, 6, 7]. As a result, the patient develops symptoms requiring second surgical measures directed to adjacent segments of the vertebrae. Preservation of movements in the segment is important to prevent problems of adjacent segments [4, 6, 8, 11].

Based on these findings, Dr. Vincent Bryan in the 1990s developed his implant for arthroplasty of the cervical disc. In January 2000, Dr. Goffin from Belgium first implanted this device [5, 8, 12, 13].

There are two main reasons to search new methods of surgery of degenerative spine diseases discrediting the gold standard of nowadays treatment like ACDF. First of all, majority of surgeons think that the creation of a block of cages by means of the functional segment has adverse effects in the long run, causing problems of adjacent segments. [6, 10] and more often problems arise in the overlying segment [13, 14]. The adjacent segments are exposed to increased load due to the fact that they equal motion of blocked segment, acquiring the risk of early degeneration [2, 5]. Hilibrand says that annually for the first 10 years after surgery 2, 9% of operated patients go through problems of adjacent segments. According to Kaplan-Meier survival analysis, for 10 years 25, 6 % of 374 patients experienced the problems of adjacent segments. Fixation at C2-C3 and C7-T1 vertebrae levels showed the less risk of problems of adjacent vertebrae otherwise C5-C6, C6-C7 levels are considered to be the biggest problem. 2. Consequentially, more than 2/3 patients had to go through second surgical measures. They believe that the primary cause of that was further progression of the degenerative process, rather than increased afterload on adjacent segments. [2]. According to Robertson, 13.9% of patients among 158 operated patients had the development of new symptoms of the disease for 24 months. [10]. The second frequent cause is various complications connected with the formation of a nearthrosis at the operated level because of the migration of the implant (cage) or the lack of fixation (screws). 6% of patients had these problems. [15]. The study is based on a randomized, multicentre, controlled trial by John G. which was published in 2009. There has been a report of 242 patients implanted by "Brian" and one more group of 221 patients operated through "ACDF". According to analyses after 12 and 24 months, both groups had a significant symptom regression. The "Brian" group was more likely to have early post-hospital rehabilitation. The difference was 2 weeks. Also in this group, there were observed 1.7% against 3.2% of patients reoperated in the control group [24].

Study objective: to analyze the clinical outcomes and instrumental data of the use of functional disks of patients with one and two-stage degenerative damages of the cervical spine.

Methods.

Study design. A monocentric prospective study was performed, a retrospective chart review was carried out.

Matching criteria. Inclusion criteria: one, two-stage degenerative diseases of the intervertebral discs with compression of the vertebral canal by the means of a hernial component.

Exclusion criteria: X-ray signs of height loss more than 2/3 of healthy discs, spondyloarthrosis with the formation of osteophytic complexes, multistaged stenosis of the spinal canal, a significant decrease of bone mineral density (osteoporosis).

Realization conditions. The study was performed on the basis of the National Center for Neurosurgery (Astana, Kazakhstan). Surgical approach and decompression of nervous structures were carried out according to the accepted standard of neurosurgery using the OPMI Pentero operating microscope (Carl Zeiss, Germany) and a retractor system for minimally invasive installation of the functional disk.

Study duration. The values of clinical and radiologic parameters before the operation, at discharge and in follow-up examinations recommended at 3, 12, months after the intervention were evaluated. The duration of observation was 13±1.5 months.

Outcomes of the study.

The main outcome of the study. Effective decompression and favourable evolution of the operated segment with postoperative recovery of the sagittal profile of the c-spine by means of functional prosthesis of the cervical intervertebral disc with low trauma of the intervention.

Additional study outcomes. We studied the sex, age, height and weight of patients. Such technical characteristics of the operative intervention as the duration of operation, extent of blood loss, duration of hospitalization and activation time were investigated.

Methods of recording outcomes. The study of clinical efficacy was carried out on the basis of researching pain severity according to the following criteria:

- 1) Visual analogue scale of pain
- 2) Standards of living, related to dorsodynia according to Oswestry Disability Index and surgical implications

Radiological outcomes were measured by:

- Functional cervical spondylograms: sagittal segmental angle at the level of implantation, regional sagittal angle at the upper edges of the vertebral bodies C3-C7.
- CT scales: the degree of dislocation of the functional disk (figure 1).



Figure 1 - Postoperative computer tomography of the cervical spine in 1 year after installation of the functional disk

Ethical review. The study was approved by the Ethics Committee of the National Center of Neurosurgery in Astana; each of the patients under the study provided written informed consent.

Results.

Study subjects (participants). The study included 10 patients (1 male and 9 female, middle age 36.8 ± 9.3 years old). The average height and weight of patients was 163.6 ± 10.6 cm and 64.6 ± 14.2 kg respectively. Polyfunctional cages Bryan cervical disc prosthesis (Medtronic, USA) are mounted. 6 polyfunctional disks were installed at the level of C5-C6 of cervical vertebrae; the remaining 5 had it at the level of C6-C7. One patient out of ten had 2 polyfunctional discs, due to the two hernias in his cervical spine. The patients' complaints were the pain of cervical spine, pain in the pectoral girdle with irradiation in the upper limbs, movement disorder and impaired awareness of hands.

Key results of the study. After the operation, all patients showed a significant decrease of abatement from 7.9 ± 1.8 cm to 1.4 ± 1.3 cm at discharge and 12 months after surgery to 1.6 ± 1.2 cm. The study of the living standards of patients according to the ODI index allowed to reveal favourable evolution in the postoperative period from $39.3 \pm 6.8\%$ to $13.8 \pm 4.7\%$ at discharge and $9.8 \pm 1.2\%$ during the long-term postoperative period. According to the results of cervical radiography of spine, lordosis smoothed from 18.3 ± 5.90 to 32.2 ± 5.20 (figure 2). According to the subjective rating scale of postoperative deaths, Macnab was 1.1 points. "Nurick" score averaged 1 point in 3 and 12 months.

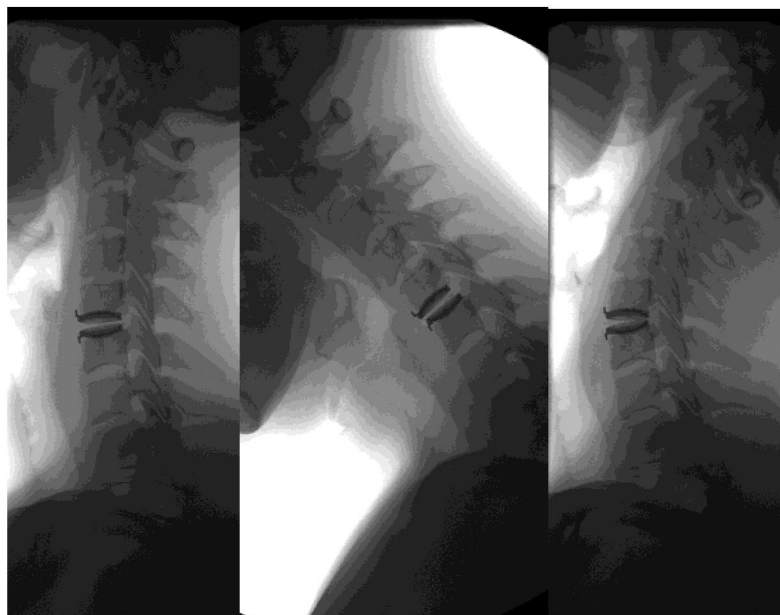


Figure 2 - X-ray radiography with functional samples after the functional disk installation of the cervical spine

Further study results. The average duration of surgery was 78.5 ± 15.5 minutes. The average volume of blood loss is 98.7 ± 25.8 ml. All patients woke up the next day after the operation. The total duration of hospital stay was 6.4 ± 1.6 days.

Adverse experience. 1 (1.0%) of postoperative complications was verified among cases, the ingoing paresis of the recurrent nerve was revealed. The delivery of therapy reversed neurological symptoms.

Study Restriction. This study is restricted by limited duration of monitoring (12 months) and its small follow-up rate (10 patients). This does not allow to assess the effect of the functional disk on the operated intervertebral disk degeneration of all patients.

Conclusion. The replacement technique of the disease segment of the cervical spine with a functional disk has a high clinical efficacy, confirmed by a significant reduction of pain severity according to the VAS (Visual analogue scale), an improve the quality of patients' life according to the Oswestry disability index and a low number of postoperative complications.

Additionally, the described method of surgical service of patients with degenerative disc disease of c-spine allows to regenerate the sagittal profile of the c-spine and to implement effective dynamic stabilization of operated motion segments with a low-risk area of developing degenerative changes in interfacing segments near to the operated segment.

Conflict of objectives. The authors of this article confirmed the absence of a conflict of objectives to be reported.

REFERENCES

- [1] Durbhakula M.M., Ghiselli G. Cervical total disc replacement, part I: rationale, biomechanics, and implant types. *OrthopClin North Am.* 2005; 36(3): 349-354.
- [2] Hilibrand A.S., Carlson G.D., Palumbo M.A., Jones P.K., Bohlman H.H. Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. *J Bone Joint Surg Am.* 1999; 81- A(4): 519-528.
- [3] Goffin J., Casey A., Kehr P., et al. Preliminary clinical experience with the Bryan cervical disc prosthesis. *Neurosurgery.* 2002; 51(3): 840-847.
- [4] Lafuente J., Casey A.Th., Petzold A., Brew S. The Bryan cervical disc prosthesis as an alternative to arthrodesis in the treatment of cervical spondylosis. 46 consecutive cases. *J Bone Joint Surg Br.* 2005; 87(4): 508-512.
- [5] Riew K.D., Buchowski J.M., Sasso R., Zdeblick T., Metcalf N.H., Anderson P.A. Cervical disc arthroplasty compared with arthrodesis for the treatment of myelopathy. *J Bone Joint Surg Am.* 2008; 90(11): 2354-2364.
- [6] Wigfield C., Gill S., Nelson R., Langdon I., Metcalf N., Robertson J. Influence of an artificial cervical joint compared with fusion on adjacent level motion in the treatment of degenerative cervical disc disease. *J Neurosurg.* 2002; 96 Suppl 1: 17-21.

- [7] Matsunaga S., Kabayama S., Yamamoto T., Yone K., Sakou T., Nakanishi K. Strain on intervertebral discs after anterior cervical decompression and fusion. *Spine*. 1999; 24(7): 670-675.
- [8] Wang M.Y., Leung C.H., Casey A.T. Cervical arthroplasty with the Bryan disc. *Neurosurgery*. 2005; 56 Suppl 1: 58-65.
- [9] Sasso R.C., Smucker J.D., Hacker R.J., Heller J.G. Artificial disc versus fusion. A prospective, randomized study with 1-year follow-up on 99 patients. *Spine*. 2007; 32(26): 2933-2940.
- [10] Robertson J.T., Papadopoulos S.M., Traynelis V.C. Assessment of adjacent segment disease in patients treated with cervical fusion or arthroplasty: a prospective 2-year study. *J Neurosurg Spine*. 2005; 3(12): 417-423.
- [11] Yang Y.C., Nie L., Cheng L., Hou Y. Clinical and radiographic reports following cervical arthroplasty: a 24-month follow-up. *IntOrthop*. 2009; 33(4): 1037-1042.
- [12] Traynelis V.C. Cervical arthroplasty. *ClinNeurosurg*. 2006; 53: 203-207.
- [13] Bryan V.E. Jr. Cervical motion segment replacement. *Eur Spine J*. 2002; 11 Suppl 2: S92-S97.
- [14] Goff in J., van Calenbergh F., van Loon J., et al. Intermediate follow-up after treatment of degenerative disc disease with the Bryan cervical disc prosthesis: single-level and bi-level. *Spine*. 2003; 28(24): 2673-2678.
- [15] Heller J.G., Sasso R.C., Papadopoulos S.M., et al. Comparison of Bryan cervical disc arthroplasty with anterior cervical decompression and fusion. Clinical and radiographic results of a randomized, controlled, clinical trial. *Spine*. 2009; 34(2): 101-107.
- [16] Fong S.Y., DuPlessis S.J., Casha S., Hurlbert R.J. Design limitations of Bryan disc arthroplasty. *Spine J*. 2006; 6(3): 233-241.
- [17] Auerbach J.D., Jones K.J., Fras C.I., Balderston J.R., Rushton S.A., Chin K.R. The prevalence of indications and contraindications to cervical total disc replacement. *Spine J*. 2008; 8(5): 711-716.
- [18] Pickett G.E., Sekhon L.H.S., Sears W.R., Duggal N. Complications with cervical arthroplasty. *J Neurosurg Spine*. 2006; 4(2): 98-105.
- [19] Sekhon L.H., Sears W., Duggal N. Cervical arthroplasty after previous surgery: results of treating.
- [20] Wenger M., van Hoonacker P., Zachee B., Lange R., Markwalder T.M. Bryan cervical disc prostheses: preservation of function over time. *J ClinNeurosci*. 2009; 16(2): 220-225.
- 24 discs in 15 patients. *J Neurosurg Spine*. 2005; 3(5): 335-341.
- [21] Anderson P.A., Rouleau J.P., Bryan V.E., Carlson C.S. Wear analysis of the Bryan cervical disc prosthesis. *Spine*. 2003; 28 Suppl 20: S186-S194.
- [22] Anderson P.A., Rouleau J.P., Toth J.M., Riew K.D. A comparison of simulator- tested and -retrieved cervical disc prostheses. Invited submission from the Joint Section Meeting on Disorders of the Spine and Peripheral Nerves, March 2004. *J Neurosurg Spine*. 2004; 1(2): 202-210.
- [23] Heidecke V., Burkert W., Brucke M., Rainov N.G. Intervertebral disc replacement for cervical degenerative disease – clinical results and functional outcome at two years in patients implanted with the Bryan cervical disc prosthesis. *ActaNeurochir*. 2008; 150(5): 453-459.
- [24] John G. Heller, MD,* Rick C. Sasso, MD,† Stephen M. Papadopoulos, MD. Comparison of BRYAN Cervical Disc Arthroplasty With Anterior Cervical Decompression and Fusion. *Spine J*. 2009. Vol. 34, N 2. P. 101-107.

**С. К. Акшулаков¹, В. А. Бывальцев², К. Люмента³, Т. Т. Керимбаев¹,
В. Г. Алейников¹, Е. А. Урунбаев¹, А. Б. Сансызбаев¹**

¹АҚ «Ұлттық нейрохирургия орталығы», Астана, Қазақстан,

²Иркутск-жолаушылар бекетіндегі жол клиникалық ауруханасы БАҚ «РТЖ», Ресей,

³Университеттік клиника, Мюнхен, Германия

**ЖҰЛЫН НЕЙРОХИРУРГИЯСЫНДАҒЫ ЗАМАНАУИ ТЕХНОЛОГИЯЛАР.
МОЙЫН ОМЫРТҚАСЫНЫҢ ДЕГЕНЕРАТИВТІ АУРУЛАРЫ КЕЗІНДЕ ҚОЛДАНЫЛАТЫН
ФУНКЦИОНАЛДЫ ДИСКТЕРДІ ПАЙДАЛАНУДЫҢ АЛҒАШҚЫ НӘТИЖЕЛЕРІН ТАЛДАУ**

Аннотация. *Kipicne.* Мойын омыртқасының дегенеративті аурулары кезінде қолданылатын функционалды диск имплантациялау операциясы 2000 жылдардың басында дүниеге келді. Қазіргі таңда ғылыми әдебиеттерде оны пайдалану тәсілі жайында жазылып жүргенімен 2016 жылға дейін бұл технология Қазақстанда қолданылмады.

Зерттеудің мақсаты. Мойын омыртқасының бір немесе екі дискісін қамтыған дегенеративті аурулар кезінде қолданылған функционалды диск имплантациялау операциясының клиникалық және инструменталды нәтижелерін талдау.

Материалдар мен әдістер. Зерттеуге АҚ «Ұлттық нейрохирургия орталығы» жұлын нейрохирургиясы және шеткі жүйке жүйесі патологиясы бөлімшесінде мойын омыртқасының зақымданған сегментіне функционалды диск имплантациялау операциясы жасалынған 10 науқас кірді. Науқастарға клиникалық және инструменталды зерттеулер операциядан кейінгі алғашқы 12 ай бойында жүргізілді.

Нәтижелер мен талқылау. Операциядан кейін науқастарда ауырсынудың азаюы (ВАШ шкаласы бойынша) және өмір сапасының жақсаруы (Овестри индексі бойынша) тіркелді. Инструменталды зерттеулер нәтижесі бойынша зақым алған сегмент өзінің қозғалғыштық қасиетін жоғалтпағанын, көршілес сегменттер дегенеративті өзгерістерге шалдықпағанын көрсетті. Онымен қоса аймақтық мойын лордозының қалыпқа келгенін байқауға болады.

Асқыну бір науқаста болып, көмейдің қайырылма нервсінің өтпелі парезі орын алды.

Қорытынды. Мойын омыртқасының дегенеративті аурулары кезінде қолданылатын зақымдалған сегментті ауыстыратын функционалды диск имплантациялау операциясы әдісі клиникалық тұрғыдан тиімділігі жоғары. ВАШ бойынша ауырсыну синдромының айтарлықтай азаюы, Овестри индексі бойынша науқастардың өмір сүру сапасының жақсаруы және операциядан кейінгі асқынулардың азаюы осыған дәлел. Сонымен қатар жоғарыда аталған мойын омыртқасының дегенеративті аурулары кезінде қолданылатын хирургиялық емдеу әдісі сагитальды профильді қалпына келтіруге және іргелес омыртқа-қозғалтқыштық сегментке күшті аз түсіру арқылы, іргелес дискілерде дегенеративтік өзгерістердің болу қаупін азайтады.

Түйін сөздер: омыртқаның мойын бөлімі, дегенеративтік аурулар, функционалды диск, артропластика.

С. К. Акшулаков¹, В. А. Бывальцев², К. Люмента³, Т. Т. Керимбаев¹,
В. Г. Алейников¹, Е. А. Урунбаев¹, А. Б. Сансызбаев¹

¹Национальный Центр Нейрохирургии, Астана, Казахстан,

²Дорожная клиническая больница на ст. Иркутск-Пассажирский ОАО «РЖД», Россия,
Университетская клиника, Мюнхен, Германия

НОВЫЕ ТЕХНОЛОГИИ В СПИНАЛЬНОЙ НЕЙРОХИРУРГИИ. АНАЛИЗ РАННИХ РЕЗУЛЬТАТОВ ИСПОЛЬЗОВАНИЯ ФУНКЦИОНАЛЬНЫХ ДИСКОВ У ПАЦИЕНТОВ С ДЕГЕНЕРАТИВНЫМИ ЗАБОЛЕВАНИЯМИ ШЕЙНОГО ОТДЕЛА ПОЗВОНОЧНИКА

Аннотация. *Обоснование.* Методика имплантации функциональных дисков для хирургического лечения пациентов с дегенеративными заболеваниями шейного отдела позвоночника разработана в начале 2000-х годов. На сегодняшний день в литературе достаточно отражены результаты лечения, однако в Казахстане до 2016 года данная технология не применялась.

Цель исследования. Проведение анализа клинических исходов и инструментальных данных использования методики имплантации функциональных дисков у пациентов с одно-, двух-уровневыми дегенеративными поражениями межпозвонковых дисков шейного отдела позвоночника.

Методы. В исследование включены 10 пациентов, которым была выполнена замена пораженного сегмента шейного отдела позвоночника, функциональным диском в условиях отделения спинальной нейрохирургии и патологии периферической нервной системы Национального Центра Нейрохирургии г. Астана. Динамическое наблюдение и комплексную клиническую и инструментальную оценку результатов лечения проводили в течение 12 месяцев после операции.

Результаты. После выполнения дискэктомии и замены пораженного уровня функциональным диском, у всех пациентов отмечено уменьшение степени выраженности болевого синдрома по ВАШ и улучшение качества жизни по индексу Овестри. По данным инструментальных методов обследования определено сохранение подвижности пораженного сегмента, без формирования дегенерации в смежном уровне. Также отмечено восстановление регионарного шейного лордоза. Осложнения наблюдались в 1 случае, развился приходящий парез возвратного нерва.

Заключение. Методика замены пораженного сегмента в шейном отделе функциональным диском обладает высокой клинической эффективностью, подтвержденной значимым снижением выраженности болевого синдрома по ВАШ, улучшением качества жизни пациентов по индексу Овестри и низким количеством послеоперационных осложнений. Также описываемый способ хирургического лечения пациентов с дегенеративными заболеваниями шейного отдела позволяет восстановить сагитальный профиль и снизить нагрузку на смежный позвоночно-двигательный сегмент с низкой степенью вероятности формирования дегенерации смежного диска.

Ключевые слова: шейный отдел позвоночника, дегенеративные заболевания, функциональный диск, артропластика.

Сведения об авторе:

Бывальцев Вадим Анатольевич – доктор медицинских наук, главный нейрохирург Департамента здравоохранения ОАО «РЖД», руководитель Центра нейрохирургии Дорожной клинической больницы на ст. Иркутск-Пассажирский ОАО «РЖД», заведующий курсом нейрохирургии Иркутского государственного медицинского университета, заведующий научно-клиническим отделом нейрохирургии и ортопедии Иркутского научного центра хирургии и травматологии, профессор кафедры травматологии, ортопедии и нейрохирургии Иркутской государственной медицинской академии последипломного образования, <http://orcid.org/0000-0003-4349-7101>, SPIN-код: 5996-6477, e-mail: byval75vadim@yandex.ru

Акшулаков Серик Куандыкович – Председатель Правления АО "Национальный центр нейрохирургии", доктор медицинских наук, профессор, член-корреспондент Национальной академии наук Республики Казахстан. Главный внештатный нейрохирург Министерства здравоохранения Республики Казахстан. Президент Казахской Ассоциации нейрохирургов, член Исполнительного комитета Азиатского Конгресса Неврологических Хирургов, член нейротравматологического комитета Всемирной Федерации Нейрохирургических Обществ, SPIN-код: отсутствует, e-mail: raim@rambler.ru

Кристиано Люмента – профессор, заведующий отделением нейрохирургии Bogenhausen Academic (Германия). Prof. Dr. med. Christiano B. Lumenta, Chefarzt Klinik für Neurochirurgie,

Klinikum Bogenhausen Akademisches Lehrkrankenhaus der Technischen Universität München Städtisches Klinikum München GmbH, neurochirurgie.kb@klinikum-muenchen.de

Керимбаев Талгат Тынышбаевич – доктор медицинских наук, заведующий отделением спинальной нейрохирургии и патологии периферической нервной системы АО «Национальный центр нейрохирургии» Астана (Казахстан). <http://orcid.org/0000-0002-0862-1747>, SPIN-код: отсутствует, e-mail: kerimbaev_t@mail.ru

Алейников Виктор Григорьевич – ординатор отделения спинальной нейрохирургии и патологии периферической нервной системы АО «Национальный центр нейрохирургии», Астана (Казахстан). e-mail: doctor.aleynikov@gmail.com

Урунбаев Ермек Ахметович – ординатор отделения спинальной нейрохирургии и патологии периферической нервной системы АО «Национальный центр нейрохирургии», Астана (Казахстан). e-mail: yermeku@rambler.ru

Сансызбаев Айбол Батырханович – ординатор отделения спинальной нейрохирургии и патологии периферической нервной системы АО «Национальный центр нейрохирургии» Астана (Казахстан). e-mail: aybol_87@mail.ru