DOI 10.18019/1028-4427-2017-23-2-140-146

The choice of stabilization technique for cervical spine injuries

A.V. Burtsev, A.V. Gubin

Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia

Background Cervical spine injuries (CSI) are considered to be a major trauma with no well-established criteria for the choice of treatment technique. **Objective** Determine criteria for the choice of surgical technique to address CSI and review current tendencies in stabilization approaches used for CSI. **Design** Retrospective review and literature survey. **Material and methods** Retrospective review included 101 CSI cases with 24 craniocervical and 77 subaxial injuries, 48 CSI publications (9 books and guidelines, and 39 articles). The patients were treated with either anterior (ACDF, ACCF) or posterior fixation using screw constructs, or with 360° stabilization. **Results** Subaxial spine injury accounts for 75 % of all CSI. C2 vertebra injury is the most severe among craniocervical trauma. Posterior C1–C2 fixation with Harms and Magerl techniques remains the method of choice. SLIC and CSISS scoring systems are mostly used to assess subaxial injury. Anterior fixation is common for unstable subaxial injury. Posterior screw fixation has become more common. **Conclusion** Injuries to the cervical spine at the C2 vertebra fractures are most challenging, and posterior fixation is the method of choice for the operative stabilization. Subaxial injuries require a thorough assessment of posterior supporting complex integrity. Anterior fixation remains the most common method of treatment. Multipillar subaxial injuries require posterior fixation and 360° stabilization in the majority of the cases.
Keywords: craniocervical, subaxial injury, classification, posterior fixation

BACKGROUND

Cervical spine injuries (CSI) are considered to be a major trauma and characterized by the diversity, high risk of severe neurological complications and mortality rate [1–4]. Trauma to the cervical spine accounts for nearly 50 % to 75 % of all spine injuries [1, 2, 5]. There are no well-established criteria regarding the choice of treatment technique. The choice of treatment tactics relies on surgeon's preferences and manual skills in majority of the cases [6].

Objective: determine criteria for the choice of surgical technique to address CSI and review current tendencies in stabilization approaches used for CSI.

Design: Retrospective review and literature survey.

MATERIAL AND METHODS

The work includes retrospective review of 101 patients with cervical spine injury who underwent surgical treatment at FSBI "RISC "RTO" Ilizarov Centre from 2010 to 2014.

The injuries were subdivided into craniocervical (n = 24) and subaxial (n = 77) depending on a trauma level (**Fig. 1**). Double-view radiography and multispiral computed tomography (MSCT) were used for diagnosis. Magnetic resonance imaging (MRI) was employed for several cases to get additional information about the injury.

Diagnostic imaging was aimed at identifying "critical" (destabilizing spinal motion segment) injuries to the bone and soft tissues (discoligamentous complex), compressed neural structures and making preoperative planning (choosing posterior stabilization, in particular).

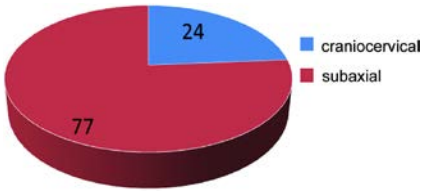

Fig. 1 Diagram showing types of cervical spine injury (CSI) (n = 101)

Total 48 CSI publications including 9 books and guidelines, and 39 articles were reviewed.

The Patients were treated with various types of anterior (ACDF, ACCF) (**Fig. 2**), posterior fixation (applying screw constructs) (**Fig. 3**) or 360° stabilization (**Fig. 4**). Various types of CS fixation

Burtsev A.V., Gubin A.V. The choice of stabilization technique for cervical spine injuries. *Genij Ortopedii*. 2017. T. 23. No 2. pp. 140-146. DOI 10.18019/1028-4427-2017-23-2-140-146

is presented in the diagram (**Fig. 5**).

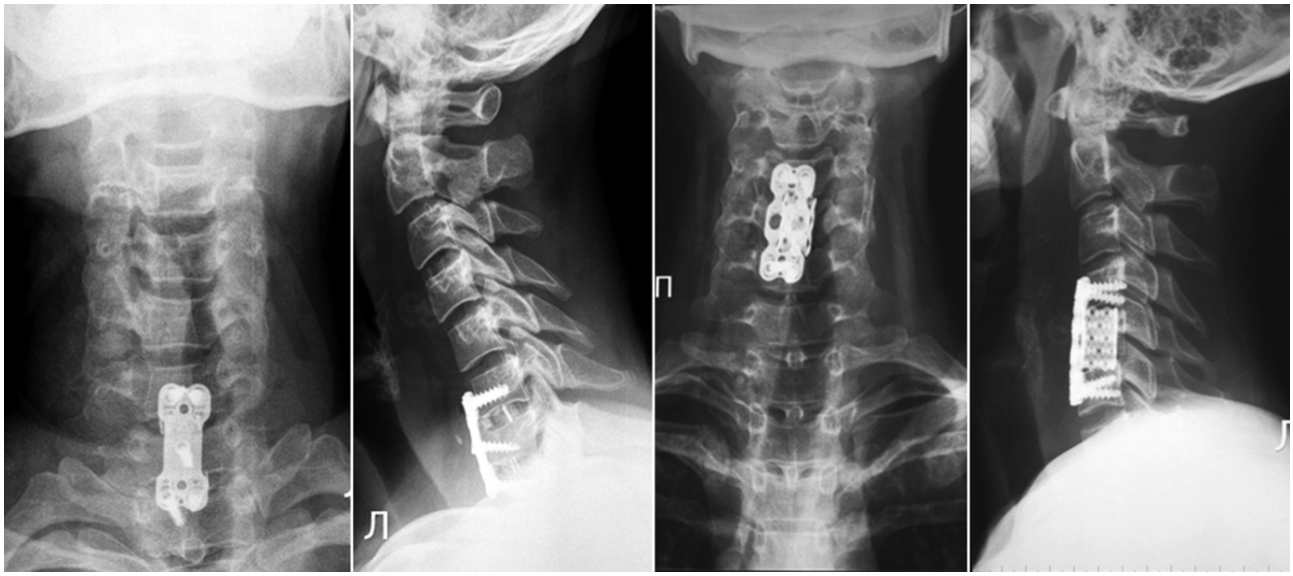

Fig. 2 Radiographs of cervical spine showing various types of anterior fixation

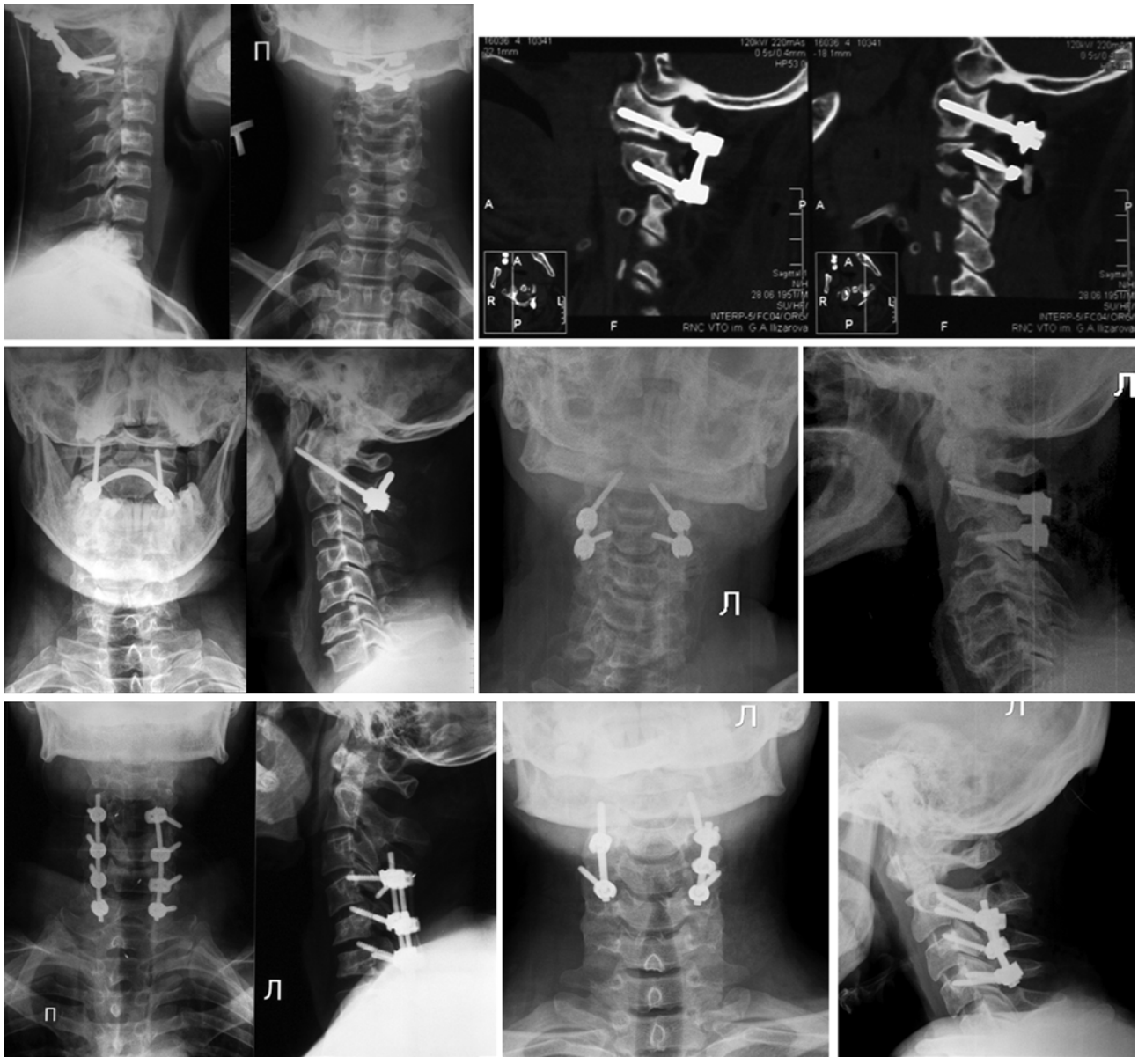

Fig. 3 Radiographs and MSCT scans of CSI showing various types of posterior fixation with screw constructs

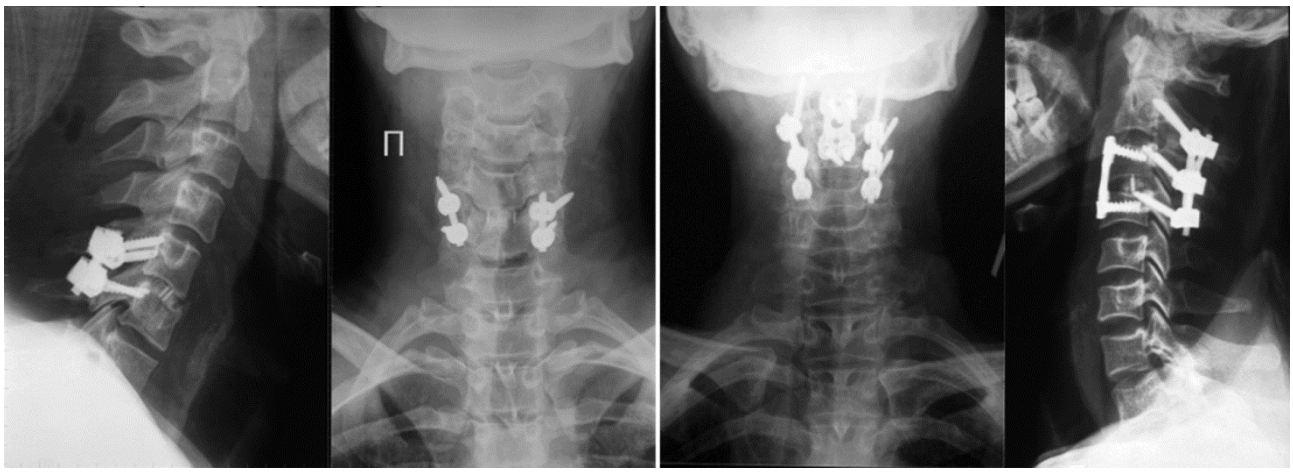

Fig. 4 Radiographs of CSI following 360° fixation (anterior and posterior)

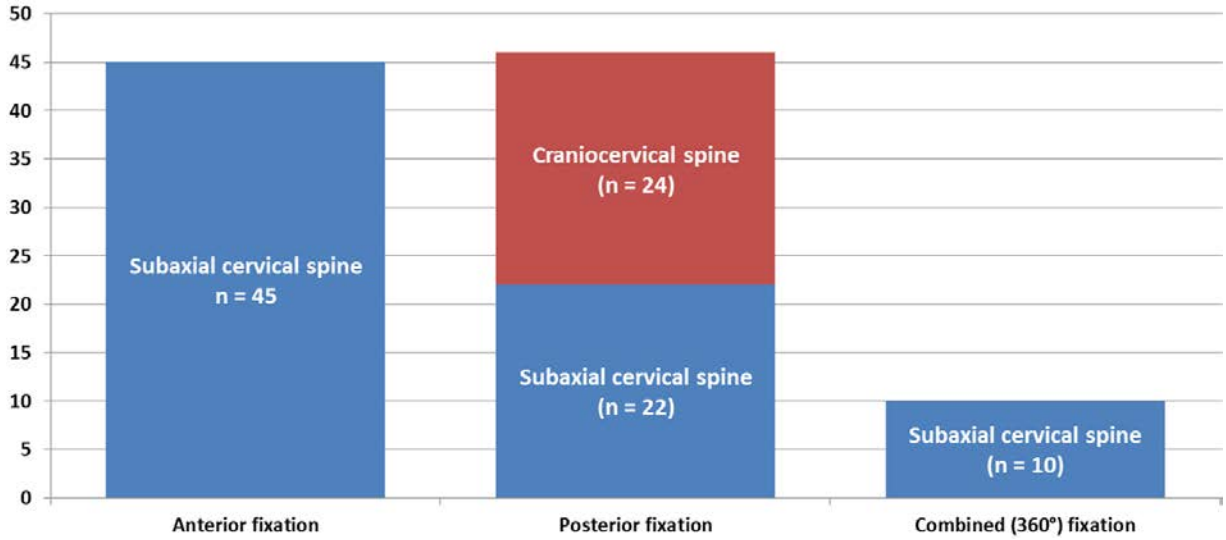

Fig. 5 Diagram showing fixation techniques used for CSI (n = 101)

RESULTS

From the analysis of the literature, most common classifications used to evaluate CSI include Anderson&Montesano system for atlanto-occipital joint (C0–CI) (type III) [1, 2, 4]; L.D. Anderson&D'Alonso system for odontoid process of C2 (type III) [1, 2], with type II injuries being subdivided into 3 subtypes depending on a fracture line, A, anterior oblique, B, posterior oblique, and C, horizontal [1, 2, 4, 7]; Levine&Edwards classification for traumatic spondylolisthesis of C2 (hangman fracture) (type III) [1, 2]. A set of morphological criteria for 'critical' craniocervical injuries includes collapsed condyle by greater than 50 % in C0 [1, 2, 4, 6], an injury to the transverse atlantal ligament in CI [2, 4, 6, 7], greater than 3 mm translation and angulation of more than 10° in type II dens fracture of CII, comminuted fracture with small fragments, shallow type III fracture [4, 6, 7, 8], a gap of more than 3 mm between the fragments and angulation of more than 8° for types II and III hangman fracture [1, 2, 4, 7, 9, 10].

A great number of morphological classification in offered for subaxial spine (C3–C7). However, SLIC [11–13] and CSISS [14] scoring systems have been considered as most common. Critical injuries to the spine include vertebral dislocation and fracture-dislocation; fracture of the lateral mass and subluxation; fracture of the vertebral body (with/without intervertebral disc rupture) combined with an injury to posterior structures (including ligaments) [1–3, 5–8, 15–17]. The summarized SLIC and CSISS scores measure 4 and 7 or over, respectively [2, 3, 7, 11–14].

Our group of patients with craniocervical injuries (n = 24) had 14 hangman fractures and miscellaneous axis fractures of C2, 8 types II and III odontoid fractures of C2, two transverse atlantal ligament rupture. Posterior fixation with polyaxial screws was performed for all the cases. Occipitospondylodesis or Harms technique was employed for transverse atlantal ligament rupture, and odontoid fractures of C2 were stabilized either with Harms or Magerl technique (**Fig. 3**).

Subaxial injuries were treated with different types of anterior (n = 45), posterior (n = 22) and combined (n = 10) fixation.

All injuries to the posterior supporting complex (ligaments and lateral mass) were stabilized with posterior fixation (**Fig. 3**). Combined 360° stabilization was used for all multicolumn injuries (**Fig. 4**). Anterior fixation was produced for isolated injuries of the anterior column with anterior compression of the nervous structures and 'non-critical' injuries of the posterior supporting complex (arch, spinous process) (**Fig. 2**).

DISCUSSION

Subaxial spine injury accounts for 75 % of all CSI. C2 vertebra injury is the most severe among craniocervical trauma [1–3, 6–8, 15, 17]. The reported incidence of atlanto-occipital dislocation does not exceed 1 % among CSI [1, 2, 4, 18]. This type of injury is fatal in 90 % of the cases [1, 2, 4]. Fractures of occipital condyles and the atlas are considered to be rare [1, 2, 4, 7]. According to international literature they constitute about 0.4 % of all injuries [4, 19, 20]. Injuries to the cervical spine at C1 vertebra make up 2 to 13 % of all CSI cases [4, 8, 21, 22]. Retrospective review of 101 patients and the reported data indicate to injuries of C2 vertebra prevailing among craniocervical trauma. Dens fractures constitute 50 to 60 % of all injuries to C2 vertebra [4, 23] with type II accounting for 37 to 83 % [4, 7, 23, 24]. Hangman fractures represent about 20 % of all injuries to C2 vertebra [4, 10]. Other types of injuries to C2 vertebra account for 19 to 32 % of all injuries to C2 vertebra [4, 7]. Several classification systems are offered for injuries to C2 vertebra depending on the location (odontoid process, vertebral pedicle). The category of miscellaneous axis fractures covers various axis injuries representing 'non-classifiable C2 trauma'. The facts indicate to fractures of C2 vertebra being most challenging among all injuries to cervical spine.

There are controversies regarding treatment of injuries to odontoid fractures types II and III in adults, in particular [23–27]. Conservative treatment may result in nonunion [23, 24], and operative management may primarily appear insufficiently worthwhile [4]. Screw fixation of odontoid process fractures using anterior approach has become more common [1, 2, 4]. However, the technique has some limitations including improper application of bad comminution, restricted reduction, obesity and short neck, barrel-shaped chest, thoracic kyphosis, injury aged over 6 months, patients aged over 50 years [1–4, 7, 28]. Consolidation is reported in 80.5 % of the cases. The reported risk of nonunion is shown to increase by 37.5 times with treatment delayed by more than one week and by 21 times if the gap between bone fragments is greater than 2 mm [1–3, 7, 8, 28]. Posterior C1–C2 fixation with Harms and Magerl techniques remains the method of choice when anterior fixation cannot be produced or conservative treatment has failed [2–5, 7, 28–30]. These techniques are practical for odontoid fractures and atlantoaxial dislocation (AAD) [29, 30, 31]. Several authors advocate anterior transoral reduction and fixation [4].

There are controversies regarding tactics of treatment used for hangman fractures [1, 2, 4, 6, 7, 15]. Types II, IIa, III injuries require operative treatment including four stabilization techniques of anterior C2–C3 fixation, posterior C2–C3 screw fixation, combined 360° fixation, direct C2 fixation with two screws [1–7, 10, 15, 32, 33]. Both anterior C2-C3 fixation and direct C2 fixation with two screws cannot provide adequate stabilization of the injured posterior structures, so external immobilization was needed to be added [2, 4, 9, 34]. Posterior C2–C3 screw fixation or 360° stabilization have shown to be most reliable methods to address types II, IIa, III fractures [9, 10, 34].

The treatment of miscellaneous axis fractures depends on the injury level. Operative stabilization is practical for vertebral body injury, and conserva-

tive treatment can be produced for isolated fractures of an arch or spinous process [4, 7].

Morphological classifications have been used for assessing subaxial cervical spine trauma. However, no MSCT and MRI findings have been incorporated into the classifications [7, 12, 13]. So they fail to provide complete description of an injury. In addition to that, interobserver and intraobserver reliability is low that creates ambiguity among in the spine community. These classifications do not incorporate a choice of a tactical algorithm that makes their application useless [7, 35]. An assessment of posterior supporting complex is very important in preoperative planning since it maintains 64 % of the loading [1, 2, 7]. SLIC and CSISS scoring systems are most common in assessing subaxial injury [2, 12, 13].

Anterior fixation is most acceptable for unstable subaxial injury [3, 6, 7, 35–37]. It can be the only technique to be used even for multicolumn injuries (dislocations, fracture-dislocations, traumatic spondylolisthesis) with a higher risk of failures [38–43]. Posterior screw fixation has become more common, in posterior supporting complex, in particular [44–47]. According to several authors, 360° stabilization is required for multicolumn injuries [12, 16, 48].

CONCLUSIONS

- C2 vertebra injury prevails among craniocervical trauma and the assessment is very difficult.
- Subaxial cervical spine injuries require a thorough assessment of the posterior supporting complex. SLIC and CSISS scoring systems are most practical to determine tactics of treatment.
- Posterior screw fixation with Harms and Magerl techniques is the method of choice for unstable craniocervical fractures.
- Various types of anterior fixation are more common for subaxial cervical spine injury.
- Posterior fixation and 360° stabilization are practical for multicolumn subaxial fractures.

REFERENCES

1. Clark C.R., Benzel E.C., Currier B.L., Dormans J.P., Dvorak J.E., Garfin S.R., Herkowitz H.N., Ullrich C.G., Vaccaro A.R., eds. Cervical Spine. 4th Ed. Lippincott, Williams & Wilkins, 2005, 1222 p.
2. Vaccaro A.R., Regan J.J., Crawford A.H., Benzel E.C., Anderson D.G., eds. Cervical Spine. 5th Ed. Lippincott, Williams & Wilkins, 2012, 1594 p.
3. Patel V.V., Burger E., Brown C.W., eds. Spine Trauma, Surgical Techniques. 1st Ed. Berlin-Heidelberg, Springer, 2010, 413 pp.
4. Suchomel P., Choutka O. Reconstruction of Upper Cervical Spine and Craniovertebral Junction. Springer, 2011, 322 pp.
5. Boos N., Aebi M. Spinal Disorders: Fun44damentals of Diagnosis and Treatment. Springer, 2008, 1166 p.
6. Frymoyer J.W., Wiesel S.W., An 42H.S., Boden S.D., Lauerman W.C., Lenke L.G., McLain R.F., eds. Adult and Pediatric Spine. 3rd Ed. Lippincott, Williams & Wilkins, 200443, 1236 p.
7. Herkowitz H.N. The Spine. 6th Edition. Elsevier Saunders. 2011, 2020 pp.
8. Vaccaro A.R., ed. Fractures of the cervical, thoracic and lumbar spine. New York, Marcel Dekker, 2003, 751 pp.
9. Liu J., Li Y., Wu Y. One stage posterior C2 and C3 pedicle screw fixation or combined anterior C2 C3 fusion for the treatment of unstable hangman's fracture. *Exp. Ther. Med.*, 2013, vol. 5, no. 3, pp. 667-672.
10. Tian W., Weng C., Liu B., Li Q., Hu L., Li Z.Y., Liu Y.J., Sun Y.Z. Posterior fixation and fusion of unstable Hangman's fracture by using intraoperative three-dimensional fluoroscopy-based navigation. *Eur. Spine J.*, 2012, vol. 21, no. 5, pp. 863-871.
11. Patel A.A., Hurlbert R.J., Bono C.M., Bessey J.T., Yang N., Vaccaro A.R. Classification and surgical decision making in acute subaxial cervical spine trauma. *Spine*, 2010, vol. 35, no. 21 Suppl., pp. S228-S234.
12. Vaccaro A.R., Hulbert R.J., Patel A.A., Fisher C., Dvorak M., Lehman R.A. Jr., Anderson P., Harrop J., Oner F.C., Arnold P., Fehlings M., Hedlund R., Madrazo I., Rechtine G., Aarabi B., Shainline M.; Spine Trauma Study Group. The subaxial cervical spine injury classification system: a novel approach to recognize the importance of morphology, neurology, and integrity of the discoligamentous complex. *Spine*, 2007, vol. 32, no. 21, pp. 2365-2374.
13. Dvorak M.F., Fisher C.G., Fehlings M.G., Rampersaud Y.R., Oner F.C., Aarabi B., Vaccaro A.R. The surgical approach to subaxial cervical spine injuries: an evidence-based algorithm based on the SLIC classification system. *Spine*, 2007, vol. 32, no. 23, pp. 2620-2629.
14. Anderson P.A., Moore T.A., Davis K.W., Molinari R.W., Resnick D.K., Vaccaro A.R., Bono C.M., Dimar J.R. 2nd, Aarabi B., Leverson G.; Spinal Trauma Study Group. Cervical spine injury severity score. Assessment of reliability. *J. Bone Joint Surg. Am.*, 2007, vol. 89, no. 5, pp.1057-1065.
15. Holtz A., Levi R. Spinal cord injury. Oxford University Press, 2010, 319 pp.

16. Song K.J., Park H., Lee K.B. Treatment of irreducible bilateral cervical facet fracture-dislocation with a prolapsed disc using a prefixed polyetheretherketone cage and plate system. *Asian Spine J.*, 2013, vol. 7, no. 2, pp. 111-114.
17. Amar A.P., ed. Surgical Management of Spinal Cord Injury. Blacwell Futura, 2007, 256 pp.
18. Hamai S., Harimaya K., Maeda T., Hosokawa A., Shida J., Iwamoto Y. Traumatic atlanto-occipital dislocation with atlantoaxial subluxation. *Spine*, 2006, vol. 31, no. 13, pp. E421-E424.
19. Maddox J.J., Rodriguez-Feo J.A. 3rd, Maddox G.E., Gullung G., McGwin G., Theiss S.M. Nonoperative treatment of occipital condyle fractures: an outcomes review of 32 fractures. *Spine*, 2012, vol. 37, no. 16, pp. E964-E968.
20. Mueller F.J., Fuechtmeier B., Kinner B., Rosskopf M., Neumann C., Nerlich M., Englert C. Occipital condyle fractures. Prospective follow-up of 31 cases within 5 years at a level 1 trauma centre. *Eur. Spine J.*, 2012, vol. 21, no. 2, pp. 289-294.
21. Koller H., Resch H., Tauber M., Zenner J., Augat P., Penzko39fer R., Acosta F., Kolb K., Kathrein A., Hitzl W. A biomechanical rationale for C1-ring osteosynthesis as treatment for displaced Jefferson burst fr40actures with incompetency of the transverse atlantal ligament. *Eur. Spine J.*, 2010, vol. 19, no. 8, pp. 1288-1298.41
22. Abeloos L., De Witte O., Walsdorff M., Delpierre I., Bruneau M. Posterior osteosynthesis of the atlas for nonconsolidated Jefferson fractures: a new surgical technique. *Spine*, 2011, vol. 36, no. 20, pp. E1360-E1363.
23. Zairul A., Vicknesh A., Zulkefli A., Ramanathan R. Conservative treatment in patients with Type 2 odontoid fracture – functional outcome following Halovest immobilization. *Malaysian Orthop. J.*, 2010, vol. 4, no. 2, pp. 13-16.
24. Smith J.S., Kepler C.K., Kopjar B., Harrop J.S., Arnold P., Chapman J.R., Fehlings M.G., Vaccaro A.R., Shaffrey C.I. Effect of type II odontoid fracture nonunion on outcome among elderly patients treated without surgery: based on the AOSpine North America geriatric odontoid fracture study. *Spine*, 2013, vol. 38, no. 26, pp. 2240-2246.
25. Pal D., Sell P., Grevitt M. Type II odontoid fractures in the elderly: an evidence-based narrative review of management. *Eur. Spine J.*, 2011, vol. 20, no. 2, pp. 195-204.
26. Fehlings M.G., Arun R., Vaccaro A.R., Arnold P.M., Chapman J.R., Kopjar B. Predictors of treatment outcomes in geriatric patients with odontoid fractures: AOSpine North America multi-centre prospective GOF study. *Spine*, 2013, vol. 38, no. 11, pp. 881-886.
27. Butler J.S., Dolan R.T., Burbridge M., Hurson C.J., O'Byrne J.M., McCormack D., Synnott K., Poynton A.R. The long-term functional outcome of type II odontoid fractures managed non-operatively. *Eur. Spine J.*, 2010, vol. 19, no. 10, pp. 1635-1642.
28. Cho D.C., Sung J.K. Analysis of risk factors associated with fusion failure after anterior odontoid screw fixation. *Spine*, 2012, vol. 37, no. 1, pp. 30-34.
29. Goel A., Desai K.I., Muzumdar D.P. Atlantoaxial fixation using plate and screw method: a report of 160 treated patients. *Neurosurgery*, 2002, vol. 51, no. 6, pp. 1351-1357.
30. Kwan M.K., Chan C.Y.W., Kwan T.C.C., Gashi Y.N., Saw L.B. Safety issues and neurological improvement following C1-C2 fusion using C1 lateral mass and C2 pedicle screw in atlantoaxial instability. *Malaysian Orthop. J.*, 2010, vol. 4, no. 2, pp. 17-22.
31. Maida G., Marcati E., Sarubbo S. Posttraumatic atlantoaxial rotatory dislocation in a healthy adult patient: a case report and review of the literature. *Case Rep. Orthop.*, 2012, vol. 2012, 183581. doi: 10.1155/2012/183581.
32. ElMiligui Y., Koptan W., Emran I. Transpedicular screw fixation for type II Hangman's fracture: a motion preserving procedure. *Eur. Spine J.*, 2010, vol. 19, no. 8, pp. 1299-1305.
33. Patibandla M.R., Mudumba V., Yerramneni V.K. Double Hangman's Fracture. *Spine*, 2013, vol. 38, no. 6, pp. E374-E377.
34. Ma W., Xu R., Liu J., Sun S., Zhao L., Hu Y., Jiang W., Liu G., Gu Y. Posterior short-segment fixation and fusion in unstable Hangman's fractures. *Spine*, 2011, vol. 36, no. 7, pp. 529-533.
35. Van Middendorp J.J., Audigé L., Hanson B., Chapman J.R., Hosman A.J. What should an ideal spinal injury classification system consist of? A methodological review and conceptual proposal for future classifications. *Eur. Spine J.*, 2010, vol. 19, no. 8, pp. 1238-1249.
36. Kim K.H., Cho D.C., Sung J.K. The management of bilateral interfacetal dislocation with anterior fixation in cervical spine: comparison with combined antero-posterior fixation. *J. Korean Neurosurg. Soc.*, 2007, vol. 42, no. 4, pp. 305-310.
37. Koller H., Reynolds J., Zenner J., Forstner R., Hempfing A., Maislinger I., Kolb K., Tauber M., Resch H., Mayer M., Hitzl W. Mid- to long-term outcome of instrumented anterior cervical fusion for subaxial injuries. *Eur. Spine J.*, 2009, vol. 18, no. 5, pp. 630-653.
38. Srivastava S.K., Agrawal K.M., Sharma A.K45., Agrawal M.D., Bhosale S.K., Renganathan S.R. C3-C4 spondyloptosis without neurological deficit – a case report. *Spine J.*, 2010, vol. 10, no. 7, pp. e16-e20.
39. Ngo L.M., Aizawa T., Hoshikawa T., Tanaka Y., Sato T., Ishii Y., Kokubun S. Fracture and contralateral dislocation of the twin facet joints of the lower cervical spine. *Eur. Spine J.*, 2012, vol. 21, no. 2, pp. 282-288.
40. Gasco J., Dilorenzo D.J., Patterson J.T. C4-C5 post-traumatic spondyloptosis with in situ fusion: systematic literature review and case report. *Spine*, 2013, vol. 38, no. 10, pp. E621-E625.
41. Kim H.J., Lee K.Y., Kim W.C. Treatment outcome of cervical tear drop fracture. *Asian Spine J.*, 2009, vol. 3, no. 2, pp. 73-79.
42. Zhou F., Zou J., Gan M., Zhu R., Yang H. Management of fracture-dislocation of the lower cervical spine with the cervical pedicle screw system. *Ann. R. Coll. Surg. Engl.*, 2010, vol. 92, no. 5, P. 406-410.
43. Gelalis I.D., Christoforou G., Arnaoutoglou C.M., Politis A.N., Manoudis G., Xenakis T.A. Misdiagnosed bilateral C5-C6 dislocation causing cervical spine instability: a case report. *Cases J.*, 2009, vol. 2, pp. 6149.
44. Yu D.K., Heo D.H., Cho S.M., Choi J.H., Sheen S.H., Cho Y.J. Posterior cervical fixation with nitinol shape memory loop in the anterior-posterior combined approach for the patients with three column injury of the cervical spine: preliminary report. *J. Korean Neurosurg. Soc.*, 2008, vol. 44, no. 5, pp. 303-307.
45. Ramieri A., Domenicucci M., Ciappetta P., Cellocco P., Raco A., Costanzo G. Spine surgery in neurological lesions of the cervicotho-

racic junction: multicentric experience on 33 consecutive cases. *Eur. Spine J.*, 2011, vol. 20, Suppl. 1, pp. S13-S19.
46. Suk K.S., Kim K.T., Lee J.H., Lee S.H., Kim J.S., Eoh J.H. Stage 4 compressive-extension injury of the cervical spine: a theoretical stage? *Spine*, 2010, vol. 35, no. 15, pp. E733-E738.
47. Dvorak M., Vaccaro A.R, Hermsmeyer J., Norvell D.C. Unilateral facet dislocations: Is surgery really the preferred option? *Evid. Based Spine Care J.*, 2010, vol. 1, no. 1, pp. 57-65.
48. Signoret F., Jacquot F.P., Feron J.M. Reducing the cervical flexion tear-drop fracture with a posterior approach and plating technique: an original method. *Eur. Spine J.*, 1999, vol. 8, no. 2, pp. 110-116.

Received: 10.02.2016

Information about the authors:

1. Aleksandr V. Burtsev, M.D., Ph.D., Russian Ilizarov Scientific Center «Restorative Traumatology and Orthopaedics», Kurgan, Russia, Scientific Clinical-and-Experimental Laboratory of Axial Skeletal Pathology and Neurosurgery; Correspondinng author: BAV31rus@mail.ru
2. Aleksandr V. Gubin, M.D., Ph.D., Russian Ilizarov Scientific Center «Restorative Traumatology and Orthopaedics», Kurgan, Russia, Director; Email: Alexander@gubin.spb.ru