COMPARATIVE CHARACTERISTIC OF ANTERIOR AND POSTERIOR STABILIZATION OF THE CERVICAL SPINE DURING SURGICAL INTERVENTIONS

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Objective. To analyze possibilities and limitations of various stabilization technologies in the surgical treatment of cervical spine pathology.

Material and Methods. Study design: retrospective monocentric observational analysis. Level of evidence: 3b (UK Oxford, version 2009). Diagnostic and treatment data are presented for 433 patients operated on using stabilization systems: patients in Group 1 (n = 228) underwent anterior fixation, those in Group 2 (n = 175) – posterior fixation with polyaxial screw systems, and in Group 3 (n = 30) – combined (anterior and posterior) fixation.

Results. For anterior fixation, ACDF, ACCF and their combinations were used as stabilization technologies. In 18.0 % of patients, 49 complications were revealed which corresponded to the 1st and 2nd categories according to the recommendations of WHO, and to grades I–IVA of Clavien – Dindo classification. For posterior fixation in Group 2, stabilization was performed using screw instrumentation systems. In 13.7 % of patients, 25 complications of the 1st and 2nd categories according to WHO recommendations and grades I–V according to Clavien-Dindo classification were revealed. Combined fixation involved the use of both anterior and posterior stabilizations. Analysis of anterior and posterior fixation techniques, as well as their comparison, showed a wide range of posterior stabilization options for a surgeon: any age, length, localization and nosology. Moreover, the realization of these advantages is carried out only through the indispensable use of screw fixation. Posterior fixation has several limitations: the impossibility of anterior decompression, limited correction of segmental lordosis, accessibility and greater trauma to soft tissues.

Conclusion. Comparative analysis of methods for the cervical spine stabilization showed that posterior fixation is an integral part of the surgical treatment of the cervical spine pathology. The obtained results indicate the complementarity of the technologies for the cervical spine stabilization, without their interchangeability. These data can be useful when choosing stabilization techniques before planning surgical treatment of cervical spine pathology, which will allow changing the existing paradigm.

Key Words: anterior and posterior stabilization, fixation, complications.

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Stabilizing surgical interventions have been successfully used for treating cervical spine pathologies. Despite the wide range of diseases, all surgical approaches for cervical spine fixation can be classified into anterior, posterior, and combined [1–7]. These approaches provide good clinical and radiological outcomes in most cases [2, 3, 7–10]. There are numerous publications comparing these techniques for certain pathologies in patients of certain age groups [4–6]. However, there are no studies providing a comparative analysis of these techniques. Thus, it limits the evidence of the advantages and disadvantages of anterior and posterior stabilization in each specific clinical case, as well as in specific nosology or syndrome and complicates the choice of surgical tactics

The aim of the study is to analyze the possibilities and limitations of various cervical spine stabilization technologies.

Material and Methods

The study presents a retrospective monocentric observational analysis (3b Level of Evidence, UK Oxford, 2009). The analysis included data of 433 patients who underwent cervical instrumental fixation at National Ilizarov Medical Research Center for Traumatology and Orthopedics in 2010–2017. A principle of patient selection for the study was continuous sampling.

Cases were divided into three groups, depending on the type of approach and used fixation system. Group 1 patients (n = 228) underwent anterior fixation, Group 2 (n = 175) posterior screw fixation and Group 3 patients (n = 30) had combined fixation.

We evaluated the following criteria: used technology, number of stabilized spinal motion segments and their location, type of pathology, age, duration of surgery, blood loss, length of hospital stay and complications.

Results

Anterior fixation. In Group 1, the following stabilization technologies were

used: anterior cervical discectomy and fusion (ACDF, 162 cases, 71 %), anterior cervical corpectomy and fusion (ACCF, 64 patients, 28.1 %) and their combination (2 cases, 0.9 %). The patient's age ranged from 5 to 76 years. The ACDF was used to stabilize one (64.2 %) to three (6.8 %) spinal motion segments: we used stand-alone cages, cage-with-plate fixation, and plate-cage constructs. The most frequently stabilized level was C5–C6 (44.2 % of cases); the most rarely fixed segment was C2–C3 (0.4 %; Fig. 1). Degenerative pathology (83.3 %) and traumatic injury (16.7 %) were the most common. We used ACCF for fixation of two (59.4 %) to six (1.6 %) spinal segments. In all cases, an interbody implant with extramedullary plate was used. The most frequently stabilized segments were C6–C7 (31.7 % of cases) and C5–C6 (29.9 %); the most rarely fixed level was C2–C3 (0.6 % of cases). Cervical spine injury ranked first (73.4 %), degenerative diseases took the second place (21.8 %). There were single cases of inflammatory process, trauma caused by Forestier's disease, and ossification of the posterior longitudinal ligament (1.6 % each; Fig. 2). The data on blood loss, duration of surgery, and the length of hospital stay are presented in the Table 1. In 18 % of patients, 49 complications of the 1st and 2nd categories [11] (Table 2) and grades I–IVA according to Clavien–Dindo classification [12] (Fig. 3) were found.

Posterior fixation. In Group 2, cervical screw fixation was performed (Table 3). The patient's age ranged from 9 months to 73 years. The number of fixed spinal segments varied greatly. In some cases of craniocervical injury, the segment-preserving fixation with reduction and screw stabilization of bone fragments was performed. Other cases included fixation from the occiput extending to the thoracic region and below. The most frequently stabilized segment was C2–C3 (21.9 %), the most rarely fixed level was C7–T1 (6.8 %; Fig. 4). The range of pathologies was wide: injury, developmental anomalies and systemic diseases, degenerative disease, oncology and inflammatory processes (Fig. 5). The duration of surgery, intraoperative blood loss, and length of hospital stay were 176.9 ± 79.9 minutes, 203.9 ± 170.2 ml, and 21.3 ± 12.3 days, respectively. A total of 25 complications of the 1st and 2nd categories according to the WHO (Table 4) and grades I–V according to Clavien – Dindo classification (Fig. 6) were observed in 13.7 % of patients.

Combined fixation. Combined fixation involves both anterior and posterior approaches (Table 5). In one case, a screw protruding beyond the vertebra was nibbled through a small anterolateral incision. Stabilized spinal segments levels were similar to Groups 1 and 2, while the nosological spectrum was like in Group 2 (Fig. 7). Combined stabilization was performed in two stages in most cases. For this reason, the data on the duration of surgery (278.3 ± 122.3 minutes), intraoperative blood loss (353.0 ± 233.9 ml) and length of hospital stay (39.6 ± 33.2 days) were summarized. Complications after combined surgery were classified based on the same principles as for groups 1 and 2 depending on the intervention that provoked their occurrence (Fig. 8).

Discussion

A comparative analysis of anterior and posterior fixation techniques demonstrated numerous advantages of dorsal stabilization (Table 6):

– wide age range (starting with patients under one year old), which has been confirmed by the literature analysis [13–16], while age restrictions for the use of screw instrumentation are observed in children under two years of age (4+);

– no restrictions on the length of fixation; it is also possible to include several transition zones; this fact has been neither confirmed nor disproved in the literature, which is due to the lack of studies on the topic;

– no restrictions on the localization for dorsal stabilization, which is confirmed by numerous works on the assessment of posterior fixation;

– applicable in any pathology.

It should be noted that no such emphasis has been placed on the length, localization, and nosology in the literature devoted to analysis of fixation

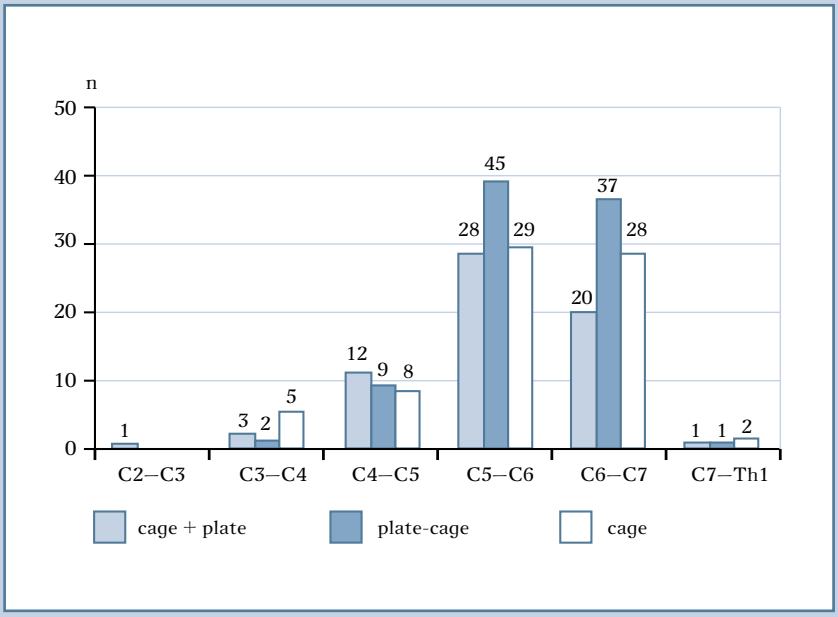

Fig. 1
Distribution ratio of spinal motion segments stabilized by the ACDF approach depending on the level and fixation technology used

techniques [8, 9, 17], which confirms the authenticity of the data obtained.

These advantages can only be achieved with the use of screw fixation [17], which is safe option even in the presence of malpositions of metal structures [14, 15]. It should be noted that, according to our data, posterior stabilization has a lower rate of complications (including implant-related ones) that require reoperations [18, 19]. However, the severity of such complications in some cases may be higher than when using anterior stabilization [14].

However, like any other technique, posterior screw fixation has a number of limitations:

– limitation for anterior decompression (it can be only indirect and achieved by the exposure of posterior structures and correction of lordotic profile over two or more spinal motion segments), especially in case of single-level lesions which is more important in trauma and degenerative disease [20–22];

– limitation for correction of segmental lordosis, especially in rigid anterior column [20];

– relatively high complexity in adoption of the approach (however, the limitation is rather subjective).

It should be noted that comparison of the techniques from the standpoint of intraoperative blood loss, duration of surgery, hospital stay length, and complications is impossible due to the large heterogeneity of the compared groups,

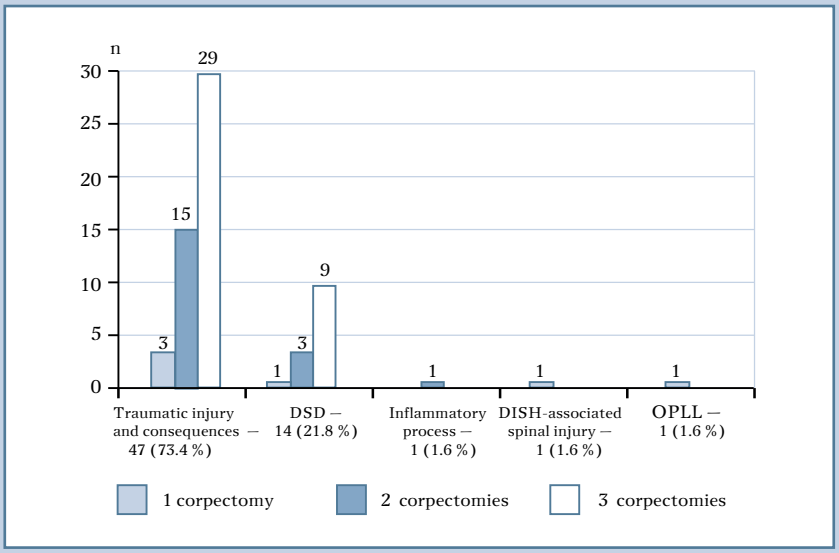

Fig. 2
Number and length of ACCF in different pathologies: DSD – degenerative spinal disease

which is undoubtedly a limitation of this work. However, the obtained data on possibilities and limitations suggests a possibility of the paradigm shift when planning surgical treatment of pathology of the cervical spine.

Study limitations. Variety of pathology, wide age range and large differences in the craniocervical and subaxial anatomy do not allow systematizing the fixation techniques and nosologies. Meanwhile, the obtained results indicate that the techniques are not interchangeable.

Conclusion

The comparative analysis of cervical spine stabilization techniques showed that posterior screw fixation is an important part of the surgical management of cervical spine pathologies. This type of fixation provides the surgeon with a wide range of technical capabilities.

Table 1
Surgery duration, intraoperative blood loss, and hospital stay length for various anterior stabilization approaches (M ± m)

Fixation type		Surgery duration, min.	Intraoperative blood loss, ml	Hospital stay, days
ACDF	1 SMS	78.5 ± 39.2	65.9 ± 66.3	12.9 ± 5.5
	2 SMS	97.8 ± 30.3	97.9 ± 50.3	12.5 ± 3.7
	3 SMS	131.4 ± 32.5	163.6 ± 80.9	12.5 ± 5.7
ACCF	1 CE	122.6 ± 42.7	184.1 ± 177.7	17.6 ± 8.5
	2 CE	171.3 ± 67.5	251.6 ± 198.7	18.0 ± 6.3
	3 CE	172.9 ± 87.5	428.6 ± 386.1	21.3 ± 8.3
Hybrid ACDF/ACCF		110.0 ± 28.3	250.0 ± 70.7	16.0 ± 7.1
Final value		103.2 ± 52.2	124.0 ± 147.3	14.3 ± 6.4

SMS — spinal motion segment, CE — corporectomy.

Table 2
Complications of different anterior stabilization approaches

Type of complication	Number of complications			Reoperation	
	n	% of all complications	% of all surgeries	one	two
Insufficient decompression	12	24.50	5.30	12	–
Aggravation of neurological deficits	8	16.30	3.50	3	–
Failure of fixation	7	14.30	3.10	5	–
Damage to the dura mater and liquorrhea	5	10.20	2.20	1	2
Damage to the adjacent segment	3	6.10	1.30	3	–
Severe dysphagia	3	6.10	1.30	–	–
Esophageal injury	2	4.10	0.90	1	1
Postoperative hematoma	1	2.05	0.40	1	–
Vertebral artery injury	1	2.05	0.40	–	–
Epidural hematoma	1	2.05	0.40	–	1
Dysphonia	1	2.05	0.40	–	–
Neuropathic pain syndrome	1	2.05	0.40	–	–
Gastrointestinal bleeding	1	2.05	0.40	–	–
Vertigo	1	2.05	0.40	–	–
Profuse wound discharge	1	2.05	0.40	1	–
Severe postoperative edema	1	2.05	0.40	–	–

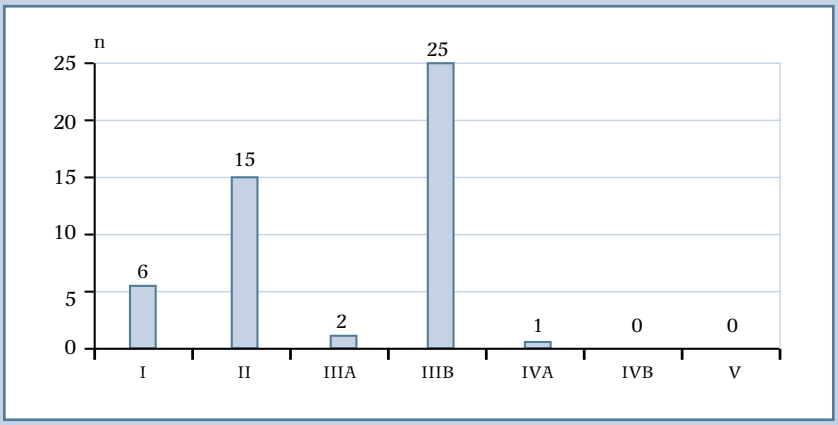

Fig. 3
Surgical complications after anterior fixation according to the Clavien–Dindo classification [12]

However, like any other technique, it also has limitations. The obtained data can be useful in choosing the stabilization technique before planning surgery for cervical spine pathology, which will allow changing the existing paradigm. Further studies should focus on a more detailed analysis of the technologies, with an emphasis on improving the evidence of results.

Table 3

Ratio of the types of pivot points used in posterior fixation (n = 842)

Fixation level	Fixation type						
	plate (n = 43)	screws (n = 781)					laminar hooks (n = 18)
		LM (n = 490)	PS (n = 188)	TL (n = 51)	PA (n = 49)	TA (n = 3)	
Occipital bone C0 (n = 43)	43	–	–	–	–	–	–
C1 (n = 66)	–	63	–	1	–	–	2
C2 (n = 218)	–	–	123	40	49	3	3
C3 (n = 135)	–	117	12	2	–	–	4
C4 (n = 179)	–	116	6	2	–	–	1
C5 (n = 105)	–	95	6	–	–	–	4
C6 (n = 79)	–	68	9	–	–	–	2
C7 (n = 71)	–	31	32	6	–	–	2

LM – lateral mass, PS – pedicle screw, TL – translaminar, PA – PARS-intraarticular, TA – transarticular..

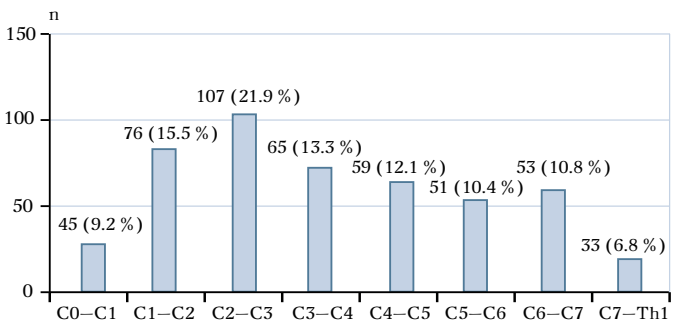

Fig. 4
Number and localization of stabilized spinal motion segments in posterior fixation

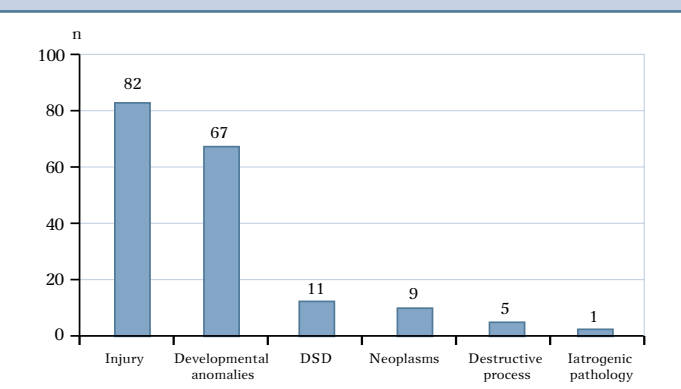

Fig. 5
Nosologies in posterior fixation of the cervical spine: DSD – degenerative spinal disease

Table 4
Complications of posterior instrumented stabilization

Type of complication	Number of complications			Reoperation	
	n	% of all complication	% of all surgeries	one	two
Pseudarthrosis	8	32.0	4.6	5	1
Postoperative wound infection	5	20.0	2.9	5	–
Prolonged wound healing	2	8.0	1.1	–	–
Damage to the dura mater membranes and liquorrhea	2	8.0	1.1	1	–
Vertebral artery injury	2	8.0	1.1	–	–
Acute intestinal obstruction	2	8.0	1.1	–	–
Screw malposition	1	4.0	0.6	1	–
Adjacent level kyphosis	1	4.0	0.6	1	–
Ping-pong fracture	1	4.0	0.6	1	–
Death	1	4.0	0.6	–	–

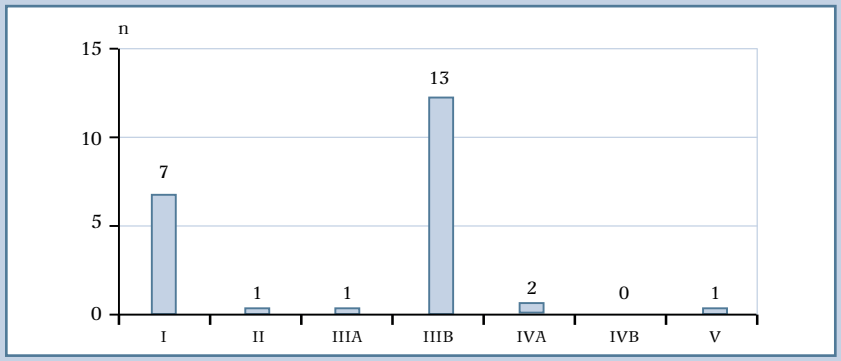

Fig. 6
Surgical complications after posterior fixation according to Clavien–Dindo classification [12]

Table 5
Ratio of the types of pivot points used in posterior fixation (n = 161)

Fixation level	Fixation type				
	plate	screws (n = 159)			
	(n = 2)	LM (n = 126)	PS (n = 19)	TL (n = 4)	PA(n = 10)
Occipital squama C0 (n = 2)	2	–	–	–	–
C1 (n = 2)	–	2	–	–	–
C2 (n = 18)	–	–	4	4	10
C3 (n = 14)	–	12	2	–	–
C4 (n = 28)	–	26	2	–	–
C5 (n = 26)	–	24	2	–	–
C6 (n = 40)	–	37	3	–	–
C7 (n = 31)	–	25	6	–	–

LM – lateral mass, PS – pedicle screw, TL – translaminar, PA – PARS-intraarticular.

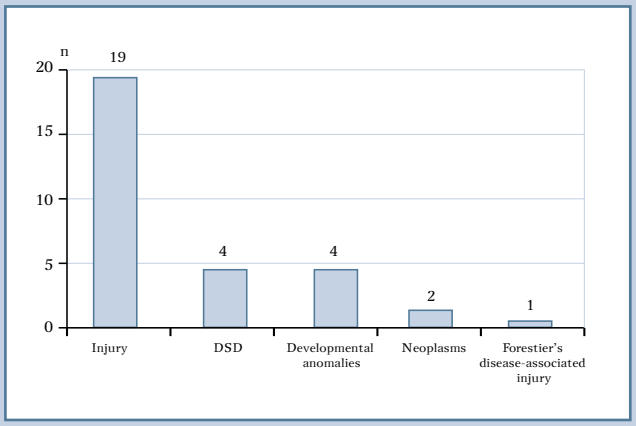

Fig. 7
Nosologies in combined surgery: DSD – degenerative spinal disease

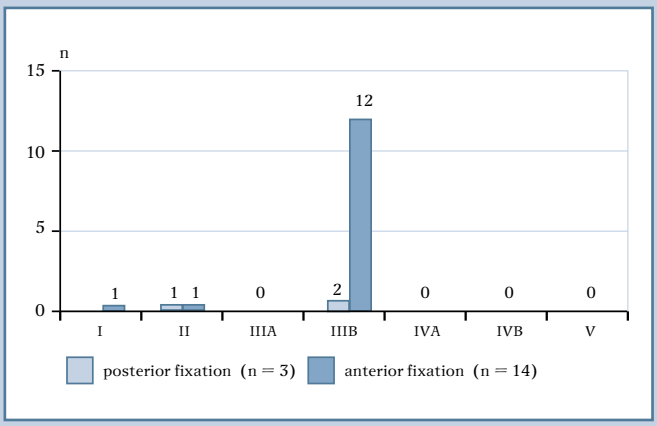

Fig. 8
Surgical complications after combined fixation according to Clavien–Dindo classification [12]

Table 6
Comparative analysis of anterior and posterior stabilization

Parameter for comparison		Type of fixation	
		anterior	posterior
Minimum age of the patient		5 years	9 months
Age group	<18 years, %	2.6	37.7
	18–60 years, %	82.0	52.6
	≥61 years, %	15.4	9.7
Maximum number of stabilized segments in one patient		3, rarely 4	Not limited
Level of fixation		C2–C3 to T2	C0 and below
Type of pathology		Injury and degenerative	Any
Mean duration of surgery*, min		103.2 ± 52.2	176.9 ± 79.9
Mean blood loss*, ml		124.0 ± 147.3	203.9 ± 170.2
Mean hospital stay*, days		14.3 ± 6.4	21.3 ± 12.3
Complications*, %		22.0	15.2
Percentage of reoperations required in case of complications*, %		81.1	55.6

*the data on the parameters to be compared do not objectively reflect the advantages and disadvantages of the approaches, which is due to nosological diversity, risk of injury, and technical features of the techniques (data are presented for general information purpose).

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References

1. **Vaccaro AR, Baron IM, eds.** Operative Techniques: Spine Surgery. Transl. under edition of Yu. A. Shcherbuk. Izdatelstvo Panfilova, 2015. In Russian.
2. **Kim DH, Vaccaro AR, Dickman CA, Cho D, Lee SK, Kim I.** Surgical Anatomy and Techniques to the Spine. Transl. from English, ed. by Yu.A. Shcherbuk. Panfilov Publishing House, 2016. In Russian.
3. **Herkowitz HN, Garfin S, Eismont F, Bell G, Balderston R.** Rothman-Simeone the Spine, 6th ed. Philadelphia: Elsevier Saunders, 2011.
4. **Spine Trauma: Surgical Techniques, ed.** by VV Patel, E Burger, CW Brown. Heidelberg: Springer, 2010.
5. **Suchomel P, Choutka O.** Reconstruction of Upper Cervical Spine and Craniovertebral Junction. Heidelberg: Springer, 2011.
6. The Cervical Spine, ed. by EC Benzel. 5th ed. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins, 2012.
7. The Textbook of Spinal Surgery, ed. by KH Bridwell, RL DeWald. 3rded. Philadelphia: Wolters Kluwer Health / Lippincott Williams & Wilkins, 2011.
8. **Ge C, Hao D, He B, Mi B.** Anterior cervical discectomy and fusion versus posterior fixation and fusion of C2–3 for unstable Hangman's fracture. J Spinal Disord Tech. 2015;28:E61–E66. DOI: 10.1097/BSD.0000000000000150.
9. **Kristof RA, Kiefer T, Thudium M, Ringel F, Stoffel M, Kovacs A, Mueller CA.** Comparison of ventral corpectomy and plate-screw-instrumented fusion with dorsal laminectomy and rod-screw-instrumented fusion for treatment of at least two vertebral-level spondylotic cervical myelopathy. Eur. Spine J. 2009;18:1951–1956. DOI: 10.1007/s00586-009-1110-x.
10. **Fang Z, Tian R, Sun TW, Yadav SK, Hu W, Xie SQ.** Expansion open-door laminoplasty with foraminotomy versus anterior cervical discectomy and fusion for coexisting multilevel cervical myelopathy and unilateral radiculopathy. Clin. Spine Surg. 2016;29:E21–E27. DOI: 10.1097/BSD.0000000000000074.
11. **Каминский Ю.В., Тимошенко В.С.** Ятрогении: классификация, категории, рубрикация // Pacific Medical Journal. 2007. № 1. С. 12–14. [Kaminsky YuV, Timoshenko VS. Iatrogenias: classification, categories, rubricating. Pacific Medical Journal. 2007;(1):12–14. In Russian].
12. **Willhuber GC, Elizondo C, Slullitel P.** Analysis of postoperative complications in spinal surgery, hospital length of stay, and unplanned readmission: application of Dindo-Clavien classification to spine surgery Global Spine J. 2019;9:279–286. DOI: 10.1177/2192568218792053.
13. **Beez T, Brown J.** Traumatic atlanto-occipital dislocation in children – a case-based update on clinical characteristics, management and outcome. Childs Nerv Syst. 2017;33:27–33. DOI: 10.1007/s00381-016-3265-1.
14. **Derman PB, Lampe LP, Lyman S, Kueper J, Pan TJ, Girardi FP, Albert TJ, Hughes AP.** Atlantoaxial fusion: sixteen years of epidemiology, indications, and complications in New York state. Spine. 2016;41:1586–1592. DOI: 10.1097/BRS.0000000000001603.
15. **Menezes AH.** Craniocervical fusions in children. J Neurosurg Pediatr. 2012;9:573–585. DOI: 10.3171/2012.2.PEDS11371.
16. **Geck MJ, Truumees E, Hawthorne D, Singh D, Stokes JK, Flynn A.** Feasibility of rigid upper cervical instrumentation in children tomographic analysis of children aged 2–6J. Spinal Disord Tech. 2014;27:E110–E117. DOI: 10.1097/BSD.0b013e318291ce46.
17. **Shuhui G, Jiagang L, Haifeng C, Hao ZB, Qing HS.** Surgical management of adult reducible atlantoaxial dislocation, basilar invagination and Chiari malformation with syringomyelia. Turk Neurosurg. 2016;26:615–621. DOI: 10.5137/1019-5149.JTN.13884-14.2.
18. **Fang Z, Tian R, Sun TW, Yadav SK, Hu W, Xie SQ.** Expansion open-door laminoplasty with foraminotomy versus anterior cervical discectomy and fusion for coexisting multilevel cervical myelopathy and unilateral radiculopathy. Clin Spine Surg. 2016;29:E21–E27. DOI: 10.1097/BSD.0000000000000074.
19. **Liu S, Tetreault L, Fehlings MG, Challier V, Smith JS, Shaffrey CI, Arnold PM, Scheer JK, Chapman JR, Kopjar B, Protopsaltis TS, Lafage V, Schwab F, Massicotte EM, Yoon ST, Ames CP.** Novel method using baseline normalization and area under the curve to evaluate differences in outcome between treatment groups and application to patients with cervical spondylotic myelopathy undergoing anterior versus posterior surgery. Spine. 2015;40:E1299–E1304. DOI: 10.1097/BRS.0000000000001152.
20. **Lee SH, Kim KT, Lee JH, Kang KC, Jang SJ, Hwang SP, Yoon KT.** 540 cervical realignment procedure for extensive cervical OPLL with kyphotic deformity. Spine. 2016;41:1876–1883. DOI: 10.1097/BRS.0000000000001794.
21. **Kim KH, Cho DC, Sung JK.** The management of bilateral interfacetal dislocation with anterior fixation in cervical spine: comparison with combined antero-posterior fixation J Korean Neurosurg Soc. 2007;42:305–310. DOI: 10.3340/jkns.2007.42.4.305.
22. **Kepler CK, Vaccaro AR, Chen E, Patel AA, Ahn H, Nassr A, Shaffrey CI, Harrop J, Schroeder GD, Agarwala A, Dvorak MF, Fourney DR, Wood KB, Traynelis VC, Yoon ST, Fehlings MG, Aarabi B.** Treatment of isolated cervical facet fractures: a systematic review. J Neurosurg Spine. 2016;24:347–354. DOI: 10.3171/2015.6.SPINE141260.

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