DEGENERATIVE CHANGES IN THE INTERVERTEBRAL JOINTS OF THE CERVICAL SPINE AFTER ANTERIOR INTERBODY FUSION AND INTERVERTEBRAL DISC ARTHROPLASTY

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Objective. To study the effect of arthroplasty and anterior interbody fusion in the cervical spine on degenerative changes in the adjacent intervertebral joints.

Material and Methods. A retrospective cohort study included 46 patients (22 with cervical total disc arthroplasy – CTDA, and 24 with anterior cervical discectomy and fusion – ACDF) with symptoms of cervical spondylogenic compression myelopathy and/or radiculopathy. The degree of degeneration of facet joints adjacent to the operated segments was evaluated 12 months after surgical treatment. Degenerative changes in the cervical spine were assessed using CT according to the Okamoto classification. Vidar Dicom Viewer 3.2 software was used to view images and evaluate intervertebral joints. Statistical processing was performed using IBM SPSS Statistics 23. Data were presented as median and 25th and 75th percentiles – Me [Q1; Q3].

Results. The mean age of patients in both groups was 47 [39; 52] years (Mann – Whitney U-test, $p = 0.047$). In the ACDF group it was 48 [42; 55] years and in the CTDA group – 42 [36; 52] years. Comparison of degenerative changes in the ACDF group before and after treatment (Wilcoxon analysis) showed a statistically significant difference in the cranial ($p = 0.023$), and caudal ($p = 0.001$) joints, with the progression of degeneration degree. In the CTDA group, no difference between pre- and post-treatment degeneration degree (Wilcoxon analysis) was found in either cranial joints ($p = 0.157$) or caudal joints ($p = 0.161$).

Conclusion. Surgeries to stabilize spinal segments in degenerative diseases undeniably affect the development of the adjacent level syndrome. However, the use of endoprosthetic technology makes it possible to aggravate the degree of degenerative changes in the intervertebral joints of adjacent segments to a lesser extent.

Key Words: spondyloarthrosis classification, facet joint, cervical arthroplasty, anterior cervical interbody fusion, ACDF, CTDA.

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An adjacent-level syndrome is one of the reasons for the repeated surgery in patients who underwent anterior cervical discectomy and fusion (ACDF). This is a degenerative disease of the segment adjacent to previously fixed spinal motion segment (adjacent segment disease – ASD). It is manifested by neck pain, possible radiculopathy and/or myelopathy, and a pronounced compression of neural structures [1, 2].

The etiology of the adjacent segment disease is multivariate and includes age and gender of patients, as well as the presence of natural degenerative changes in the intervertebral disc, the type of fixation of the adjacent segment with dynamic or rigid implants, the extension of spinal fusion, the presence of a fixing plate, and the effect of radiological parameters of the cervical spine balance [3–7]. It is known that the frequency of repeated surgeries for adjacent segment disease after endoprosthetics (arthroplasty) of the intervertebral disc of the cervical spine (cervical total disc arthroplasty – CTDA) is less than after discectomy with spinal fusion [3, 4, 8, 9]. It should be noted that published papers paid insufficient attention to the grade of degenerative changes in the intervertebral joints that may differ from the grade of degeneration of the intervertebral disc, affect the mobility of the segment and be the reason of pain [10, 11].

Intervertebral joints have been identified as a possible source of neck pain [12, 13]. However, the assessment of degeneration of facet joints is not widespread in clinical practice due to the lack of a significant correlation with the severity of symptoms of radiculopathy and myelopathy, as well as due to the lack of a generally accepted classification of changes. Nevertheless, morphometric parameters of intervertebral joints can show changes before the manifestation of clinically significant symptoms. Thus, we have decided to conduct a study to compare degenerative changes in the intervertebral (facet) joints after performing CTDA and ACDF according to the Okamoto classification [10]. The classification features lie in its ease of application, since it is based on CT identification of the cervical spine according to explicitly prescribed evaluation criteria. The classification showed good consistency of application among spinal neurosurgeons [10].

The objective is to analyze the effect of arthroplasty and anterior interbody fusion in the cervical spine on degenerative changes in the adjacent intervertebral joints.

Material and Methods

The study comprised 46 patients with cervical spondylogenic compression myelopathy and/or radiculopathy (22 underwent CTDA and 24 – ACDF). Surgery on one or two spinal motion segments was performed in patients with degenerative diseases of the cervical spine, with clinical manifestations of cervical myelopathy and/or radiculopathy who had no results after non-surgical treatment for at least 6 weeks. The grade of facet joint degeneration adjacent to the operated segment was assessed 12 months after surgery.

According to the Okamoto classification, degenerative changes of the cervical spine were assessed using CT of the spine [10]. There are 6 grades, yet the authors classify the latter into two subtypes: 5A and 5B, since the last stage of degeneration of the intervertebral joint may result in both instability and stabilization via ankylosis. The Vidar Dicom Viewer 3.2 software was used to view images and assess intervertebral joints.

Statistical processing was performed using IBM SPSS Statistics 23. The data were presented as the median of both the 25th and 75th percentiles, Me [Q1; Q3]. Shapiro – Wilk test was used to evaluate the distribution of the samples; nonparametric analysis test (Mann – Whitney U test, Wilcoxon signed-rank test) were used for distribution other than normal ($p \leqslant 0.017$). The null hypothesis was not discarded at $p \geqslant 0.05$.

Results

The mean age of patients in both groups was 47 [39; 52] years (Mann-Whitney U test; $p = 0.047$). It was 48 [42; 55] years in the ACDF group and 42 [36; 52] years in the CTDA group.

The diagrams present data on the severity of degenerative changes in the intervertebral joints of the cranial and caudal adjacent segments (Fig. 1–4). There were no patients with grade 4 degeneration of the intervertebral joints. Grade 5A degeneration was registered in one case.

There was no statistical difference in the grade of degeneration between ACDF and CTDA groups (Mann – Whitney U test) before surgery in both cranial facet joints ($p = 0.297$) and caudal ones ($p = 0.585$).

A comparison of degenerative changes in the ACDF group before and after treatment (Wilcoxon signed-rank test) showed a statistically significant difference in cranial ($p = 0.023$) and caudal ($p = 0.001$) joints with the progression of the grade of degenerative changes. There was no difference in the CTDA group before and after treatment (Wilcoxon signed-rank test) in either cranial joints ($p = 0.157$) or caudal joints ($p = 0.161$).

Case history. Patient D., 41 years old, complained of neck pain with irradiation in the right arm (5–7 points according to VAS), numbness and weakness in the IV and V fingers of the right hand.

Complaints has been registered since October 2020. Non-surgical treatment has been performed for 6 months. The pain slightly decreased during the treatment, but in the last month the patient began to suffer from pronounced weakness in the right arm.

On examination: deficit of active and passive movements in the cervical spine, reduction of muscle strength in the right hand up to 4 points (active movements are preserved, resistance against a light external retroaction), reduction of pain and temperature sense in the area of the little finger on the right hand.

According to MRI and CT findings, compression of cerebrospinal nerves was verified at the level of the C5–C6, C6–C7 segments. The patient underwent anterior microsurgical decompression of spinal roots, interbody fusion with osteoconductive cages and anterior fixation with a plate at the C5–C6, C6–C7 levels.

A positive outcome was achieved 12 months after surgery: complete disappearance of neurologic impairment and absence of pain syndrome in neck and arm (Fig. 5–7).

Discussion

In cervical spine surgery the disappearance of neurologic deficit and improvement in quality of life of patients were achieved due to anterior discectomy with interbody fusion that made this treatment option the gold standard. Nevertheless, quality of life is a subjective criterion that is influenced by a large number of factors, including repeated spinal surgeries. Adjacent segment disease is a common reason for repeated surgeries during several years after ACDF. The search for the reason for its development has resulted in a better understanding of the cervical spine biomechanics [14]. One of the reasons for ASD was considered to be the spinal fusion of a previously operated adjacent segment. This assumption formed the foundation for the creation of dynamic implants, including endoprostheses of intervertebral discs of the cervical spine.

The effect of segment mobility on the grade of degeneration of intervertebral discs has been proven [15, 16]. This means that the same changes should occur in the intervertebral joints. It is somewhat difficult to identify changes in the joints by MRI due to the peculiarities of the anatomocal structure, in contrast to CT which allows to study their condition in details. In addition, the correlation between the determination of the grade of degeneration in the joints by CT and the severity of neurological disorders is recognized [10].

In the course of the study we used the Okamoto classification [10] to assess degenerative changes in the intervertebral joints of the cervical spine. The data obtained show an aggravation of the severity of degeneration in the cranial and caudal adjacent intervertebral joints after ACDF. There was no statistically significant deterioration in the grade of degeneration in the adjacent joints after CTDA. Nevertheless, it is clear from CTDA diagrams that the number of patients with grades 2 and 3 were increased after treatment.

The study proves the effect of spinal fusion on degenerative changes in the intervertebral joints. Nevertheless, as far as we know, this is the first study where the Okamoto classification is applied and there are no other outcomes to compare the obtained data with.

The Okamoto classification is a new scientific contribution representing a different approach to the classification of degenerative abnormalities of intervertebral joints of the cervical spine using CT findings. This differentiates it from current classifications and adds new aspects to the understanding of degenerative changes in the facet joints of the cervical spine. The classification is based on a visual evaluation of degenerative changes in the facet joints by means of CT imaging and considers not only the presence or absence of degenerative changes in the facet joints but also their features (the amount of narrowing of the intra-articular gap, the formation of osteophytes and periarticular cysts). Nevertheless, this approach may lead to subjectivity and variability in the interpretation of the outcomes between different observers. There is a necessity for a more standardized and objective approach that could be an important complement to this classification. Despite the fact that in the original Okamoto study the classification concerned the clinical assessment of the myelopathy severity, its clinical significance remains questionable. The simplicity of the assessment criteria renders the classification available. Nonetheless, the limitation with the CT study alone, without specifying kinematic data on the condition of the facet joints, does not provide a complete understanding of the effect of degeneration in the facet joints on the cervical spine function and potential consequences for patients. Additional studies with long follow-up period and identification of the correlation between classification and treatment outcomes may contribute to more precise determination of the clinical applicability and prognostic value of the classification. Kinematics analysis can be helpful for a fundamental understanding of the effect of degenerative changes

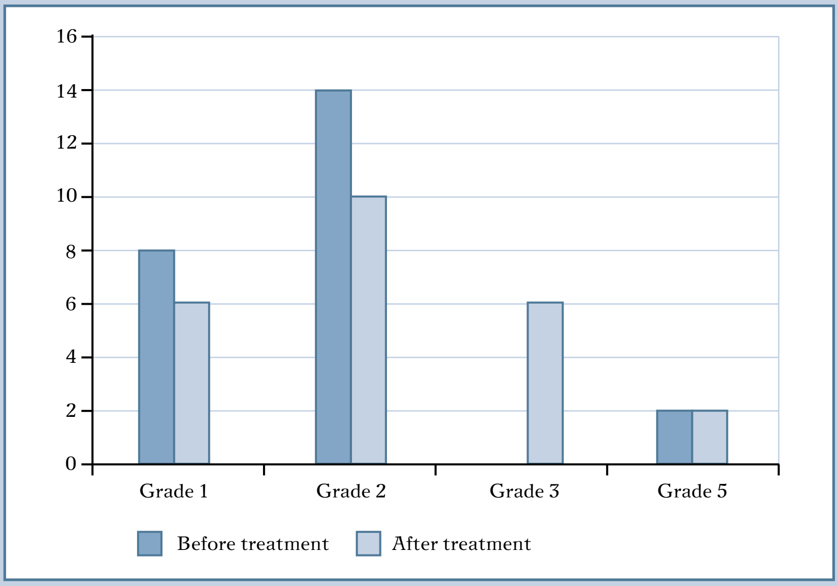

Fig. 1
Degenerative changes in the adjacent cranial facet joints before and after spinal fusion (p = 0.023)

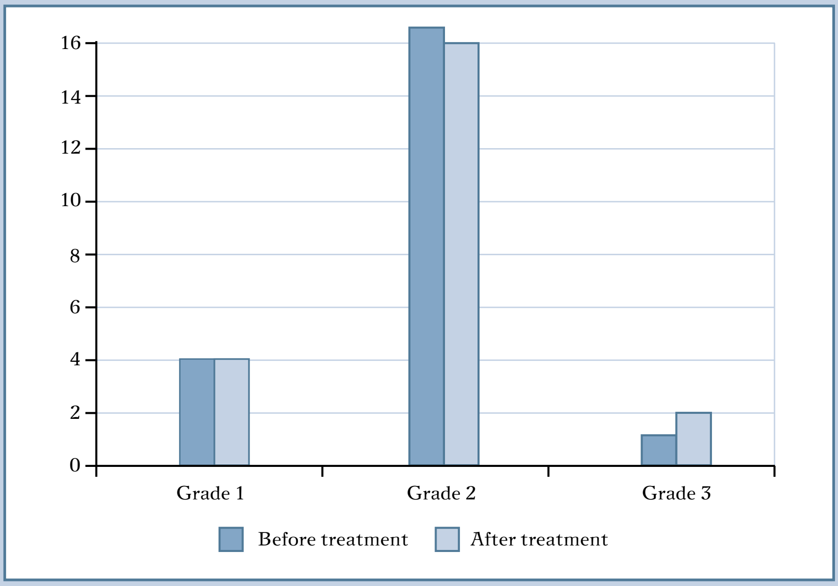

Fig. 2
Degenerative changes in the adjacent cranial facet joints before and after arthroplasty (p = 0.157)

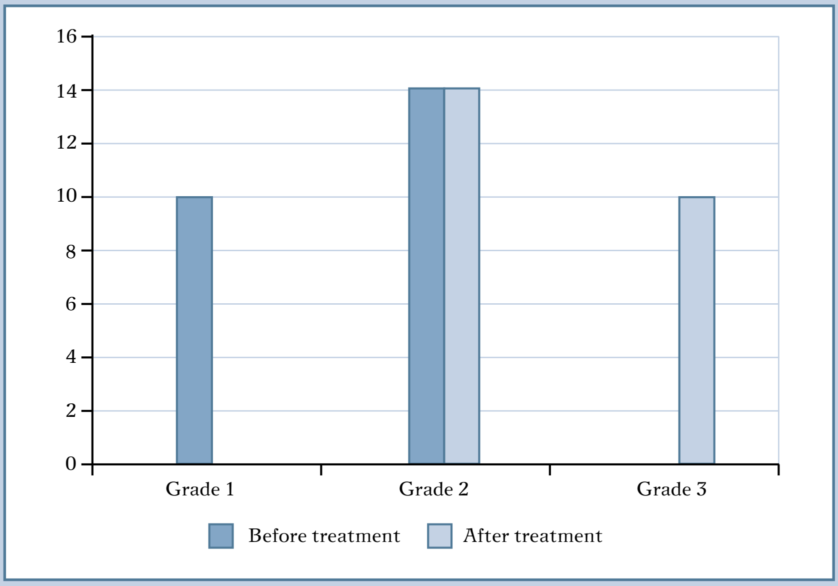

Fig. 3
Degenerative changes in the adjacent caudal facet joints before and after spinal fusion ($p = 0.001$)

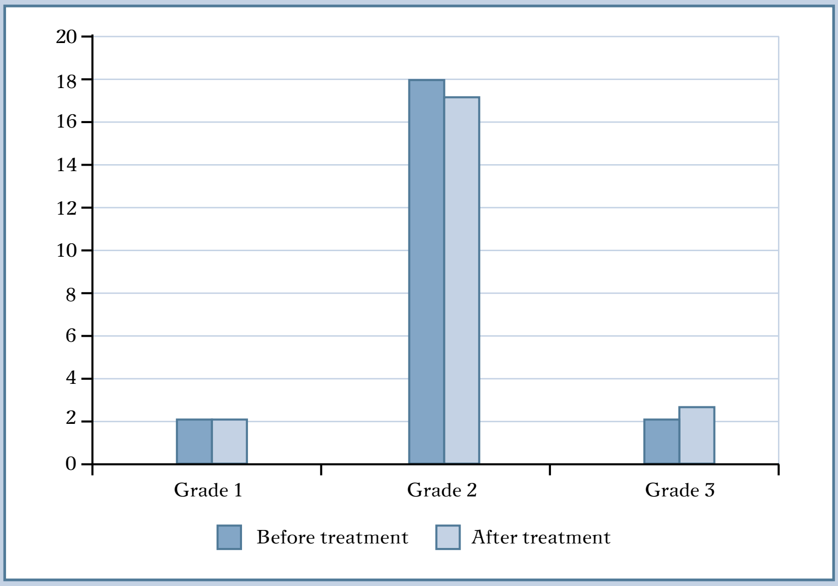

Fig. 4
Degenerative changes in the adjacent caudal segments before and after arthroplasty ($p = 0.161$)

in facet joints on the development of spondylogenic cervical myelopathy and radiculopathy.

Generally, the Okamoto classification presents a new approach to assessment of the degeneration of the facet joints in the cervical spine. Nevertheless, despite its novelty, further trials and improvements are required for a more standardized and complete assessment of degenerative changes in facet joints and their clinical significance in degenerative spondylogenic cervical myelopathy.

Conclusion

Surgeries for stabilization of spinal segments in degenerative diseases have an unquestionable effect on the development of the adjacent segment disease. Nevertheless, the application of endoprosthesis replacement technique allows for less pronounced degenerative changes in the intervertebral joints of adjacent segments.

The study was performed under state assignment No. 121030100311-3 "Development of techniques to increase the efficiency of decompression and stabilization surgeries with the application of transpedicular fixation and bone grafting in patients with degenerative abnormalities and traumatic spinal injuries".
The authors declare that they have no conflict of interest.
The study was approved by the local ethical committees of institutions.
All authors contributed significantly to the research and preparation of the article, read and approved the final version before publication.

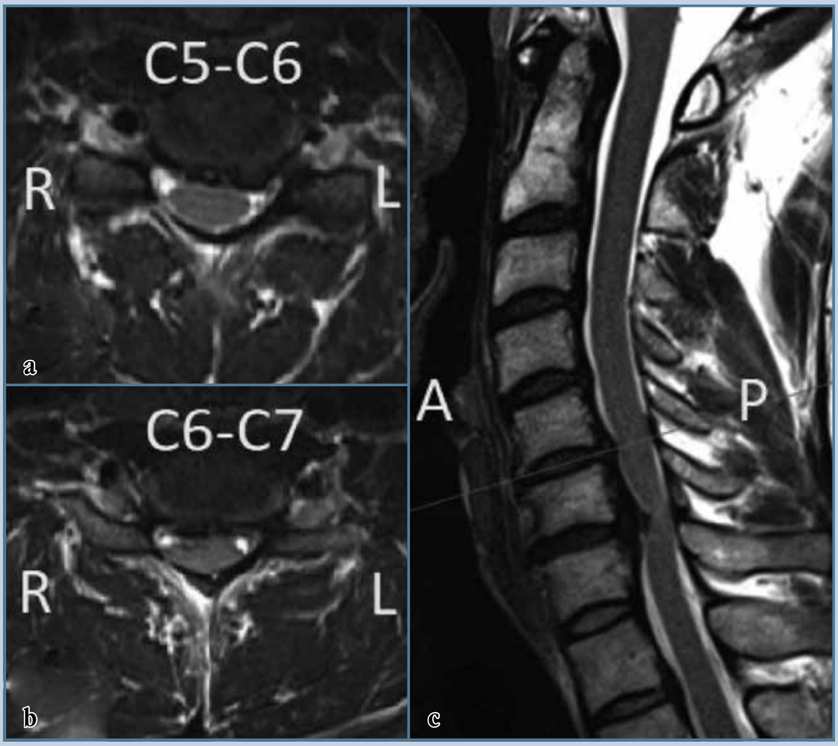

Fig. 5
MRI of the cervical spine of patient D.: **a** – axial view of the C5–C6 intervertebral disc; **b** – axial view of the C6–C7 intervertebral disc; **c** – sagittal view of the cervical spine

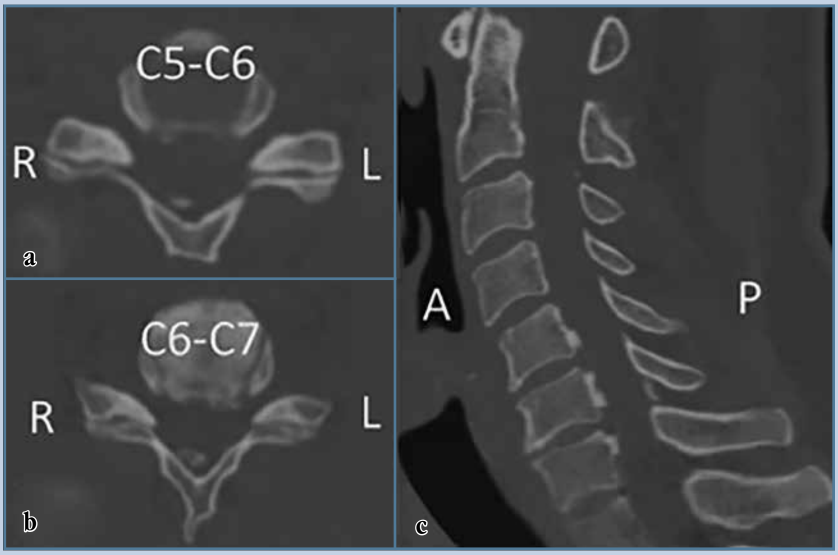

Fig. 6
CT of the cervical spine of patient D.: **a** – axial view of the C5–C6 segment; **b** – axial view of the C6–C7 segment; **c** – sagittal view of the cervical spine

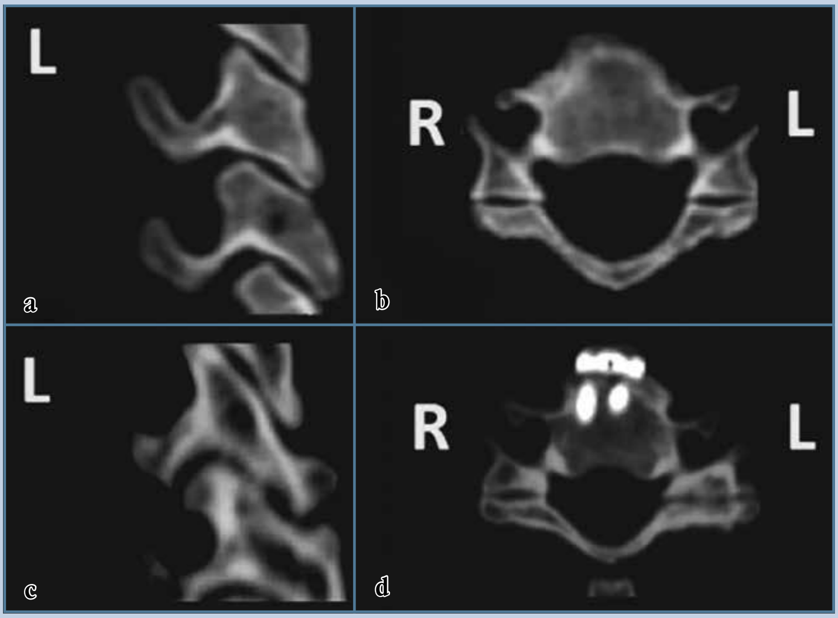

Fig. 7
Change in the grade of degeneration in the adjacent cranial facet joints in patient D. 12 months after ACDF according to CT findings: **a** – sagittal view of the left facet joint before spinal fusion; **b** – axial view before spinal fusion; **c** – axial view of the left facet joint 12 months after spinal fusion; **d** – axial view 12 months after spinal fusion

References

1. **Hilibrand AS, Robbins M.** Adjacent segment degeneration and adjacent segment disease: the consequences of spinal fusion? Spine J. 2004;4(6 Suppl):S190–S194. DOI: 10.1016/j.spinee.2004.07.007.
2. **Alhashash M, Shousha M, Boehm H.** Adjacent segment disease after cervical spine fusion: evaluation of a 70 patient long-term follow-up. Spine. 2018;43:605–609. DOI: 10.1097/BRS.0000000000002377.
3. **Chung JY, Kim SK, Jung ST, Lee KB.** Clinical adjacent-segment pathology after anterior cervical discectomy and fusion: results after a minimum of 10-year follow-up. Spine J. 2014;14:2290–2298. DOI: 10.1016/j.spinee.2014.01.027.
4. **Wu JC, Chang HK, Huang WC, Chen YC.** Risk factors of second surgery for adjacent segment disease following anterior cervical discectomy and fusion: a 16-year cohort study. Int J Surg. 2019;68:48–55. DOI: 10.1016/j.ijsu.2019.06.002.
5. **Nassr A, Lee JY, Bashir RS, Rihn JA, Eck JC, Kang JD, Lim MR.** Does incorrect level needle localization during anterior cervical discectomy and fusion lead to accelerated disc degeneration? Spine. 2009;34:189–192. DOI: 10.1097/BRS.0b013e3181913872.
6. **Chang HK, Chang CC, Tu TH, Wu JC, Huang WC, Fay LY, Chang PY, Wu CL, Cheng H.** Can segmental mobility be increased by cervical arthroplasty? Neurosurg Focus. 2017;42:E3. DOI: 10.3171/2016.10.FOCUS16411.
7. **Chang PY, Chang HK, Wu JC, Huang WC, Fay LY, Tu TH, Wu CL, Cheng H.** Is cervical disc arthroplasty good for congenital cervical stenosis? J Neurosurg Spine. 2017;26:577–585. DOI: 10.3171/2016.10.SPINE16317.
8. **Xu S, Liang Y, Zhu Z, Qian Y, Liu H.** Adjacent segment degeneration or disease after cervical total disc replacement: a meta-analysis of randomized controlled trials. J Orthop Surg Res. 2018;13:244. DOI: 10.1186/s13018-018-0940-9.
9. **Xu S, Liang Y, Meng F, Wang K, Liu H.** Radiological exploration on adjacent segments after total cervical disc replacement with Prodisc-C prosthesis. J Orthop Surg Res. 2019;14:160. DOI: 10.1186/s13018-019-1194-x.
10. **Okamoto A, Takeshima Y, Yokoyama S, Nishimura F, Nakagawa I, Park YS, Nakase H.** Prevalence and clinical impact of cervical facet joint degeneration on degenerative cervical myelopathy: a novel computed tomography classification study. Neurospine. 2022;19:393–401. DOI: 10.14245/ns.2143258.629.
11. **Lee SH, Son DW, Lee JS, Sung SK, Lee SW, Song GS.** Relationship between endplate defects, Modic change, facet joint degeneration, and disc degeneration of cervical spine. Neurospine. 2020;17:443–452. DOI: 10.14245/ns.2040076.038.
12. **Manchikanti L, Kaye AD, Soin A, Albers SL, Beall D, Latchaw RE, Sanapati MR, Sairam Atluri SS, Abd-Elsayed A, Abdi S, Aydin S, Bakshi S, Boswell MV, Buenaventura R, Cabaret J, Calodney AK, Candido KD, Christo PJ, Cintron L, Diwan S, Gharibo C, Grider J, Gupta M, Haney B, Harned ME, Ii SH, Jameson J, Jha S, Kaye AM, Knezevic NN, Kosanovic R, Manchikanti MV, Navani A, Racz G, Pampati V, Pasupuleti R, Philip C, Rajput K, Sehgal N, Sudarshan G, Vanaparthy R, Wargo BW, Hirsch JA.** Comprehensive evidence-based guidelines

for facet joint interventions in the management of chronic spinal pain: American Society of Interventional Pain Physicians (ASIPP) guidelines. Pain Physician. 2020;23(3S):S1–S127.

13. **Manchikanti L, Singh V, Falco FJ, Cash KA, Fellows B.** Comparative outcomes of a 2-year follow-up of cervical medial branch blocks in management of chronic neck pain: A randomized, double-blind controlled trial. Pain Physician. 2010;13:437–450.
14. **Sawa AGU, de Andrada Pereira B, Rodriguez-Martinez NG, Reyes PM, Kelly BP, Crawford NR.** In vitro biomechanics of human cadaveric cervical spines with mature fusion. Int J Spine Surg. 2021;15:890–898. DOI: 10.14444/8114.
15. **Dmitriev AE, Cunningham BW, Hu N, Sell G, Vigna F, McAfee PC.** Adjacent level intradiscal pressure and segmental kinematics following a cervical total disc arthroplasty: an in vitro human cadaveric model. Spine. 2005;30:1165–1172. DOI: 10.1097/01.brs.0000162441.23824.95.
16. **Helgeson MD, Bevevino AJ, Hilibrand AS.** Update on the evidence for adjacent segment degeneration and disease. Spine J. 2013;13:342–351. DOI: 10.1016/j.spinee.2012.12.009.

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