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Comparison of One-day Combined versus Staged Anterior and Posterior Cervical Decompression, Fixation, and Fusion

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ABSTRACT

AIM: To compare the perioperative outcomes between single-day combined or separate-day staged surgeries for cervical spinal stenosis.

MATERIAL and METHODS: A retrospective cohort analysis was conducted on consecutive patients admitted at a single institution between July 2015 and April 2019, who underwent either single-day combined or separate-day staged surgeries during the same hospitalization period. Demographics, comorbidities, hospital length of stay, and perioperative complications were compared between the patient groups.

RESULTS: Eighty patients (combined surgery: n=68, staged surgery: n=12) were included. Dysphagia was the most commonly reported postoperative complication in 44/80 patients (55%). There were no significant differences in the baseline demographics between the two groups. The staged surgery group had significantly longer total time in the operating room (7.2 vs. 8.5 hours, p=0.002), longer duration of general anesthesia (6.7 vs. 7.6 hours, p=0.006), and higher incidence of postoperative delirium (12.1% vs. 50% p=0.005) than the combined surgery group. The mean hospital length of stay was similar in the two groups (combined surgery: 7.5 days vs. staged surgery: 15.1 days, p=0.09).

CONCLUSION: Staged anterior and posterior cervical decompressions, stabilizations, and fusions are associated with longer total time in the operating room, longer duration of general anesthesia, and higher incidence of postoperative delirium than combined surgeries.

KEYWORDS: Cervical spine, Combined spine surgery, Staged spine surgery, Postoperative complications

ABBREVIATIONS: LoS: Length of stay, **ACDF:** Anterior cervical discectomy and fusion, **PSF:** Posterior cervical stabilization and fusion, **BMI:** Body mass index, **OR:** Operating room, **EBL:** Estimated blood loss, **SSI:** Surgical site infection

INTRODUCTION

Spinal stenosis is the abnormal narrowing of the spinal canal or neural foramen that leads to pressure on the spinal cord and nerve roots (1,25). The most common forms are cervical and lumbar spinal stenoses, whereas the much less common form is thoracic spinal stenosis (22). The etiology of cervical spinal stenosis is usually chronic degeneration, which is more commonly seen in the elderly

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population; however, it may also be congenital or traumatic (23). In North America, the incidence of cervical spondylotic myelopathy-related hospitalizations has been estimated at 4.04/100,000 person-years, and the surgical rates seem to be increasing (27). The median hospitalization for affected patients costs over $14,000 (18,24), with treatment often including surgical intervention (20,23).

Anterior or posterior cervical decompression, stabilization, and fusion can be successfully performed in most patients with cervical spinal stenosis. A certain patient population has spinal compression both anteriorly and posteriorly, and a subset of these patients requires circumferential decompression owing to complex pathology (16,19,35). This can be performed with either a staged approach, in which the first surgery addresses the anterior region and the second surgery addresses the posterior region, or a combined approach, in which both anterior and posterior procedures are performed on the same day under a single anesthesia. The patients' general condition has been reported to be an indication for staging this procedure (4,21). Although several studies have demonstrated lower postoperative complication rates and better outcomes with the combined approach than with the staged approach in thoracolumbar spine surgeries (6,28,32,37), these findings have not been validated in cervical spine surgeries. As such, whether to perform these surgeries in a single-day combined or separate-day staged fashion remains controversial (11,33).

Although cervical spine surgeries have been an active topic of research for years, there is a paucity of literature regarding the comparison of the perioperative outcomes between combined and staged surgical approaches. It is anticipated that reaching consensus in this area will likely lead to higher quality care and a reduction in healthcare costs. Thus, the aim of this study was to investigate and compare the immediate perioperative outcomes between the two surgical approaches.

MATERIAL and METHODS

Study Design

This study was approved by our Institutional Review Board (NCR191289), and a total waiver of consent was obtained. A retrospective analysis was conducted to evaluate patients undergoing anterior decompression and fusion surgery, characterized by anterior cervical discectomy and fusion (ACDF) and/or cervical corpectomy, as well as cervical posterior spinal fusion (PSF) and decompression crossing the cervico-thoracic junction, from July 2015 to April 2019. All surgeries were performed during the same hospitalization period for each patient. The decision to perform the surgeries in a combined or staged fashion was at the discretion of the primary surgeon, who performed all the surgeries. The patients in the combined surgery group underwent surgical repair via the anterior approach first, followed by the posterior approach under a single anesthesia. The patients in the staged surgery group underwent surgical repair via the anterior approach first, followed by the posterior approach on a separate day. The number of days between the staged surgeries was decided upon by the primary surgeon, depending on the patients' conditions. To best compare only the two surgical approaches and their perioperative outcomes, we excluded patients with polytrauma. The study variables were age, sex, body mass index (BMI), number of anterior and posterior levels fused, comorbidities, emergent surgery due to trauma, total time in the operating room (OR), duration of anesthesia, postoperative complications, and total hospital length of stay (LoS).

Statistical Analysis

The study variables were compared between the combined and staged surgical approaches. For categorical variables, the chi-square and Fisher's exact tests for adequate and low cell counts (≥25% of expected cell counts of ≤5) were used. For parametric continuous variables, an independent samples t-test was used for comparison. All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC). Statistical significance was set at $p<0.05$. Trends were reported when the p-value was between 0.05 and 0.1.

RESULTS

Patient Demographics

A total of 89 patients were identified, of whom nine were excluded owing to polytrauma. Eighty patients met the inclusion criteria: 24 (30%) were women, and 56 (70%) were men. The combined surgery group included 68 patients, while the staged surgery group included 12 patients. The mean patient age at the time of surgery was 61.4 (range: 33–88) years in the combined surgery group and 63.7 (range: 30–85) years in the staged surgery group (p=0.64) (Table I). The mean BMI was 27.4 (range: 19.2–37.1) kg/m^2 in the combined surgery group and 26.1 (range: 21.2–38.7) kg/m^2 in the staged surgery group (p=0.64). The mean number of anterior levels fused was 2.6 (range: 1–3) in the combined surgery group and 2.4 (range: 1–3) in the staged surgery group (p=0.49). The mean number of posterior levels fused was 6.1 (range: 2–7) in the combined surgery group and 5.8 (range: 2–7) in the staged surgery group (p=0.71). The mean number of days between surgeries was 2.2 (range: 1–5) days in the staged surgery group. No significant difference was observed with respect to comorbidities (diabetes, hypertension, and cardiovascular disease) and smoking status between the two groups (Table I). The incidence of emergent trauma was similar in the two groups (combined surgery: 25% vs. staged surgery: 16.7%, p=0.38). The most common indication for surgical intervention was degenerative disease, which was seen in 38.8% of the patients. More details on the indications in each group are provided in Table II. All patients underwent comprehensive radiographic and clinical evaluations both before (Figure 1) and after surgery (Figure 2).

Operative Outcomes

The mean total time in the OR (recorded from the time the patients entered the OR to the time they exited the OR) was significantly longer in the staged surgery group than in the combined surgery group (8.5 vs. 7.2 hours, p=0.002). The mean total duration of anesthesia (recorded from when anesthesia induction started to the time when anesthesia

Table I: Patient Characteristics: Combined Versus Staged Surgery Groups

Characteristic variable	Combined (n=68)	Staged (n=12)	p
Mean age at time of surgery (years)	61.4 (range 33-88 years)	63.7 (range 30-85 years)	0.64
Sex Male Female	 48 (70.6) 20 (29.4)	 8 (66.7) 4 (33.3)	0.68
Mean BMI	27.4 (range 19.2-37.1)	26.1 (range 21.2-38.7)	0.64
Mean number of anterior levels fused	2.6 (range 1-3)	2.4 (range 1-3)	0.49
Mean number of posterior levels fused	6.1 (range 2-7)	5.8 (range 2-7)	0.71
Diabetes	14 (20.6)	3 (25)	0.84
Hypertension	31 (45.6)	8 (66.7)	0.17
Cardiovascular Disease	26 (38.2)	5 (41.7)	0.89
Smoker	24 (35.3)	3 (25)	0.27
Emergency surgery	17 (25)	2 (16.7)	0.38

Notation in parentheses indicate the percentage for sex, diabetes, hypertension, cardiovascular disease, and emergency surgery.
***BMI:** Body mass index.*

Table II: Indications for Surgery in the Two Groups

Diagnostic indication	Combined (n=68)	Staged (n=12)	Total (n=80)
Degenerative disease	27 (39.7)	4 (33.3)	31 (38.8)
Pseudoarthrosis	4 (5.9)	1 (8.3)	5 (6.3)
Deformity	10 (14.7)	3 (25.0)	13 (16.3)
Infection	2 (2.9)	0 (0)	2 (2.5)
Malignancy	8 (11.8)	2 (16.7)	10 (12.5)
Trauma	17 (25.0)	2 (16.7)	19 (23.8)

Notation in parentheses indicate the percentage for degenerative disease, pseudoarthrosis, deformity, infection, malignancy, and trauma.

Table III: Operative Outcomes: Combined Versus Staged Surgery Groups

Outcome	Combined (n=68)	Staged (n=12)	p
Mean total OR time[1] (hours)	7.2 (range 4.3-10.5)	8.5 (range 4.5-14.3)	**0.002***
Mean total anesthesia time[2] (hours)	6.7 (range 3.6-9.8)	7.6 (range 3.8-13.7)	**0.006***
Mean EBL (mL)	350 (range 50-875)	525 (range 100-1100)	0.13

[1]Time from when the patients entered the room to the time they exited the room
[2]Time from when anesthesia induction started to the time when anesthesia administration ended
***OR:** Operating room, **EBL:** Estimated blood loss, *statistical significance.*

Figure 1: Preoperative T2-weighted sagittal magnetic resonance images of a 69-year-old woman demonstrating cervical spinal stenosis.

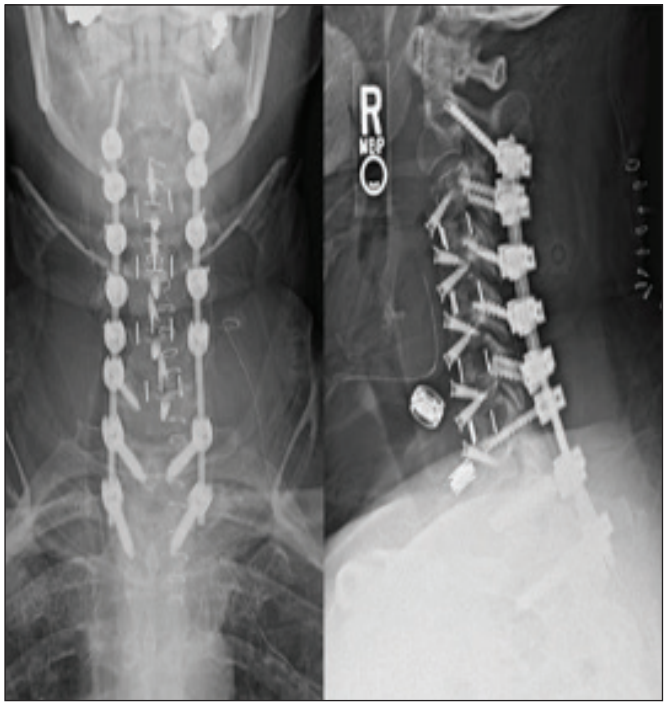

Figure 2: Postoperative anteroposterior and lateral radiographs obtained after single-day combined C3–7 ACDF, C2–T2 PSF, and C3–7 laminectomy. **ACDF:** Anterior cervical discectomy and fusion, **PSF:** Posterior cervical stabilization and fusion.

administration ended) was significantly longer in the staged surgery group than in the combined surgery group (7.6 vs. 6.7 hours, p=0.006). The mean estimated blood loss (EBL) was similar in the two groups (combined surgery: 350 mL vs. staged surgery: 525 mL, p=0.13) (Table III).

Postoperative Complications

One or more postoperative complications were recorded in 51/80 patients (63.7%). The most common postoperative complication in the entire cohort was dysphagia, which was seen in 44/80 patients (55%), with a similar incidence in the two groups (Table IV). The mean number of anterior levels fused was 2.8 (range: 1–3) in the patients with dysphagia and 2.5 (range: 1–3) in those without dysphagia, with no significant difference observed (p=0.72). The incidence of surgical site infection (SSI) was similar in the two groups (1.5% vs. 8.3%, p=0.33). The incidence of pneumonia was also similar (7.4% vs. 8.3%, p=0.90). There were no significant differences in the incidence of dysphonia and the rate of percutaneous endoscopic gastrostomy tube insertion and reintubation between the groups. However, postoperative delirium was significantly more common in the staged surgery group than in the combined surgery group (50% vs. 13.2%, p=0.005). The mean hospital LoS was 7.5 (range: 2–21) days in the combined surgery group and 15.1 (range: 4–39) days in the staged surgery group (p=0.09).

DISCUSSION

The incidence of cervical spinal stenosis and hospitalization costs associated with the disease have been increasing (18,24,27). A subset of patients with cervical spinal stenosis requires circumferential decompression in either a combined or a staged fashion (16,19,35); however, a universally accepted surgical approach is yet to be established. In this study, we compared and analyzed the perioperative outcomes between the two surgical approaches.

In this series, the mean age at the time of surgery for the entire cohort was 62.9 years, with men accounting for 70% of all patients. These findings align with previous reports in the literature, illustrating cervical myelopathy as a common condition in the elderly population (sixth or seventh decade of life), while predominantly affecting men (17,26). In a case series of 219 patients, Hukuda and Kojima noted a significantly smaller spinal canal to anteroposterior diameter of the vertebral body (canal/body ratio) in men than in women, which may explain the male sex prevalence of cervical myelopathy (13).

In our study, we observed significantly longer total time in the OR and duration of general anesthesia in the staged surgery group. Such findings not only contribute to increased healthcare costs but may also compromise the quality of care owing to increased postoperative complications. Phan et al. demonstrated in a large case series of over 3,800 patients that prolonged anesthesia is an independent risk factor for venous thromboembolism and increased hospital LoS (30). Longer duration of anesthesia has also been associated with the

Table IV: Postoperative Complications: Combined Versus Staged Surgery Groups

Outcome	Combined (n=68)	Staged (n=12)	p
SSI	1 (1.5)	1 (8.3)	0.33
Pneumonia	5 (7.4)	1 (8.3)	0.90
Dysphagia	36 (52.9)	8 (66.7)	0.50
Dysphonia	11 (16.2)	2 (16.7)	0.96
PEG tube	7 (10.3)	1 (8.3)	0.79
Reintubation	9 (13.2)	2 (16.7)	0.67
Postoperative delirium	9 (13.2)	6 (50.0)	**0.005***

Notation in parentheses indicate the percentage for SSI, pneumonia, dysphagia, dysphonia, PEG tube insertion, reintubation, and postoperative delirium.

***SSI:** Surgical site infection, **PEG:** Percutaneous endoscopic gastrostomy, *statistical significance.*

development of postoperative delirium (31), a complication that was significantly more common in the staged surgery group than in the combined surgery group in this study, and is associated with poorer patient outcomes, particularly in the elderly population (8,14).

Our study is one of the first studies to compare the perioperative complications between combined and staged surgical approaches for managing cervical spinal stenosis. In this series, one or more complications were seen in 63.7% of the patients, consistent with the report of Hart et al., in which postoperative complications were seen in 69% of patients (12). The most common complication reported in our series was dysphagia, similar to other reports in the literature (7,9,33,34,36). Although no significant difference was found between the number of fused anterior cervical levels and the incidence of dysphagia, multiple-level fusion has been previously demonstrated as a risk factor for the development of this complication (2,15). The failure to observe the aforementioned association may be attributed to the small sample size, which limited the statistical power of the study. Postoperative infections are another important complication of spine surgeries (5,29), as Harel et al. noted a significantly higher incidence of postoperative infections in their staged surgery cohort than in their combined surgery cohort (11). In a large retrospective cohort analysis of over 900,000 adults undergoing cervical fusion, Deng et al. identified postoperative infections as one of the costliest complications (5). Consistent with the study by Siemionow et al. (33), our study reported a similar incidence of SSI and pneumonia in the two groups. Meanwhile, Harel et al. reported a significantly higher incidence of postoperative infections in their staged surgery cohort than in their combined surgery cohort (staged surgery: 41.4% vs. combined surgery: 9.4%, p<0.001) (11). Selecting a surgical approach that offers the lowest incidence of infectious complications will be favorable for delivering higher quality care and reducing healthcare costs.

Hospital LoS is an important contributor to healthcare costs (10,18). Although no significant difference in hospital LoS was found between the two groups, such an association has previously been established (11,33). In a case series of 135 patients, Harel et al. reported a significantly longer LoS in their staged surgery cohort than in their combined surgery cohort (6.8 vs. 9.3 days), although such results were no longer significant in the multivariate analysis (p=0.69) (11). In a case series of 35 patients, Siemionow et al. reported a significantly longer LoS in their staged surgery cohort than in their combined surgery cohort (10 vs. 18 days, p=0.03) (33). Although our results on hospital LoS did not reach statistical significance, there was an objective trend toward an increased LoS in the staged surgery group (combined surgery: 7.5 days vs. staged surgery: 15.1 days, p=0.09). Our analysis, along with previous studies (11,33), highlights increased hospital LoS and associated costs with the staged surgical approach, without providing alternative benefits.

Our study was a retrospective chart review, which has innate limitations. In the single-center evaluation, only 80 patients were included. A non-random assignment of patients to each surgical group was performed at the discretion of the primary surgeon. In addition, there was a disproportionately higher number of patients in the combined surgery group than in the staged surgery group (68 vs. 12 patients), thus limiting the statistical power of the study. Although a significant relationship was not found between the staged surgical approach and other parameters of interest (EBL and hospital LoS), this may be attributed to the small sample size, as this relationship has been previously demonstrated in the literature (11, 33). While our patient demographics seem to be similar as shown in Table I, we did not control for other comorbidities, which have been shown to be correlated with an increased risk of complications (3). Lastly, this study focused on the immediate perioperative outcomes, and otherwise valuable data regarding long-term outcomes were beyond the scope of this study.

CONCLUSION

The perioperative analysis demonstrated that the patients who

underwent surgery via the staged approach for ACDF followed by PSF had significantly longer total time in the OR, longer total duration of general anesthesia, and higher incidence of postoperative delirium. The current healthcare system aims to reduce excess costs while providing quality care to patients. Based on our findings, staged procedures not only yield a higher incidence of postoperative complications but may also increase hospitalization costs, as they require a longer time in the OR. Such findings call for further studies to evaluate the two approaches, with a specific focus on perioperative complications. Ultimately, our findings add unique insight into the growing body of literature aimed at optimizing outcomes in patients undergoing cervical spine surgery.

AUTHORSHIP CONTRIBUTION

Study conception and design: KM, EC, NDA, MKR

Data collection: KM, EC, MAS, NDA

Analysis and interpretation of results: KM, HP, ADS, MKR

Draft manuscript preparation: KM, EC, NDA, MAS, ADS

Critical revision of the article: HP, MKR

Other (study supervision, fundings, materials, etc...): NDA

All authors (KM, EC, MAS, HP, ADS, NDA, MKR) reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Andresen AK, Ernst C, Andersen MØ: Lumbar spinal stenosis. Ugeskr Laeger 178(41):V04160245, 2016
2. Bazaz R, Lee MJ, Yoo JU: Incidence of dysphagia after anterior cervical spine surgery: A prospective study. Spine 27(22):2453-2458, 2002
3. Campbell PG, Yadla S, Nasser R, Malone J, Maltenfort MG, Ratliff JK: Patient comorbidity score predicting the incidence of perioperative complications: Assessing the impact of comorbidities on complications in spine surgery. J Neurosurg Spine 16(1):37-43, 2012
4. Colak A, Kutlay M, Kibici K, Demircan MN, Akin ON: Two-staged operation on C2 neoplastic lesions: Anterior excision and posterior stabilization. Neurosurg Rev 27(3):189-193, 2004
5. Deng H, Yue JK, Ordaz A, Rivera EJ, Suen CG, Sing DC: Cervical fusion for degenerative disease: A comprehensive cost analysis of hospital complications in the United States from 2002 to 2014. J Craniovertebral Junction Spine 9(3):140-147, 2018
6. Dick J, Boachie-Adjei O, Wilson M: One-stage versus two-stage anterior and posterior spinal reconstruction in adults. Comparison of outcomes including nutritional status, complications rates, hospital costs, and other factors. Spine 17(8 Suppl):S310-316,1992
7. Fehlings MG, Smith JS, Kopjar B, Arnold PM, Yoon ST, Vaccaro AR, Brodke DS, Janssen ME, Chapman JR, Sasso RC, Woodard EJ, Banco RJ, Massicotte EM, Dekutoski MB, Gokaslan ZL, Bono CM, Shaffrey CI: Perioperative and delayed complications associated with the surgical treatment of cervical spondylotic myelopathy based on 302 patients from the AOSpine North America Cervical Spondylotic Myelopathy Study. J Neurosurg Spine 16(5):425-432, 2012
8. Fineberg SJ, Nandyala SV, Marquez-Lara A, Oglesby M, Patel AA, Singh K: Incidence and risk factors for postoperative delirium after lumbar spine surgery. Spine 38(20):1790-1796, 2013
9. Fountas KN, Kapsalaki EZ, Nikolakakos LG, Smisson HF, Johnston KW, Grigorian AA, Lee GP, Robinson Jr JS: Anterior cervical discectomy and fusion associated complications. Spine 32(21):2310-2317, 2007
10. Guan J, Karsy M, Schmidt MH, Dailey AT, Bisson EF: Multivariable analysis of factors affecting length of stay and hospital charges after single-level corpectomy. J Clin Neurosci 44:279-283, 2017
11. Harel R, Hwang R, Fakhar M, Steinmetz MP, Novak E, Wang JC, Mroz TE: Circumferential cervical surgery: To stage or not to stage? J Spinal Disord Tech 26(4):183-188, 2013
12. Hart RA, Tatsumi RL, Hiratzka JR, Yoo JU: Perioperative complications of combined anterior and posterior cervical decompression and fusion crossing the cervico-thoracic junction. Spine 33(26):2887-2891, 2008
13. Hukuda S, Kojima Y: Sex discrepancy in the canal/body ratio of the cervical spine implicating the prevalence of cervical myelopathy in men. Spine 27(3):250-253, 2002
14. Inouye SK, Rushing JT, Foreman MD, Palmer RM, Pompei P: Does delirium contribute to poor hospital outcomes? A three-site epidemiologic study. J Gen Intern Med 13(4):234-242, 1998
15. Kalb S, Reis MT, Cowperthwaite MC, Fox DJ, Lefevre R, Theodore N, Papadopoulos SM, Sonntag VKH: Dysphagia after anterior cervical spine surgery: Incidence and risk factors. World Neurosurg 77(1):183-187, 2012
16. Kim PK, Alexander JT: Indications for circumferential surgery for cervical spondylotic myelopathy. Spine J 6 Supplement 6:S299-307, 2006
17. Kokubun S, Sato T, Ishii Y, Tanaka Y: Cervical myelopathy in the Japanese. Clin Orthop Relat Res 323:129-138, 1996
18. Liu CY, Zygourakis CC, Yoon S, Kliot T, Moriates C, Ratliff J, Dudley RA, Gonzales R, Mummaneni PV, Ames CP: Trends in utilization and cost of cervical spine surgery using the national inpatient sample database, 2001 to 2013. Spine 42(15):E906-913, 2017
19. McAfee P, Bohlman H: One-stage anterior cervical decompression and posterior stabilization with circumferential arthrodesis. A study of twenty-four patients who had a traumatic or a neoplastic lesion. J Bone Jt Surg 71(1):78-88, 1989
20. McCormick WE, Steinmetz MP, Benzel EC: Cervical spondylotic myelopathy: Make the difficult diagnosis, then refer for surgery. Cleve Clin J Med 70(10):899-904, 2003

21. Mehdian H, Weatherley C: Combined anterior and posterior resection and spinal stabilization for aneurysmal bone cyst. Eur Spine J 4(2):123-125, 1995
22. Melancia JL, Francisco AF, Antunes JL: Spinal stenosis. Handb Clin Neurol 119:541-549, 2014
23. Meyer F, Börm W, Thomé C: Degenerative cervical spinal stenosis: current strategies in diagnosis and treatment. Dtsch Arzteblatt Int 105(20):366-372, 2008
24. Missios S, Bekelis K: Hospitalization cost after spine surgery in the United States of America. J Clin Neurosci 22(10):1632-1637, 2015
25. Nancy Garrick DD: Spinal Stenosis. National Institute of Arthritis and Musculoskeletal and Skin Diseases, 2017. www.niams.nih.gov
26. Northover JR, Wild JB, Braybrooke J, Blanco J: The epidemiology of cervical spondylotic myelopathy. Skeletal Radiol 41(12):1543-1546, 2012
27. Nouri A, Tetreault L, Singh A, Karadimas SK, Fehlings MG: Degenerative cervical myelopathy: Epidemiology, genetics, and pathogenesis. Spine 40(12):E675-693, 2015
28. Ozturk C, Aydinli U, Vural R, Sehirlioglu A, Mutlu M: Simultaneous versus sequential one-stage combined anterior and posterior spinal surgery for spinal infections (outcomes and complications). Int Orthop 31(3):363-366, 2007
29. Pawar AY, Biswas SK: Postoperative spine infections. Asian Spine J 10(1):176-183, 2016
30. Phan K, Kim JS, Kim JH, Somani S, Di'Capua J, Dowdell JE, Cho SK: Anesthesia duration as an independent risk factor for early postoperative complications in adults undergoing elective ACDF. Glob Spine J 7(8):727-734, 2017
31. Shi C, Yang C, Gao R, Yuan W: Risk factors for delirium after spinal surgery: A meta-analysis. World Neurosurg 84(5):1466-1472, 2015
32. Shufflebarger HL, Grimm JO, Bui V, Thomson JD: Anterior and posterior spinal fusion. Staged versus same-day surgery. Spine 16(8):930-933, 1991
33. Siemionow K, Tyrakowski M, Patel K, Neckrysh S: Comparison of perioperative complications following staged versus one-day anterior and posterior cervical decompression and fusion crossing the cervico-thoracic junction. Neurol Neurochir Pol 48(6):403-409, 2014
34. Smith-Hammond CA, New KC, Pietrobon R, Curtis DJ, Scharver CH, Turner DA: Prospective analysis of incidence and risk factors of dysphagia in spine surgery patients: Comparison of anterior cervical, posterior cervical, and lumbar procedures. Spine 29(13):1441-1446, 2004
35. Song KJ, Lee KB: Anterior versus combined anterior and posterior fixation/fusion in the treatment of distraction-flexion injury in the lower cervical spine. J. Clin Neurosci 15(1):36-42, 2008
36. Tervonen H, Niemelä M, Lauri ER, Back L, Juvas A, Räsänen P, Roine RP, Sintonen H, Salmi T, Vilkman SE, Aaltonen LM: Dysphonia and dysphagia after anterior cervical decompression. J Neurosurg Spine 7(2):124-130, 2007
37. Viviani GR, Raducan V, Bednar DA, Grandwilewski W: Anterior and posterior spinal fusion: Comparison of one-stage and two-stage procedures. Can J Surg 36(5):468-473, 1993