



Intravenous and local steroid use in the management of dysphagia after anterior cervical spine surgery: a systematic review of prospective randomized controlled trails (RCTs)

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Abstract

Purpose To conduct a high-level systematic review of the literature to evaluate intravenous and local steroid use in the management of dysphagia after anterior cervical spine surgery.

Methods We searched the database PubMed, EMBASE, Clinical key, the Cochrane library and Wiley Online Library without time restriction using the terms ‘dysphagia’ or ‘odynophagia’ or ‘swallowing disorder,’ ‘steroid,’ ‘anterior cervical spine surgery.’ Randomized controlled trails (RCTs) were selected, and effects of intravenous and local steroids were investigated from these studies.

Results The initial search yielded 67 citations. Six of these studies met the inclusion and exclusion criteria. All of them were prospective RCTs which were evaluated as level 1 evidence. One study found that perioperative intravenous steroid use is not effective in reducing severity of early postoperative dysphagia after one-level ACDF, while five studies suggested that perioperative intravenous and local steroid use seemed to be more effective on reducing incidence and severity of early dysphagia after multilevel ACSS. One double-blinded study still found that locally administered dexamethasone on a collagen sponge significantly decreases early dysphagia incidence and severity after ACSS using low-dose BMP.

Conclusions Perioperative intravenous and local steroid use could reduce incidence and severity of early dysphagia after ACSS postoperatively, especially for multilevel surgeries. For the patients underwent revision surgery or at high risk for pseudarthrosis having to use BMP during surgery, locally administered dexamethasone on a collagen sponge was suggested to decrease early dysphagia incidence and severity after ACSS.

Graphical abstract These slides can be retrieved under Electronic Supplementary Material.

Patients (N=total)	Indications	Follow up	Complications	Conclusions

Jingwei Liu and Yiqi Zhang have contributed equally to this work, and they are the co-first authors.

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Keywords Steroid · Dysphagia · Anterior cervical spine surgery · RCT · Systematic review

Introduction

The anterior approach is commonly used to treat numerous cervical spine pathologies, such as degenerative, traumatic, inflammatory and congenital diseases. Dysphagia following anterior cervical spine surgery (ACSS) is one of the most common complications, with the reported incidence from 1.7 to 88% [1–12].

Previous studies indicated that dysphagia was more severe and easily occurred in the early stage postoperatively [1, 5, 11, 12]. And up to 26% patients got dysphagia persisting more than 1 year, which troubled them for a long time [1, 5, 13, 14].

Risk factors of dysphagia after anterior cervical spine surgery included female gender, revision surgery, prolonged operative time, multilevel fusion, use of rhBMP-2, duration of preexisting pain, cervical plate type and position, tobacco usage. Contributing factors include prevertebral soft-tissue swelling, vocal cord paresis, scar tissue formation, SLN or RLN palsy or injury of branches [4–7, 11–21].

A lot of preventative measures have been used to decrease the incidence of dysphagia after ACSS [22–34]. The use of intravenous and local steroids has been reported an effective way but still remains controversial [9, 17, 22, 35, 36]. The purpose of this review was to evaluate intravenous and local steroid use in the management of dysphagia after anterior cervical spine surgery (ACSS) by performing a systematic review of all randomized controlled trails (RCTs).

Materials and methods

We performed a medical literature search in the database PubMed, EMBASE, Clinical key, the Cochrane library and Wiley Online Library without time restriction using the terms ‘dysphagia’ or ‘odynophagia’ or ‘swallowing disorder,’ ‘steroid,’ ‘anterior cervical spine surgery’ looking for papers published in English that reported intravenous

or local steroid use in the management of dysphagia after anterior cervical spine surgery.

The search produced a total of 67 published papers. We included any prospective randomized controlled study focusing on intravenous or local steroid use in the management of dysphagia after anterior cervical spine surgery. Exclusion criteria included case reports, reviews, case series, meta-analysis, commentaries and cadaveric or experimental studies in animals. Six prospective randomized controlled studies were included in this systematic review (Table 1).

Level of evidence ratings was assigned to each article independently by two reviewers (J. L. and Y. Z.) using published guidelines [37]. The results of this literature search are summarized in the PRISMA flow diagram (Fig. 1).

Results

All the six articles [38–43] were prospective randomized controlled trails which were graded as level of evidence 1, and two of them were double-blinded studies [38, 40]. A total of 550 patients were included across all the six randomized controlled studies. A total of 194 patients were administered intravenous steroids, and 52 patients were administered local steroids, while 304 patients were served as controls. Dysphagia was measured 0–5 days post-op and 1–24 months post-op for the systemic steroid-administered patients and 0–28 days post-op for the local steroid-administered patients (Table 2). Details of study demographics of steroid-administered patients and steroids effects assessment after ACSS of the six RCT studies are summarized in Tables 3 and 4.

Intravenous steroid

Jeyamohan [38] performed a prospective randomized double-blinded controlled study of 112 patients undergoing multilevel (≥ 2 levels) anterior cervical discectomy and fusion (ACDF) to determine the effects of intravenous steroids

Table 1 Studies included in the systematic review

References	Study type	Sample size	Level of evidence	Steroid use
Perdam [43]	Randomized controlled trail	236	I	Systemic
Lee [39]	Randomized controlled trail	50	I	Local
Nam [42]	Randomized controlled trail	62	I	Systemic
Song et al. [41]	Randomized controlled trail	40	I	Systemic
Jeyamohan [38]	Randomized controlled double-blinded trail	112	I	Systemic
Edwards [40]	Randomized controlled double-blinded trail	50	I	Local

Fig. 1 PRISMA (preferred reporting items for systematic reviews) flow diagram for selection of studies based on inclusion criteria during systematic review

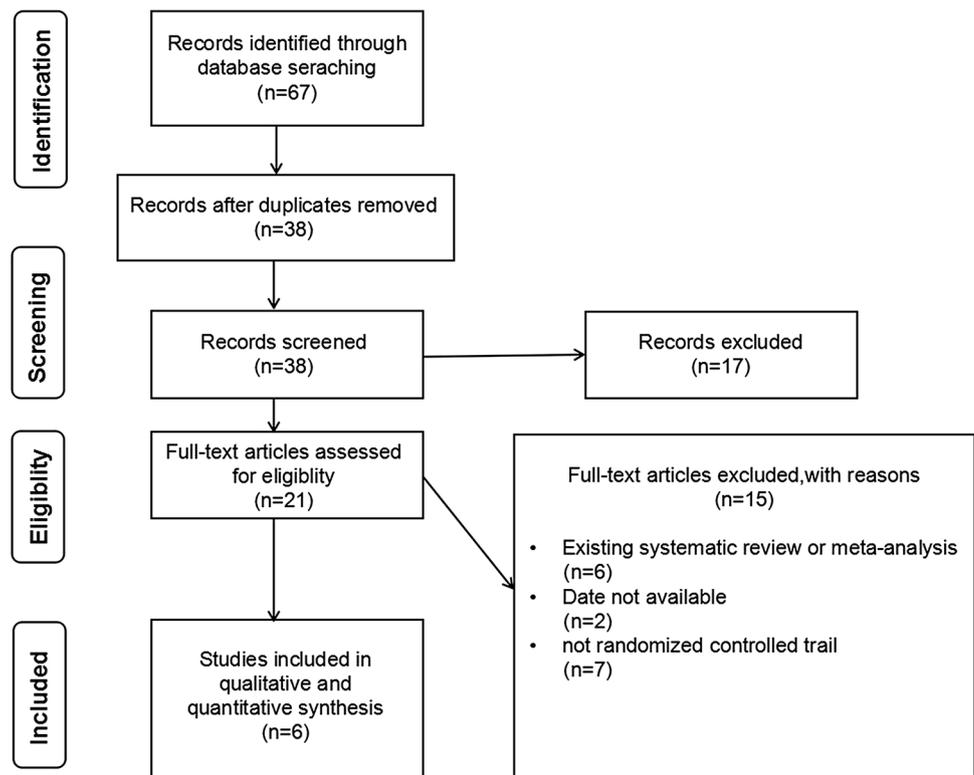


Table 2 Summary of the combined data of patients' outcomes

Patients (550 total)	Indications	Follow-up	Complications	Conclusions
Systemic steroid 194	Cervical radiculopathy myelopathy spondylosis canal stenosis disk herniation trauma	0–5 POD 1–24 m PO	Lower fusion rates at 6 months	Perioperative intravenous steroid use could reduce incidence and severity of early dysphagia after ACSS postoperatively, especially for multilevel surgeries
Local steroid 52		0–28 POD	No complications related to steroid were found	Perioperative local steroid use significantly reduces dysphagia in the early postoperative period after ACSS For the patients who have to use BMP during surgery, locally administered dexamethasone on a collagen sponge significantly decreases early dysphagia incidence and severity after ACSS

ACSS anterior cervical spine surgery, PO postoperative, POD postoperative day

(dexamethasone) on improving perioperative dysphagia. The right-sided approach of Smith-Robinson technique was used, and Thompson-Farley static (self-retaining) retractor was applied in every case of cervical spondylosis by the senior surgeon D.J.D. The patients and investigators were blinded, and patients were randomized into two groups. The intervention group received intravenous dexamethasone in a dose of 0.2 mg/kg intraoperatively and followed by four doses of 0.06 mg/kg every 6 h in the first day postoperatively. Dysphagia was measured by the functional outcome swallowing

scale (FOSS), and patients were followed-up at 1, 3, 6, 12 and 24 months postoperatively. They observed that swallowing function and length of hospital stay were significantly better in the dexamethasone group at 1 month postoperatively but no difference in long-term follow-up. They also found that 7 of the patients in the control group compared to only 1 patient in the steroid group got severe dysphagia which needed further treatment. The authors observed lower fusion rates in the steroid group patients at 6 months, while the difference disappeared at 12- and 24-month follow-up.

Table 3 Summarized data of demographics of patients receiving steroid after ACSS

References	Surgery		Steroid administration				Follow-up		
	Type	Indication	Exclusion	Control group	Intervention group	Frequency		Dose	Equivalent ^a
Perdam [43]	One to five levels ACSS	Cervical canal stenosis, herniated disk, trauma	N/A	N/A 158 patients	IV methylprednisolone 78 patients	0 h, 12 h, 24 h, PO	1 mg/kg	0.19 mg/kg	24–36 h, PO
Lee [39]	One- or two-level ACDF	Cervical radiculopathy, myelopathy	≥ 3 segments, revision surgery, corpectomy, tumor, trauma, infection, metabolic diseases	N/A 25 patients	RP triamcinolone 25 patients	IO	40 mg	7.5 mg	0, 2, 4 POD; 2 w PO
Nam [42]	One-level ACDF	Cervical radiculopathy	≥ 2-level ACDF, myelopathic disease, cervical trauma, corpectomy, traffic accidents, and workers' compensation	NS 22 patients	IV dexamethasone 20 patients, high dose; 20 patients, low dose	0 h, 24 h, 48 h, PO	High dose 20/10/10 mg Low dose 10/5/5 mg	High dose 20/10/10 mg Low dose 10/5/5 mg	0–5 POD
Song et al. [41]	3–4-level ACDF	Cervical radiculopathy, myelopathy	Trauma or any other situation that could cause soft-tissue swelling Gastrointestinal (GI) problems, diabetes mellitus (DM) history received steroids	N/A 20 patients	IV methylprednisolone 20 patients	0 h, 6 h, 12 h, 18 h, 24 h, PO	250 mg	46.88 mg	1-discharge POD
Jeyamohan [38]	≥ 2 levels ACSS	Cervical spondylosis	Age < 18 years, pregnancy chronic pre-op steroid use, coma or incapacitation, unable to provide consent, allergy to dexamethasone or related drugs	NS 56 patients	IV dexamethasone 56 patients	IO; 6 h, 12 h, 18 h, 24 h, PO	0.2 mg/kg IO, 0.06 mg/kg PO	0.2 mg/kg IO, 0.06 mg/kg PO	1 m, 3 m, 6 m, 12 m, 24 m PO

Table 3 (continued)

References	Surgery		Steroid administration				Follow-up		
	Type	Indication	Exclusion	Control group	Intervention group	Frequency		Dose	Equivalent ^a
Edwards [40]	1–3-level ACDF	Cervical spondylosis	Non-degenerative pathology, age < 18 years or > 70 years, combined surgery	NS 23 patients	RP methylprednisolone 27 patients	IO	40 mg	7.5 mg	1, 4, 7, 14, 28 POD

ACSS anterior cervical spine surgery, ACDF anterior cervical discectomy and fusion, 0 h immediately postoperatively, NS normal saline, IO intraoperative, IV intravenous, m month, PO postoperative, POD postoperative day, RP retropharyngeal; w: week
Equivalent^a: Dose equivalents relative to dexamethasone

Table 4 Summarized data of assessment of dysphagia and outcomes of the studies

References	Assessment of dysphagia	Results	Conclusion
Perdam [43]	Nasofibrosopic ENT examination	56 patients (71.8%) treated with steroid had dysphagia, odynophagia or impaired swallowing compared to 130 (82.3%) patients in the controlled group postoperatively	Perioperative intravenous steroid use could reduce incidence of early dysphagia after ACSS postoperatively
Lee [39]	VAS for odynophagia	Mean VAS for odynophagia in the steroid group was significantly better than that in the control group immediately, 4 days and 2 weeks post-op	Perioperative local steroid use significantly reduces dysphagia in the early postoperative period after ACDF
Nam [42]	VAS for dysphagia	No significant difference between controlled group and high-dose, low-dose steroid-administered group as to VAS for dysphagia	Perioperative intravenous steroid use is not effective in reducing severity of early postoperative dysphagia
Song et al. [41]	Bazaz dysphagia score	Steroid group had improved Bazaz dysphagia score than the control group during POD 2–5	Short-term perioperative intravenous steroid use was effective in reducing dysphagia after ACDF
Jeyamohan [38]	FOSS	FOSS score was significantly better in the steroid group at 1 month postoperatively	Perioperative intravenous steroid use improved swallowing function significantly in the early postoperative period of multilevel ACSS
Edwards [40]	Modified Dysphagia Scoring System	Average modified dysphagia scores are significantly different between the steroid and placebo group at 4, 7, 14 and 28 postoperative days	Perioperative local steroid use significantly decreases incidence and severity of early dysphagia after ACSS using low-dose rhBMP-2

ACSS anterior cervical spine surgery, ACDF anterior cervical discectomy and fusion, VAS visual analogue scale, FOSS functional outcome swallowing scale

Perdam [43] conducted a prospective controlled study of 236 patients undergoing 1–5 levels ACSS to determine the effect of methylprednisolone. Right-sided approaches were performed, and Cloward retractor was used in all cases by 11 surgeons. The treated group received intravenous methylprednisolone in a dose of 1 mg/kg at the end of operation, 12 and 24 h postoperatively. Swallowing function was assessed by the nasofibrosopic ENT examination preoperatively and 24–36 h postoperatively. They found that 56 patients (71.8%) treated with steroid had dysphagia, odynophagia or impaired swallowing compared to 130 (82.3%) patients in the controlled group postoperatively. The authors concluded that perioperative intravenous steroid use could reduce incidence of early dysphagia after ACSS postoperatively.

Song et al. [41] performed a prospective randomized controlled study of 40 patients undergoing 3–4-level ACDF to investigate the role of short-term methylprednisolone use in decreasing dysphagia and prevertebral soft-tissue swelling (PSTS). The left-sided approach of Smith-Robinson technique was performed for all the patients by the same surgeon K-JS. Methylprednisolone was given in a dose of 250 mg intravenously at the end of surgery and followed by the same dose every 6 h for the first 24 h postoperatively. Dysphagia was evaluated with Bazaz dysphagia score from the postoperative day (POD) 1 to the day of discharge. They observed that steroid group had improved Bazaz dysphagia score than the control group during POD 2–5.

Nam [42] performed a prospective randomized controlled study of 62 consecutive patients undergoing one-level ACDF to investigate the effect of intravenous dexamethasone on reducing PSTS at 0, 24 and 48 h postoperatively. The left-sided Smith-Robinson approach was used, and patients were randomly divided into 3 groups: Group 1 was administered 10/5/5 mg of dexamethasone, group 2 was administered 10/5/5 mg of dexamethasone, and group 3 was administered normal saline. Dysphagia was evaluated with VAS score at POD 0–5. They observed no significant difference between controlled group and high-dose, low-dose steroid-administered group as to VAS for dysphagia.

Local steroid

Lee [39] performed a prospective randomized study of 50 patients undergoing one- or two-level ACDF to determine the role of local retropharyngeal steroid in decreasing PSTS. The right-sided Smith-Robinson approach was conducted, and 40 mg triamcinolone was administered with a morcellized collagen sponge to the retropharyngeal space before wound closure. Swallowing function was evaluated with VAS score immediately after surgery and at 2 days, 4 days and 2 weeks postoperatively. The authors found that the mean VAS for odynophagia in the steroid group was significantly better than that in the control group immediately,

4 days and 2 weeks postoperatively. They also observed that PSTS was also lower in the triamcinolone group at any followed-up time point. They concluded that perioperative local steroid use significantly reduces dysphagia in the early postoperative period after ACDF.

Edwards [40] performed a prospective randomized placebo-controlled double-blind study to determine whether the local administration of depomedrol decreases the incidence and severity of dysphagia after ACSS using BMP. All the 50 patients underwent one-, two- and three-level left-sided Smith-Robinson ACDF procedure and were randomized into to 2 groups. Interbody fusion was carried out using 0.35 cc (0.5 mg) of BMP-2 per level for all patients, and a 1 × 3 cm collagen sponge was saturated with either saline (1 cc) or depomedrol (40 mg/1 cc) based on their randomization protocol (27 patients received depomedrol and 23 patients received saline). Modified Dysphagia Scoring System was used to evaluate the swallowing functions of the patients. They found that the depomedrol-group patients experienced reduced dysphagia incidence and severity on postoperative days 4, 7, 14 and 28 ($P < 0.05$). This study provides level 1 evidence that locally administered depomedrol on a collagen sponge which significantly decreases early dysphagia incidence and severity after ACSS using low-dose BMP.

Discussion

The purpose of this study was to evaluate intravenous and local steroid use in the management of dysphagia after ACSS. For all the six randomized controlled studies, only Nam [42] found that perioperative intravenous steroid use is not effective in reducing severity of early postoperative dysphagia after one-level ACDF. The perioperative intravenous and local steroid use seemed to be more effective on reducing incidence and severity of early dysphagia after multilevel ACSS.

There is evidence that the use of bone morphogenetic protein (BMP) can increase the severity and incidence of postoperative dysphagia after ACSS [25–27, 44]. Vaidya [45] suggested that spine surgeons should avoid routine use of BMP except for patients who underwent revision surgery or at high risk for pseudarthrosis. For the patients who have to use BMP during surgery, Edwards [40] suggested that locally administered depomedrol on a collagen sponge could decrease the incidence and severity of early dysphagia.

Suk [35] reported the natural change of PSTS in the early postoperative period. PSTS was increased continuously from the second day and reached a plateau on the third day postoperatively and decreased gradually at the fourth day after surgery. Shi [17] and Riley [9] all found that PSTS was relating to dysphagia after ACDF in their retrospective studies. PSTS was one of the significant risk factors of

dysphagia after ACSS. Song et al. [41] and Lee [39] found that prevertebral soft-tissue swelling as well as postoperative dysphagia reduced significantly with steroid administration during ACSS, especially for multilevel procedures. The role of steroids on preventing dysphagia may result from reducing PSTS in the early postoperative period.

Jeyamohan [38] and Song et al. [41] found that the average length of hospital stay was shorter in the steroid group. The improved symptoms of dysphagia incidence and severity in the steroid group transferred to significantly shorter length of hospital stay.

Although lower fusion rates in the treated groups at 6 months was found in the study of Jeyamohan [38], it disappeared at long-term follow-up and did not affect the functional and pain outcome at any time point. Use of steroid did not affect the long-term fusion rates and patients' outcomes. The result was similar to the finding of Lee [39] in which all the patients were in good fusion by the last follow-up. No other steroid-related complications were found in the studies.

Moreover, craniovertebral junction (CVJ) anterior procedures can also lead to 'dysphagia' or 'odynophagia' or 'swallowing disturbances.' Visocchi et al. [46] performed a non-systematic review to investigate anatomic fundamentals and clinical results of endoscopic-assisted surgery to CVJ. Dysphagia was found in the transcervical approach. Visocchi et al. [47] and Visocchi et al. [48] did not find dysphagia or dysphonia in their studies related to video-assisted or endoscope-assisted microsurgical transoral approach to the anterior CVJ, which suggested that the transoral approach still remains the gold standard as Visocchi et al. [46] concluded in their review study. Genovese et al. [49] gave us many details about anesthesiological and intensive care management in CVJ, which could help us to prevent dysphagia after CVJ anterior procedures.

Limitations and future directions

No study compared the effect between intravenous and local steroid use, and every study had its own dose and administration of the steroid. We did not get information of the optimal dose, administration and the specific contraindications for use.

Different evaluating methods were used to observe dysphagia in the six studies which may result in different outcomes of the patients.

Large patients studies were needed, and future studies of steroids use should further define the optimal dose, route of administration and the specific contraindications for use.

We focused on the prospective randomized controlled trails and missed a wider discussion about the possible

complications related to administering steroids, particularly intravenously in some other studies.

Conclusions

Perioperative intravenous and local steroid use could reduce incidence and severity of early dysphagia after ACSS postoperatively, especially for multilevel surgeries. For the patients underwent revision surgery or at high risk for pseudarthrosis having to use BMP during surgery, locally administered dexamethasone on a collagen sponge was suggested to decrease early dysphagia incidence and severity after ACSS.

Compliance with ethical standards

Conflict of interest We do not have a financial or personal relationship with a third party. On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

- Liu JM (2017) The incidences and risk factors related to early dysphagia after anterior cervical spine surgery: a prospective study. *PLoS ONE* 12(3):e0173364
- Yang Y (2016) A meta-analysis of the incidence of patient-reported dysphagia after anterior cervical decompression and fusion with the zero-profile implant system. *Dysphagia* 31(2):134–145
- Joaquim AF (2014) Dysphagia after anterior cervical spine surgery: a systematic review of potential preventative measures. *Spine J* 14(9):2246–2260
- Anderson KK, Arnold PM (2013) Oropharyngeal dysphagia after anterior cervical spine surgery: a review. *Glob Spine J* 3(4):273–286
- Zeng JH, Zhong ZM, Chen JT (2013) Early dysphagia complicating anterior cervical spine surgery: incidence and risk factors. *Arch Orthop Trauma Surg* 133(8):1067–1071
- Danto J (2012) Multiple cervical levels: increased risk of dysphagia and dysphonia during anterior cervical discectomy. *J Neurosurg Anesthesiol* 24(4):350–355
- Cho SK, Lu Y, Lee DH (2013) Dysphagia following anterior cervical spinal surgery: a systematic review. *Bone Joint J* 95-b(7):868–873
- Rihn JA (2011) What is the incidence and severity of dysphagia after anterior cervical surgery? *Clin Orthop Relat Res* 469(3):658–665
- Riley LH (2010) Postoperative dysphagia in anterior cervical spine surgery. *Spine (Phila Pa 1976)* 35(9 Suppl):S76–S85
- Kasimatis GB (2009) Complications of anterior surgery in cervical spine trauma: an overview. *Clin Neurol Neurosurg* 111(1):18–27
- Singh K (2013) Incidence and risk factors for dysphagia after anterior cervical fusion. *Spine (Phila Pa 1976)* 38(21):1820–1825
- Kalb S (2012) Dysphagia after anterior cervical spine surgery: incidence and risk factors. *World Neurosurg* 77(1):183–187
- Olsson EC, Jobson M, Lim MR (2015) Risk factors for persistent dysphagia after anterior cervical spine surgery. *Orthopedics* 38(4):e319–e323

14. Lee MJ, Bazaz R, Furey CG, Yoo J (2007) Risk factors for dysphagia after anterior cervical spine surgery: a two-year prospective cohort study. *Spine J* 7(2):141–147
15. Carucci LR, Turner MA, Yeatman CF (2015) Dysphagia secondary to anterior cervical fusion: radiologic evaluation and findings in 74 patients. *AJR Am J Roentgenol* 204(4):768–775
16. Chen CJ (2013) Dysphagia following combined anterior-posterior cervical spine surgeries. *J Neurosurg Spine* 19(3):279–287
17. Shi S (2016) Risk factors for dysphagia after single-level anterior cervical decompression with arthroplasty or fusion: a prospective study comparing 2 zero-profile implants. *World Neurosurg* 95:148–155
18. Tian W, Yu J (2017) The role of C2–C7 angle in the development of dysphagia after anterior and posterior cervical spine surgery. *Clin Spine Surg* 30(9):E1306–E1314
19. Mehra S, Heineman TE, Cammisa FP (2014) Factors predictive of voice and swallowing outcomes after anterior approaches to the cervical spine. *Otolaryngol Head Neck Surg* 150(2):259–265
20. Wu B, Song F, Zhu S (2016) Reasons of dysphagia after operation of anterior cervical decompression and fusion. *Clin Spine Surg* 78(F2):250–258
21. Netterville JL, Koriwchak MJ, Winkle M (1996) Vocal fold paralysis following the anterior approach to the cervical spine. *Ann Otol Rhinol Laryngol* 105(2):85–91
22. Kang SS (2014) The association between psychiatric factors and the development of chronic dysphagia after anterior cervical spine surgery. *Eur Spine J* 23(8):1694–1698
23. Chen Z (2012) Tracheal traction exercise reduces the occurrence of postoperative dysphagia after anterior cervical spine surgery. *Spine (Phila Pa 1976)* 37(15):1292–1296
24. Ratnaraj J (2002) Effects of decreasing endotracheal tube cuff pressures during neck retraction for anterior cervical spine surgery. *J Neurosurg* 97(2 Suppl):176–179
25. Burkus JK (2016) Clinical and radiographic outcomes in patients undergoing single-level anterior cervical arthrodesis: a prospective trial comparing allograft to a reduced dose of rhBMP-2. *Clin Spine Surg* 30(9):E1321–E1332
26. Cole T (2014) Usage of recombinant human bone morphogenetic protein in cervical spine procedures: analysis of the MarketScan longitudinal database. *J Bone Joint Surg Am* 96(17):1409–1416
27. Jain A (2014) rhBMP use in cervical spine surgery: associated factors and in-hospital complications. *J Bone Joint Surg Am* 96(8):617–623
28. Liu Y (2016) Comparison of a zero-profile anchored spacer (ROI-C) and the polyetheretherketone (PEEK) cages with an anterior plate in anterior cervical discectomy and fusion for multilevel cervical spondylotic myelopathy. *Eur Spine J* 25(6):1881–1890
29. Yin M (2016) The new Zero-P implant can effectively reduce the risk of postoperative dysphagia and complications compared with the traditional anterior cage and plate: a systematic review and meta-analysis. *BMC Musculoskelet Disord* 17(1):430
30. Xiao S (2016) Zero-profile anchored cage reduces risk of postoperative dysphagia compared with cage with plate fixation after anterior cervical discectomy and fusion. *Eur Spine J* 26(4):975–984
31. Lee MJ (2005) Influence of anterior cervical plate design on dysphagia: a 2-year prospective longitudinal follow-up study. *J Spinal Disord Tech* 18(5):406–409
32. Pattavilakom A, Seex KA (2011) Results of a prospective randomized study comparing a novel retractor with a Caspar retractor in anterior cervical surgery. *Neurosurgery* 69(2 Suppl Operative):ons156–ons160 (**discussion ons160**)
33. Tian W, Yu J (2016) The role of C2–C7 angle in the development of dysphagia after anterior and posterior cervical spine surgery. *Clin Spine Surg* 28(2):131–138
34. Siska PA (2011) Dysphagia after anterior cervical spine surgery: a prospective study using the swallowing-quality of life questionnaire and analysis of patient comorbidities. *Spine (Phila Pa 1976)* 36(17):1387–1391
35. Suk KS (2006) Prevertebral soft tissue swelling after anterior cervical discectomy and fusion with plate fixation. *Int Orthop* 30(4):290–294
36. Kepler CK, Rihn JA, Bennett JD (2012) Dysphagia and soft tissue swelling after anterior cervical surgery: a radiographic analysis. *Spine J* 12(8):639–644
37. Wright JG, Swiontkowski MF, Heckman JD (2003) Introducing levels of evidence to the journal. *J Bone Joint Surg* 85:1–3
38. Jeyamohan SB (2015) Effect of steroid use in anterior cervical discectomy and fusion: a randomized controlled trial. *J Neurosurg Spine* 23(2):137–143
39. Lee SH (2011) Effect of retropharyngeal steroid on prevertebral soft tissue swelling following anterior cervical discectomy and fusion: a prospective, randomized study. *Spine (Phila Pa 1976)* 36(26):2286–2292
40. Edwards CC (2016) Can dysphagia following anterior cervical fusions with rhBMP-2 be reduced with local dexamethasone application?: A prospective, randomized, placebo-controlled, double-blind trial. *Spine (Phila Pa 1976)* 41(7):555–562
41. Song KJ, Lee SK, Ko JH (2014) The clinical efficacy of short-term steroid treatment in multilevel anterior cervical arthrodesis. *Spine J* 14(12):2954–2958
42. Nam TW (2013) Effect of intravenous dexamethasone on prevertebral soft tissue swelling after anterior cervical discectomy and fusion. *Acta Orthop Belg* 79(2):211–215
43. Pedram M (2003) Pharyngolaryngeal lesions in patients undergoing cervical spine surgery through the anterior approach: contribution of methylprednisolone. *Eur Spine J* 12(1):84–90
44. Lu DC, Tumialan LM, Chou D (2013) Multilevel anterior cervical discectomy and fusion with and without rhBMP-2: a comparison of dysphagia rates and outcomes in 150 patients. *J Neurosurg Spine* 18(1):43–49
45. Vaidya R (2007) Complications of anterior cervical discectomy and fusion using recombinant human bone morphogenetic protein-2. *Eur Spine J* 16(8):1257–1265
46. Visocchi M, Della Pepa GM, Doglietto F, Esposito G, La Rocca G, Massimi L (2011) Video-assisted microsurgical transoral approach to the craniocervical junction: personal experience in childhood. *Childs Nerv Syst* 27(5):825–831
47. Visocchi M, Doglietto F, Della Pepa GM, Esposito G, La Rocca G, Di Rocco C, Maira G, Fernandez E (2011) Endoscope-assisted microsurgical transoral approach to the anterior craniocervical junction compressive pathologies. *Eur Spine J* 20(9):1518–1525
48. Visocchi M, Di Martino A, Maugeri R, González Valcárcel I, Grasso V, Paludetti G (2015) Videoassisted anterior surgical approaches to the craniocervical junction: rationale and clinical results. *Eur Spine J* 24(12):2713–2723
49. Genovese O, Tosi F, Piastra M, Chiaretti A, Conti G, Di Rocco C, Visocchi M (2014) Anaesthesiological and intensive care management in craniocervical junction surgery. *Adv Tech Stand Neurosurg* 40:171–197

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