World Journal of Orthopedics

Submit a Manuscript: http://www.f6publishing.com

World J Orthop 2017 October 18; 8(10): 770-776

DOI: 10.5312/wjo.v8.i10.770

ISSN 2218-5836 (online)

ORIGINAL ARTICLE

Retrospective Cohort Study

Soft tissue swelling incidence using demineralized bone matrix in the outpatient setting

Kingsley R Chin, Fabio JR Pencle, Jason A Seale, Juan M Valdivia

Kingsley R Chin, Charles E. Schmidt College of Medicine at Florida Atlantic University, Boca Raton, FL 33431, United States

Kingsley R Chin, Jason A Seale, Juan M Valdivia, Less Exposure Surgery Specialists Institute, Fort Lauderdale, FL 33311, United States

Kingsley R Chin, Herbert Wertheim College of Medicine at Florida International University, Miami, FL 33199, United States

Fabio JR Pencle, Jason A Seale, Juan M Valdivia, Less Exposure Surgery Society, Malden, MA 02148, United States

Author contributions: All authors contributed with drafting writing and final revision of manuscript; Pencle FJR performed statistical analysis; Valdivia JM provided independent assessment of pre and post op radiographs; Chin KR performed supervision and important critical revision.

Institutional review board statement: IRB approval was granted for patients involved in study from George Washington University as part of a cohort of patients who had anterior cervical surgery.

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: We did not seek or receive any funding from the National Institutes of Health (NIH), Wellcome Trust, Howard Hughes Medical Institute (HHMI), or others for this work. Chin KR is a shareholder in and receives other benefits from SpineFrontier Inc.; none of the other authors (Pencle FJR, Valdivia JM and Seale JA) have any potential conflicts of interest to declare for this work.

Data sharing statement: This dataset available from the corresponding author at Dryad repository, who will provide a permanent, citable and open-access home for the dataset.

Manuscript source: Unsolicited manuscript

Correspondence to: Fabio JR Pencle, Research Fellow, Less Exposure Surgery Society, 350 Main Street, Malden, MA 02148, United States. fabiopencle@thelessinstitute.com
Telephone: +1-954-6406010
Fax: +1-855-4114647

Received: February 21, 2017
Peer-review started: February 26, 2017
First decision: July 10, 2017
Revised: July 28, 2017
Accepted: August 15, 2017
Article in press: August 16, 2017
Published online: October 18, 2017

Abstract

AIM

To assess use of demineralized bone matrix (DBM) use in anterior cervical discectomy and fusion (ACDF) in outpatient setting.

METHODS

One hundred and forty-five patients with prospectively collected data undergoing single and two level ACDF with DBM packed within and anterior to polyetheretherketone (PEEK) cages. Two groups created, Group 1 (75) outpatients and control Group 2 (70) hospital patients. Prevertebral soft tissue swelling (PVSTS) was measured anterior to C2 and C6 on plain lateral cervical radiographs preoperatively and one week postoperatively and fusion assessed at two years.

RESULTS

There was no intergroup significance between preoperative and postoperative visual analogue scales (VAS)

and neck disability index (NDI) scores between Group 1 and 2. Mean preoperative PVSTS in Group 1 was 4.7 ± 0.2 mm at C2 level and 11.1 ± 0.5 at C6 level compared to Group 2 mean PVSTS of 4.5 ± 0.5 mm and 12.8 ± 0.5, P = 0.172 and 0.127 respectively. There was no radiographic or clinical evidence of adverse reaction noted. In Group 1 mean postoperative PVSTS was 5.5 ± 0.4 mm at C2 and 14.9 ± 0.6 mm at C6 compared Group 2 mean PVSTS was 4.9 ± 0.3 mm at C2 and 14.8 ± 0.5 mm at C6, P = 0.212 and 0.946 respectively. No significant increase in prevertebral soft tissue space at C2 and C6 level demonstrated.

CONCLUSION

ACDF with adjunct DBM packed PEEK cages showed a statistical significant intragroup improvement in VAS neck pain scores and NDI scores (P = 0.001). There were no reported serious patient complications; post-operative radiographs demonstrated no significant difference in prevertebral space. We conclude that ACDF with DBM-packed PEEK cages can be safely done in an ASC with satisfactory outcomes.

Key words: Ambulatory surgery center; Anterior cervical discectomy and fusion; Demineralized bone matrix; Less Exposure Surgery; Packed polyetheretherketone cages

Core tip: This manuscript scientifically assesses prevertebral swelling with the use of demineralized bone matrix (DBM) anterior to cervical cage. The use of clinical and radiographic outcomes demonstrates the safety of DBM in the outpatient setting. There are no studies showing safety or outcomes of DBM anterior to the cage and directly exposed to the pre vertebral soft tissues therefore we wanted to document this study.

Chin KR, Pencle FJR, Seale JA, Valdivia JM. Soft tissue swelling incidence using demineralized bone matrix in the outpatient setting. *World J Orthop* 2017; 8(10): 770-776 Available from: URL: http://www.wjgnet.com/2218-5836/full/v8/i10/770.htm DOI: http://dx.doi.org/10.5312/wjo.v8.i10.770

INTRODUCTION

Instrumented anterior cervical discectomy and fusion (ACDF) introduced in 1952[1] has remained the gold standard in the treatment of cervical spondylosis. Complications ranging from relatively minor and transient dysphagia, hoarseness, post-operative neck pain and wound infection to potentially catastrophic hematoma and airway compromise, vertebral artery and neurologic injury as well as esophageal perforation[2] have reduced over the years. This can be attributed to better technology and less exposure surgery techniques.

The outcome of ACDF is based on adequate decompression and osseous radiographic fusion[3,4]. Autogenous bone grafts have demonstrated high fusion rates however; the immediate and long-term morbidity associated with iliac crest harvest is well recognized[5-7]. The use of demineralized bone matrix (DBM) to aid in fusion has been demonstrated to be safe and effective[8-10]. A review conducted by Aghdashi *et al*[9], DBM has similar outcome to autogenous bone graft[11]. Studies also revealed good outcomes compared to recombinant bone morphogenic proteins (rh-BMP)[12]. Rh-BMP has been shown to cause life threatening airway edema and compromise[13-15].

Several studies over recent years have looked at the feasibility of ACDF being done on an outpatient basis with promising results and low complication rates[2,16-18]. Additionally, there are studies which have found that it is clinically safe to use DBM during ACDF within cages in a hospital setting[4,11,19]. A study by Suk *et al*[20] demonstrated peak onset of prevertebral soft tissue swelling (PVSTS) at 3 d post op. There were no studies assessing prevertebral soft tissue swelling and DBM in the outpatient setting found. The authors aim to demonstrate the safety of DBM in the outpatient setting.

MATERIALS AND METHODS

This was a non-randomized, single-center, prospective study of a total of 145 patients. We reviewed the charts retrospectively of 75 consecutive patients who single and two-level instrumented ACDF in the ASC (Outpatient ACDF), in which polyetheretherketone (PEEK) cages (Arena-C®, SpineFrontier Inc. Malden, MA, United States) with DBM (DBM pure®, SpineFrontier Inc., Malden, MA, United States) packed within and anterior to the cage and assigned them to Group 1. Fusion was reinforced with an anterior cervical plate (Inset®, SpineFrontier Inc. Malden, MA, United States). Our control group, Group 2 included 70 patients who had single and two levels ACDF in the hospital setting (Inpatient ACDF), all implants and DBM was from the same company and design. IRB approval was granted for patients involved in study as part of a cohort of patients who had anterior cervical surgery.

Operations were performed by a single surgeon, who was experienced in performing procedures in academic and private hospitals, prior to commencing in an outpatient setting. Patients were only considered for surgery after failed conservative management for at least six weeks. Indications for surgery included but not limited to patients with cervical degenerative disc degeneration (DDD) and herniated nucleus pulposus. Decision on type of surgery was based on severity of pathology. Exclusion criteria for surgery included acute severe trauma, fractures, malignancy, infection, unstable chronic medical illnesses, prior anterior cervical fusions and BMI > 42[21-23]. All patients were assessed preoperatively and narcotics were recommended to be discontinued

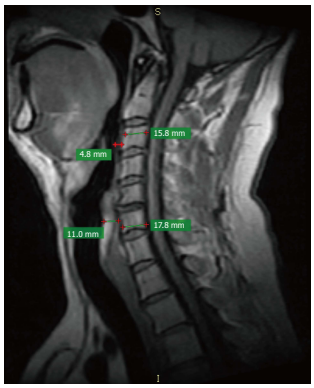

Figure 1 Preoperative radiograph showing retropharyngeal/prevertebral soft tissue at the level of C2 vertebral body and at the level of C6 vertebral body.

in patients with chronic use[24]. Patients with chronic but stable medical conditions, including hypertension, diabetes mellitus, asthma, hypercholesterolemia and heart disease were medically cleared by their family practitioner and/or cardiologist where applicable. All preoperative radiographs were reviewed by the chief surgeon, as well as two additional researchers, to rule out pre-existing abnormal widening of the prevertebral soft tissue space. This was standardized by ensuring that the prevertebral soft tissue space (PVSTS) at the level of C2 was less than 50% of the C2 vertebral body and at the level of C6 measurements were approximately less than 22 mm or the prevertebral measurement should not be greater than the width of the vertebral body of C6[25] (Figure 1). Post-operative radiographs were assessed at one week, 3 mo and at the end of follow up. Prevertebral soft tissue space (PVSTS) was compared between pre-op and 1 wk post-op films[20,26,27].

Surgical technique

Signed consent was obtained for the procedure and under general anesthesia; patients were prepped and draped under sterile conditions. Surgical exposure of the desired vertebral level was achieved through a midline anterior cervical incision. Following discectomy, the posterior longitudinal ligament was retained *in situ*[28] and the appropriately sized PEEK cage was inserted. DBM was packed within and anterior to the cage prior to an anterior cervical plate (ACP) being placed (Figure 2). The smallest sized ACP was placed, hemostasis confirmed and a Penrose drain was placed in all patients for wound drainage for 24 h to prevent postoperative hematoma development at home.

Discharge and follow up

Outpatients were discharged within hours of completing surgery after being deemed oriented and neurologically intact by the anesthesiologist and operating surgeon[22,23]. Outpatient postoperative instructions were discussed with patients and caregivers with written copies provided. An assigned member of the outpatient team was responsible for educating patients prior to consent on the risks and benefits of outpatient ACDF, as well as potential complications such as transient to persistent dysphagia, postoperative hematoma, infection and soft tissue edema with possible airway compromise. A team member called patients postoperatively on the night of surgery as well as the following morning to ensure a normal and comfortable postoperative recovery period, as well as to identify any evolving complications, which may require hospital admission. In the event of a complication, a prearranged agreement with a nearby local hospital was established before surgery. Patient reported outcomes included visual analogue scales (VAS) for neck pain, neck disability index (NDI) score and Nurick grade for those with myelopathy. Clinical outcomes were assessed based on the presence of soft tissue swelling and airway compromise. Postoperative potential DBM-related side effects were assessed clinically in all patients by palpating for soft tissue edema or swelling along the medial aspect of the sternocleidomastoid muscle. Postoperative radiological assessment was conducted with the use of anteroposterior (AP) and lateral plain radiographs looking for soft tissue emphysema, airway narrowing, tracheal deviation and PVSTS measurement in the first week postoperatively[25-27]. Evidence of interbody fusion was assessed by radiographs at the patient's final follow up. Follow up visits occurred within the first week, one month, three months, six months, twelve months and at final two year follow up. Additional postoperative complications were also recorded.

Statistical analysis

Statistical analysis was performed using SPSS v22 (IBM corporation, New York, United States). An independent sample student *T*-test was used to compare groups for continuous data and χ^2 used for categorical data. Continuous data comparisons were expressed as means with standard error. Tests were considered significant if $P < 0.05$.

RESULTS

Comparing group 1 (75 patients outpatient ACDF) to group 2 (70 patients inpatient ACDF) no statistical differences in age, BMI and gender were found between groups, $P = 0.591$, 0.484 and 0.631 respectively. Demographics and initial diagnosis are illustrated in Table 1.

There was no significance between preoperative VAS and NDI scores between Group 1 and 2, $P = 0.75$, $P = 0.289$ respectively as shown in Table 2. After two years follow up intragroup significant improvement was demonstrated in both groups for VAS and NDI scores demonstrated in Table 2. Statistical comparison of postoperative outcomes between Group 1 and 2 shows no statistical difference in VAS and NDI scores $P = 0.62$, $P = 0.34$ respectively (Table 2). The surgical operative time in Group 1 was 92 ± 15 min as compared to Group 2 which was 140 ± 3 min. This difference of 48 min did

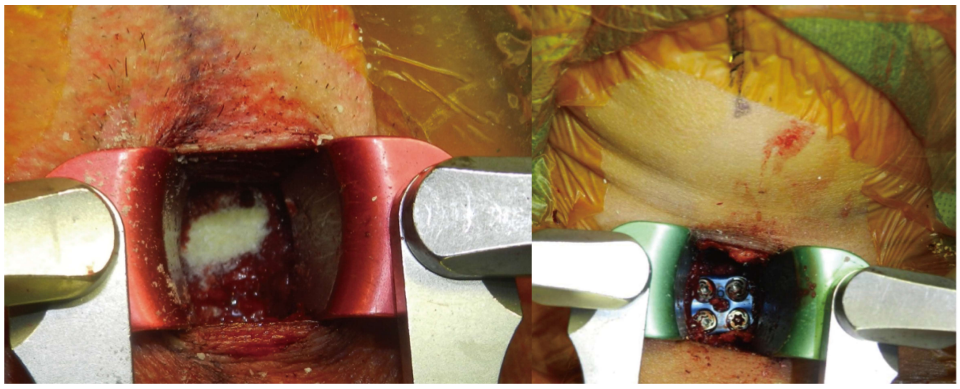

Figure 2 Photograph showing demineralized bone matrix packed within cage after insertion into disc space and anterior cervical discectomy and fusion plate.

Table 1 Cohort demographics with chief complaint

Variable	ACDF + DBM outpatient	ACDF + DBM inpatient	*P* value
Sample size (*n*)	75	70	
Age (yr)	53 ± 1.0	53.4 ± 1.6	0.591
BMI (kg/m^2)	27.9 ± 0.8	25.4 ± 1.0	0.484
Male	33	34	0.631
Female	42	36	
Diagnosis			
Herniated disc	28	23	
Degenerative disc disease	26	24	
Spondylosis (chronic pain)	7	12	
Myelopathy	3	4	
Radiculopathy	11	7	

ACDF: Anterior cervical discectomy and fusion; DBM: Demineralized bone matrix; BMI: Body mass index.

Table 2 Showing preoperative and postoperative visual analogue scales and neck disability index scores

	Preoperative VAS	Postoperative VAS	Intragroup *P* value	Preoperative NDI	Postoperative NDI	Intragroup *P* value
Group 1	7.4 ± 0.2	4.0 ± 0.2	0.001	46.9 ± 1.9	26.1 ± 1.2	0.001
Group 2	8.9 ± 1.5	5.3 ± 0.3	0.03	46.2 ± 2.6	33.4 ± 2.4	0.002
Intergroup *P* value	0.75	0.62		0.289	0.34	

VAS: Visual analogue scales; NDI: Neck disability index.

achieve statistical significance, $P = 0.001$. Estimated blood loss of 42 ± 6 mL in group 1 compared to 77 ± 9 mL in Group 2 showed no intergroup significance, $P = 0.131$.

Preoperative dimensions of airway diameter were all within normal limits[29]. No intergroup significance demonstrated (Table 3) preoperatively at C2 and C6, $P = 0.172$ and 0.127 respectively. None of our patients complained of difficulty breathing within the first 24 h postoperatively. There was no radiographic[30] or clinical evidence of adverse reaction in the patients who had ACDF to DBM (airway edema or neck swelling) within the first week postoperatively, Figure 3. Postoperative PVSTS dimension increased in both groups; however this was not a significant intragroup increase or intergroup difference as shown in Table 3. Additionally, all our patients achieved solid bony fusion[31] as evidenced by clinical and radiological (confirmed by report from independent radiologist) by the final follow up visit.

Three patients (4%) in Group 1 diagnosed with myelopathy without radiculopathy had a preoperative Nurick grade of 2, 1 and 1 respectively, which improved to 1 and 0 for the first two patients and remained unchanged for the third patient by the final follow up visit.

During the study period from 2011-2014, no major complications were reported in our series and there were no unplanned postoperative admissions for pain, nausea or any other complaints, all complaints are listed in Table 4. The main postoperative complaint of postoperative dysphagia was defined as any discomfort or difficulty with swallowing which was not historically present prior to surgery[32]. The severity was assessed using the Bazaz-Yoo dysphagia severity scale

Table 3 Showing preoperative and postoperative prevertebral soft tissue swelling at C2 and C6 vertebrae

	C2 preop PVSTS (mm)	C2 postop PVSTS (mm)	C2 intragroup *P* value	C6 preop PVSTS (mm)	C6 postop PVSTS (mm)	C6 intragroup *P* value
Group 1	4.7 ± 0.2	5.5 ± 0.4	0.08	11.1 ± 0.5	14.9 ± 0.6	0.285
Group 2	4.5 ± 0.5	4.9 ± 0.3	0.107	12.8 ± 0.5	14.8 ± 0.5	0.873
Intergroup *P* value	0.172	0.212		0.127	0.946	

PVSTS: Prevertebral soft tissue swelling.

Table 4 Demonstrating complications after surgery in each group

Complication	Outpatient	Inpatient
Dysphagia	4	5
Visited ER (not admitted)	3	0
Pain not relieved by TTH medications	2	0
Dressing completely soaked	1	0
Intractable pain	0	1

TTH: To take home.

of mild, moderate and severe, over the initial 3 mo postoperative period[33].

DISCUSSION

The authors aimed to demonstrate the safety of the use of DBM within and anterior to an ACDF PEEK cage in the outpatient setting. This study shows significant improvement in postoperative outcomes in both groups; however no intergroup significance was noted. Analysis of postoperative PVSTS demonstrated no clinical or statistically significant intragroup increase as well as no significant difference between groups.

The literature has copious studies endorsing ACDF as the gold standard treatment for failed conservative management of numerous cervical pathologies[34-37]. More recently, patients and spine surgeons are turning their attention toward the potential benefits of ACDF in an ambulatory surgery center, based on promising results of preliminary reports[2,16,17,38]. While the feasibility and safety of outpatient ACDF has been established for up to three cervical levels[39], there is a lack of consensus regarding the safety of DBM in the anterior cervical spine as an adjunct to fusion. Studies have looked at the effectiveness, safety of its use in a hospital setting[4,11,19] as well as normal prevertebral soft tissue swelling post ACDF[30]; however, the paucity of data on the clinical outcomes of DBM use during ACDF in an ASC, prompted the authors to report the results of a single-center local experience.

In this series there were no adverse graft related complications noted. There was no clinical or radiologic evidence of edema one week post-operative and therefore no further evaluation for this finding performed beyond this point. The creation of DBM involves a process of allograft bone acid extraction[40] which exposes type Ⅰ collagen, growth factors and BMPs. Although lacking in structural integrity, DBM contains osteoconductive agents, which render it a viable alternative biologic agent for bony fusion. This study has demonstrated the effective use of DBM within and anterior to PEEK cages therefore, the authors conclude that the exposed BMPs within DBM is not significant in concentration to cause a clinical or radiographic response.

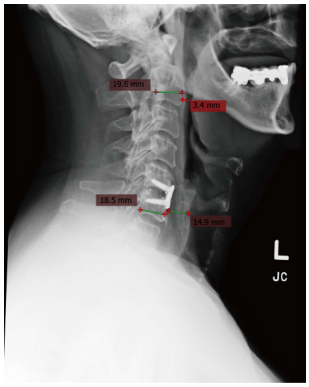

Figure 3 Plain lateral radiograph of the cervical spine, taken one week postoperatively, which shows the normal dimensions of the prevertebral space being less than 50% of the vertebral body at C2 and less than the body width of C6 respectively.

The adherence to our local, standardized outpatient criteria[21-23], comprehensive patient education and postoperative protocol were instrumental in providing self-assurance to both patients and the surgeon when proceeding with this operation[4,11,19]. Included in all preoperative counseling and consent sessions, were the potential risks for postoperative dysphagia, airway irritation and soft tissue swelling. Additional comfort was added by calling our patients the night of, and the morning after surgery in order to act in a timely manner should any complications occur, requiring immediate admission to hospital, which is always within 30 min of the patients' location.

As the literature expands on the safety and effectiveness of anterior cervical fusions in ambulatory surgery centers, this paper reinforces the conclusion that it is safe, with excellent patient satisfaction. The authors do acknowledge the limitations of this study: Its retrospective nature and the lack of CT scan to assess post-op soft tissue swelling. However, despite these limitations, we are confident that adherence to our strict patient selection criteria, preoperative education, consistent operating team, and systematic postoperative protocol can safely produce excellent outcomes. Our findings show that the

use of DBM within and anterior to cervical PEEK cages in the outpatient setting is safe with similar outcomes in the inpatient setting.

ACDF with adjunct DBM packed PEEK cages showed a statistical significant intragroup improvement in VAS neck pain scores and NDI scores. There were no reported serious patient complications; post-operative radiographs demonstrated no statistically significant difference in prevertebral space. We conclude that ACDF with DBM-packed PEEK cages can be safely done in an ASC with satisfactory outcomes.

COMMENTS

Background

Demineralized bone matrix (DBM) has been demonstrated to be safe in the hospital setting; however concerns may be heightened with use anterior to the cage in the outpatient setting. The authors hypothesize that clinical outcomes and safety should be similar or improved in the outpatient setting.

Research frontiers

Outpatient spine surgery continues to evolve with the introduction of minimally invasive and less exposure surgery. This study adds to the body of knowledge for outpatient surgery.

Innovations and breakthroughs

Based on literature no other study has assessed clinically DBM being placed anterior to the cage as well as within the cages looking specifically at soft tissue swelling.

Applications

This study demonstrates the safety of DBM being used anterior to polyetheretherketone interbody cage with no additional complications.

Terminology

Standard terminology used throughout text.

Peer-review

It is a well written paper.

REFERENCES

1 **Bailey RW**, Badgley CE. Stabilization of the cervical spine by anterior fusion. *J Bone Joint Surg Am* 1960; **42-A**: 565-594 [PMID: 13848906 DOI: 10.2106/00004623-196042040-00001]

2 **Erickson M**, Fites BS, Thieken MT, McGee AW. Outpatient anterior cervical discectomy and fusion. *Am J Orthop* (Belle Mead NJ) 2007; **36**: 429-432 [PMID: 17849028]

3 **Lied B**, Roenning PA, Sundseth J, Helseth E. Anterior cervical discectomy with fusion in patients with cervical disc degeneration: a prospective outcome study of 258 patients (181 fused with autologous bone graft and 77 fused with a PEEK cage). *BMC Surg* 2010; **10**: 10 [PMID: 20302673 DOI: 10.1186/1471-2482-10-10]

4 **Park HW**, Lee JK, Moon SJ, Seo SK, Lee JH, Kim SH. The efficacy of the synthetic interbody cage and Grafton for anterior cervical fusion. *Spine* (Phila Pa 1976) 2009; **34**: E591-E595 [PMID: 19644317 DOI: 10.1097/BRS.0b013e3181ab8b9a]

5 **Silber JS**, Anderson DG, Daffner SD, Brislin BT, Leland JM, Hilibrand AS, Vaccaro AR, Albert TJ. Donor site morbidity after anterior iliac crest bone harvest for single-level anterior cervical discectomy and fusion. *Spine* (Phila Pa 1976) 2003; **28**: 134-139 [PMID: 12544929 DOI: 10.1097/00007632-200301150-00008]

6 **Summers BN**, Eisenstein SM. Donor site pain from the ilium. A complication of lumbar spine fusion. *J Bone Joint Surg Br* 1989; **71**: 677-680 [PMID: 2768321]

7 **Castro FP Jr**, Holt RT, Majd M, Whitecloud TS 3rd. A cost analysis of two anterior cervical fusion procedures. *J Spinal Disord* 2000; **13**: 511-514 [PMID: 11132982 DOI: 10.1097/00002517-200012000-00008]

8 **Tilkeridis K**, Touzopoulos P, Ververidis A, Christodoulou S, Kazakos K, Drosos GI. Use of demineralized bone matrix in spinal fusion. *World J Orthop* 2014; **5**: 30-37 [PMID: 24649412 DOI: 10.5312/wjo.v5.i1.30]

9 **Aghdasi B**, Montgomery SR, Daubs MD, Wang JC. A review of demineralized bone matrices for spinal fusion: the evidence for efficacy. *Surgeon* 2013; **11**: 39-48 [PMID: 23040457 DOI: 10.1016/j.surge.2012.08.001]

10 **Bruce C**, Chin KR, Cumming V, Crawford NR. Stabilizing Effects of a Particulate Demineralized Bone Matrix in the L4 Interbody Space with and without PEEK Cage - A Literature Review and Preliminary Results of a Cadaveric Biomechanical Study. *West Indian Med J* 2013; **62**: 748-751 [PMID: 25014862]

11 **An HS**, Simpson JM, Glover JM, Stephany J. Comparison between allograft plus demineralized bone matrix versus autograft in anterior cervical fusion. A prospective multicenter study. *Spine* (Phila Pa 1976) 1995; **20**: 2211-2216 [PMID: 8545714 DOI: 10.1097/00007632-199510001-00006]

12 **Vaidya R**, Carp J, Sethi A, Bartol S, Craig J, Les CM. Complications of anterior cervical discectomy and fusion using recombinant human bone morphogenetic protein-2. *Eur Spine J* 2007; **16**: 1257-1265 [PMID: 17387522]

13 **Carragee EJ**, Hurwitz EL, Weiner BK. A critical review of recombinant human bone morphogenetic protein-2 trials in spinal surgery: emerging safety concerns and lessons learned. *Spine J* 2011; **11**: 471-491 [PMID: 21729796 DOI: 10.1016/j.spinee.2011.04.023]

14 **Lebl DR**. Bone morphogenetic protein in complex cervical spine surgery: A safe biologic adjunct? *World J Orthop* 2013; **4**: 53-57 [PMID: 23610751 DOI: 10.5312/wjo.v4.i2.53]

15 **Mroz TE**, Wang JC, Hashimoto R, Norvell DC. Complications related to osteobiologics use in spine surgery: a systematic review. *Spine* (Phila Pa 1976) 2010; **35**: S86-104 [PMID: 20407355 DOI: 10.1097/BRS.0b013e3181d81ef2]

16 **Garringer SM**, Sasso RC. Safety of anterior cervical discectomy and fusion performed as outpatient surgery. *J Spinal Disord Tech* 2010; **23**: 439-443 [PMID: 20087224 DOI: 10.1097/BSD.0b013e3181bd0419]

17 **Lied B**, Rønning PA, Halvorsen CM, Ekseth K, Helseth E. Outpatient anterior cervical discectomy and fusion for cervical disk disease: a prospective consecutive series of 96 patients. *Acta Neurol Scand* 2013; **127**: 31-37 [PMID: 22571345 DOI: 10.1111/j.1600-0404.2012.01674.x]

18 **Liu JT**, Briner RP, Friedman JA. Comparison of inpatient vs. outpatient anterior cervical discectomy and fusion: a retrospective case series. *BMC Surg* 2009; **9**: 3 [PMID: 19265540 DOI: 10.1186/1471-2482-9-3]

19 **Topuz K**, Colak A, Kaya S, Simşek H, Kutlay M, Demircan MN, Velioğlu M. Two-level contiguous cervical disc disease treated with peek cages packed with demineralized bone matrix: results of 3-year follow-up. *Eur Spine J* 2009; **18**: 238-243 [PMID: 19130094]

20 **Suk KS**, Kim KT, Lee SH, Park SW. Prevertebral soft tissue swelling after anterior cervical discectomy and fusion with plate fixation. *Int Orthop* 2006; **30**: 290-294 [PMID: 16521012 DOI: 10.1007/s00264-005-0072-9]

21 **Chin KR**, Coombs AV, Seale JA. Feasibility and patient-reported outcomes after outpatient single-level instrumented posterior lumbar interbody fusion in a surgery center: preliminary results in 16 patients. *Spine* (Phila Pa 1976) 2015; **40**: E36-E42 [PMID: 25271488 DOI: 10.1097/BRS.0000000000000604]

22 **Chin KR**, Pencle FJ, Coombs AV, Packer CF, Hothem EA, Seale JA. Eligibility of Outpatient Spine Surgery Candidates in a Single Private Practice. *Clin Spine Surg* 2016; Epub ahead of print [PMID: 26992175]

23 **Chin KR**, Pencle FJR, Seale JA, Pencle FK. Clinical Outcomes of Outpatient Cervical Total Disc Replacement Compared With Outpatient Anterior Cervical Discectomy and Fusion. *Spine* (Phila Pa

1976) 2017; **42**: E567-E574 [PMID: 27755491]
24 **Lawrence JT**, London N, Bohlman HH, Chin KR. Preoperative narcotic use as a predictor of clinical outcome: results following anterior cervical arthrodesis. *Spine* (Phila Pa 1976) 2008; **33**: 2074-2078 [PMID: 18758363 DOI: 10.1097/BRS.0b013e3181809f07]
25 **Song KJ**, Choi BW, Kim HY, Jeon TS, Chang H. Efficacy of postoperative radiograph for evaluating the prevertebral soft tissue swelling after anterior cervical discectomy and fusion. *Clin Orthop Surg* 2012; **4**: 77-82 [PMID: 22379559 DOI: 10.4055/cios.2012.4.1.77]
26 **Kepler CK**, Rihn JA, Bennett JD, Anderson DG, Vaccaro AR, Albert TJ, Hilibrand AS. Dysphagia and soft-tissue swelling after anterior cervical surgery: a radiographic analysis. *Spine J* 2012; **12**: 639-644 [PMID: 22561176 DOI: 10.1016/j.spinee.2012.03.024]
27 **Khaki F**, Zusman NL, Nemecek AN, Ching AC, Hart RA, Yoo JU. Postoperative prevertebral soft tissue swelling does not affect the development of chronic dysphagia following anterior cervical spine surgery. *Spine* (Phila Pa 1976) 2013; **38**: E528-E532 [PMID: 23380821 DOI: 10.1097/BRS.0b013e31828a2992]
28 **Chin KR**, Ghiselli G, Cumming V, Furey CG, Yoo JU, Emery SE. Postoperative magnetic resonance imaging assessment for potential compressive effects of retained posterior longitudinal ligament after anterior cervical fusions: a cross-sectional study. *Spine* (Phila Pa 1976) 2013; **38**: 253-256 [PMID: 23104194 DOI: 10.1097/BRS.0b013e3182796e9c]
29 **Dai LY**, Jia LS. Radiographic measurement of the prevertebral soft tissue of cervical vertebrae. *Chin Med J* (Engl) 1994; **107**: 471-473 [PMID: 7956490]
30 **Sanfilippo JA Jr**, Lim MR, Jacoby SM, Laterra R, Harrop JS, Vaccaro AR, Hilibrand AS, Anderson DG, Albert TJ. "Normal" prevertebral soft tissue swelling following elective anterior cervical decompression and fusion. *J Spinal Disord Tech* 2006; **19**: 399-401 [PMID: 16891973 DOI: 10.1097/00024720-200608000-00004]
31 **Rhee JM**, Chapman JR, Norvell DC, Smith J, Sherry NA, Riew KD. Radiological Determination of Postoperative Cervical Fusion: A Systematic Review. *Spine* (Phila Pa 1976) 2015; **40**: 974-991 [PMID: 25893344 DOI: 10.1097/BRS.0000000000000940]
32 **Webster-Kerr KR**, Christie C, Grant A, Chin D, Burrowes H, Clarke K, Wellington I, Shaw K, De La Haye W. Emergence of Zika Virus Epidemic and the National Response in Jamaica. *West Indian Med J* 2016; **65**: 243-249 [PMID: 28375542]
33 **Bazaz R**, Lee MJ, Yoo JU. Incidence of dysphagia after anterior cervical spine surgery: a prospective study. *Spine* (Phila Pa 1976) 2002; **27**: 2453-2458 [PMID: 12435974 DOI: 10.1097/00007632-200211150-00007]
34 **Hacker RJ**. A randomized prospective study of an anterior cervical interbody fusion device with a minimum of 2 years of follow-up results. *J Neurosurg* 2000; **93**: 222-226 [PMID: 11012052 DOI: 10.3171/spi.2000.93.2.0222]
35 **Martin GJ Jr**, Haid RW Jr, MacMillan M, Rodts GE Jr, Berkman R. Anterior cervical discectomy with freeze-dried fibula allograft. Overview of 317 cases and literature review. *Spine* (Phila Pa 1976) 1999; **24**: 852-858; discussion 858-859 [PMID: 10327505 DOI: 10.1097/00007632-199905010-00004]
36 **Daentzer D**, Floerkemeier T, Bartsch I, Masalha W, Welke B, Hurschler C, Kauth T, Kaltbeitzel D, Hopmann C, Kujat B, Kalla K. Preliminary results in anterior cervical discectomy and fusion with an experimental bioabsorbable cage - clinical and radiological findings in an ovine animal model. *Springerplus* 2013; **2**: 418 [PMID: 24024102 DOI: 10.1186/2193-1801-2-418]
37 **Korinth MC**. Treatment of cervical degenerative disc disease - current status and trends. *Zentralbl Neurochir* 2008; **69**: 113-124 [PMID: 18666050 DOI: 10.1055/s-2008-1081201]
38 **Sheperd CS**, Young WF. Instrumented outpatient anterior cervical discectomy and fusion: is it safe? *Int Surg* 2012; **97**: 86-89 [PMID: 23102004 DOI: 10.9738/CC35.1]
39 **Villavicencio AT**, Pushchak E, Burneikiene S, Thramann JJ. The safety of instrumented outpatient anterior cervical discectomy and fusion. *Spine J* 2007; **7**: 148-153 [PMID: 17321962 DOI: 10.1016/j.spinee.2006.04.009]
40 **Miyazaki M**, Tsumura H, Wang JC, Alanay A. An update on bone substitutes for spinal fusion. *Eur Spine J* 2009; **18**: 783-799 [PMID: 19280232]

P- Reviewer: Dye DC, Korovessis P, Lykissas MG, Sancheti P
S- Editor: Ji FF **L- Editor**: A **E- Editor**: Lu YJ

Published by **Baishideng Publishing Group Inc**
7901 Stoneridge Drive, Suite 501, Pleasanton, CA 94588, USA
Telephone: +1-925-223-8242
Fax: +1-925-223-8243
E-mail: bpgoffice@wjgnet.com
Help Desk: http://www.f6publishing.com/helpdesk
http://www.wjgnet.com