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## Abstract

**Study Design:** Multi-institutional retrospective case series of 8887 patients who underwent anterior cervical spine surgery.

**Objective:** Anterior decompression from discectomy or corpectomy is not without risk. Surgical morbidity ranges from 9% to 20% and is likely underreported. Little is known of the incidence and effects of rare complications on functional outcomes following anterior spinal surgery. In this retrospective review, we examined implant extrusions (IEs) following anterior cervical fusion.

**Methods:** A retrospective multicenter case series study involving 21 high-volume surgical centers from the AOSpine North America Clinical Research Network. Medical records for 17 625 patients who received cervical spine surgery (levels from C2 to C7) between January 1, 2005, and December 31, 2011, were reviewed to identify occurrence of 21 predefined treatment complications.

**Results:** Following anterior cervical fusion, the incidence of IE ranged from 0.0% to 0.8% across 21 institutions with 11 cases reported. All surgeries involved multiple levels, and 7/11 (64%) involved either multilevel corpectomies or hybrid constructs with at least one adjacent discectomy to a corpectomy. In 7/11 (64%) patients, constructs ended with reconstruction or stabilization at C7. Nine patients required surgery for repair and stabilization following IE. Average length of hospital stay after IE was 5.2 days. Only 2 (18%) had residual deficits after reoperation.

**Conclusions:** IE is a very rare complication after anterior cervical spine surgery often requiring revision. Constructs requiring multilevel reconstruction, especially at the cervicothoracic junction, have a higher risk for failure, and surgeons should proceed with caution in using an anterior-only approach in these demanding cases. Surgeons can expect most patients to regain function after reoperation.

## Keywords

implant extrusion, anterior cervical spine, ACDF, ACCF, corpectomy, discectomy

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## Introduction

Anteriorly directed decompression and arthrodesis can be achieved with a broad variety of techniques from simple discectomy and interspace replacement with autograft or allograft to corpectomy and anterior column reconstruction with internal fixation and grafting. Advancements in instrumentation and interspace grafting have resulted in improved success and safety of these procedures. The broad indications for anterior cervical spine surgery vary across clinical presentations from degenerative disease, neoplasm, infection, trauma, and iatrogenic, but always include restoring stability to a structurally compromised spine, prevent progression of neurologic symptoms or deformity, and to alleviate pain. The evolution of interbody fusion techniques for arthrodesis is ongoing, and little data exist regarding the rare and potentially catastrophic complication of acute graft extrusion. In this article, we performed a multi-institutional retrospective case series of nearly 9000 cases to isolate instances of acute implant extrusion (IE). We hoped to elucidate any significant trends in these select instances, review technical considerations for avoidance, and highlight functional outcomes after these events.

## Methods

We conducted a retrospective multicenter case series study involving 21 high-volume surgical centers from the AOSpine North America Clinical Research Network, selected for their excellence in spine care and clinical research infrastructure and experience. Medical records for 17 625 patients who received anterior or posterior cervical spine surgery (levels from C2 to C7) between January 1, 2005, and December 31, 2011, were reviewed to identify occurrence of 21 predefined treatment complications occurring within 30 days from the index surgery. One hundred and thirty-nine rare complications were identified including re-intubation requiring evacuation, esophageal perforation, epidural hematoma, C5 palsy, recurrent laryngeal nerve palsy, superior laryngeal nerve palsy, hypoglossal or glossopharyngeal nerve palsy, dural tear, brachial plexopathy, blindness, implant extrusion, misplaced screws requiring re-operation, anterior cervical infection, carotid artery injury or cerebrovascular accident, vertebral artery injuries, Horner's syndrome, thoracic duct injury, quadriplegia, intraoperative death, revision of arthroplasty, and pseudomeningocele. Trained research staff at each site abstracted the data from medical records, surgical charts, radiology imaging, narratives, and other source documents for the patients who experienced one or more of the complications from the list. Implant extrusion was defined as movement of the implant anteriorly or posteriorly on imaging and symptoms of intractable neck pain or new neurologic deficits after anterior cervical spine surgery. Cases of isolated posterior cervical surgery were excluded from our data analysis, yielding 8887 patients to include in our study. Data were transcribed into study-specific paper case report forms (CRF). Copies of CRF forms were transferred to the AOSpine North America Clinical Research Network Methodological Core for processing,

cleaning, and data entry. Descriptive statistics were provided for baseline patient characteristics. Paired *t* test, with statistical significance of  $P < .05$ , was used to analyze changes in clinical outcomes at follow-up compared to preoperative status.

## Results

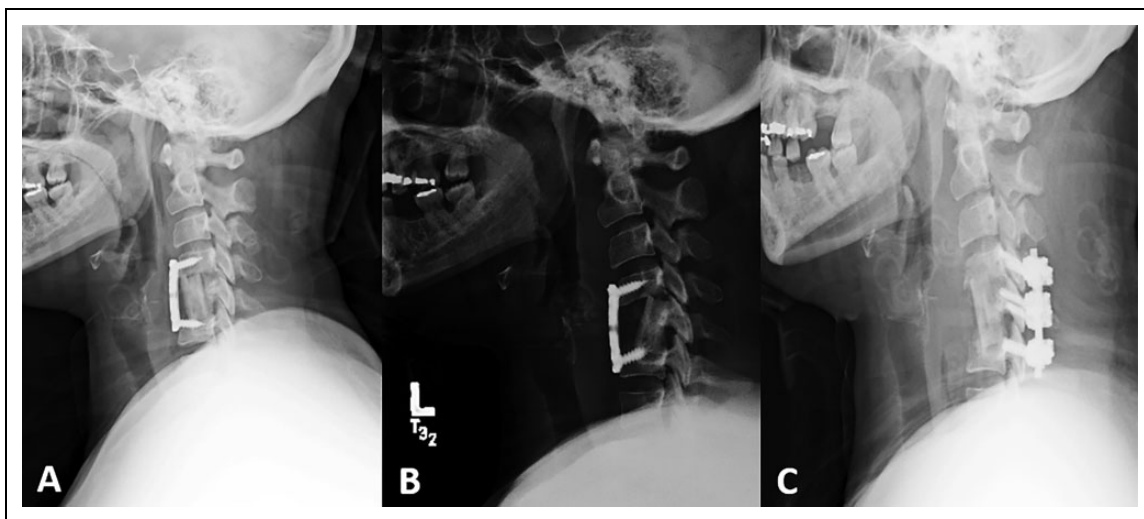
From 2005 to 2011, a total of 8887 patients underwent anterior cervical surgery at 21 institutions. Eleven cases of acute IE in the first 30-day postoperative period were reported (Table 1). The incidence across sites ranged from 0% to 0.8% over this 6-year period. Mean age of patients with IE was 60 years. Nine patients had surgery for degenerative disease. Two patients had a history of osteomyelitis at time of the index surgery. No patients included had IE after surgery for trauma stabilization or tumor resection. None had a history of prior cervical spine surgery. Eight patients presented with myelopathy, 4 for radiculopathy, and 2 patients had both (Table 1). Mean hospital length of stay was 5.2 days following this complication. All cases were multilevel constructs with 10 including a corpectomy of at least one vertebral body. Three patients had single-level corpectomy at C5 with graft failure (Figure 1), 3 involved multilevel corpectomies (Figure 2), whereas the remainder had hybrid constructs with at least one adjacent discectomy (Figure 3). Two patients had additional posterior instrumentation at initial surgery and still exhibited IE. Of the 11 failures, 7/11 (64%) constructs ended with reconstruction or stabilization at C7. Two out of 11 constructs did not involve plating. One of these was one 3-level discectomy with a graft failure at C7-T1. The second case involved a C5-6 discectomy and C7 corpectomy without a plate, but did have posterior supplement instrumentation. Grafting was heterogeneous across cases with 3/11 (27%) using iliac crest, 2/11 (18%) allograft alone, and 5/11 (45%) using local mixed with allograft. Bone morphogenetic protein was used in 3 cases. Only one titanium cage was used with allograft. External orthoses were used in 9/11 (82%) of cases.

IE was identified from 1 to 29 days out from the index surgery. Eight patients had IE within 2 weeks and 3 were within 24 hours of surgery. The remaining 3 presented over 3 weeks out. After identification of IE, 2 patients were kept in cervical orthosis while 9 patients required surgery for repair and stabilization. Revision surgery was performed at the discretion of each surgeon; however, 7 patients reported intractable neck pain while 2 had new neurologic deficits prior to surgery. Two patients were revised anteriorly or posteriorly alone, respectively, whereas 5 had anterior revision surgery with added posterior instrumentation. Mean time of follow-up was 35 days after IE. Nine patients had no residual deficits whereas 2 reported deficits. One patient had paresthesias and sensory loss whereas the other had residual weakness (4/5 strength in C5-C8 in bilateral upper extremities) at 30-day follow-up. Preoperative mean neck disability index score, modified Japanese Orthopaedic Association score, and Short Form-36 (SF-36) physical and mental sections were 53, 6, 24.972, and 54.879, respectively. At follow-up after revision surgery, neck disability index, modified Japanese Orthopaedic Association, SF-36

**Table 1.** Description of Original Surgeries Performed and Revision Surgeries After Implant Extrusion.

Patient	Indication for Index Surgery	Original Surgery	Revision Surgery
1	Myelopathy	C5 ACC, C6-C7 ACD, C4-C7 plating	Removal of C4-7 plate and graft Posterior fusion of C4-7
2	Myelopathy	C5 ACC, C4-C6 plating	Posterolateral instrumentation and fusion Repair of construct anteriorly C4-C6
3	Myelopathy	C5 ACC, C4-C6 plating	Removal of anterior instrumentation; C7 corpectomy; Posterior segmental instrumentation C4-T1 w/posterolateral fusion C4-T1
4	Myelopathy	C5, C6 ACC, C7-T1 ACD, C4-T1 plating	Revision anterior cervical graft C3-7
5	Myelopathy and radiculopathy	C5-C6 ACD, C7 ACC, C4-T2 posterior instrumentation	Extended time in Aspen collar
6	Myelopathy with history of prior osteomyelitis	C5, C6, C7, T1 ACC with C4-T1 plating; C3-T2 posterior instrumentation	Graft revision—anterior C4 corp. w/fusion using fib allograft, local bone graft, and anterior cervical plate from C3-C7
7	Myelopathy	C3-4 ACD, C4-5 ACD, C6 ACC, C3-C7 plating	Posterior cervical
8	Osteomyelitis	C5, C6 ACC, C4-C7 plating	Instrumented fusion C2-C7 + iliac crest bone graft Stage I: revision ant. cervical C4-7 fusion with exchange of plate Stage II: post. cervical fusion C3-T1 with iliac crest bone harvest + instrumentation
9	Radiculopathy	C5-6, C6-7, C7-T1 ACD, C5-T1 plating	Primary revision of graft was aborted due to scar tissue, extended time in collar
10	Radiculopathy	C3 ACC, C2-4 plating	Extended time in Aspen collar
11	Myelopathy and radiculopathy	C5 ACC, C4-6 plating	Posterior cervical fusion and instrumentation C2-T3

Abbreviations: ACC, anterior cervical corpectomy; ACD, anterior cervical discectomy.

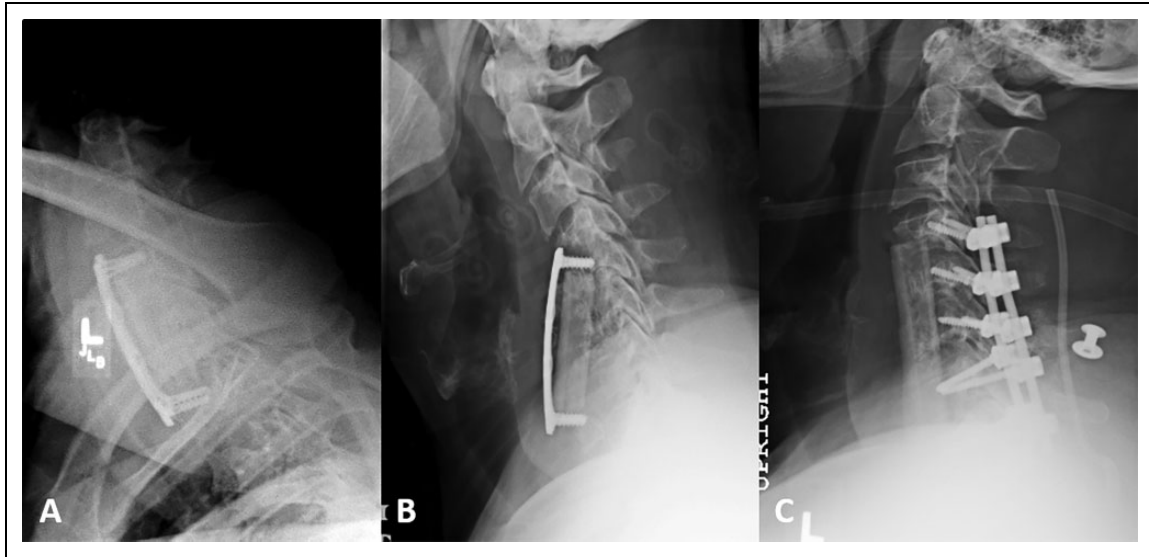


**Figure 1.** (A) Patient with progressive myelopathy, underwent C5 corpectomy. (A) Immediate postoperative film with good alignment of the construct. Developed persistent neck pain postoperatively and ataxia. (B) Lateral X-ray revealed graft retropulsion into canal. (C) Taken back to surgery for anterior revision and posterior instrumentation at C4-C6.

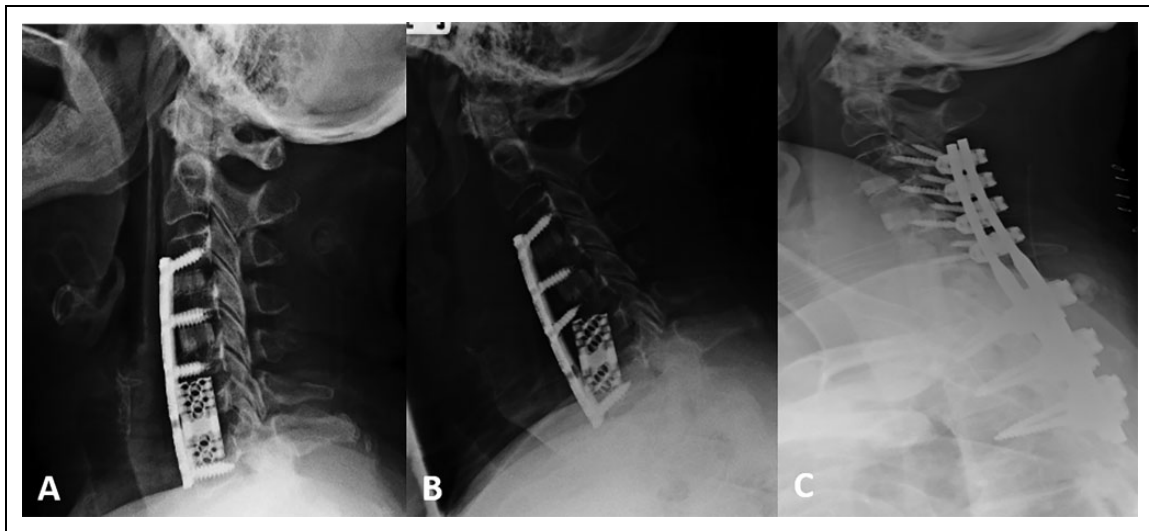
physical, and SF-36 mental scored were 42, 9.5, 34.842, and 24.937, respectively. Eight patients had Nurick myelopathy grading pre- and postoperatively with mean scores of 1.875 and 0.467, respectively, with statistically significant improvement ( $P < .0379$ ). These results suggest functional outcome can still be obtained if reoperation and revision is necessary.

## Discussion

The risks to anterior cervical spine surgery are well documented, with morbidity rates ranging from 9% to 20%.<sup>1-4</sup> Well-known common complications are postoperative dysphagia, dural tear, and recurrent laryngeal nerve injury resulting in



**Figure 2.** (A) Patient with progressive myelopathy, underwent a C5 and C6 corpectomy with fibular strut grafting and anterior plating C4-C7. On postoperative day 1, noted to have neck pain and dysphagia; lateral X-ray revealed pistoning of graft and dislodgement of caudal screws. (B) Taken back to surgery for repositioning of graft and posterior instrumentation from C4 to T2.



**Figure 3.** Patient with spondylotic cervical myelopathy, underwent C3-4, C4-5 discectomies, C6 corpectomy with cage placement and allograft interbodies. (A) Patient with immediate postoperative film with good alignment. (B) Patient with neck pain postoperative day 1; lateral X-ray with retropulsion of C6 cage. (C) Taken back to operative room for replacement of cage with a fibular strut graft, and posterior instrumentation from C3 to T3.

hoarseness. Rare complications remain underreported in the literature. In this multi-institutional retrospective cohort, we identified 11 cases of acute IE in 8887 anterior cervical surgeries, with an incidence range of 0% to 0.8% across 21 academic institutions. This is similar to the incidence quoted in prior literature of 0.88% to 1.3% of IE following discectomy.<sup>1,5</sup> Prior case series have reviewed extruded grafts and pseudoarthrosis found during follow-up.<sup>6-11</sup> Early research showed very high reoperation rates of 10% to 18% among patients with nonplated multilevel anterior discectomy (ADF) or anterior corpectomy (ACF).<sup>7</sup> After the popularity of plating began,

Caspar and colleagues observed 19/219 (8.6%) patients undergoing nonplated ADF required reoperation whereas only 3/146 (2%) with plated constructs.<sup>12-14</sup> Connolly and colleagues studied addition of a plate in single and multilevel ACF and ADF. They found plating did not improve outcome; however, plating multilevel surgery reduced IE and pseudoarthrosis.<sup>7,15,16</sup>

In our case series, all IEs were in very complex constructs spanning at least 3 levels, and all but one involved a corpectomy (Table 1). Complications of multilevel surgery are well documented in the literature.<sup>17,18</sup> Sasso and colleagues reviewed 40 cases of 2- and 3-level corpectomies and found

2/33 (6%) and 5/7 (71%) had plate or graft migration and failure.<sup>17,18</sup> Wang and colleagues reviewed 249 cases of ACF over a 25-year period with autogenous bone grafting.<sup>19</sup> They found migration in 16 patients with rates of 4/95 (4%), 4/76 (5%), 7/71 (10%), and 1/6 (16.7%) in cases of 1- to 4-level corpectomies, respectively. Interestingly, they found 14/16 patients had IE after C6 corpectomy with fusion extending to the C7 vertebral body.<sup>19</sup> Biomechanically, the cervicothoracic junction poses a unique segment of the spine with an abrupt transition between kyphosis and lordosis in some patients. This transition zone can lead to large variations in the angle of the disc spaces of C5-6, C6-7, C7-T1, and T1-T2. This can create unique shear stresses not seen in the rostral subaxial spine. In our case series, 7/11 constructs involved reconstruction at C7 or T1. We hypothesize many of these failures were due to biomechanical failure during this transition zone where shear stresses on the construct may have been underestimated by the index surgeon. To lower the risk of IE, we recommend careful planning and consideration for supplemental posterior instrumentation when multilevel constructs will end at the cervicothoracic junction.

Biomechanical studies have also evaluated the strength of constructs in the subaxial cervical spine. In our study, 10/11 patients had a corpectomy incorporated in their anterior column reconstruction. A corpectomy has inherent advantages with fewer sites for fusion, but biomechanically may not be as stable due to the variations in axial loading during flexion and extension predisposing graft movement. Plating for corpectomies has universally been accepted to improve fusion and stability.<sup>4,7,8</sup> In our series, the 2 cases without plating were high-risk constructs as one was a multilevel discectomy and the other a corpectomy. Plating may have decreased the risk for IE in these cases, and should be recommended in these difficult cases.

In multilevel corpectomies with just anterior plating, the plate provides constraint only in flexion but in extension the load is placed on the graft. If the axial load is not perpendicular to the caudal end plate, erosion and even rupture can occur leading to settling or telescoping of the graft and construct failure.<sup>20-23</sup> Thus, supplement posterior instrumentation in cases of multilevel corpectomies should be considered to provide extra resistance against extension and offset loading of the graft leading to failure especially when reconstruction involves the cervicothoracic junction. In our series, 7/11 involved either multilevel corpectomies or hybrid constructs with at least one adjacent discectomy to a corpectomy, but posterior instrumentation was only utilized in 2/11 index surgeries. These data suggest inherent instability in these constructs may have been underappreciated at the initial time of surgery, and they were predisposed to failure.

Our study has several limitations that make the results difficult to generalize. Surgical technique is difficult to assess and the complexity of constructs involved in this case series may be understated in many instances on the CRFs submitted. Post-operative care and protocols including mobilization instructions was not reported on our CRFs. External orthoses were not specifically defined on the case reporting form. Acute and

subacute implant failure only were evaluated in this study and long-term follow-up would be needed to make stronger conclusions on the role of pseudoarthrosis, subsidence, and instrumentation failure on IE. Moreover, graft and plate usage was not completely documented, and it is difficult to draw conclusions about trends in different plate or graft designs that also may have predisposed these constructs to fail.

## Conclusion

Surgeons should discuss rare complications with patients prior to anterior cervical surgery. Our case series highlights the importance of counseling patients on the possibility of hardware failure with complex anterior reconstruction, and most important, if the construct involves the cervicothoracic junction. Posterior supplemental instrumentation is worth considering when complex anterior column reconstruction is going to be performed. Prospective and biomechanical research is needed to further elucidate risks with different construct designs to minimize this rare complication and help guide treatment strategies when they occur.

## Authors' Note

This study was ethically approved by the institutional ethics committees at all participating sites.

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