Multi-level Anterior Cervical Discectomy and Fusion (ACDF) with segmental plating: Case Study and Clinical Rationale

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Introduction – Anterior cervical discectomy and fusion (ACDF) is one of the most widely used treatments for cervical myelopathy and spondylosis. In addition to its successful clinical history, one primary advantage of the anterior surgical approach is that it allows for easier cervical lordosis restoration which has a statistically significant correlation with regional and global spinal sagittal balance[1]–[3]. ACDFs that achieved a significant amount of cervical lordosis were consistently associated with improved clinical outcomes[4][5], while ACDFs that failed to correct pre-operative kyphosis reported worse scores in multiple clinical outcome assessments such as Neck Disability Index (NDI) and Visual Analogue Scale (VAS)[6][7]. A study done by Hu *et al.* in 2015[8] with 104 multi-level ACDF patients showed a 35% incidence of symptomatic adjacent segmental disease (ASD) and reoperations due to ASD in patient groups who had post-operational kyphosis, compared to a 12% incidence in a patient groups with restored lordosis. In a retrospective study of 672 patients[9], ASD was accountable for 47.5% of all ACDF revision surgeries, mainly due to suboptimal lordosis correction.

Despite this compelling data, optimal cervical lordosis is either never achieved intra-operatively or lost over time post-operatively[10] due, in part, to the limitations of the two current ACDF solutions: 1) interbody spacers with multi-level plating or 2) zero-profile standalone devices. Multi-level plates have a pre-determined lordotic curvature that can force a patient's spine to conform to the plate's lordotic shape. This compromises the lordosis gained during the ACDF procedure, applies a preload to the plate and screw/bone interface and potentially stress shields a level from the effects of Wolf's Law. Standalone interbody spacers typically lack the mechanical stability of a plate-cage construct due to their constrained screw angulation and often violate the integrity of the vertebral endplates resulting in higher subsidence rates. Subsidence contributes to a significant amount of post-operative loss of lordosis and is statistically correlated with segmental kyphosis and lower fusion rates [11]–[13].

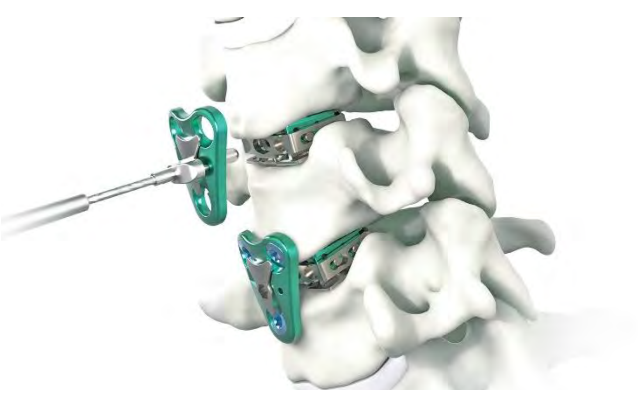

Figure 1: V3 Guided Segmental Plating System

While one and two level ACDFs have consistently shown higher fusion rates, longer constructs of both plate/cage and standalone devices show a precipitous drop in fusion rates.

A third option to be considered for ACDF involves segmental plating. This technique involves applying multiple single-level plates anteriorly in combination with interbody cages for each spinal level. Advantages of segmental plating include its inherent ease of use, but more importantly, the potential for better long-term alignment and fusion rates [19].

This case study presents an evaluation of the novel V3™ Guided Segmental Plating System designed explicitly for a segmental technique (Atlas Spine, Inc.) and a broader discussion of the potential intra-op and post-op benefits of this approach.

Figure 2: Retrospective fusion rates using segmental approach across 105 patients (227 levels) [19]

Patient History – A 67-year-old male presented with increasing chronic neck pain, occipital headaches, and bilateral shoulder and arm radiculopathy, with the left side worse than the right. The pain, and associated decreased range of motion, was so severe that it forced him to stop driving. He tried all the usual non-operative treatments without success, including anti-inflammatories, oral steroid tapers, physical therapy, and injections.

Imaging studies, including x-rays and an MRI, demonstrated multi-level degenerative disc disease and facet arthropathy contributing to central and foraminal stenosis from C3-7. It was felt that the stenosis at all four levels would need to be addressed to adequately alleviate his symptomology and he was scheduled for an ACDF from C3-7.

Surgical Intervention – The procedure involved a standard Smith-Peterson anterior approach to expose the spine from C3-7. Caspar pins were used for distraction, initially spanning C3-5 then from C5-7. Anterior osteophytes were removed from all levels and decompression was performed with discectomies, resection of posterior osteophytes, and resection of the posterior longitudinal ligament in a similar fashion for all levels.

After adequate decompression was achieved for each disc space, expandable titanium spacers (HiJAK AC, Atlas Spine Inc.) were placed as interbody devices to assist with restoring lordosis and fusion. Each spacer was packed with a combination of allograft bone chips mixed with an umbilical cord blood-derived cellular allograft liquid (BioBurst, Burst Biologics) prior to insertion. After implantation, each implant was expanded to its limit. A bone funnel was then used to add more graft to each spacer, filling the void created as a result of the expansion process.

Segmental plating (V3, Atlas Spine Inc.) was then used to augment the fusion process at each level. A total of four plates were used, one for each level, with each plate requiring 3 screws as fixation. Locally obtained autograft bone from the decompression was then packed lateral to the spacers where possible.

Results – A quantitative analysis was performed on the patient's cervical sagittal alignment. Lateral standing radiographs taken immediately before and after surgery (Figure 4a-b) showed a corrected global cervical lordosis (C2-7 Cobb's Angle) of 21.4° from the previous 9.5°. Segmental lordosis from pre-op to 2-week post op showed the following changes: C3-4 0.77° to 4.5°, C4-5 0.86° to 4.7° and C5-6 0.75° to 6.4° (C6-C7 could not be measured).

Figure 3: Pre-op MRI

Discussion - The radiographic results shown indicate a clear improvement of the overall sagittal balance of the patient. While conventional plating could have been used, the value of a segmental plating system was evident as discussed below.

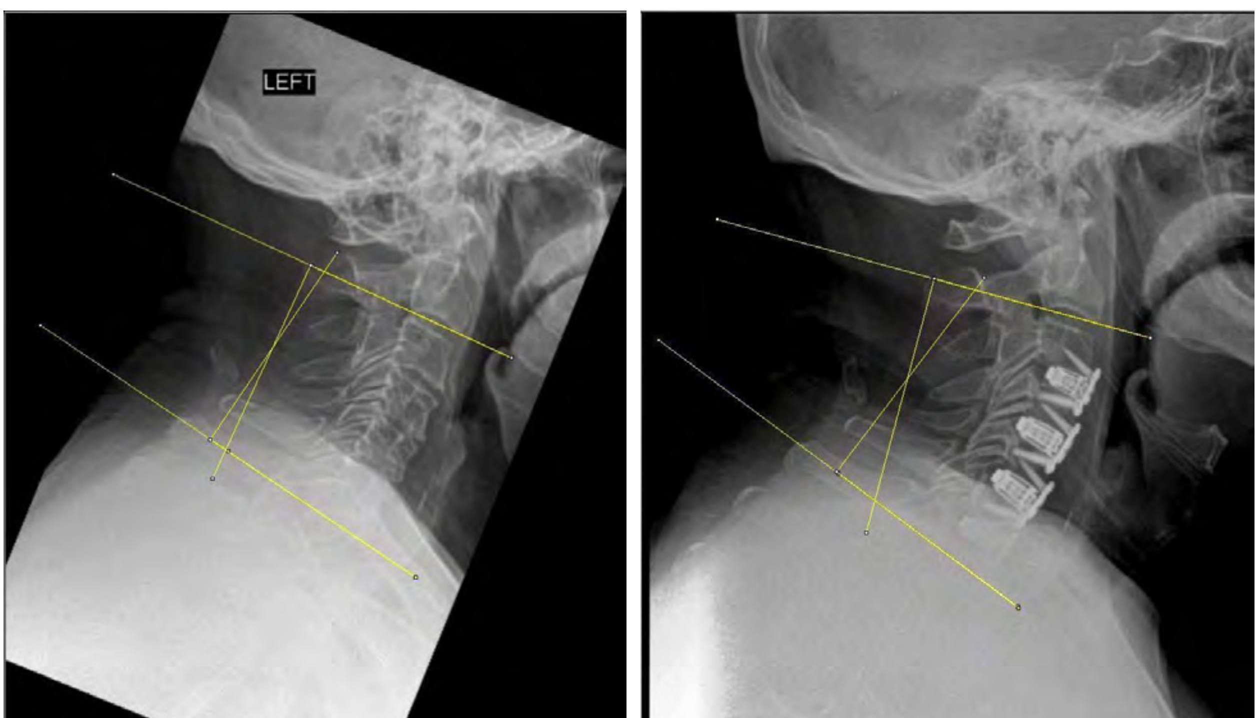

Figure 4a and 4 b: Pre- and post-operative standing radio- graphs showing global cervical lordotic improvement

Segmental Plating versus Zero-Profile Standalone

Better Access & Screw Purchase – Zero-profile interbody systems often require steep screw angles to ensure adequate bone purchase. At the top and bottom of the construct this angle can be difficult to achieve. Jointed/flexible instruments can be ineffective and fiddle some. The alternative is a screw trajectory that is more parallel to the endplates and risks skiving off offering no substantial purchase. Blade-based zero profile options avoid screw angle difficulties but can't be "lagged" and often violate the very endplates relied upon to ensure post-operative height is maintained. The V3 segmental plating system, aided by its guided plate holder, offers optimal bone purchase at the cortical rim without violating the endplate at a far easier screw angulation.

Greater Stability – A traditional plate and cage construct shows a mechanical advantage over a standalone cage. As shown below, biomechanical studies have shown that plate and cage constructs reduce ROM to 37%, while zero-profile cages provided just a 69% reduction. This mechanical advantage allows plate and cage constructs to provide more immediate post-operative stability and could also contribute to a higher fusion rate[14] in multi-level ACDFs.

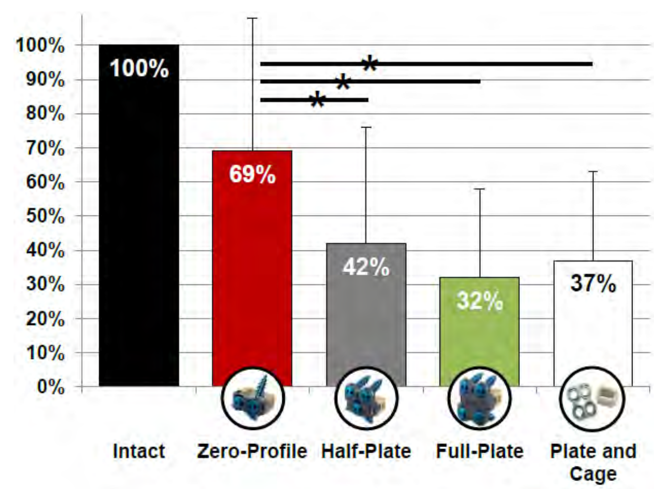

Fig. 5: Flexion/Extension range of motion for various ACDF constructs

Reduced Subsidence – A traditional plate and cage construct is commonly known to be less likely to subside than standalone cages[15]–[18]. Although it is still unclear whether subsidence has a direct negative impact on clinical outcomes, it can affect the patient's global sagittal balance, as shown in *Figure* 6, which has been shown to increase the likelihood of symptomatic adjacent segmental disease (sASD)[9].

Fig. 6. Common ACDF kyphosis due to subsidence

Segmental Plating vs. Conventional Plating

Ease of Retraction – Traditional ACDF techniques require insertion of the plate after all interbody devices are placed. This often requires an extension of the incision, re-exposing a portion of the wound, sweeping back tissue and removal and reinsertion of retractors. This adds time and difficulty to the end of the procedure and introduces a risk of soft tissue damage. A segmental plating system, like standalone devices, solves this problem by breaking down one complicated multi-level surgical procedure into multiple simple single-level procedures.

Reduce Perioperative Morbidity – The alternative to re-exposure is to maintain the full exposure length throughout the procedure which increases the likelihood of dysphagia. For a segmental 3 or 4-level ACDF, surgeons only need to prepare and distract the level of operation. This approach significantly reduces the duration and amount of tissue retraction needed which can reduce the incidence of post-operative dysphagia.

Optimized Plate Length – The segmental plating system, complemented by the guided plate holder, allows the surgeon to secure each segment with an individual plate size optimal for that level. It eliminates the difficulty of selecting and positioning a multi-level plate that fits the overall operated segment and provides the best screw positions for the individual vertebral body. Along with overall ease of use, minimizing plate length has been shown to reduce adjacent level ossification which is thought to be associated with adjacent level disease progression.

Better Axial Alignment – The guidance post of V3 segmental plating system eliminates the fiddle of chasing a plate while attempting to secure it to the vertebral body. This guided plating system simplifies alignment for multi-level constructs and ensures a straight overall construct on the post-operative AP, as shown in *Figure* 7. While there is no data to suggest a misaligned plate has a post-op impact clinically, the aesthetic is less than desirable during patient follow-ups.

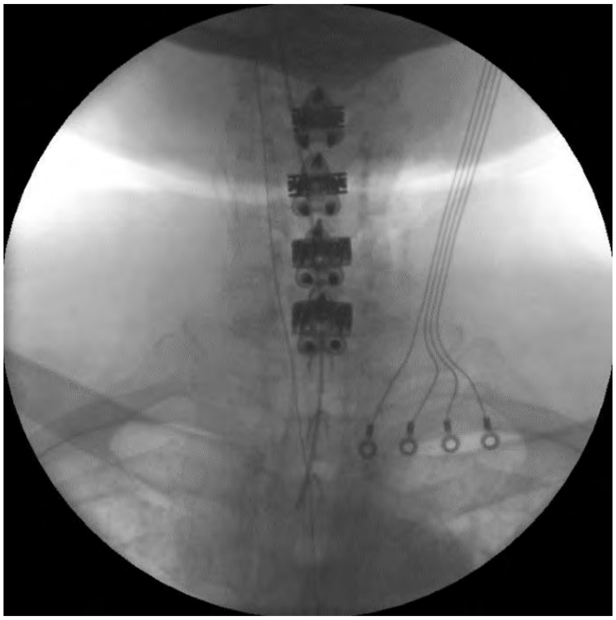

Fig. 7: Case study patient post-op AP

Preserve Segmental Lordosis – Conventional plating systems often make the spine "conform" to the pre-defined contour of the plate, causing the loss of segmental lordosis previously restored through distraction and interbody insertion. Segmental plating helps surgeons preserve the lordosis gained by stabilizing each level individually.

Prevent End-level Pseudarthrosis – Theoretically, segmental plating ensures load sharing and prevents stress shielding, a problem commonly manifested as end-level pseudarthrosis with conventional plating in multi-level ACDFs. This concept was tested by Hynes et al [19] in 2017 and achieved 92% fusion rate for 3 and 4-level ACDF cases, contrary to the commonly reported 58-69%[20]–[22] low fusion rate in literature.

Aid In Future Revisions – The high probability of pseudarthrosis will continue to be a multifactorial problem for multi-level ACDFs [20]–[22]. For a future revision surgery, a segmental plating technique serves as a fail-safe for surgeons as they can remove one single-level plate at the revision level rather than affect the entire construct or introduce a secondary posterior interventional treatment.

Conclusion - This clinical case study demonstrated clear advantages of a segmental plating system over both zero-profile interbody devices and traditional plating systems. The segmental plating system used in this surgical reconstruction provided optimal lordosis preservation and greater operational expediency while affording a less invasive approach. By eliminating the need for multi-level soft tissue retraction, it converted a more complicated, multi-level surgical procedure into several simple single-level procedures. Additionally, the systems' segmental technique, coupled with its guided instrumentation, provided a distinct advantage toward achieving plate size optimization and midline plate alignment. Further investigation of the intraoperative and postoperative implications of segmental plating system is warranted.

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