



Original Article

## Management of hangman's fractures using anchored anterior cervical cages

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### ABSTRACT

**Background:** Hangman's fractures comprise approximately 20% of C2 fractures and often require surgery to correct significant angulation and/or subluxation. Recently, anchored anterior cervical cages (ACCs) have been used to fuse C2-3 as they reduce the risks of soft-tissue dissection, bone drilling, operative time, and postoperative dysphagia.

**Methods:** This single-center and retrospective study (2012–2019) included 12 patients (3 type I, 6 type II, and 3 type IIa fractures) undergoing C2-3 ACCs (zero profile, half plate, full plate). Preoperative and postoperative radiographic and clinical data were analyzed.

**Results:** The 12 patients demonstrated the following findings: a mean operative time of  $106 \pm 21$  min, blood loss averaging  $67 \pm 58$  mL, and mean length of stay of  $9.8 \pm 7.7$  days ( $6.4 \pm 5.5$  days in intensive care). The mean differences in preoperative versus postoperative radiographs showed an increase in disc angle ( $9.0^\circ \pm 9.4^\circ$  vs.  $14.0^\circ \pm 7.2^\circ$ ), reduction of subluxation ( $18.5\% \pm 13.6\%$  vs.  $2.6\% \pm 6.2\%$ ), and maintenance of C2-7 lordosis ( $14.3^\circ \pm 9.5^\circ$  vs.  $14.4^\circ \pm 9.5^\circ$ ). All patients demonstrated fusion on dynamic films obtained  $>6$  months postoperatively. In addition, only one patient had Grade 0 subsidence, three had transient postoperative dysphagia, whereas none had either intraoperative complications or 90-day readmissions.

**Conclusion:** ACCs proved to be a viable alternative to traditional anterior cervical discectomy/fusion to treat 12 patients with C2-3 hangman's fractures in this preliminary study.

**Keywords:** Anchored cervical cages, Anterior cervical discectomy and fusion, Hangman's fracture, Zero-profile

### INTRODUCTION

Surgical alternatives for C2-C3 fusions include C2 pedicle screws, C2-3/C1-3 posterior spinal fusion, single-level C2-3 anterior cervical discectomy and fusion (ACDF), or, since 2009, anchored cervical cages (ACCs: Zero profile, half plate, or full plate).<sup>[3,6]</sup> Here, we present our institutional experience regarding the strength, long-term efficacy, fusion rates, and complications using the three different types of ACCs for patients with traumatic hangman's fractures.

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## MATERIALS AND METHODS

### Study design

We performed an IRB-approved retrospective cohort study of 12 patients who underwent C2-3 ACDF with ACCs to treat traumatic C2 pars fractures between 2012 and 2019. Patient billing codes, operative notes, and imaging data were evaluated by three senior authors blinded to the study design. Anteroposterior and lateral cervical radiographs were obtained 1 month postoperatively, and dynamic films obtained >6 months postoperatively were used to assess fusion (i.e., criteria of <2 mm between C2 and C3 spinous processes).<sup>[1]</sup> The subsidence of the graft was measured using the Marchi grading scale.<sup>[2]</sup>

### Clinical data

Twelve patients underwent C2-3 ACDF with ACCs to treat traumatic hangman's fractures [Table 1]. One patient had an additional C6-7 flexion dislocation and subluxation, whereas two other patients had nonoperative mild-to-moderate traumatic brain injuries. Patients were followed-up for a mean of 8.6 ± 4.4 months (range: 3–16 months).

### Preoperative imaging

In the 12 patients, the mean preoperative C2-3 disc angle was 9.0° ± 9.4°, whereas the mean preoperative subluxation, relative to the length of the C3 superior endplate, was 18.5% ± 13.6% [Table 1]. In the nine patients with >0 subluxation, the mean subluxation was 24.7% ± 9%. The mean preoperative C2-7 lordosis was 14.3° ± 9.5° (range: 3.0°–34.0°).

### Operative procedure

One of three types of ACC devices was placed following routine C2-3 anterior discectomies. These devices were all polyetheretherketone cages with the following designs: Zero-profile plates (*n* = 1), half plates (*n* = 6), and full plates (*n* = 5). The choice of plate type was based on the fracture morphology and presence of osteophytes. For those with Subaxial Injury Classification and Severity Scale score ≥4, a half- or full-plate ACC was used, except when significant osteophytes made it difficult to place the plate safely.

### Statistical analysis

Statistical analyses were performed using STATA 10 and included paired *t*-tests and analysis of variance (ANOVA).

## RESULTS

### Postoperative imaging

For all 12 patients, the mean postoperative C2-3 disc angle on postoperative images averaged 14.0° ± 7.2° and the mean

**Table 1:** Demographic, preoperative, and postoperative characteristics for 12 patients with hangman's fractures using anchored anterior cervical cages.

Characteristic	Patients ( <i>n</i> =12)*
Age, years, mean±SD (range)	47.9±10.8 (29–66)
Male: Female ratio	9:3
BMI, mean±SD (range)	27.2±6.1 (19–40)
Smoker at time of surgery	8
Mechanism of injury	
Motor vehicle crash	7
Ground-level fall	3
Other <sup>†</sup>	2
SLICS score	
<4	0
4	6
>4	6
Fracture type	
I	3
II	6
IIa	3
III	0
Neurologic deficit	
Preoperative	1 ASIA C, 1 ASIA D, 10 ASIA E
Postoperative	12 ASIA E
ACC types	
Zero profile	1
Half plate	6
Full plate	5
C2-3 disc angle (°), mean±SD	
Preoperative	9.0±9.4
Postoperative	14.0±7.2
C2-3 subluxation (%), mean±SD	
Preoperative	18.5±13.6‡
Postoperative	2.6±6.2
Cervical lordosis (°), mean±SD	
Preoperative	14.3±9.5
Postoperative	14.4±9.5

ACC: Anchored cervical cage, ASIA: American Spinal Injury Association, BMI: Body mass index, calculated as weight in kilograms divided by height in meters squared, SD: Standard deviation, SLICS: Subaxial Injury Classification and Severity Scale. \*Data are shown as number of patients unless otherwise indicated. <sup>†</sup>1 diving accident, 1 auto versus pedestrian crash. <sup>‡</sup>*P*=0.002 by paired *t*-test, preoperative versus postoperative.

postoperative subluxation for all 12 patients was 2.6% ± 6.2% [Table 1]. Preoperative subluxation was corrected in seven of nine patients and was significantly reduced by surgery; only two patients had residual C2 subluxation relative to C3 (11.0% and 19.6%). The final postoperative C2-C7 lordosis was 14.4° ± 9.5° (i.e., comparable to preoperative values). Flexion-extension plain-films were obtained 6–16 months postoperatively in nine of the 12 patients and demonstrated fusion in all nine patients; three patients were lost to follow-up before the 6-month postoperative follow-up visit. Only one patient had Grade 0 subsidence.

**Comparable postoperative results/outcomes for all three fusion constructs**

Fusion rates were comparable for all three types of fusion plates (i.e., a zero-profile plate [one patient], half plate [six patients], and full plate [five patients]) as documented using the ANOVA test [Table 2]. For all 12 cases, the mean length of surgery was 106 ± 21 min, the mean blood loss was 67 ± 58 mL, the mean length of hospital stay was 9.8 ± 7.7 days, and the mean intensive care unit stay was

6.4 ± 5.5 days. At the time of discharge, all patients were neurologically intact.

**Postoperative complications limited to dysphagia**

The only postoperative complication observed in all three treatment groups were three instances of dysphagia at the time of discharge (i.e., resolved within 1–2 postoperative months). On follow-up, 10 patients remained in American Spinal Injury Association (ASIA) E, while the two patients with preoperative ASIA C and ASIA D deficits improved to ASIA E status.

**Table 2:** Surgical data for 12 patients with hangman’s fractures treated using anchored anterior cervical cages.\*

Measurement	Anchored cervical cage type			All cases (n=12)	P-value
	Zero profile (n=1)	Half plate (n=6)	Full plate (n=5)		
Length of surgery, min	107	76–126	68–115	68–126	0.85
Blood loss, mL	100	20–100	10–200	10–200	0.73
Hospital length of stay, days					
ICU	4	2–20	2–12	2–20	0.87
Floor	1	2–7	1–9	1–7	0.40
Total	5	4–27	3–21	3–27	0.36
Postoperative infection	0	0	0	0	NA
Postoperative transient dysphagia	0	3	0	3	0.06†
Revision of hardware	0	0	0	0	NA
90-day readmission	0	0	0	0	NA
Follow-up, months, range (mean)	15 (NA)	3.5–16 (10.8)	3–11 (6.6)	3–16 (8.6)	NA
Fusion rate>6-month postop, % of pt.**	100 (n=1)	100 (n=5)	100 (n=3)	100 (n=9)	NA
Subsidence	0	1	0	1	NA

ICU: Intensive care unit, NA: Not applicable. \*Data are no. of patients unless otherwise indicated. P values are from ANOVA with significance set at P<0.05. †Unable to compare to zero-profile cage (n=1). \*\*Assessed in 9 patients in whom radiographs were obtained >6 months postoperatively.

**Table 3:** Study results from published literature on surgical fixation of cervical fractures or hangman’s fractures.

Study (y)	Patients	Study type	Surgical approach	Mean operative time	Subsidence	Fusion rate	Complications
Salunke et al. (2016) <sup>[6]</sup>	11	Retrospective database analysis	C2 pars-pedicle screw	Not described	NA (posterior fixation)	100% at 3–6 months	1 of 11, developed C2-3 deformity
Murphy et al. (2017) <sup>[3]</sup>	417 surgically treated (548 total)	Systematic review	200 ACDF 193 PFF 24 combined	Not described	Not described	99.35%	17 of 417
Vaishnav et al. (2019) <sup>[7]</sup>	64	Retrospective database analysis	ACDF	45 min (zero profile) 54 min (plate)	Not described	Not described	4 of 64 (not specified)
Rajan et al. (2021) <sup>[5]</sup>	24,593	Retrospective database analysis	ACDF	104 min	Not described	Not described	Not specified
Current study	12	Retrospective cohort	ACDF with ACC	106 min	1 Grade 0 subsidence	100% at > 6-mo follow-up (n=9)	3 of 12, transient (1–2 mo postop) dysphagia

ACC: Anchored cervical cages, ACDF: Anterior cervical discectomy and fusion, NA: Not applicable, PFF: Posterior fixation and fusion, Postop: postoperative. mo: Month

## DISCUSSION

### ACCs viable alternative for anterior stabilization of C2-3 hangman's fractures

Surgical stabilization for traumatic hangman's fractures is typically achieved using one of several constructs: C2 pedicle screws, C1-3 posterior spinal fusion, or C2-3 ACDF. However, ACCs, with the anterior plate attached to the graft and directly fixed to the vertebral bodies, offer a viable alternative to the traditional ACDF.<sup>[3,6]</sup> In addition, ACCs offer shorter operations attributed to reduced soft-tissue dissections and avoidance of separate hardware placement.

### Comparable operative time and fusion but possibly reduced dysphagia rates for single-level ACCs versus ACDF

Our mean operative time for a single-level ACC at the C2-3 level was 106 min versus an average time for a single-level ACDF of 104 min in a retrospective study of 24,593 patients.<sup>[5]</sup> Our fusion rate of 100% for single-level ACC fusions was largely comparable to rates from other studies, plus we found no differences in lateral bending range of motion (ROM) (i.e., the full-plate ACC offered the lowest axial rotation ROM).<sup>[4]</sup> In addition, ACCs demonstrated comparable or lower rates of postoperative dysphagia as they reduced soft-tissue dissection while providing a lower profile implant. We found three of 12 of our patients had transient postoperative dysphagia for 1–2 months, which is similar to prior studies showing comparable or possibly lower rates of dysphagia using zero-profile devices.<sup>[7]</sup> Table 3 displays a summary of these previously published studies.<sup>[3,5-7]</sup>

## CONCLUSION

We successfully used three types of ACC devices to perform 12 C2-3 fusions for treatment of traumatic hangman's fractures. ACCs offered comparable operative times and fusion rates with similar to lower rates of postoperative dysphagia compared with standard fixation techniques.

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### Disclaimer

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### Declaration of patient consent

Patient's consent not required as patients' identities were not disclosed or compromised.

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### Conflicts of interest

John E. Wanebo is a consultant for Zimmer Biomet. All other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this manuscript. Portions of this manuscript were presented orally at the Western Neurosurgical Society 63<sup>rd</sup> Annual Meeting, September 9, 2017, Banff, Canada.

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