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ORIGINAL ARTICLE

Comparison of a novel anterior-only approach and the conventional posterior–anterior approach for cervical facet dislocation: a retrospective study

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Abstract

Objective The surgical treatment of lower cervical facet dislocation is controversial. The objective of this study was to compare the surgical trauma and clinical results of a novel anterior-only approach and with those of the conventional posterior–anterior approach to obtain an optimal method to treat lower cervical facet dislocation.

Methods From January 2012 to December 2017, 93 patients with lower cervical facet dislocations were enrolled in the study and divided into two groups as follows: 63 conventional patients who enrolled between January 2014 and December 2017 were included in the anterior-only approach group, and 30 conventional patients who enrolled between January 2012 and December 2013 were included in the posterior–anterior approach group. For the anterior-only approach group, two reduction techniques, including Caspar pins kyphotic paramedian distraction and anterior facetectomy, were used in sequence if the former technique failed. The parameters were as follows: the operation time, the intraoperative blood loss, the number of fixed segments, the fusion rate, and the improvement in the ASIA grade and JOA score.

Results All patients in the anterior-only approach group were successfully reduced by the two techniques. The mean operation time in the posterior–anterior approach group (274.0 ± 114.7 min) was significantly longer than that in the anterior-only approach group (88.6 ± 35.0 min) ($p = 0.000$). The mean blood loss during the surgery and the number of fixed segments in the posterior–anterior approach group (275.0 ± 183.2 ml; 1.4 ± 0.7, respectively) were significantly greater than those in the anterior-only approach group (92.5 ± 84.0 ml, $p = 0.000$; 1.2 ± 0.5, $p = 0.030$, respectively). A 100% fusion rate was observed in both groups after 12-month follow-up. There were no significant differences between the two groups regarding the improvement in the ASIA grade ($p = 0.900$) or JOA score ($p = 0.717$).

Conclusions Compared with the conventional posterior–anterior approach, the novel anterior-only approach with two reduction techniques, including Caspar pins kyphotic paramedian distraction and anterior facetectomy, achieved a 100% reduction success rate and induced less surgical trauma, indicating that this method can be recommended as an alternative for lower cervical facet dislocation.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00586-019-06073-3) contains supplementary material, which is available to authorized users.

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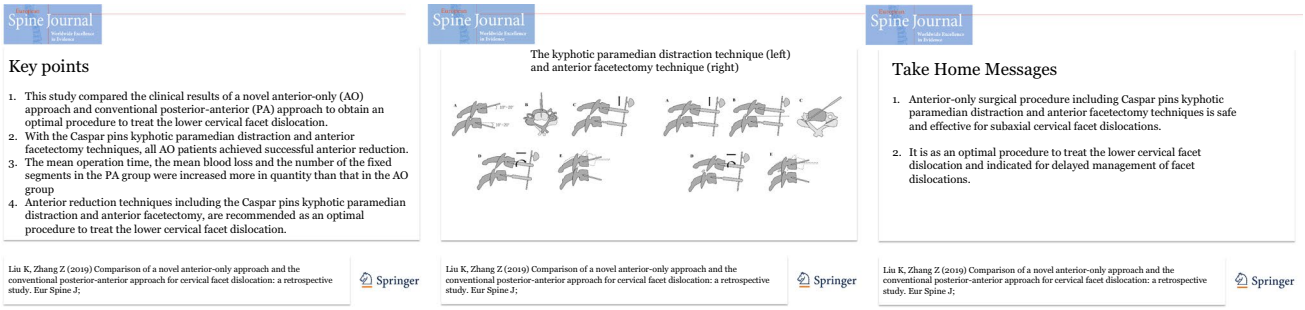
Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.



Keywords Cervical spine · Facet dislocation · Surgical approach · Anterior-only procedure · Posterior–anterior procedure

Introduction

Cervical facet dislocation is a common spinal trauma caused by flexion-distraction violence that usually results in damage to the three-column structure, as well as intervertebral dislocation, facet locking, and disc destruction. The treatment of lower cervical facet dislocation is generally recognized as reduction, decompression, fixation, and fusion. The surgical strategy is highly variable, including anterior alone, posterior alone, anterior–posterior, posterior–anterior, and anterior–posterior–anterior approaches according to reduction and fixation [1, 2]. There is no clear evidence indicating the optimal approach for the treatment of lower cervical facet dislocation [3, 4].

The posterior approach has been advocated for easy reduction and postoperative recovery of the cervical spinal sequence. However, the posterior approach has many disadvantages, such as risk of neurologic deterioration due to the presence of traumatic prolapse, postoperative axial pain, multiple fixation segments, and the need for concomitant anterior surgery in most cases [5–7]. The anterior approach, which is performed with a completely anterior cervical discectomy, is supported by many surgeons for its various advantages, such as smaller iatrogenic soft tissue injury, lower infection rates, and reduced risks of secondary spinal cord injury caused by the posterior approach [3, 8, 9]. In a prospective randomized controlled study of anterior and posterior stabilization in 52 patients with unstable cervical spine injuries and associated spinal cord injuries, Brodke and colleagues [10] reported no significant differences in neurologic outcome, fusion status, postoperative pain, and complications between the two approaches. However, for some intractable or bilateral facet dislocations, especially for delayed facet dislocations, the failure rate of anterior-only reduction using the previous anterior techniques was approximately 25–40% [3, 11], requiring combined posterior approach surgery. Thus, it is desirable for an anterior-only surgical procedure to achieve a 100% success rate of anterior reduction and anterior reliable fixation to avoid the need for supplemental posterior reduction and/or fixation. We have therefore developed a novel anterior-only reduction and fixation procedure, including Caspar pins kyphotic paramedian distraction reduction plus vertebral screw plate fixation, and anterior facetectomy reduction plus anterior cervical pedicle screw plate fixation. We conducted a comparative analysis of this novel anterior-only approach versus the conventional posterior–anterior approach for cervical facet dislocation.

Materials and methods

Patients

Between January 2012 and December 2017, 101 patients with cervical facet dislocations were admitted to and treated surgically by the investigator's (Z.Z.) group. For the comparison study, the inclusion criteria were as follows: (1) patients with lower cervical facet dislocations who were treated by open reduction; (2) single segment facet dislocation; (3) no other systemic disease affected the number of segments to be fixed; and (4) postoperative follow-up for more than 12 months. The exclusion criteria were as follows: (1) patients who have been successfully reduced by imaging examination at admission or close reduction before operation; (2) patients with incomplete data; (3) multi-segment facet dislocation; and (4) ankylosing spondylitis, severe osteoporosis, or other systemic diseases affecting the fixed segment. There were 93 subjects in this study, excluding five patients who underwent posterior-only reduction and fixation (which was rarely used), two patients with double-segment dislocation, and one patient who developed a postoperative infection that was treated by posterior–anterior

reduction and fixation. Between January 2012 and December 2013, there were 30 patients enrolled that underwent the conventional posterior–anterior approach. Between January 2014 and December 2017, all 63 patients underwent the anterior-only procedure.

There were 80 males and 13 females, with an average age of 48.2 ± 11.9 years (ranging from 21 to 73 years). The causes of injury included: motor vehicle accident for 24 cases, falling for 28 cases, and other causes for 41 cases. All patients underwent anterior and lateral X-ray films, CT and MRI examination to determine the location of fracture and dislocation of the cervical spine. The distribution of injury segments was: C3–C4 in 6 cases, C4–C5 in 13 cases, C5–C6 in 33 cases, C6–C7 in 33 cases, and C7–T1 in 8 cases. Dislocation types included: unilateral facet joint lock in 34 cases and bilateral facet joint lock in 59 cases. The spinal cord injury (American Spinal Injury Association) grades at admission were: ASIA Grade A in 29 cases, Grade B in 3 cases, Grade C in 6 cases, Grade D in 36 cases, and Grade E in 19 cases. There were 34 cases with vertebral fracture and 26 cases with articular process fracture. Because all patients had dislocation (with or without fracture), they were classified as Type C and F4 according to the new AOSpine classification on subaxial cervical spine injuries [12]. The follow-up ranged from 12 to 24 months after the surgery (average 15.9 ± 4.8 months) (Table 1).

Table 1 Demographics

	AO group	PA group	*p* value	χ^2 value
Age (year)	48.8 ± 12.2 (range 21–73)	47.1 ± 11.6 (range 28–67)	0.541	
Gender				
Male	55	25		
Female	8	5	0.606	0.266
Injury mechanism				
MVA	18	6		
Fall	14	14		
Others	31	10	0.056	5.773
Involved levels				
C3/4	4	2		
C4/5	9	4		
C5/6	26	7		
C6/7	22	11		
C7/T1	2	6		0.081
Unilateral/bilateral dislocation				
Unilateral	22	12		
Bilateral	41	18	0.634	0.226
ASIA grade				
A	17	12		
B	3	0		
C	3	3		
D	23	13		
E	17	2	0.084	
Vertebral fracture				
With	20	14		
Without	43	16	0.163	1.951
Articular process fracture				
With	14	12		
Without	49	18	0.074	3.189
Traumatic disc herniation				
With	18	11		
Without	45	19	0.431	0.621
Follow-up (month)	16.1 ± 4.5 (range 12–24)	15.5 ± 5.3 (range 12–24)	0.548	

AO group anterior-only group, *PA group* posterior–anterior group, *MVA* motor vehicle accident, *ASIA* American Spinal Injury Association

Surgical procedures

Anterior-only procedure

All reductions and operations were performed by the senior investigator (Z.Z.). Two reduction techniques, including Caspar pins kyphotic paramedian distraction and anterior facetectomy, were used in sequence if the former technique failed.

Caspar pins kyphotic paramedian distraction technique

The patients were under cervical traction. The level of the injured cervical spine was exposed through a transverse skin incision and a standard Smith–Robinson approach [13]. Two Caspar pins were placed at approximately a 10 to 20 angle with respect to each other in the sagittal plane. Both the entry point and direction of the upper pin were inclined to the dislocation side so that more distraction forces could be applied to the dislocated joint such that the distraction was presented in a kyphotic paramedian manner to mimic segmental flexion and aid facet subluxation. Anterior discectomy was performed beyond the posterior longitudinal ligament to ensure complete decompression. Gradually, distraction was performed under fluoroscopy until the locked facets disengagement was observed on the lateral view. Then, a dorsal and rotational force to the rostral vertebra was provided to achieve reduction (Fig. 1). Once reduction was succeeded, a matched peek cage with autologous bone, anterior vertebral screw and locking plate was installed. For patients with failed reduction or contralateral reduction, an anterior facetectomy technique was performed under the same Caspar pins distraction.

Anterior facetectomy technique

Anterior facetectomy for reduction followed our previous protocol [14]. Briefly, after discectomy, anteromedial foraminotomy was performed by resection of the posterior foraminal part of the uncovertebral joint. After the nerve root was retracted cephalad in the neuroforamina, the edge of the dislocated superior facet was broken to achieve reduction. The Caspar retractor was pushed in a posterior direction to achieve posterior translation of the upper segment and the broken lower segment (a part of the superior facet) (Fig. 2). After the reduction of the ipsilateral facet dislocation, the retractor was pushed and rotated in a cephalad direction to achieve posterior translation of the contralateral upper segment. If the reduction of the contralateral facet by rotation failed, the same facetectomy procedure was performed on this side. After reduction and insertion of an autogenous bone cage, an anterior cervical pedicle screw plate (Z3; Wego; Weihai, Shandong, China) was used for fixation. The anterior pedicle screws were inserted along the pedicle axis using fluoroscope-assisted view imaging as described previously [15, 16].

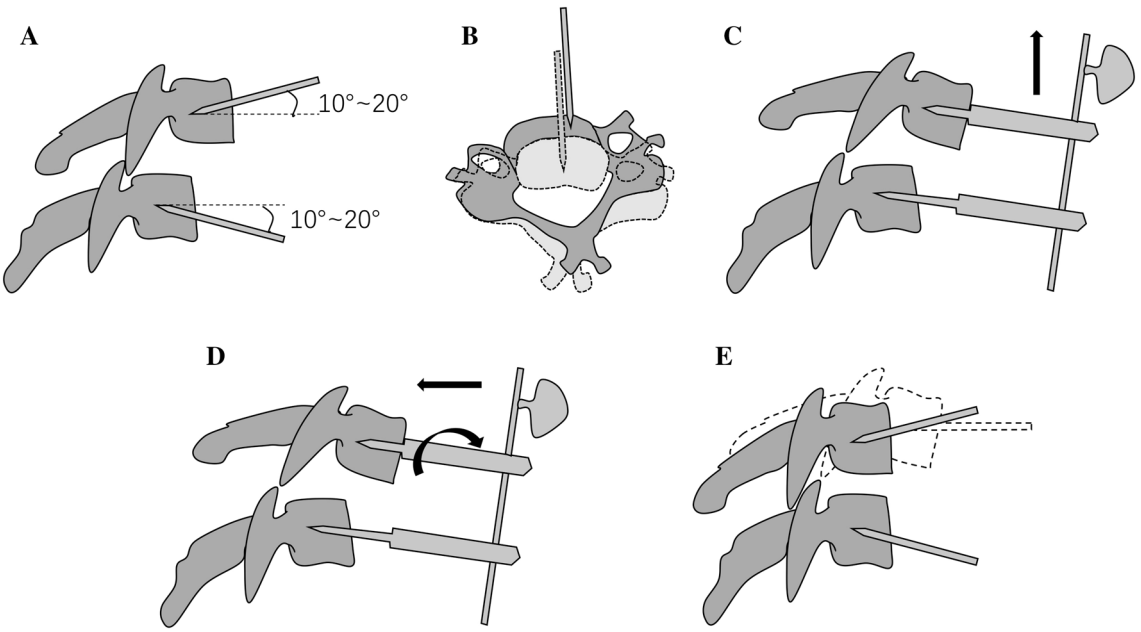


Fig. 1 The kyphotic paramedian distraction technique of anterior reduction. **a** Placing Caspar pins at an approximately 10 to 20 angle with respect to each other in the sagittal plane. **b** Direction of the upper pin placed to the dislocation side in the axial plane. **c** After anterior discectomy, gradual distraction under fluoroscopy until the locked facets disengagement was observed on the lateral view. **d**, **e** A dorsal and rotational force to the rostral vertebra was applied to achieve reduction

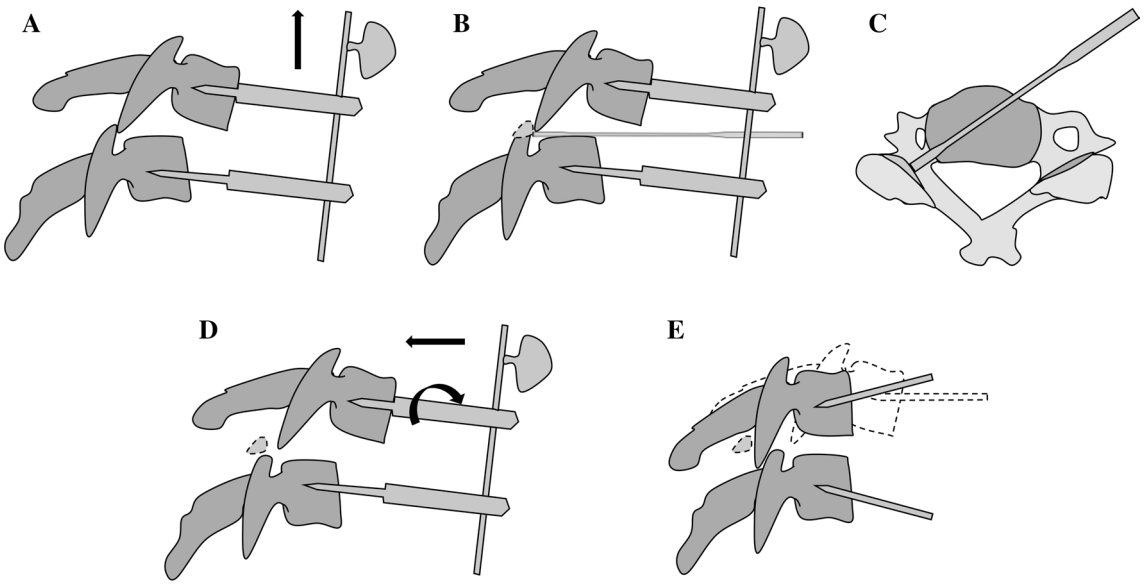


Fig. 2 Anterior facetectomy technique of anterior reduction. **a** If facet locking remains after the kyphotic paramedian procedure of reduction. **b**, **c** An anteromedial foraminotomy by resection of the posterior foraminal part of the uncovertebral joint and resection of the edge of the dislocated superior facet after the nerve root was retracted cephalad in the neuroforamina. **d**, **e** A dorsal and rotational force to the rostral vertebra was applied to achieve reduction

Posterior–anterior procedure

The patient was first placed in a prone position under tong traction. A standard posterior middle incision was made, and a gradually distraction force was used between the spinous processes using bone-holding forceps until the locked facets disengagement, and then, a dorsal force to the rostral vertebra was used to achieve reduction. If the reduction was still unsuccessful, additional resection of the tip of the superior articular process of the lower vertebrae by a high-speed burr was used [17] (Fig. 3). The pedicle or lateral mass screw was used for fixation. After closing the incision, the patient was placed in a supine position and a standard ACDF was performed.

Postoperatively, the patients in both groups had drainage for 2–3 days and were supported with neck braces for

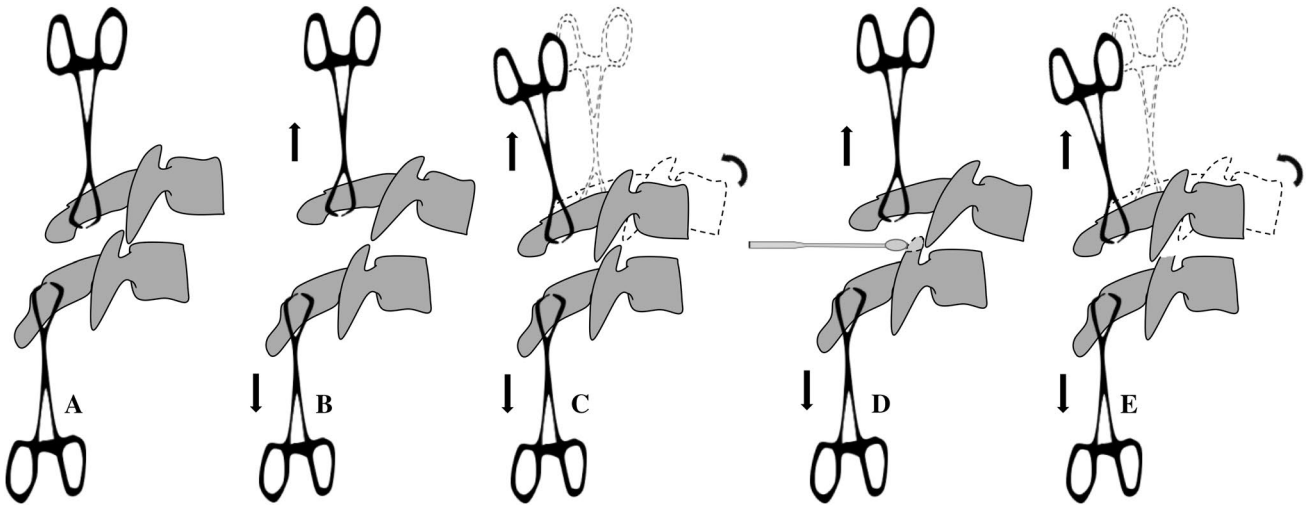


Fig. 3 Posterior reduction techniques. **a** Two bone-holding forceps were used between the spinous processes. **b**, **c** A gradual distraction force was used by bone-holding forceps until the locked facets disengaged, and a dorsal force to the rostral vertebra was applied to achieve reduction. **d**, **e** If the reduction was still unsuccessful, a resection of the tip of the superior articular process of the lower vertebrae by a high-speed burr was needed, and then, a dorsal force to the rostral vertebra was applied to achieve reduction

6–8 weeks. These patients were followed up periodically with the recovery of neurologic function as reflected by improvement in the ASIA grade [18], JOA score [19], and radiographs of the cervical spine for at least 12 months.

The clinical results and the degree of neurologic recovery were examined and compared. The surgical trauma was assessed by operation time, intraoperative blood loss and number of fixed segments. The recovery of neurologic function was reflected by improvement in the ASIA grade and JOA score. Fusion was defined using radiographs as the trabecular formation of the grafted bone between the upper and lower vertebrae.

Data were expressed as the mean ± standard deviation ($x \pm s$). The two independent sample t test or the Mann–Whitney U test were adopted for statistical comparison. A p value < 0.05 was considered statistically significant.

Results

There were no statistically significant differences between the anterior-only group (63 patients) and the posterior–anterior group (30 patients) for age, gender, injury mechanism, injury levels, unilateral/bilateral facets dislocation, and the initial neurologic status as measured by ASIA grading and JOA scoring (Table 1). Both the anterior-only group and the posterior–anterior group achieved a 100% reduction rate. For the anterior-only approach group, 52 patients were successfully reduced by the Caspar pins kyphotic paramedian distraction technique, and the remaining 11 patients were reduced using the anterior facetectomy technique.

Comparing the two groups, the mean operation time in the posterior–anterior approach group (274.0 ± 114.7 min) was significantly longer than that in the anterior-only approach group (88.6 ± 35.0 min) (Mann–Whitney U test, $p = 0.000$). The mean blood loss during the surgery and the number of fixed segments in the posterior–anterior approach group (275.0 ± 183.2 ml; 1.4 ± 0.7, respectively) were significantly greater than those in the anterior-only approach group (92.5 ± 84.0 ml, Mann–Whitney U test, $p = 0.000$; 1.2 ± 0.5, Mann–Whitney U test, $p = 0.030$, respectively) (Table 2). There was a 100% fusion rate in both groups after 6-month follow-up (Figs. 4, 5). No patient showed loosening or breakage of the instrument.

The ASIA grade (A–E) was converted to a numerical quantization score (1–5). In the anterior-only group and the posterior–anterior group, the ASIA score improved from 3.3 to 3.7 and 2.8 to 3.1 after the operation, respectively, which was not statistically significant between the two groups (two independent samples t test, $p = 0.900$) (Table 3). In 23 patients (36.5%) in the anterior-only group and 10 patients (33.3%) in the posterior–anterior group, the ASIA grade was improved by at least one level (Table 4).

The JOA score increased from 10.4 to 11.8 in the anterior-only group and 8.2 to 9.4 in the posterior–anterior group, which was not significantly different between the two groups (two independent sample t test, $p = 0.717$) (Table 3). There were three patients in the anterior-only group who showed neurologic deterioration by 1–2 points and one patient in the posterior-anterior group who deteriorated by 1 point.

Discussion

The principle of treatment of lower cervical facet dislocation is early reduction, complete decompression, rigid internal fixation, and fusion. Generally, the reduction should be performed as soon as possible to relieve spinal cord compression, especially for patients with incomplete spinal cord injury. However, the surgical strategy is highly variable, including anterior alone, posterior alone, anterior–posterior, posterior–anterior, and anterior–posterior–anterior approaches according to closed, anterior open, or posterior open reduction.

In the previous studies, closed reduction with traction is usually initially performed [20–23], even before MRI examination, to restore cervical alignment and reduce compression of the spinal cord in order to provide a favourable condition for neural recovery [24]. However, some have suggested that MRI examination should be improved before traction to assess the cervical spinal cord; otherwise, the spinal cord injury during traction could easily occur [25]. In the present study, most patients were delayed several days and weeks due to transfer from other hospitals or emergency rooms. Although we tried a closed reduction under general anaesthesia in the operation room, only a few cases obtained successful reduction and underwent ACDF.

Table 2 Surgical trauma

	Group (n)	Operation time (min)	Blood loss (ml)	Fixed segments (n)
Means	AO (63)	88.6 ± 35.0	92.5 ± 84.0	1.2 ± 0.5
	PA (30)	274.0 ± 114.7	275.0 ± 183.2	1.4 ± 0.7
p value		$p = 0.000$	$p = 0.000$	$p = 0.030$

Two independent samples t test or Mann–Whitney U test, $p < 0.05$

AO anterior-only, *PA* posterior–anterior

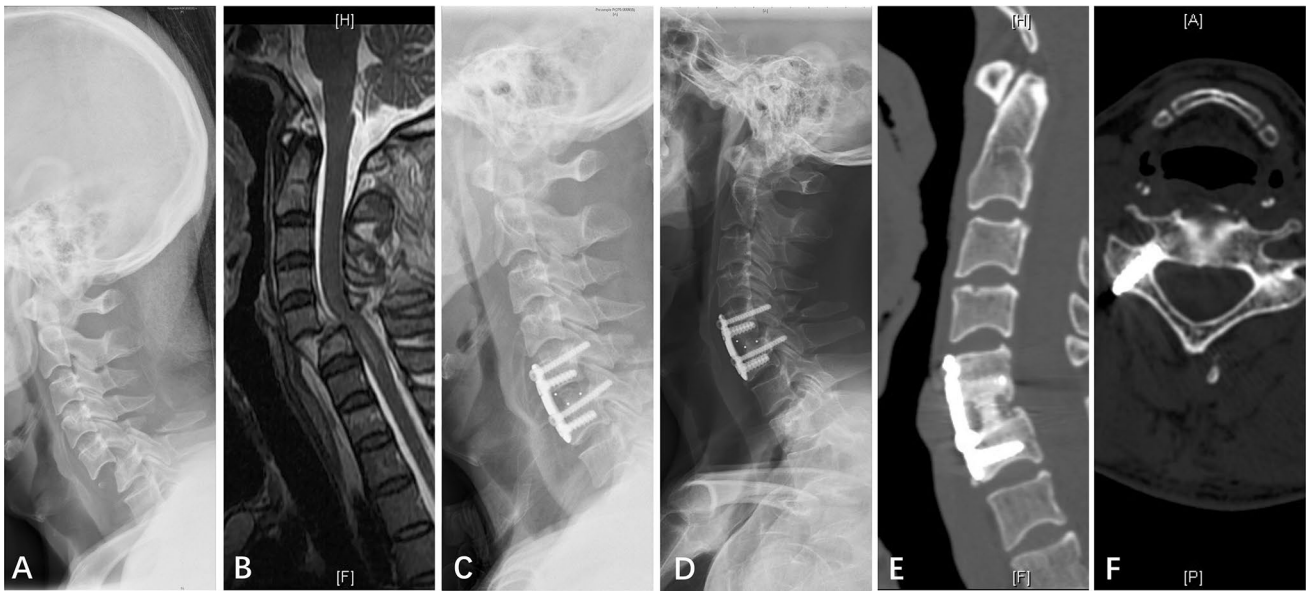


Fig. 4 The illustrative case of the anterior-only approach. **a**, **b** Preoperative lateral radiograph and T_2-weighted sagittal MRI of a 47-year-old man with a C5–C6 bilateral facet dislocation and complete spinal cord injury. **c** After failure of the kyphotic paramedian distraction technique, the patient was ultimately treated with an anterior facetectomy and cervical pedicle screw plate fixation. **d**, **e** Follow-up at 4 months with the lateral radiograph showing the trabecular formation of the graft bone confirmed by sagittal CT. **f** The axial CT image demonstrating good placement of the anterior pedicle screw

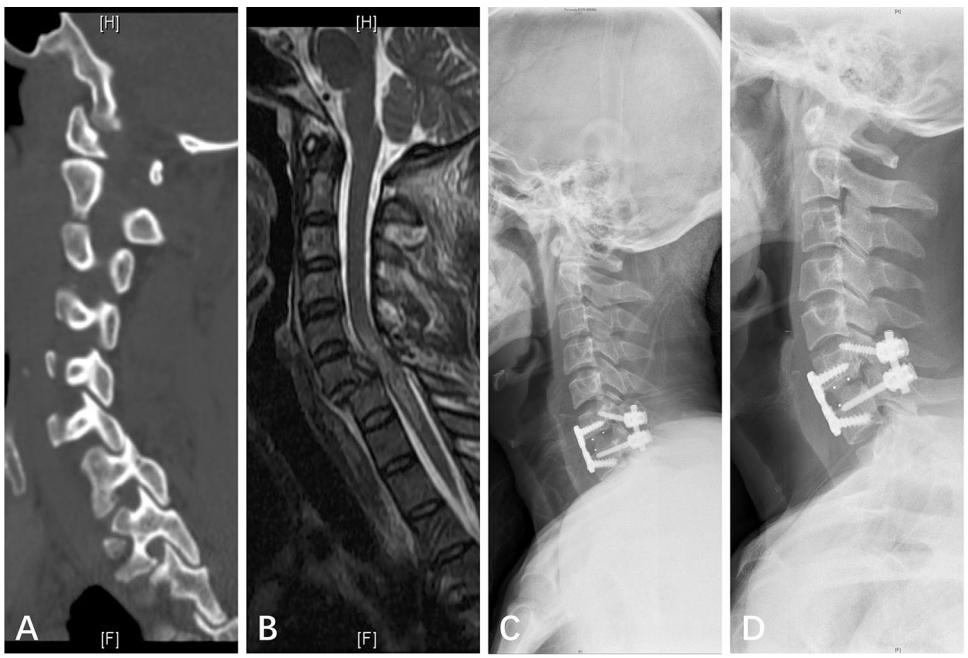


Fig. 5 The illustrative case of the posterior–anterior approach. **a**, **b** Preoperative sagittal CT and MRI of a 43-year-old man with a C6–C7 facet dislocation. **c** The patient was treated with a posterior–anterior procedure. **d** Follow-up at 6 months with the lateral radiograph showing the trabecular formation of the graft bone

Good results have been reported by many studies using the posterior technique [20, 26–28]. Biomechanical investigations have demonstrated the advantages of posterior fixation and the high stability of the cervical pedicle screw [29–31]. The posterior approach is mainly suitable for patients with compression from the posterior of the spinal cord or posterior column injury as it directly reduces the compression and provides high stability. However, the incidence of traumatic disc herniation may be high in patients with cervical facet dislocation, ranging from 0.7 to 42% [5, 6]. We found that 29 out of 93 patients (31.2%) had associated traumatic disc herniation in our series. The risk of

Table 3 Neurologic outcome

	AO group	PA group	*p* value
ASIA grade			
Preoperative	3.32	2.77	
Postoperative	3.70	3.13	
Change	0.38	0.36	0.900
JOA score			
Preoperative	10.38	8.17	
Postoperative	11.75	9.37	
Change	1.37	1.20	0.717

Two independent samples *t* test, $p < 0.05$

AO group anterior-only group, *PA group* posterior–anterior group, *ASIA* American Spinal Injury Association, *JOA* Japanese Orthopedic Association

Table 4 Neurologic outcome (ASIA grade)

Preoperative (AO group/PA group)	Postoperative (AO group/PA group)				
	A	*B*	*C*	*D*	*E*
A	13/12	3/0	1/0		
B		2/0	1/0		
C				3/3	
D				8/7	15/7
E					17/1

AO group anterior-only group, *PA group* posterior–anterior group, *ASIA* American Spinal Injury Association

iatrogenic neurologic deterioration during reduction may be increased if a posterior technique is performed. Moreover, even without traumatic disc herniation, patients are often accompanied by injury to the intervertebral disc; the posterior approach alone cannot remove the compression of the disc or ligaments from the front of the spinal cord. Thus, it is necessary to add anterior decompression and fusion. Combined posterior and anterior reduction and fixation have the advantages of both the anterior and posterior approaches. This method can provide strong stability and adequate decompression as confirmed by many surgeons [32]. However, the procedure of the combined technique requires a better physical condition of the patient, and more importantly, this procedure may increase the risk of postoperative infection and iatrogenic spinal cord injury due to greater trauma, longer anaesthesia and more changes in posture. In the present study, compared with the anterior-only approach, this procedure required a longer time, shed more blood and fixed more segments.

The anterior-only approach presented with less iatrogenic soft tissue injury. In addition, decompression can be performed under direct observation to avoid secondary spinal cord injury. So far, an increasing number of anterior reduction methods have been reported [3, 8, 9, 33]. Using these traditional anterior reduction techniques, the reduction rate of cervical facet dislocation within 2 weeks was reported to be between 60 and 100%. However, for some patients with persistent or bilateral facet dislocation, the failure rate of anterior reduction was as high as 25% to 40% because the previous anterior techniques could not directly extend the force on the locked joints [3, 9, 11, 34]. To unfasten the locked facet, too much traction is often given, which may cause secondary iatrogenic injury to the spinal cord. For patients with severe vertebral fracture, the vertebral body cannot withstand the force of the anterior opener on the cephalic and caudal sides. Oberkircher et al. [35] believed that the stability of anterior reduction and fixation was mainly dependent on the integrity of the facet joint and that anterior-only fixation could not achieve sufficient stability for patients with injury to the articular process. Therefore, it was suggested that in cases with severe posterior column injury, posterior fixation was needed in order to ensure postoperative stability [36].

In our anterior-only procedure, including Caspar pins kyphotic paramedian distraction and anterior facetectomy, we could not only directly open the facet through the anterior approach but also remove the locking of the articular processes under direct view, ultimately yielding a 100% reduction rate even for delayed management of facet dislocation. The key elements of this procedure are as follows: (1) We modified the Caspar pins kyphotic methods [8] to kyphotic paramedian distraction. Both the entry point and direction of the Caspar pin are biased towards the dislocation side to facilitate more distraction forces on the dislocated joint; this step can complete most of the reduction (with a greater than 80% success rate). (2) Even if the reduction fails, an anterior facetectomy can be added to release the locking of the joint, and almost all patients can be reduced (100% success rate).

With regard to fixation, a stable internal fixation plays an important role in fusion. Although there is ample evidence [37–40] indicating that anterior fixation could provide clinically satisfactory results, there are some reports of failed internal fixation with severe instability, especially for C6/7 and C7T1 cases [41, 42]. To achieve three-column fixation, we performed anterior cervical pedicle screw plate fixation on patients with anterior facetectomy and patients with C6/7 or C7T1 facet dislocation who had poor biomechanical stability of the posterior column [16]. In our study, all patients achieved satisfactory fusion after 6-month of follow-up, and no case showed loosening or breakage of the instrument.

Although the clinical outcomes are promising, there are still some limitations to the study. In light of the small number of cases and the specificity of the indication of posterior-only approach surgery, including ruptures and herniation of the ligamentum flavum, fracture of the lamina, and other causes of spinal cord compression mainly from the posterior,

this approach was not included in our study and compared with the other groups. Furthermore, all patients were limited to a single level in the cervical spine without other systemic disease. If other fractures/dislocation or osteoporosis were present, surgeons may need to resort to other techniques. In short, during the treatment of cervical facet dislocation, a comprehensive consideration should be made to choose a suitable surgical plan according to the actual patient pathology, including indications of fracture, dislocation, traumatic disc herniation, compression of the spinal cord, and other factors.

Conclusion

In conclusion, compared with the conventional posterior–anterior reduction and fixation, the present novel anterior-only approach, including Caspar pins kyphotic paramedian distraction and anterior facetectomy, achieved a 100% reduction rate and induced less surgical trauma and complications, indicating that it can be recommended as an alternative method for lower cervical facet dislocation. However, familiarity with cervical anatomy and experienced surgical teams are crucial for this procedure.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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