Original Article
The Techniques of Ventral Reduction and Stabilization for Cervical Facet Dislocation: Early Experience and Review of Literature

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ABSTRACT
Background: Facet dislocation constituted an important subgroup of cervical spine injuries that result from flexion-rotation or flexion-distraction injury. Management of cervical spine dislocations represents an area of substantial controversy regarding the appropriate diagnostic work-up and the available treatment options either conservative or surgical. Anterior cervical approach is an option for treatment of cervical spine facet dislocations. Objectives: To evaluate the efficacy and safety of anterior cervical stabilization in treatment of cervical facet dislocation and to review the specific areas of controversy generated by this issue. Patients and Methods: Ten patients with single level cervical facet dislocation were admitted in the Department of Neurosurgery, Benha University in the period between January 2012 and December 2014. Seven male and three female patients who ranged in age from 18 to 50 years (average 32.1 years). Six patients presented with unilateral cervical facet dislocation and four patients with bilateral cervical facet dislocation. The level of facet dislocation was C5–6 in four, C6–7 in two, C3–4 in two and C4–5 in two patients. Three patients presented with a complete spinal cord injury (SCI), two patients with an incomplete SCI, four with radicular symptoms, and one patient was neurologically intact. All patients underwent computerized tomography evaluation of the cervical spine. Plain radiography and preoperative MRI cervical spine were not routinely done, but tailored according to patient’s condition. Decompression, reduction, and stabilization of the cervical spine via the ventral approach were accomplished in all cases. Results: Adequate decompression of neural tissue by satisfactory reduction of deformity and meticulous diskectomy was achieved in all patients, followed by fixation using anterior plate. Postoperative neurological status was unchanged in three patients and improved in four patients, one patient died due to respiratory compromise caused by diaphragmatic paralysis that was present preoperatively. There was no deterioration of preoperative neurological function. The only complication related to the approach was transient recurrent laryngeal nerve palsy encountered in one case. Conclusion: Anterior cervical approach is effective and reliable alternative for decompression, reduction, and stabilization of the dislocated cervical spine facets in selected patients.

INTRODUCTION
Cervical facet dislocations account for 6-15% of cervical spine injuries that may follow motor vehicle accidents, diving accidents and falls. Common mechanisms for this injury include a flexion-rotation or flexion-distraction that makes the inferior facet of the rostral vertebra to slip forward anterior to the superior facet of the caudal vertebra, with or without associated fractures of posterior or anterior elements. Facet dislocations may be associated with either an intact neurological status, nerve root injury, incomplete or complete spinal cord injury. The issue of cervical facet dislocations continues to generate considerable controversy regarding the pathological spectrum, the appropriate diagnostic workup and the timing and method of reduction, as well as the optimal approach for stabilization when indicated.

PATIENTS & METHODS
Ten patients (seven men and three women) with single level cervical facet dislocation were admitted in the Department of Neurosurgery, Benha University in the period between January 2012 and December 2014.
The patients aged from 18 to 50 years (average 34.75 years). The etiology of trauma was road traffic accidents (RTA) (five patients), high falls (three patients), assault (one patient) and diving accident (one patient). The interval between injury and admission was 6—24 hours with a mean of 9 hours. Three patients presented with a complete spinal cord injury (SCI), two patients with an incomplete SCI, four patients with root syndromes and one patient was neurologically intact. Six patients presented with unilateral cervical facet dislocation and four patients with bilateral cervical facet dislocation. The level of facet dislocation was at C5–6 level (four patients), C6–7 (two patients), C3-4 (two patients) and C4–5 (two patients) (Table 1).

All patients underwent computerized tomography (CT) with (axial, coronal, sagittal and 3D) reconstruction of the cervical spine that was of satisfactory diagnostic outcome (Fig. 1). Plain radiography and preoperative MRI cervical spine were not routinely done, but tailored according to patient’s condition. Plain radiography was used in five patients and MRI cervical spine was used in four patients.

Patients who presented with complete or incomplete SCI were treated using the standard high-dose methylprednisolone protocol.

In all patients, Preoperative closed reduction was not performed. All patients underwent surgery within 48 hours of admission and ventral decompression, reduction, and stabilization of the cervical spine was accomplished in all cases. A postoperative neck collar was used for at least one month. The follow-up period ranged from three months to one year. Rehabilitation was started according to patient’s overall status, neurological injury and pain.

### Table 1: Preoperative characteristics in 10 patients treated for cervical facet dislocation

<table>
<thead>
<tr>
<th>Case</th>
<th>Age(yrs)</th>
<th>Sex</th>
<th>Mode of trauma</th>
<th>Type</th>
<th>Level</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38</td>
<td>M</td>
<td>RTA</td>
<td>Bilat</td>
<td>C5-6</td>
<td>Complete SCI</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>F</td>
<td>RTA</td>
<td>Bilat</td>
<td>C6-7</td>
<td>Complete SCI</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>M</td>
<td>Fall</td>
<td>Unilat</td>
<td>C6-7</td>
<td>Incomplete SCI</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>M</td>
<td>RTA</td>
<td>Unilat</td>
<td>C3-4</td>
<td>Root syndrome (brachialgia)</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
<td>M</td>
<td>RTA</td>
<td>Unilat</td>
<td>C3-4</td>
<td>Complete SCI + diaphragmatic paralysis</td>
</tr>
<tr>
<td>6</td>
<td>42</td>
<td>M</td>
<td>diving accident</td>
<td>Unilat</td>
<td>C5-6</td>
<td>Root syndrome (Monoplegia)</td>
</tr>
<tr>
<td>7</td>
<td>48</td>
<td>M</td>
<td>RTA</td>
<td>Unilat</td>
<td>C4-5</td>
<td>Root syndrome (brachialgia)</td>
</tr>
<tr>
<td>8</td>
<td>27</td>
<td>F</td>
<td>Fall</td>
<td>Unilat</td>
<td>C5-6</td>
<td>Intact</td>
</tr>
<tr>
<td>9</td>
<td>45</td>
<td>M</td>
<td>Fall</td>
<td>Unilat</td>
<td>C4-5</td>
<td>Root syndrome (brachialgia)</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
<td>F</td>
<td>RTA</td>
<td>Bilat</td>
<td>C5-6</td>
<td>Incomplete SCI</td>
</tr>
</tbody>
</table>

### Surgical Technique

- General anaesthesia with the patient supine and neck collar applied;
- A roll was placed beneath the shoulders, and the head was supported on a roll, with caudally fixed shoulders;
- Removal of the neck collar;
- Standard preparation of the skin at the neck and iliac crest donor sites;
- A standard right side anterior cervical approach was performed in all cases;
- Meticulos microsurgical diskectomy;
- Incision of posterior longitudinal ligament with meticulous neural decompression;
- For reduction, we adopted the technique described by Ordonez, et al. 
- A vertebral body post distractor (Caspar pins) were placed at approximately a 10 to 20° divergent angle with respect to each other in the sagittal plane. Angling the vertebral body posts provides for the application of a bending movement when distraction is applied. This, in turn, allows the locked facets to be disengaged prior to the application of distraction forces. Dorsally directed pressure to the rostral vertebral body was applied using manual pressure (Fig. 2). Removal of distraction forces allows the facets to resume a normal position. An intraoperative radiograph was...
then obtained to confirm that the deformity has been adequately reduced. In cases of unilateral facet dislocation, in which there is an accompanying rotational deformity, the patient can be additionally managed by placing the Caspar pins at an angle with respect to each other in the coronal plane. This permits a biomechanical advantage regarding the correction of the rotational component of the deformity (Fig. 3).

■ After reduction and adequate alignment (proved by intra-operative fluoroscopy), iliac crest bone graft is harvested, designed and put in the disc space in eight patients. Inter-body cages were used in two cases;
■ Then anterior cervical fixation by plates and screws was fashioned followed by wound closure with drain.

Fig. 2 a-c: a: Placing distractor pins. b: Distraction disengages the facets. c: Dorsal force applied by manual pressure permits reduction of the dislocation.

Fig. 3: Illustration showing how a rotational deformity can be reduced by placing the pins at approximately a 15° angle with respect to each other in the coronal plane. This permits correction of the rotational deformity when distraction is applied.

RESULTS

Apart from one patient with transient recurrent laryngeal nerve palsy, there was no operative-related morbidity or mortality. There was no deterioration of preoperative neurological function. Follow-up clinical assessment revealed improvement in three patients with root syndromes, the neurologically intact patient remain as such, the two patients with complete SCI remained handicapped and were sent for rehabilitation, one patient with incomplete SCI was diagnosed to have central cord syndrome showed partial improvement with residual deficit in distal upper limb muscles and one patient died due to respiratory failure caused by diaphragmatic paralysis that was present preoperatively. Follow-up radiological assessment revealed successful reduction with satisfactory alignment of the spine in all patients.

Illustrative Cases

Case 1

A thirty-eight years old male presented with quadriplegia following motor vehicle accident, CT cervical spine revealed bilateral facet dislocation with complete dislocation at C5-6 level. Patient underwent surgery within 8 hours of admission and ventral decompression, reduction, and stabilization with inter-body cages and anterior cervical fixation by plates and screws (Fig. 4). Then, patient was referred to rehabilitation center.

Fig. 4 a-c: a: Pre-operative axial CT showing bilateral facet dislocation. b: Pre-operative sagittal CT showing complete dislocation, c: Post-operative sagittal CT showing adequate reduction and stabilization.
Case 9
A forty-five years old manual worker was presented with severe left brachialgia after falling from a scaffold urgent CT and MRI cervical were done (Fig.5). Patient was operated by anterior approach on the next operative list, post-operative CT revealed adequate reduction (Fig. 6).

Fig. 5 a-c: a: Axial CT of cervical spine showing unilateral left facet dislocation which was also evident on sagittal cuts "black arrow" on b, c: MRI cervical spine showing C4-5 subluxation with intracanicular disc fragment.

Fig. 6 a-c: a,b: Sagittal CT showing realignment of cervical spine with fixation by plate and screws with inter-body iliac crest bone graft. c: Lateral sagittal cuts revealing reduction of the locked facet "white arrow".

DISCUSSION
Cervical facet injuries present a significant clinical dilemma with potentially devastating outcomes. These injuries have been classified into four stages: 1) facet subluxation; 2) unilateral facet dislocation with 25% displacement; 3) bilateral facet dislocation with 50% displacement; and 4) complete dislocation.

It was reported that bilateral facet dislocation is associated with more significant soft tissue disruption and more profound neurological injury with C5– C6 and C6– C7 to be the most commonly involved levels. The most common level involved in this series was C5–C6 level (four patients), and bilateral facet dislocation was present in four cases.

The appropriate imaging analysis of suspected cervical facet dislocation is widely debated, and this was the core of multiple studies to outline clear diagnostic guidelines aiming to predict high risk patients to avoid misdiagnosis of devastating injuries and to reduce unnecessary examinations.

Traditionally, plain radiography was used for initial evaluation of these injuries being a safe, good test in conscious, cooperative patients however; it is of limited diagnostic role as they are time consuming, less sensitive especially in poorly visualized craniocervical/cervicothoracic junctions and difficult positioning with painful restricted neck movements, intoxication, unconsciousness or concurrent severe injuries.

The advent of helical and recently multidetector CT scanners with multiplanar (axial, coronal, sagittal and 3D) reconstruction provides a faster, cost effective and comprehensive display of spinal anatomy, facet morphology and fracture detection with reduced number of missed injuries and better assessment of the inadequately shown craniocervical/cervicothoracic junctions with sensitivity and specificity up to 100% and this has led most trauma centers to use CT as an
integral part for diagnosis of cervical spine dislocations. Additionally multidetector CT give the opportunity for simultaneous assessment of the cervical region for vascular injuries if intravenous contrast material is used and to assess other body regions including the spine as a part of multisegment scan. However, to date, the CT scan is considered neither sensitive nor accurate in identifying soft-tissue injuries.

Magnetic Resonance Imaging (MRI) plays a crucial role in evaluating cervical dislocations. It provides more adequate information about spinal cord parenchymal lesions (edema, contusion, hemorrhage and ischemia), cord compression by (epidural collections, vertebral body fractures), ligamentous injury and bone marrow changes. MRI has further benefits in detecting noncontiguous spinal injuries and late post-traumatic complications e.g. cord atrophy, cystic degeneration, myelomalacia, meningoceles or post-traumatic syrinx formation.

Magnetic resonance imaging provides an effective means by which to identify traumatic disc herniations in association with cervical facet dislocations. In the literature, the incidence of this association has ranged from 0.7% to 42%. Devastating neurological sequelae that may result from attempted closed reduction or open dorsal reduction of cervical facet dislocation, presumably caused by retropulsion of disc material into the spinal cord.

The indications and timing of MRI to evaluate cervical facet dislocation remains controversial especially when reduction is considered. Those who favor the use of MRI considered the significant cost of overlooking some injuries and the fact that MRI is not only helpful in diagnosis but also in planning management and may help in prognosticating the disease. Others believe that many reasons limit frequent use of MRI in trauma setting as it is time consuming delaying spinal column realignment, the lack of correlation between the MRI findings and neurological deterioration in this patient population. Furthermore, MRI is not widely available, sensitive to motion artifact, may be contraindicated e.g. those with pacemakers and difficult monitoring of unstable patients on the MRI suite. Also, MR imaging may not necessarily be predictive of the development of disc herniation during attempted closed or open dorsal reduction of cervical facet dislocations because the disc may be severely disrupted but not herniated before reduction is attempted.

In this study, we found that CT with (axial, coronal, sagittal and 3D) reconstruction of the cervical spine was of satisfactory diagnostic outcome. Plain radiography was used in five patients (four patients with root syndromes and one neurologically intact patient) to fulfill investigations for teaching purposes. We reserved the use of MRI for four patients (two patients with an incomplete SCI, two patients with root syndromes) because MRI scanner is not available in our center, is time consuming delaying spinal column realignment, and unsuitable for unstable patients.

The goal of treatment is to preserve the functional and anatomical integrity of the spinal cord and nerve roots, to restore the anatomic alignment of the spine, to achieve long-term stability to prevent secondary or delayed neurologic deficit and to enhance neurologic recovery to the best achievable level.

In this series, we used the anterior approach in all patients. No attempt was made to achieve closed reduction before surgery. Anterior open reduction and stabilization was done as described earlier (see Surgical Technique). Intra-operative traction was used in one patient with complete dislocation to assist reduction. Satisfactory reduction of deformity was achieved in all patients. Follow-up radiography revealed satisfactory sagittal plane alignment in all patients.

Despite the considerable controversy regarding optimal management, there is consensus on the fact that a facet dislocation should be reduced at all times with poor agreement on the technique of reduction (open versus closed), and if open there is no consensus on the best approach and optimal technique of stabilization. It remains difficult also to define the optimal time window for effective decompression of the spinal cord but many authors favor reduction as rapidly as possible after injury to maximize the potential for neurological recovery. Beyond 2 weeks following the injury, it becomes increasingly difficult, if not impossible, to achieve adequate decompression due to scar formation and early fracture healing.

Closed reduction of cervical facet dislocation by manipulation was first described by Walton and weighted cranio-cervical traction was introduced by Crutchfield and since that different techniques have been successfully used for traction-reduction of dislocated facets and open reduction methods have been well described.

The requirements for safe closed reduction are the ability to monitor the patient during reduction process (so should be done in awake, cooperative and alert but not in an obtunded patient), the ability to visualize the cervical spine (fluoroscopy or plain radiographs) and safe skull traction e.g. no skull fracture. The high failure rate and the potential neurological deterioration during or after attempted closed reduction procedures give more popularity for open reduction techniques.

Open reduction can be accomplished through stand-alone anterior approach, stand alone posterior approach, combined anterior and posterior approach, or a staged anterior/posterior or posterior/anterior approach. The choice of approach depend on the degree of instability, direction of maximum cord compression, which approach is safe and effective for reducing the dislocation and personal judgment of the surgeon.
Posterior open reduction can be accomplished by a bone spreader, a towel clip, manipulation with a small dissector wedged between the facets, or by modified interlaminar spreader. 20 If failed partial or complete facetectomy is done followed by posterior stabilization that can be accomplished by two basic techniques: simple wiring or segmental screw fixation.28

Wiring techniques include facet wiring, interspinous wiring, triple wiring, and bilateral facet to spinous process wiring using wires or newer braided cables.8,42 Segmental fixation includes lateral mass plates, hook plates, and screw-rod fixation systems6,38,41

The advantages of the posterior approach include direct visualization and reduction of the injured elements,28 high rate of successful arthrodesis and the familiarity of the approach.18 But it does not allow the surgeon to control the disc fragments with potential devastating neurological sequelae caused by retropulsion of disc material into the spinal canal.40

After being introduced the anterior cervical decompression and fusion (ACDF) has gained much popularity with favorable clinical outcome and adequate long-term stability without significant complications in most cases.6, 30 It can be performed acutely (without a prior closed reduction, following successful closed reduction, or following failed closed reduction) or in chronic dislocation.31,39

Anterior open reduction can usually be accomplished by one of two basic maneuvers. The first is the Cloward maneuver7 which consists of introduction of a blunt instrument (such as a laminar spreader or curette) into the disc space to act as a lever. This is followed by simultaneously pushing on the lever in a caudal direction while exerting pressure on the anterolateral upper vertebra in a dorsal direction.15 The second is the reverse Cloward maneuver, consists of pushing the same lever in a cephalad direction to simultaneously disengage the facets and thrust them into their anatomic position. Other variations include use of vertebral body posts (i.e., Caspar pins) placed at a small divergent angle with respect to each other in the sagittal plane, thus affording a bending moment when distraction is applied to the posts, and causing disengagement of the facets.23 Adaptation of this technique to irreducible unilateral facet dislocations, calls for placing the posts at an angle with respect to each other, in the coronal plane, thus permitting correction of the rotational deformity when distraction is applied.38

Advantages over posterior surgery include that ACDF is simple, less traumatizing, can be performed in the normal dorsal decubitus with a skull traction device in place, involve one motion segment stabilization and adequate one approach spinal canal decompression without any risk of persistent soft tissue (e.g. herniated disc) cord compression.19,27,33,37 Moreover, some studies suggest that the anterior fixation still yields a construct of stability superior to that of the normal spine.18

However, there are some drawbacks to the anterior approach: some cases may be difficult to reduce using only the anterior approach, necessitating posterior reduction,35 anterior plating was prone to fail with significant dorsal element disruption and comminuted fractures of the facet complex.37 31,29

CONCLUSION

Deciding the optimal treatment of cervical facet dislocation is sometimes difficult. Acute surgical management yields good results. Open reduction followed by immediate stabilization by ACDF is highly safe and effective option avoiding the possible neurological complications of closed reduction and posterior approaches.

REFERENCES


