Clinical Article

Bifacet dislocations of cervical spine: acute management and outcome

Dr Albert B du Toit*, Dr Robert Dunn**
*Department of Orthopaedic Surgery, Stellenbosch University, UCT rotation
**Head Orthopaedic Spinal Services, Acute Spinal Cord Injury Unit,
University of Cape Town

Reprint requests:
Dr DN Dunn
Head of Spinal Services
Division of Orthopaedic Surgery
University of Cape Town
PO Box 30086
Tokai
Cape Town
7966
Tel: (021) 404-5108
Fax: 086 671 5294
email: robdunn@mweb.co.za

Abstract

Introduction:

Although the goal in treating bilateral facet dislocations remains the early realignment of the spine, there is controversy regarding the timing and method of reduction, as well as the optimal approach for stabilisation.

A retrospective analysis of prospective collected data from 36 consecutive patients treated for bilateral cervical facet dislocations (BCFD) at the Groote Schuur Hospital Acute Spinal Cord Injury Unit (ASCI) is presented.

Methods:

Case notes and radiographs of 36 BCFD patients managed from April 2003 to January 2007 were reviewed with reference to reduction, stabilisation, radiographic measurements, union, neurology and complications.

Results:

There were 27 males and 9 females. MVAs were the cause in 26 cases. C6/7 was the commonest level of dislocation, followed by C5/6. Seventy-five per cent of the patients had a complete neurological deficit, with only three limited to radiculopathy. Thirteen out of 21 had successful closed reductions, while 14/17 underwent successful open reduction via an anterior approach. Anterior cervical discectomy and fusion (ACDF) was utilised in 25 cases, posterior fixation in five, anterior and posterior in four, and conservative management in two cases. There were three cases of fixation failure, with two requiring revision. There were two transient recurrent nerve palsies but no sepsis. There was a 100% confirmed union rate. There were three deaths related to respiratory compromise. There was no difference in outcome between the posterior and anterior approaches. Although only a few patients improved neurologically, there were no patients with deteriorating motor function at last follow-up.

Conclusion:

Early aggressive surgical management for cervical bifacet dislocations yields good results. Open reduction followed by immediate stabilisation by ACDF is highly successful in the acute case and obviates the need for traction and possible associated neurological complications. In highly unstable cases or cases with poor screw purchase, supplemental posterior fixation may be required. Posterior alone surgery is occasionally indicated, such as delayed presentation and cervico-thoracic junction. Closed reduction with delayed stabilisation remains an acceptable option in the resource-restricted environment.

The cervical spine is the most vulnerable spinal segment and the most frequently injured portion of the spinal column after high-velocity trauma. Cervical facet dislocations account for 6-15% of cervical spine injuries.[1] Bilateral facet dislocation is associated with neurological deficit in the region of 90%.[2]

The management of cervical spine facet dislocations continues to generate considerable controversy with arguments made for non-operative management, anterior, posterior, and combined surgical reduction and fixation devices.

The results of 36 consecutive patients with bilateral cervical facet dislocations (BCFD) treated over a 45-month period are presented.

Materials and methods

A retrospective review of prospectively collected data was undertaken. Thirty-six consecutive patients who sustained BCFD were identified from the spinal surgery database from April 2003 to January 2007. Case notes and radiographs were reviewed and clinical data were collected for all patients. The outcome of BCFD in this patient cohort with regards to demographics, method of reduction, stabilisation, union, alignment, neurological status and surgically related complications was assessed. Pre-admission and in-hospital treatment were also reviewed.

The majority of patients were initially treated at a peripheral hospital where our unit had no influence on management. This consisted of closed reduction (protocol unspecified) in two patients, cones callipers and traction in eight, and immobilisation in hard or Philadelphia collar (no attempted reduction) in 26. The patients were transferred to Groote Schuur Hospital Acute Spinal Cord Injury (GSH ASCI) Unit as soon as a bed became available. The average delay before reaching the spinal unit was 2 days (0-10). This excludes two patients who presented on day 50 and 129 due to missed diagnosis. The delay was largely due to limited bed availability.

The management of cervical spine facet dislocations continues to generate considerable controversy

Once admitted to the unit, patients were stabilised according to ATLS and ACLS principles. Because this is a retrospective review, a consistent reduction protocol was not followed for every patient. In general an attempt was made to reduce the dislocation as soon as it was recognised. Closed reduction was achieved in 11 patients with cones callipers traction at an average weight of 75.8 lb (15-140). This is from early in the study when the technique of high weight rapid reduction was employed. Subsequently this technique was less frequently utilised due to logistics difficulties, perceived risk and success with open reduction as discussed later. One patient presented after 50 days and no attempt at closed reduction was attempted. The remaining unreduced dislocations underwent intra-operative reduction via anterior and/or posterior approaches.

Operative stabilisation was achieved either by anterior (n=25), posterior (n=5) or a combination of the two (n=4). The decision regarding anterior or posterior approach was made by the surgeon based on preference and surgical experience. Posterior approach is preferred for patients presenting late and for injuries at the cervico-thoracic junction due to the biomechanical stresses and poor fluoroscopy visualisation of the area. Anterior reduction and stabilisation consisted of a standard anterior Smith-Robinson approach with the patient supine and cones callipers in situ. Following complete discectomy, reduction was done by traction and manual pressure on the superior vertebral body. Failing this an interbody spreader was applied to facilitate distraction. The superior and inferior endplates were prepared and an autologous tricortical bone graft from the iliac crest was placed in the disc space, restoring intervertebral height and lordosis. A locking plate was then placed. The posterior approach included resection of a portion of the inferior vertebra facet if needed. Elevators was placed between the superior and inferior facets and manual reduction done under direct supervision and fluoroscopy guidance by unlocking the facets and then extending the neck and translating the superior dislocated segment posterior. Then either interspinous wiring or lateral mass screws was used for fixation. One patient who presented at 129 days post-injury could not be reduced and she received a posterior onlay fusion only. This patient was protected in a Philadelphia collar for 12 weeks post-op.

Postoperatively, patients were neurologically assessed for deterioration, and plain radiographs were done. Once patients were stabilised and their associated injuries treated they were immobilised in Philadelphia collars and discharged to appropriate rehabilitation centres.

Follow-up was continued until bony union, at which stage flexion-extension radiographs were done, neurological status re-evaluated and any complications noted. Radiologically, immediate postoperative films were compared with supine lateral and flexion-extension follow-up films to assess graft settling, kyphotic angle, translation, union and any instrumentation failure. A positive angle reflected kyphotic angulation, whereas a negative degree measurement reflected lordosis at that segment. Fusion was noted based on the presence of a bony bridge incorporating the graft and the adjacent endplates and that no motion or radiolucencies were detected on the instrumentation.

Results

Clinical data

The patient population consisted of 27 males and nine females with an average age of 33.3 years (19-74). Twenty-six patients were involved in motor vehicle accidents (72%), five were injured in falls (13.88%), four in sport or diving accidents (11%) and one was due to assault *(Figure 1)*. The level of facet dislocation was C4-5 in six, C5-6 in 13, C6-7 in 15 and C7-T1 in two patients *(Figure 2)*.

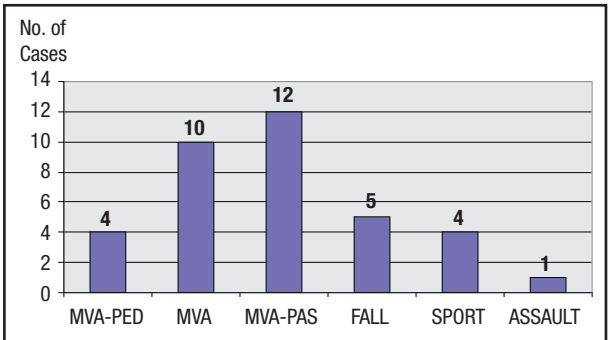

Figure 1: Mechanism of injury

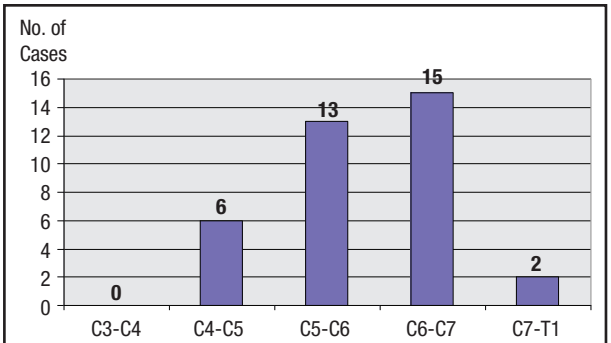

Figure 2: Level of injury

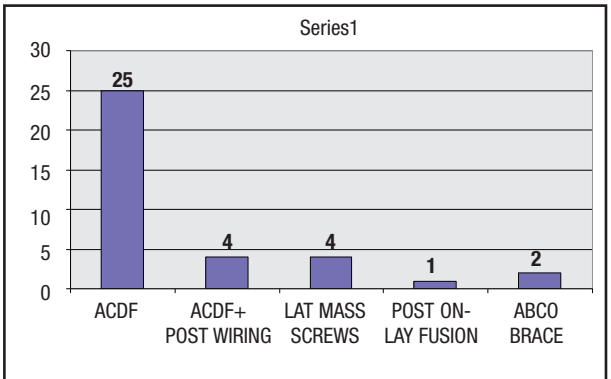

Figure 3: Stabilisation method

Reduction

Satisfactory closed reduction of deformity was achieved in two out of six patients attempted by the peripheral hospitals. A further 11 out of 15 patients attempted closed reductions were reduced in the ASCI unit. Intra-operative open reduction via anterior approach alone was successful in 14 out of 17 patients. In two patients there were still residual perched facets on postoperative radiographs and the third needed additional posterior reduction. Posterior open reduction alone was successful in four out of five cases.

Stabilisation

Anterior decompression and instrumented fusion (ACDF) (n=25) was the method mostly used followed by ACDF combined with posterior wiring (n=4), posterior lateral mass screws alone (n=4) and posterior onlay fusion (n=1) *(Figure 3)*. The onlay fusion was done in a patient who presented after 129 days and was clinically stable in theatre. Two patients were managed non-operatively by means of cones callipers for 6 weeks and then mobilised in a Philadelphia collar. One presented only after 50 days and had pulmonary tuberculosis, and the other patient was medically unfit for surgery. The combined anterior and posterior approach had the longest surgery time with 200 (150-230) minutes, but the time differences were small between the average anterior (129.75 min) or average posterior (140 min) alone approaches.

Radiographic measurements

Residual vertebral translation and kyphosis were assessed on postoperative X-rays. This measured 0.81 mm and –2.69° in the ACDF group, 0 mm and –4.8° in the ACDF and posterior wiring group, and 0 mm and 3.25° in the lateral mass group. Negative angles represent lordosis and positive kyphosis. The two patients who presented late had kyphotic angles of 30º and 25º respectively.

There were three fixation failures. The first patient was taken back to theatre for revision after re-dislocation following ACDF. The second patient had 7 mm translation post-op which increased to 10 mm at last follow-up. This patient had a partial corpectomy for endplate fracture and wedge bone graft followed by ACDF. The inferior locking screws were placed in the disc space. The third patient had 11 mm translation and a kyphotic angle of –18° on post-op radiographs. This patient also had a partial corpectomy and wedge-bone graft for an associated endplate fracture. An ACDF was used to stabilise the injury. The kyphotic angle was improved to –4° two weeks later by adding posterior lateral mass screws. The translation remained unchanged.

Complications

Apart from instrumentation failure the most common surgery-related complications were temporary recurrent laryngeal nerve palsy (n=2), CSF leak (n=1) and chronic post-op neck pain (n=1). There were no wound sepsis or donor site problems.

The most common hospital-related complication was pneumonia (n=12). Other serious complications included pulmonary emboli (n=2), peptic ulcers (n=1), aspiration (n=1), renal failure (n=1) and lung collapse (n=1). These are the recognised complications of spinal cord injury.

Three patients died in the acute hospitalisation phase. One was due to multi-organ failure and the other two from respiratory compromise following severe pneumonia. All three these patients were motor-sensory complete spinal cord injuries.

Hospital stay

The average hospital stay was 37.6 days (2-196). The main reason for the long hospital stay was recovery from pneumonia. Thirty-two patients were discharged to the Western Cape Rehabilitation Centre and two were transferred to UCT Private Rehabilitation Unit.

Neurology

Twenty-seven patients (75%) presented with complete spinal cord injuries (ASIA A), six had incomplete spinal cord injuries (ASIA B,C,D) and three had only upper limb radicular deficits. The average ASIA motor score improved from 28.4 (0-100) to 36.6 (0-100). In 23 patients the ASIA score was unchanged, in eight patients the ASIA grade improved one level and in one patient the ASIA score improved by two grades *(Table I)*.

Fusion

Bone graft incorporation was confirmed in 28 of 32 patients (84.5%) at 12 weeks' follow-up. The other four patients were united at recall to the unit. The overall union rate was 100%.

Discussion

Bilateral facet dislocation is defined as the anterior displacement of both articular facets at the same level, so that the posterior inferior margin of the inferior articular processes lies anterior to the superior articular process of the level below. Because of the forces involved and the degree of distraction, BCFD results in extensive soft tissue injury and thus an unstable spine. Beatson,[3] utilising a cadaveric experimental model, described the soft tissue injury. BCFD could only occur if the superior vertebral body slipped forward by at least 50% of its anterior-posterior length. For this to occur, the facet capsule, interfacetal ligaments, interspinous ligaments, annulus fibrosis, and the posterior longitudinal ligament (PLL) needed to be ruptured. Carrino *et al*[4] performed MRI on patients with BCFD and found only 26.7% cases of ALL and 40% of PLL complete disruptions. They comment that Beatson3 did his study on cadavers with different ligament elasticity and concluded that complete anatomic disruption of the ALL and PLL is not a prerequisite for developing a BFD.[4]

Table I: ASIA grades

Admission ASIA GRADE	Discharge A	B	C	D	E
A (27) 3 died	21	3			
B (0)					
C (4)			1	2	1
D (5)				2	3
E (0)					

Since Crutchfield introduced weighted cranio-cervical traction in 1933 it has been implemented worldwide with mixed success. In our patient cohort 66% of patients failed reduction when attempted at peripheral hospitals. This may be due to limited experience and skill available at secondary level. We experienced four closed reduction failures in our ASCI unit, despite following a standardised technique. One patient had a non-contiguous C2 fracture which limited the weight that could be used in the attempted reduction. There was no delay in reduction in either of these four patients. Success rates from 27-100 % are reported in the literature.[5,6,7] Failure may be due to deteriorating neurology, severe pain, or fracture of the facets at the locked level. Neurological deterioration has been reported in 8.1%.[8] It may be due to over-distraction, failure to recognise a non-contiguous injury, disc herniation, epidural haematoma, and spinal cord oedema.[9] Disc herniation before reduction of cervical spine dislocation is reported in 54-80%.[10] Post-reduction disc herniation varies between 9-77%, with an average incidence of 40%, according to the literature.[11]

Vaccaro *et al*[11] showed an increase in the prevalence of disc herniation after closed reduction from 18% to 56%, but no deterioration of neurological function. However Doran,[12] Robertson and Ryan[9] and Eismont *et al*[13] have reported neurological deterioration after reduction manoeuvres. This seems to be more common after posterior open reduction.

BCFD results in extensive soft tissue injury and thus an unstable spine

When skull traction fails to reduce the locked facets, various management approaches have been advocated. These include application of extraordinary heavy weight traction, manual closed reduction under anaesthesia, and open reduction.[14] Cotler *et al*[15] reported that weights up to 140 lb can be used for more difficult reduction with no risk to the subject. Closed reduction in an anaesthetised patient has been advocated by many authors.[7,16] The advantages are to eliminate pain and relax the musculature, but one is unable to monitor neurological function. Lee *et al*[16] had a success rate of 73% in the cohort of 91 patients with manipulation under anaesthesia, but had 16 mortalities. Twelve of these mortalities were secondary to respiratory deterioration and in three there was associated deterioration in their neurological status. It is uncertain whether the neurological deterioration was due to the MVA itself or the reduction. *Figure 4* demonstrates a post-reduction MRI with disc extrusion in the canal.

The time to attempted closed reduction may result in increased difficulty. Braakman *et al*[17] found that beyond 2 weeks following injury, it became increasingly difficult, if not impossible, to obtain a successful closed reduction due to scar formation and early fracture healing.

Open surgical reduction may be performed acutely without a prior closed reduction, or following failed attempted closed reduction. This can be accomplished through either anterior, posterior or a combination of both.

In our study we successfully reduced 14 of 17 (82%) patients by means of anterior open reductions and 80% of posterior open reductions. Two patients had residual perched facets on postoperative radiographs that were not appreciated in theatre and the third needed a combined approach. Posterior open reduction failed in a patient who presented after 129 days.

The delay before decompression has been the subject of debate. The ultimate neurological outcome may be affected by both patient variables (age, sex, medical status, other injuries) and by management variables (early reduction, steroids, blood pressure management). Cord oedema, hypoxia, and ischaemia within a constitutionally narrowed vertebral canal can also contribute further to secondary cord damage.[9,18,19] Many authors advocate early reduction and thus reconstitution of the normal vertebral canal, thereby improve neurological outcome. No class 1 studies to support this have been forthcoming. Animal studies support neurological recovery when compression is relieved within one hour and up to 9 hours.[20-22] In humans this time frame is more difficult to determine. Robertson and Ryan reported on three cases of late onset neurological deterioration ranging up to 72 hours after intervention.[9] Fehlings *et al*[8] conducted a review of the literature dating from 1966 to 2001 and reviewed 97 articles related to the timing of the spinal cord compression. They concluded that there is no class 1 evidence regarding the role and timing of decompression in acute SCI. Class 2 evidence exists proving that surgery can be safely undertaken in patients with acute SCI, and class 3 data support urgent reduction for patients with bilateral cervical facet dislocation and urgent decompression for patients with deteriorating neurological status.

Stabilisation of the spine after BCFD is another area of controversy. Earlier forms of treatment included prolonged traction but this is associated with increased complications, including pulmonary problems, pressure sores, osteoporosis and venous thrombosis, and is now rarely recommended.[9] Key and Retief reported an in-hospital mortality of 22% in 300 patients of whom only 2% were treated surgically, with a further 8% demising once home.[23] Although commonly used as a treatment alternative for stabilising facet dislocations, three months of halo vest immobilisation may lead to resubluxation and a poor clinical result. Only 22% of patients treated experienced good anatomic result after facet dislocations when they were treated with a halo vest, according to the study by Sears and Fazl.[24] In his large series of cervical spine injuries, Bohlman[25] found late instability in 42% of dislocations that were treated non-operatively and Cheshire[26] drew attention to instability in 17% of his patients where non-operative measures were used. Most authors would agree that non-operative treatment is not indicated in disco-ligamentous injuries, but some do achieve good results in cervical spine dislocations associated with fractures.

Figure 4: Post-reduction disc herniation with torn ligamentum flavum and cord compression

Figure 5: Posterior lateral mass screw fixation

Figure 6: ACDF

In our study, two patients were managed with long-term traction because they were unfit for surgery. Both these patients were stable at the injured level on their 12-week follow-up radiographs.

Internal fixation can be via anterior or posterior alone, or a combination of the two techniques. If open reduction is required, internal fixation at the same operative setting is the most efficacious treatment for these patients.[2] Posterior stabilisation includes wiring techniques or segmental screw fixation.

Introduced by Hadra (1891), interspinous wiring has the advantage of simplicity and preservation of intact facet joint capsules, but the disadvantage of requiring intact posterior elements and post-op external immobilisation. Govender *et al* achieved a 100% fusion rate by using a modified triple wiring technique that is more stable and only requires 8-12 weeks of soft collar support post-op.[27] Segmental screw fixation gained recognition in 1970 when Roy-Camille and Saillant published a technique of posterior fusion using a plate fixed with screws to the articular processes. Replacing the plates with rods has yielded similar results *(Figure 5)*.

Benefits of the posterior approach for fixation includes a high rate of successful arthrodesis and the safety and familiarity of the approach.[29] The posterior approach was complicated with an increased incidence of infection as found by Keynan *et al*.[18]

Anterior cervical decompression and fusion (ACDF), described by Smith and Robinson in 1955, has gained much popularity *(Figure 6)*. Clinical outcomes have been reported as good or excellent in 72-94% and complications are not common.[28]

Non-union are seen in 4-26% of cases and graft extrusion or angular collapse in 2-8%.[29] Introducing a locking plate instrumentation system has reduced some of these complications considerably. Advantages over posterior surgery include ease of positioning, one motion segment stabilisation only with associated posterior element fractures and the ability to remove a herniated disc if present. Although biomechanical studies have concluded that anterior fixation alone is inferior to posterior fixation or combined anterior and posterior fixation, the anterior fixation still yields a construct of stability superior to that of the normal spine.[29] Combined anterior and posterior fixation may also not improve the stability significantly when compared to posterior grafting with lateral mass screws and interbody grafting. Johnson *et al* found that anterior plating was prone to fail if there were facet fractures or endplate compression fractures associated with the flexion distraction injury. They found no correlation between failure and age, gender, surgeon, plate type, level of injury, degree of translation, or alignment at the time of injury. They reported an overall 13% mechanical failure rate in 87 patients, 75% of which had bilateral facet injuries.[30]

In our study we had three fixation failures following ACDF. One patient re-dislocated post-op and was revised The other two had poor inferior screw placement with pull-out. One was revised with a combined anterior posterior approach due to progressive translation while the other patient's failure was static and no revision was done. Both these patients have gone on to asymptomatic bony union. None of our patients developed wound infections. There were two patients who developed transient recurrent laryngeal nerve palsy from the anterior approach. Another patient had a CSF leak following ACDF.

Bony union was achieved in 28 of 32 (84.5%) patients at 12 weeks, and another four patients were confirmed united at recall to the unit. There was no progressive kyphotic deformity in these patients. The confirmed bony union rate was 100%.

Neurological recovery or functional outcome remains the main goal in treating any patient with a SCI. Burns *et al* reviewed the literature regarding neurological recovery. They found that an examination at 72 hours is superior to the first day examination for long-term prognostication.[31] In complete tetraplegia there is little chance of functional motor recovery in the lower extremities if the patient remains motor and sensory complete more than one month post-injury. Incomplete injuries of the cervical spine recover to a greater extent than complete injuries. Lintler *et al* found that 61% of incomplete spinal cord injuries improved at least one Frankel grade.[32] More than 90% of incomplete injuries gained at least one additional motor level in the upper extremities. There is an excellent chance (92%) of recovery to >3 motor strength for initially 0 of 5 muscles if pinprick is spared at the same dermatome.

Variables that may affect neurological recovery include age, medical status, other injuries, time to reduction, steroids used and blood pressure management. Anderson *et al*[33] noted in their review of 28 BCFD noted an increase in age yielded a significantly lower improvement in ASIA motor score if compared with younger patients ($p=0.01$). The initial motor score was highly predictive in a non-linear fashion of the final motor score ($p<0.01$). The majority of neurological recovery in complete and incomplete spinal cord injuries occurs during the first 6 to 9 months. Twenty-three patients in our cohort were unchanged neurologically at final follow-up.

Three patients in our study who were motor-sensory complete tetraplegics regained one Frankel level. Their ASIA motor score improved from an average of 17.7 to 25.7 in 12 weeks. Two of these patients had a reduction on day one post injury, while the third was only reduced after 10 days. This delay was due to awaiting transfer to our facility. Eight incomplete SCI patients improved at least one Frankel grade. In this group the ASIA motor score improved from an average of 71.0 to 94.8 in 12 weeks. Only one had reduction on the day of injury, while the others had a delay ranging from one to four days. Only one patient improved two grades, and this patient was discharged with fully intact neurological status. No patients improved more than two Frankel grades.

Conclusion

Although surgery plays little role, if any, in neurological recovery, early aggressive intervention allows early commencement of rehabilitation. Acute reduction is possible at the time of surgery via the anterior approach which allows immediate stabilisation by means of plating. Should there be a delay to reduction a posterior approach should be considered.

Closed reduction remains useful in this patient group and should be used if there is delayed access to theatre. During the initial post-injury, spinal shock may mask underlying residual cord function, creating a false impression of complete neurological injury. Therefore an attempt at early reduction to decompress the canal should always be made. Success however does depend on the skill level available as evidenced by the high failure rate at the referral centres.

This article was not submitted to an ethical committee for approval. The content of this article is the sole work of the authors. No benefits of any form have been derived from any commercial party related directly or indirectly to the subject of this article.

References

1. Greg Anderson D, Voets C, Ropiak R, *et al.* Analysis of patient variables affecting neurologic outcome after traumatic cervical facet dislocation. *Spine J* 2004; **4**:506-12.
2. Hadley MN, Fitzpatrick BC, Sonntag VK, *et al.* Facet fracture-dislocation injuries of the cervical spine. *Neurosurgery* 1992; **30**:661-6.
3. Beatson TR. Fracture and dislocations of the cervical spine. *JBJS* Br 1983;**45**:21-35.
4. Carrino *et al.* Posterior longitudinal ligament status in cervical spine bifacet dislocations. *Skeletal Radiology* 2006;**35**:510-4.
5. Grant GA, Mirza SK, Chapman JR, *et al.* Risk of early closed reduction in cervical spine subluxation injuries. *J Neurosurg* 1999;**90**:13-8.
6. Star AM, Jones AA, Cotler JM, *et al.* Immediate closed reduction of cervical spine dislocations using traction. *Spine* 1990;**15**:1068-72.
7. Vital JM, Gille O, Senergas J, *et al.* Reduction technique for uni- and bi-articular dislocations of the lower cervical spine. *Spine* 1998;**23**:949-54.
8. Fehlings MG, Sekhon LH, Tator C. The role and timing of decompression in acute spinal cord injury: What do we know? What should we do? *Spine* 2001;**26**:S101-10.
9. Robertson PA, Ryan MD. Neurological deterioration after reduction of cervical subluxation. Mechanical compression by disc tissue. *J Bone Joint Surg* Br 1992;**74**:224-7.
10. Rizzolo SJ, Piazza MR, Cotler JM. Intervertebral disc injury complicating cervical spine trauma. *Spine* 1991;**16**:5187-9.
11. Vaccaro AR, Falatyn SP, Flanders AE, *et al.* Magnetic resonance evaluation of the intervertebral disc, spinal ligaments and spinal cord before and after closed traction reduction of cervical spine dislocations. *Spine* 1999;**24**:1210-7.
12. Doran SE, Papadopoulos SM, Ducher TB, Lillekei KO. Magnetic resonance imaging documentation of coexistent traumatic locked facets of the cervical spine and disc herniation. *J Neurosurg* 1993;**79**:341-5.
13. Eismont FJ, Arena MJ, Green BA. Extrusion of an intervertebral disc associated with traumatic subluxation or dislocation of cervical facets. Case report. *J Bone Joint Surg* Am 1991;**73**:1555-60.
14. Lu K, Lee TC, Chen HJ. Closed reduction of bilateral locked facets of the cervical spine under general anaesthesia. *Acta Neurochir (Wien)* 1998;**140**:1055-61.
15. Cotler JM, Herbison GJ, Nasuti JF, *et al.* Closed reduction of traumatic cervical spine dislocation using traction weights up to 140 pounds. *Spine* 1993;**18**:386-90.
16. Lee AS, Maclean JC, Newton DA. Rapid traction for reduction of cervical spine dislocations. *JBJS* (Br) 1994;**76**:352-6.
17. Braakman R, Vinken PJ. Unilateral facet interlocking in the lower cervical spine. *J Bone Joint Surg* Br 1967;**49**:249-57.
18. Keynan O, Dvorak M, Fisher C. Reduction techniques in cervical facet dislocations. *Techniques in Orthopaedics* 2003;**17**:336-44.
19. Ludwig SC, Vaccaro AR, Balderston RA, *et al.* Immediate quadriparesis after manipulation for bilateral cervical facet subluxation. A case report. *J Bone Joint Surg* Am 1997;**79**:587.
20. Carlson GD, Minato Y, Okada A, *et al.* Early time-dependent decompression for spinal cord injury: vascular mechanisms of recovery. *J Neurotrauma* 1997;**14**:951-62.
21. Delamarter RB, Sherman J, Carr JB. Pathophysiology of spinal cord injury. Recovery after immediate and delayed decompression. *J Bone Joint Surg* Am 1995;**77**:1042-9.
22. Jacobs R. MRI pre- and post rapid heavy weight closed reduction. *SAOJ* 2006;**5**:40-8.
23. Key AG, Retief PJ. Spinal cord injuries. An analysis of 300 new cases. *Paraplegia* 1970;**7**:243-9.
24. Sears W, Fazl M. Prediction of stability of cervical spine fracture managed in the halo vest and indications for surgical intervention. *J Neurosurg* 1990;**72**:426-32.
25. Bohlman HA. Adult fractures and dislocations of the cervical spine. *JBJS* (Am) 1979;**61**A:1119.
26 Cheshire DJ. The stability of the cervical spine following the conservative treatment of fractures and fracture dislocations. *Paraplegia* 1969;**2**:193.
27. Stathoutis B and Govender S. The triple wire technique for bifacet dislocation of the cervical spine injury. *Injury* 1997;**28**(2):123-5.
28. Brodke D, MD and Zdeblick T, MD. Modified Smith-Robinson procedure for anterior cervical discectomy and fusion. *Spine* 1992;**17**(105):427-30.
29. Doh Koh Y, Lim T, Won You J. A biomechanical comparison of modern anterior and posterior plate fixation for the cervical spine. *Spine* 2001;**26**:15-21.
30. Johnson MG, Fisher CG, Boyd M, *et al*. Radiographic failure of single segment anterior cervical plate fixation in traumatic cervical flexion injuries. *Spine* 2004;**29**(24):2815-20.
31. Burns AS, Ditunno JF. Establishing prognosis and maximizing functional outcomes after spinal cord injury: a review of current and future directions in rehabilitation management. *Spine* 2001;**26**:S137-45.
32. Lintler DM, Knight RQ, Cullen JP. The neurologic sequellae of cervical spine facet injuries. The role of canal diameter. *Spine* 1993;**18**(6):775-9.
33. Anderson DG, *et al.* Analysis of patient variables affecting neurological outcome after traumatic cervical facet dislocation. *Spine* 2004;**4**:506-12.