

INITIAL CLOSED REDUCTION OF CERVICAL SPINAL FRACTURE-DISLOCATION INJURIES

RECOMMENDATIONS

Standard: There is insufficient evidence to support treatment standards.

Guideline: There is insufficient evidence to support treatment guidelines.

Option:

- Early closed reduction of cervical spinal fracture-dislocation injuries with cranio-cervical traction is recommended for the restoration of anatomic alignment of the cervical spine in awake patients.
- Closed reduction in patients with an additional rostral injury is not recommended.
- Patients with cervical spinal fracture dislocation injuries who are not able to be examined during attempted closed reduction, or prior to open posterior reduction, should undergo MRI prior to attempted reduction. The presence of a significant disc herniation in this setting is a relative indication for a ventral decompression prior to reduction.
- MRI study of patients who fail attempts at closed reduction is recommended.
- Pre-reduction MRI performed in patients with cervical fracture dislocation injury will demonstrate disrupted or herniated intervertebral discs in one third to one half of patients with facet subluxation. These findings do not appear to significantly influence outcome following closed reduction in awake patients and therefore the utility of pre-reduction MRI in this circumstance is uncertain.

RATIONALE

Spinal cord injury is frequently associated with traumatic cervical spine fractures and cervical facet dislocation injuries because of the narrowing of the spinal canal caused by displacement of fracture fragments or subluxation of one vertebra over another. Reduction of the deformity helps to restore the diameter of the bony canal and eliminates bony compression of the spinal cord due to the vertebral fracture and/or subluxation. Theoretically, early decompression of the spinal cord after injury may lead to improved neurological outcome. Several large series of patients describe excellent results with closed reduction of cervical fractures and facet subluxations. However, descriptive series using pre-reduction MRI have reported a high incidence of cervical disc herniation in the facet dislocation patient population. Furthermore, case reports and small series of patients who worsened neurologically following closed cervical spinal reduction exist. Several of these reports implicate ventral compression of the spinal cord by displaced disc material. The purpose of this qualitative review is to address the following issues:

1. Is closed reduction safe and effective for reducing cervical spinal deformity in patients with cervical fractures or unilateral or bilateral facet dislocation injuries?
2. Is a pre-reduction MRI essential for the management of these patients?

SEARCH CRITERIA

A National Library of Medicine computerized literature search from 1966 to 2001 was undertaken using medical subject headings in combination with “spinal cord injury”: spinal fracture, spinal injury and human. Approximately 12,300 citations were acquired. Non-English language citations were deleted. Searching this set of publications with the keyword “cervical” resulted in 2,154 matches. Further refining the search with the terms “reduction” or “fracture”

yielded 606 articles. Titles and abstracts of each of these 606 references were reviewed. Clinical series dealing with adult patients in the acute setting were selected. Case reports and case collections were included in the review but were not included in the Evidentiary Tables. Additional references were culled from the reference lists of the remaining papers. The members of the author group were asked to contribute articles known to them on the subject matter that were not found by other search means. Finally, the tables of contents of the journal *Spine* were hand searched from 1993 through May, 2000. Thirty-five papers relevant to this topic were identified and form the basis of this guideline. The larger clinical series are summarized in Evidentiary Table format.

There were no randomized clinical trials, no prospective cohort studies and no case controlled studies. There was one historical cohort study comparing awake traction-reduction with manipulation under anesthesia (MUA). The remainder of the publications consisted of case series of patients with acute or subacute unilateral or bilateral cervical facet dislocation injuries treated with open or closed reduction. Several case reports and case series of patients who deteriorated following closed reduction were identified and are included. Several studies included pre- and post-reduction MRI findings.

SCIENTIFIC FOUNDATION

Closed reduction of cervical spinal deformity due to facet dislocation by manipulation was first described by Walton in 1893.(35) Crutchfield introduced tongs for inline traction-reduction in 1933 (6), and similar techniques have been successfully used for traction-reduction of cervical deformity by a large number of authors.(1-5,11,12,16,21,23,27,29-31,34,37) Observations by Evans and Kleyn popularized reduction under anesthesia, although other authors condemned the procedure as potentially dangerous compared to cranio-cervical traction-

reduction. Manipulation under anesthesia (MUA) is still a frequently practiced technique, usually employed following failure of traction-reduction but occasionally used as a primary means of achieving reduction.(9,16) Only one cohort study has been performed comparing the two modalities. Lee et al found a higher rate of success and a lower complication rate with traction-reduction as opposed to MUA.(16) The significance of their results is questionable due to the historical cohort design of the study. Lee attributed the higher complication rate in the MUA group to the effects of anesthesia on perfusion of the injured spinal cord. It is possible, however, that advances in the pharmacological and medical management of spinal cord injured patients over the 10-year period of data accrual accounted for the improved results the authors noted in the traction-reduction group.(16) For this reason, the evidence provided by this study is considered to be Class III medical evidence.

Recent reports of neurological deterioration following closed or open posterior reduction of cervical fracture-dislocation injuries has led some authors to recommend the use of pre-reduction MRI to assess for ventral cord compromise due to traumatic disc disruption. Several investigators believe that disc disruption in association with facet fracture-dislocation increases the risk of spinal cord injury by disc material following reduction.(7,8,20,25) Other authors, however, have found no relationship between findings on pre-reduction MRI, neurological outcome, or findings on post-reduction MRI.(33) The nature of the injury predisposes a large percentage of patients with cervical facet dislocation injuries to have MRI evidence of disc material ventral to the spinal cord. Rizzolo et al found evidence of disc disruption/herniation in 55% of patients studied with pre-reduction MRI.(24) The clinical relevance of these findings has not been proven. The use of pre-reduction MRI may delay reduction of the spinal deformity and therefore may delay decompression of the compromised spinal cord. Pre-reduction MRI assessment requires the transport of a patient with a highly unstable cervical spinal fracture to the

MRI suite. Recent laboratory work, as well as Class III evidence, suggests that early reduction of fracture-dislocation injuries may improve neurological outcome.(2,10,16,20,26) If stabilization of the unstable cervical spine protects against additional injury to the cervical spinal cord, then the information gained by pre-reduction MRI must be of sufficient value to warrant the delay in treatment and the associated potential morbidity of transport.

The majority of clinical series reviewed were based on patient data accrued prior to the introduction of MRI. These combined series encompass over 1200 patients treated with closed reduction in the acute or subacute (days) period following injury. The success rate for restoration of anatomical alignment by closed reduction in these studies was approximately 80%. The reported permanent neurological complication rate was less than 1.0%.(3,5,9,11,12,15,16,20-21,23,27-31,34,36) Of the 11 patients reported to develop new permanent neurological deficits with attempted closed reduction, two had root injuries, (11,12) and two had ascending spinal cord deficits noted at the time of reduction.(3,30) Seven patients were noted to have decreased American Spinal Injury Association (ASIA) scores post-reduction, however neither the nature nor the cause of the new deficits in these patients was described.(16)

Transient neurological deterioration following closed reduction has been reported. In addition to the permanent deficits noted above, temporary deficits have been described in 20 additional patients of these 1200. These deficits reversed spontaneously, or improved following reduction of weight or following open reduction.(3,11,12,16,20,31) The causes of neurological deterioration associated with closed reduction in these and other series included over-distraction (3,21,30), failure to recognize a more rostral non-contiguous lesion (30,32), disc herniation (11), epidural hematoma (17), and spinal cord edema. (19,20)

A variety of authors have provided general suggestions on how craniocervical traction for closed reduction of cervical spinal fracture-dislocation injuries is best accomplished. (14,15,18,40) No study has been undertaken to determine the superiority of one method or technique over another. Tongs (Crutchfield or Gardner-Wells) or a halo ring are applied to the injury patient's head utilizing sterile technique and local anesthesia at the tong or pin insertion sites. Most contemporary descriptions incorporate the use of an MRI compatible halo ring as the cranial fixation device for four-point fixation of the cranium, better control of the head and neck if positioning and directional traction are needed (e.g., passive directional traction in positions of flexion or extension of the neck depending on the injury type), and to facilitate halo-ring vest application once closed reduction has been accomplished.(14,15,18,40)

Hadley et al suggest closed-reduction of acute cervical spinal fracture-dislocation injuries is best accomplished as part of the early overall medical management of the potential spinal cord injured patient in the ICU setting utilizing bedside fluoroscopy, with close monitoring of each patient's clinical and neurological status, as well as cardiac, respiratory, and hemodynamic parameters. Pain control and modest sedation-relaxation is provided utilizing short-acting intravenous agents that do not impair the patient's level of consciousness or alter their hemodynamic performance parameters. (14,18)

Cranial-cervical traction is typically arbitrarily initiated with the application of weight beginning with three pounds per superior injury level. A patient with an isolated C5-6 fracture dislocation injury using this scheme would begin treatment with an initial weight of 15 pounds (3 lbs. x 5 rostral vertebral levels). Caveats to the use of this initial weight suggestion include patients with fracture-dislocations involving C2 and above and patients with ankylosing spondylitis in whom very little weight, if any, may be needed to accomplish reduction. Judgment and experience must be utilized in this setting as some more proximal cervical spinal

injuries may be distraction injuries and will not require traction, and are perhaps best managed with realignment and compression.

Weight may be added as often as every ten to fifteen minutes as long as close clinical, neurological, and radiographic monitoring is reassessed throughout the process. No upper limit of weight has been described in the literature. In general, increasing weight is applied until closed reduction and realignment occurs or until patient complaints are great (increasing, intractable pain or a subjective worsening of neurologic status), the patient's neurological examination worsens, over-distraction occurs as noted on fluoroscopy or lateral cervical spine x-rays, when it is impractical to add further weight (no additional weight can be applied to the distraction device, no additional weight available, patient sliding upward in bed) or when the clinician's judgment is that closed reduction has failed.

Once closed reduction has been accomplished, or once the determination has been made that closed reduction has failed, it is recommended that the patient be immobilized to provide stabilization of the cervical spinal injury before transport to radiology for further assessment or to the operating room for surgical management.(14,18)

Herniated disc fragments causing compression of the cervical spinal cord at the level of facet dislocation have been described by several authors.(3,8,11,16,20,22,25,28,37) Eismont reported a series of 63 patients managed with closed traction-reduction followed by open reduction if closed reduction was unsuccessful.(8) One of these patients worsened following posterior open reduction and fusion. A herniated disc was found ventral to the cord on post-procedure myelography. Herniated discs were found in three other patients who failed closed reduction, and in two patients with static neurological deficits following fracture-dislocation reduction (one open, one closed). One of these patients deteriorated after subsequent anterior

cervical discectomy and fusion (ACDF). Eismont did not report his overall results with closed reduction. However, it is clear from his case descriptions that no awake patient experienced neurological deterioration as a result of attempted closed reduction.(8) Olerud described two patients found to have disc herniations on post-reduction MRI or CT myelography.(22) Both patients deteriorated following open reduction following failure of attempted closed reduction.(22) Robertson and Ryan reported three patients who deteriorated during management of cervical subluxation injuries.(25) One of their patients worsened during transport to the hospital. That patient's vertebral injury was found to have spontaneously partially reduced. MRI revealed a disc fragment compressing the cord. A second patient deteriorated following posterior open reduction. MRI revealed disc fragments compressing the cord. The patient underwent subsequent anterior decompression. The third patient deteriorated three days following successful closed-reduction. A subsequent MRI study demonstrated disc material compressing the ventral cervical spinal cord. Five days following deterioration, the patient underwent anterior decompression. All three patients recovered to at least their pre-deterioration neurological examination.(25) Grant et al reported a single case of neurologic deterioration in their series associated with closed reduction that also occurred in a delayed fashion (six hours following reduction). This occurred in a patient subsequently found to have a herniated disc at the level of injury.(11)

Mahale et al reviewed 16 cases of neurological deterioration in patients with cervical spinal cord injuries following reduction of facet dislocations.(20) Seven of the sixteen patients developed complete cord injuries, six following open reduction and one following manipulation under anesthesia. Five patients developed partial injuries, three following manipulation under anesthesia and two following closed traction-reduction. Of the two patients who deteriorated following closed reduction, one was found to be over-distracted. Minor injuries were suffered by

the remaining four patients, including one who deteriorated when the skull traction pins slipped, one who deteriorated in a plaster brace, one who lost reduction and had neurological worsening, and one patient who underwent open reduction. Six patients were investigated with myelography following deterioration, two with MRI and one was evaluated with CT. A disc protrusion was noted in one patient, and a “disc prolapse with hematoma” was noted in another. Both of these patients were treated conservatively. The most common imaging finding in these nine patients was cord edema. (20)

The prevalence of MRI documented disc herniation in association with cervical facet injury with subluxation has caused a number of authors to recommend pre-reduction MRI in patients with these injuries. Harrington et al. reported a series of 37 patients managed with closed reduction, in whom a 97% rate of successful reduction was achieved with no neurologic morbidity.(16) Post-reduction imaging revealed disc herniations in nine patients, four of whom underwent later anterior decompression. Doran et al reported a series of 13 patients drawn from four institutions over an unspecified time period.(8) Nine patients were treated with attempted early closed reduction. Subluxations in three patients were reduced without incident; three patients failed to reduce. Closed reduction was abandoned in another three patients because of worsening pain (one patient) or arm weakness (two patients). All patients underwent MRI evaluation (four pre-reduction). Herniated discs were visualized in ten patients, bulging discs were imaged in three. No patient treated developed a permanent neurological deficit as a result of attempted closed reduction. No patient who underwent successful closed reduction deteriorated. All three who had injuries that were successfully reduced showed significant neurologic improvement despite the MRI appearance of a disc herniation in two and a disc bulge in the third. The authors concluded that pre-reduction MRI studies should be obtained prior to closed reduction in patients with cervical spine facet dislocation injuries. Because there was not

correlation between the presence of disc herniation and neurological deterioration, the recommendation for a pre-reduction MRI in patients with cervical facet dislocation injuries cannot be supported.

Vaccaro and associates studied 11 consecutive patients with pre- and post-reduction MRI. The authors found herniated discs in two patients in the pre-reduction group and in five of nine patients who underwent successful closed reduction. The presence of a herniated disc on pre-reduction MRI or post-reduction MRI did not predict neurological deterioration. No case of deterioration following successful reduction occurred.(37) Grant et al obtained post-reduction MRI studies on 80 patients treated with closed reduction and found herniated or bulging discs in 46%. They found no correlation between MRI results and neurological outcome.(11) Finally, Rizzolo et al performed MRI pre-reduction on 55 patients with cervical fractures and dislocation injuries.(28) They found evidence of disc herniation in 54% of these patients. Awake and alert patients underwent closed traction-reduction. There were no instances of neurological deterioration in this group. The authors did not attempt closed reduction in patients who were not awake.

In summary, a review of the literature reveals only two documented cases (11,25) of neurological deterioration associated with attempted closed reduction of cervical spine fracture-dislocation injuries due to cord compression from disc herniation. Both of these cases were characterized by deterioration hours to days following closed reduction. A number of large clinical series have failed to establish a relationship between the presence of a pre-reduction herniated disc and subsequent neurological deterioration with attempted closed traction-reduction in awake patients.

SUMMARY

Closed reduction of fracture-dislocation injuries of the cervical spine by traction-reduction appears to be safe and effective for the reduction of spinal deformity in awake patients. Approximately 80% of patients will have their injuries reduced with this technique. The overall permanent neurological complication rate of closed reduction is approximately 1%. The associated risk of a transient injury with closed reduction appears to be 2% to 4%. Closed traction-reduction appears to be safer than manipulation under anesthesia.

There are numerous causes of neurological deterioration in patients with unstable cervical spinal injuries. These include inadequate immobilization, unrecognized rostral injuries, over-distraction, loss of reduction, and cardiac, respiratory and hemodynamic instability. Therefore, the treatment of cervical spine fracture-dislocation injuries must be supervised by an appropriately trained specialist.

Although pre-reduction MRI will demonstrate disc herniation in up to half of patients with facet subluxation injuries, the clinical importance of these findings is questionable. Only two case reports exist which document neurological deterioration due to disc herniation following successful closed traction-reduction in awake patients. Both occurred in delayed fashion after closed reduction. In addition, several investigators have demonstrated the lack of correlation between the MRI finding of disc herniation and neurological deterioration in this patient population. The use of pre-reduction MRI has therefore not been shown to improve the safety or efficacy of closed traction-reduction in awake patients. MRI prior to fracture-dislocation reduction may result in unnecessary delays in accomplishing fracture realignment and decompression of the spinal cord. As Class III evidence exists in support of early closed reduction of cervical fracture-dislocation injuries with respect to neurological function, pre-reduction MRI in this setting is not necessary. The ideal timing of reduction is unknown, but

many investigators favor reduction as rapidly as possible after injury to maximize the potential for neurological recovery.

Patients who fail attempted closed reduction of cervical fracture injuries have a higher incidence of anatomic obstacles to reduction including facet fractures and discs herniation. Patients who fail closed reduction should undergo more detailed radiographic study prior to attempts at open reduction. The presence of a significant disc herniation in this setting is a relative indication for an anterior decompression procedure, either in lieu of or preceding a posterior procedure.

Patients with cervical fracture dislocation who cannot be examined, due to head injury or intoxication, cannot be assessed for neurologic deterioration during attempted closed traction-reduction. For this reason, an MRI prior to attempted reduction is recommended as a treatment option.

KEY ISSUES FOR FUTURE INVESTIGATION

A prospective cohort study of patients with cervical spinal cord injuries due to facet fracture-subluxation injuries treated with or without pre-reduction MRI would provide Class II medical evidence in support of a treatment recommendation on this issue. This could address issues of timing. A randomized controlled trial may provide Class I medical evidence.

No prospective comparative study of closed reduction versus anterior decompression and stabilization for patients with MRI documented herniated discs in association with unreduced cervical fracture-dislocation injuries has been performed. A prospective study of this issue would provide Class II medical evidence in support of a treatment recommendation.

EVIDENTIARY TABLES

First Author Reference	Description of Study	Results	Data Class	Conclusions
Grant et al. <i>J Neurosurg</i> Spine 90:13-18, 1999	82 pts. Retrospective series All closed C-spine injuries with malalignment included Unilateral and Bilateral locked facets Early rapid closed reduction attempted in all patients MRI scans obtained after reduction ASIA and Frankel Grades determined on admission, 6, 24 hrs Weight up to 80% of patient's body weight	Successful reduction in 97.6% Average time to reduction 2.1 +/- 0.24 hours Overall ASIA scores improved by 24 hours following reduction. 1 patient deteriorated 6 hours post-reduction (probable root lesion). 46% had disc injury on MRI, 22% had herniation. Disc injury on MRI did correlate with cord edema on MRI	III	Closed reduction is effective and safe despite high incidence of MRI demonstrable disc injuries/ herniations
Vital et al, <i>Spine</i> 23:949-955, 1998	168 Patients retrospective series unilateral and bilateral employed manipulation under general anesthesia in minority of cases used relatively light weights (max 8.8 lbs plus 2.2 per level for max ox 40 lbs) All patients operated upon immediately post-reduction or post failure of reduction MRI's not done prereduction (although discs noted in 7 patients?)	43% reduced by traction without anesthesia (time <2 hrs) 30% reduced by manipulation under anesthesia 27% reduced intraoperatively 5 patients did not reduce (delayed referral, surgical error) Authors observed no cases of neurological deterioration	III	Authors promote their protocol as a safe and effective means for reduction and stabilization of fractures.
Lee AS: <i>JBJS</i> 76B: 352-6, 1994	210 pts Rapid traction-reduction 119, manipulation under anesthesia in 91 Retrospective historical cohort study Groups similar except traction group had longer delay to treatment Weights up to 150 lbs used No MRI done pre-reduction	Reduction Successful: MUA: 66/91 (73%) RT: 105/119 (88%) All failures in RT group were due to associated fractures or delayed referral Time to reduction: RT 21 minutes MUA: not reported No loss of Frankel Grade in either group 6 MUA and 1 RT had deterioration on ASIA score	III	RT superior to MUA, both procedures safe and effective, MRI not done.

First Author Reference	Description of Study	Results	Data Class	Conclusions
Cotler, <i>Spine</i> 18:386-390, 1993	24 patients (all awake) prospective study no fractured facets all acute injuries (1 5 day patient) Weights up to 140 lbs used No CT or MRI done	All 24 reduced No incidence of neurological deterioration Manipulation used in addition to weights in 9 patients (when facets perched) Time required ranged from 8-187 minutes	III	Reduction with weights up to 140 lbs is safe and effective in monitored setting with experienced physicians
Mahale, <i>JBJS</i> 75B:403-9, 1993	341 patients treated for traumatic dislocations of cervical spine 15 suffered neurological deterioration variety of treatments used to reduce deformity (4.3%)	Complete injuries: 6 after OR, 1 after manipulation Incomplete Injuries: 1 after OR, 3 after manipulation, 2 after traction, 1 during application of cast Radiculopathy: 1 (occurred when tongs slipped during traction) Deterioration delayed in 11 patients	III	Numbers of patients subject to each treatment arm not given. Purely a descriptive paper. Only conclusion is that neurological deterioration can happen.
Hadley et al. <i>Neurosurg</i> 30:661-666, 1992	68 patients retrospective series Facet fracture dislocations only Unilateral and Bilateral locked facets 66 treated with early attempted closed reduction (2 late referrals) Average weights used for successful reduction were between 9-10 lbs/cranial level	58% of patients had successful reduction Overall, most patients (78%) demonstrated neurological recovery by last followup (not quantified) 7 patients deteriorated during "treatment" (six improved following ORIF, one permanent root deficit following traction) No MRI data reported	III	Early decompression by reduction led to improved outcomes based on fact that patients who did best were reduced early (<5-8 hrs). No comparison possible between CR and ORIF due to small numbers. 1.2% permanent deficit (root) related to traction
Starr et al. <i>Spine</i> 15:1068-1072, 1990	57 patients retrospective series Unilateral and bilateral Early rapid reduction attempted in all patients No MRI done pre-reduction One patient was a delayed transfer Weights up to 160 lbs (began at 10 lbs) Frankel grades recorded at admission and discharge	53/57 (93%) reduced mean time to reduction was 8 hours no patient deteriorated a Frankel grade Two patients lost root function, one transiently 45% improved one Frankel grade by time of d/c, 23% improved less substantially 75% of patients required >50 lbs	III	Closed reduction is safe and effective for decompressing cord and establishing alignment.

First Author Reference	Description of Study	Results	Data Class	Conclusions
Sabiston et al. <i>J Trauma</i> 28:832-835, 1988	39 patients retrospective series unilateral and bilateral injuries up to 70% of body weight used all acute injuries No MRI	35/39 (90%) of patients successfully reduced average weight used 62.5 lbs no neurological deterioration failures due to surgeon unwillingness to use more weight	III	Closed reduction with up to 70% of body weight is safe and effective for reducing locked facets. Authors state that patients seen in delayed fashion (>10 days) are unlikely to reduce (no evidence presented here)
Maiman, DJ: <i>Neurosurg</i> 18:542-547, 1986	28 patients Variety of treatments offered No MRI 18 patients had attempt at closed reduction (max weight 50 lbs)	10/18 reduced with traction No patient treated by authors deteriorated One referred patient had an over distraction injury	III	Mixed group of patients and treatments. In general, traction seemed to be safe.
Kleyn, PJ: <i>Paraplegia</i> 22: 271-281, 1984	101 patients unilateral and bilateral, all with neurological involvement All treated with traction If injury <24 hours, MUA attempted initially, if reduction fails with max 18 kgs weight, MUA performed Pre-MRI	82/101 successfully reduced (4 open reduction, 6 partial reduction accepted, 9 no further attempt due to poor condition of patient) 37/45 incomplete lesions improved 7/56 complete lesions improved no neurological deterioration	III	Traction followed by MUA is safe, usually (80%) effective, and may result in improved neurological function.
Sonntag, <i>J Neurosurg</i> 8:150-152, 1981	15 patients retrospective analysis all bilateral locked facets all acute injuries manual traction, tong traction, and open reduction used weight used ranged from 30-75 lbs No MRI done	Reduction with traction successful in 10 patients 5 failed: 1 with C1 fracture which did not allow traction, 2 with fractured facets, 1 with radicular sx's worsened by traction (transient), 1 with an ascending spinal cord injury (patient died of pulmonary complications 2 weeks later)	III	Stepwise algorithm (traction, manual manipulation, operative reduction is indicated. Closed reduction by weight application is the preferred method for reduction of deformity.

First Author Reference	Description of Study	Results	Data Class	Conclusions
Shrosbee R <i>Paraplegia</i> 17: 212-221, 1979-80	216 patients identified with locked facets* Used traction (no weight specified) followed by manipulation under anesthesia if traction failed. Pre-MRI *86 died within 3 months, excluded from series	70/95 unilaterals reduced (74%) 77/121 bilaterals reduced (64%) No neurological morbidity reported Patients who were successfully reduced improved more often than patients who were not successfully reduced (41% vs 32% unilateral, 16% vs. 0% bilateral)	III	Discarded patients and lack of statistical analysis preclude firm statements. Highly suggestive paper. Conclusions: Traction followed by manipulation is safe, usually effective, and reduction seems to improve outcome (or, patients who are reducible do better)
Burke <i>DCJBJS</i> 53B:165-182, 1971	41 patients treated by MUA light traction followed by induction of anesthesia and intubation, followed by manipulation under anesthesia if necessary (same as Evans) 32 patients treated with traction alone 3 treated by traction after manipulation failed C7-T1 not attempted Pre-MRI	37/41 successfully reduced by MUA 21/25 reduced with traction prior to anesthetic 7 patients were judged too sick for anesthesia and underwent traction for stabilization, not reduced 2 cases of neurological deterioration: 1 over distraction 1 unrecognized injury	III	MUA and traction both safe if proper diagnosis and careful attention paid to radiographs
Evans DK: <i>JBJS</i> 43B:552-555, 1961	17 patients treated by induction of anesthesia and intubation, sometimes with manipulation under anesthesia Pre-MRI	No neurological deterioration noted All successfully reduced 2 unchanged, 2 died, 13 improved	III	Reduction under anesthesia safe and effective. Small series.

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