SPINE Volume 18, Number 3, pp 386–390

Closed Reduction of Traumatic Cervical Spine Dislocation Using Traction Weights Up to 140 Pounds

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The purpose of this study was to demonstrate that Gardner-Wells skull tong traction up to 140 lb was both safe and effective in reducing dislocation, without fractures, of facet joints involving the C4–C7 vertebral bodies when applied by experienced practitioners in a spinal cord injury center under close scrutiny. Twenty-four awake patients were selected for the study (age range, 16–82 years). These patients were evaluated for the number of millimeters (7–17 mm) of dislocation as measured from the posterior aspect of the superior vertebral body to the posterior aspect of the inferior vertebral body at the level of injury. The maximum weight required to produce the reduction of the facet joints and the time from the onset of traction were recorded. The patients' neurologic status was monitored before traction, after each increment in weight applied, and after reduction. Careful examination of motor function and sensation was done and recorded at each interval. The 24 patients with cervical spine dislocation of the facet joints underwent successful reduction with traction weights (range, 10–140 lb). Seventeen patients required weights of more than 50 lb. The traction procedures lasted for a period of 8–187 minutes per procedure. Worsening neurologic status did not occur in any of the patients involved in this study. These results supported the hypothesis that, in experienced hands in a spinal cord injury center, the use of Gardner-Wells skull tong traction with weights up to 140 lb applied under close scrutiny was an acceptable, safe, and effective method of reducing a dislocation of the facet joints in the absence of fractures at the C3–C7 level in this group of patients.
[Key words: spinal dislocation, traction, reduction]

Research suggests that early reduction after spinal dislocations improved the chances of neurologic recovery at or below the zone of injury.[5,8,11] In a group of 76 patients with unilateral or bilateral dislocations of the cervical spine, 13 were treated with closed manipulative reduction.[5] These authors found improvement of incomplete lesions in 9 of 13 patients. They also evaluated patients treated with an early reduction using skull tong traction and reported improvement in 13 of 14 patients with incomplete lesions. Patients who did not undergo early reduction did not show such improvement in their neurologic status.

Another study reported that only 2 of 40 patients with incomplete lesions from compression injuries of the cervical spinal cord, who underwent surgical reduction an average of 31 days postinjury, showed improvement in their neurologic status.[2] In a group of patients with unilateral facet dislocations with and without facet or body fractures, an attempt was made to treat these patients using skull tong traction up to 45 lb.[8] Only 6 of the 26 patients underwent successful reduction. Of the 20 patients with reduction attempted by skull tong traction, 10 were allowed to heal in a dislocated state. The remaining 10 patients underwent open reduction and single-level posterior fusion. Those whose injury was reduced had better results at the 3-year follow-up than those that healed in an unreduced state. Based on these results, the authors suggested that anatomic reduction and fusion were more effective in giving functional results than nonoperative treatment. Others studied the effect of experimentally induced compression of canine spinal cords in which complete paralysis occurred over a 75-minute period of gradually increasing compression.[11] All animals recovered fully if the compression was released within 9 hours, but not later.

These studies suggest that early reduction and decompression may be correlated positively with neurologic recovery and the absence of disabling convalescent pain. Rapid reduction using weights up to 120 lb may be beneficial in reducing unilateral and bilateral cervical spine dislocations.[6,7] These authors demonstrated (with biomechanical analyses) the alternative weight requirements for reduction of unilateral versus bilateral facet dislocation. Mathematic

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Supported in part by awards from the National Institute of Disability and Rehabilitation Research to the Regional Spinal Cord Injury Center of Delaware Valley (grant G008535135) and the National Rehabilitation Research and Training Center in Spinal Cord Injury (grant H133B80017).
Accepted for publication November 12, 1992.

equations were reported, and in general, more weight was required for the reduction of a unilateral versus bilateral facet dislocation.[7]

Surgeons recognize the advantage of doing a technically demanding operation with experienced personnel as an elective versus an emergent procedure. In these circumstances, an elective fusion is accomplished in a more expedient manner with fewer complications than setting up an operating room on an emergency basis. Based on these studies, which suggest the value of early decompression and the potential advantages of elective fusion, it would appear reasonable to evaluate immediate rapid closed reduction of cervical dislocations. The current prospective study was designed to support a retrospective report[9] to show that early closed reduction using Gardner–Wells skull traction weights of up to 140 lb applied by experienced orthopedic surgeons in a regional spinal cord injury center is an acceptable, safe, and effective technique in reducing cervical spine dislocations at the C3–C7 vertebral levels. All of these patients were reduced in the awake state.

■ Materials and Methods

Twenty-four patients with cervical spine dislocations participated in this study. None had a history of neurologic deficits, all were healthy before their spinal cord injuries. Table 1 indicates the demographic, neurologic, and orthopedic status of the patients (age range, 16–82 years). Neurologically intact motor-complete (Frankel A and B) and motor-incomplete (Frankel C and D)[1] patients were included in this prospective study to determine whether traction caused any deterioration of strength either at the zone of partial preservation of function at the cervical level of injury or below. The neurologic status of the patients was monitored throughout the period of reduction. The dislocation of the facet joints was from C4–C7 cervical vertebral bodies. There were no fractures of the facets or lamina and no free bony fragments in the neural canal in any of the patients. All those with dislocations in the absence of fractures were included in this study independent of the weight required for reduction. This approach provided an opportunity to evaluate the range of weights required for reduction in the current study.

Data collected by analysis of lateral cervical spine radiographs at regular intervals during the traction procedures included the level of facet dislocation and the millimeters of dislocation of the vertebral bodies measured from the posterior aspect of the superior vertebral body to the posterior aspect of the inferior vertebral body at the level of injury (Table 1). Preoperative evaluation of the cervical spine was limited to routine radiographs; computed tomography and magnetic resonance imaging were not done before traction reduction. The maximum weight and the time necessary to achieve reduction (measured from the onset of the traction procedure until successful relocation of the facet joints) was recorded. All reductions were done using dedicated radiographic equipment and a technologist.

All patients were admitted to the Regional Spinal Cord Injury Center of the Delaware Valley and were placed on a Stryker frame in the reverse Trendelenburg position. Gardner–Wells tongs were applied for traction, which was initiated with 10 lb and increased by an average of 10 lb sequentially at 5–20-minute intervals until reduction of the facet joints was achieved. Diazepam was administered to 15 patients before the traction procedure to relax them.

Displacement measurements of the vertebral bodies were done after each change in traction weights by analyzing lateral cervical spine radiographs taken 3–10 minutes after the weight change. The neurologic status of each patient was checked immediately after each change in traction weights by inspecting the patient's ability to do an established motor function and/or sensory examination based on the patient's ability in this area before the traction procedure.

After relocation of the facet joint, the maximum weight used to achieve reduction was recorded, and then the traction weight was reduced to 10–20 lb. Both the mechanism of injury, type of dislocation, and mechanisms used for stabilization were recorded for each patient, as were the dates of injury and traction reduction (Table 1). The mechanism of injury and type of dislocation were determined from the pretraction cervical spinal radiographs. The changes in neurologic status from admission to the 3-month follow-up were determined using the Frankel classification of degree of incompleteness scale (Table 2) and the modified motor index score from the Standards of the American Spinal Cord Injury Association.[1] We used the following muscles to determine the motor index score: biceps, extensor carpi radialis, triceps, flexor digitorum profundus, interroseous quadriceps, tibialis anterior, extensor hallucis longus, and triceps, flexor hallucis longus muscles. Each key muscle was graded according to the standard.[1] Our total maximal score was 90. The safety and effectiveness of the procedure was determined by analyzing the neurologic and radiographic information obtained from each patient (Table 1).

■ Results

All 24 patients underwent reduction with Gardner–Wells skull tong traction. Fourteen patients had a dislocation that measured from 7–10 mm of dislocation, whereas the remaining 10 patients had 11–17 mm of dislocation between the C3–C7 cervical vertebral spine level (Table 1). Those with dislocations measuring 7–10 mm underwent reduction with traction weights ranging from 30 to 140 lb and times, from 20 to 140 minutes. The 10 patients with dislocations of 11–17 mm underwent reduction with traction weights ranging from 10 to 120 lb and times from 8 to 187 minutes. Seventeen patients required greater than 50 lb to accomplish reduction. The mechanisms of injury for the 24 patients in this study were as follows: 17 patients had distractive flexion and 7 had compression flexion. All 24 patients had anterior displacements. Manipulation was used to assist the traction weights in achieving reduction in 9 of the 24 patients (5 with bilateral dislocation and 4 with unilateral dislocation, Table 1). A prerequisite to manipulation was a perched position of the facet or fac-

Table 1. Patient Data

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8
Date of injury	6/8/89	6/24/89	5/2/88	1/10/89	6/10/88	7/25/88	8/26/88	5/25/89
Date of reduction	6/8/89	6/24/89	5/2/88	1/10/89	6/10/88	7/25/88	8/26/88	6/15/89
Level of dislocation	C6–7	C5–6	C6–7	C5–6	C6–7	C5–6	C4–5	C4–5
Facet dislocation	Bilateral	Bilateral	Bilateral	Bilateral	Unilateral	Bilateral	Bilateral	Unilateral
Mechanism of injury	Distractive flexion	Distractive flexion	Distractive flexion	Compression flexion	Compression flexion	Distractive flexion	Flexion compression translation	Distractive flexion, mild compression
Time to reduce (min)	90	20	135	10	120	90	120	45
Maximum weight (lb)	70	30	115	30	50	75	120	40
Dislocation (mm)	10	7	12	15	15	13	10	9
Direction of dislocation	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior
Medications used	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Use of manipulation	No	Yes	No	No	No	No	No	Yes
Neurologic status	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Date of surgical stabilization	6/14/89	6/27/89	5/31/88	1/17/89	6/11/88	8/1/88	8/29/88	6/20/89
Admission of Frankel	C4–D	Intact	C6–A	C5–A	C7–A	C4–A	C4–D	Intact
72-hr–1 wk Frankel	C4–D	Intact	C6–A	C4–A	C7–C	C4–A	C4–D	Intact
2–4 mo Frankel	N/A	Intact	C6–A	C5–A	C7–C	C4–A	N/A	Intact
Most recent Frankel (time post-SCI)	C4–D (1 mo)	Intact	C6–A (24 mo)	C4–A (18 mo)	C7–C (4 mo)	C4–A (24 mo)	Intact (1 wk)	Intact
MIS admission	27.5	Intact	14.0	11.5	29.0	8.0	90.0	Intact
MIS 72-hr–1 wk	53.0	Intact	17.5	8.0	33.0	2.0	88.0	Intact
MIS 2– 4 mo	N/A	Intact	22.5	11.5	39.5	3.0	N/A	Intact
MIS most recent (time post-SCI)	74.0 (1 mo)	Intact	26.5 (24 mo)	17.5 (18 mo)	44.5 (4 mo)	10.5 (24 mo)	88.0 (1 wk)	Intact
Comments	No follow-up	Intact	—	—	—	—	No follow-up	Date of admission > 2 wk from SCI,

	Patient 9	Patient 10	Patient 11	Patient 12	Patient 13	Patient 14	Patient 15	Patient 16
Date of injury	4/15/89	7/8/89	7/8/89	7/24/89	7/28/89	10/30/88	12/7/89	3/29/90
Date of reduction	4/20/89	7/9/89	7/10/89	7/24/89	7/28/89	10/30/88	12/7/89	3/30/90
Level of dislocation	C4–5	C5–6	C6–7	C4–5	C4–5	C6–7	C5–6	C5–6
Facet dislocation	Bilateral	Unilateral	Bilateral	Unilateral	Bilateral	Unilateral	Unilateral	Unilateral
Mechanism of injury	Distractive flexion	Distractive flexion	Distractive flexion	Compression flexion	Distractive flexion	Compression flexion	Distractive flexion	Distractive flexion
Time to reduce (min)	105	110	30	50	55	105	140	54
Maximum weight (lb)	70	70	40	40	90	130	140	90
Dislocation (mm)	7	10	10	10	10	10	8	10
Direction of dislocation	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior
Medications used	No	Yes	No	Yes	No	No	No	Yes
Use of manipulation	No	No	No	No	Yes	No	Yes	No
Neurologic status	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Date of surgical stabilization	4/20/89	7/11/89	7/31/89	7/26/89	7/29/89	11/1/88	12/11/89	4/3/89
Admission of Frankel	C4–A	Intact	C6–B	C4–A	C4–B	C7–A	Intact	C4–A
72h–1 wk Frankel	C4–B	Intact	C5–B	C4–A	C4–B	C6–B	Intact	C6–A
2–4 mo Frankel	C5–B	Intact	N/A	C4–A	C7–D	T1–C	Intact	C6–B
Most recent Frankel (time post-SCI)	C6–B (12 mo)	Intact	C6–B (3 wk)	C4–A (24 mo)	C7–D (24 mo)	T1–C (48 mo)	Intact	C6–B (24 mo)
MIS admission	6.0	Intact	20.5	6.0	0	25.5	Intact	5.5
MIS 72hr–1 wk	6.0	Intact	18.0	6.0	11.0	46.0	Intact	5.5
MIS 2–4 mo	14.0	Intact	N/A	7.0	84.5	57.5	Intact	23.0
MIS most recent (time post-SCI)	17.0 (12 mo)	Intact	19.5 (3 wk)	14.0 (24 mo)	84.0 (12 mo)	62.0 (48 mo)	—	34.0 (24 mo)
Comments	—	—	No follow-up	—	—	—	—	—

SCI = spinal cord injury; MIS = motor index score; N/A = not applicable, no follow-up.

ets to complete reduction while traction was maintained. Eight patients received no medication before traction reduction. The neurologic status of these 24 patients remained unchanged relative to their status before the onset of the traction procedure (Table 1), and there was no evidence of sudden longitudinal displacement of intervertebral spaces. All 24 patients underwent posterior fusions; 3 of these also underwent anterior fusions. Eleven patients were stabilized surgically within 1 week after spinal cord injury, and one patient underwent fusion approximately 1 month after injury.

■ Discussion

It was suggested that it is unwise to attempt closed reduction with weights larger than 40–50 lb because of

Table 1. Patient Data (Continued)

	Patient 17	Patient 18	Patient 19	Patient 20	Patient 21	Patient 22	Patient 23	Patient 24
Date of injury	6/15/90	7/17/90	8/12/90	10/11/90	10/21/90	11/10/90	1/4/91	1/19/91
Date of reduction	6/15/90	7/17/90	8/13/90	10/12/90	10/22/90	11/24/90	1/6/91	1/19/91
Level of dislocation	C5–6	C6–7	C5–6	C6–7	C4–5	C6–7	C6–7	C4–5
Facet dislocation	Bilateral	Bilateral	Bilateral	Unilateral	Unilateral	Bilateral	Bilateral	Bilateral
Mechanism of injury	Compression flexion	Distractive flexion	Compression flexion	Distractive flexion	Distractive flexion	Distractive flexion	Distractive flexion	Distractive flexion
Time to reduce (min)	187	52	147	75	10	53	8.8	20
Maximum weight (lb)	115	100	120	90	70	60	60	10
Dislocation (mm)	14	12	11	8	12	10	17	14
Direction of dislocation	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior	Anterior
Medications used	Yes	Yes	Yes	Yes	No	No	Yes	No
Use of manipulation	Yes	No	Yes	Yes	Yes	No	Yes	No
Neurologic status	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Date of surgical stabilization	6/16/90	7/19/90	Unknown	10/16/90	Unknown	11/24/90	Unknown	1/21/91
Admission of Frankel	C6–A	Intact	C5–A	C5–A	C3–A	Intact	C6–A	C4–C
72 hr– 1 wk Frankel	C6–B	Intact	C5–B	C6–B	N/A	Intact	C6–A	C4–D
2–4 mo Frankel	C6–C	Intact	C5–B	—	N/A	Intact	N/A	N/A
Most recent Frankel (time post-SCI)	C6-D (24 mo)	Intact	C4-B (24 mo)	C7–B (24 mo)	N/A	Intact	N/A	Intact (1 mo)
MIS admission	17.5	Intact	6.0	12.0	0.0	Intact	23.0	26.5
MIS 72 hr–1 wk	21.5	Intact	7.0	25.5	N/A	Intact	23.0	84.0
MIS 2– 4 mo	62.0	Intact	17.5	N/A	N/A	Intact	N/A	N/A
MIS most recent (time post-SCI)	81.5 (24 mo)	Intact	17.5 (24 mo)	33.0 (24 mo)	N/A	Intact	N/A	90.0 (1 mo)
Comments	Surgery open reduction	—	—	—	No follow-up	Fx spinous process	Deceased 1/21/91	—

the risk of overdistraction.[3,4] These authors state that it is preferable to do an open reduction and posterior fusion than use traction in excess of these weights. Others reported that, if there is no neurologic loss, then there is no urgency.[10] In the presence of neurologic deficit, however, they believed that reduction should be done as soon as possible. They suggested a maximum of 35–40 lb for dislocation at C6–7 and less weight applied for cervical dislocations at a higher level. If these traction weights were ineffective, they considered changing the direction of traction or trying manipulative reduction. In another study, neural recovery distal to the zone of injury was reviewed in 172 patients.[12] Although these authors could not substantiate their impression, they suggested that weights larger than 20 lb during reduction may cause overdistraction and increased neural damage. All 24 patients in the current study, however, underwent successful reduction with Gardner–Wells skull traction. By contrast to the previous studies, 17 of these patients were treated with traction weights in excess of 50 lb. None of the patients in our study had a loss in neurologic status during the traction procedure either at the zone of partial preservation[1] of function in complete or incomplete injuries or in the lower extremities in incomplete injuries. Manipulation during traction was done in equal numbers of patients with unilateral or bilateral conditions. The ligamentous complex and disc at the level of injury may have been affected by the traction; however, the motion segment was fused sequentially to provide definitive stability. The results of the current study supported the concept that Gardner–Wells skull tong traction is safe and effective for reducing cervical spine dislocation of the facet joints as soon as possible after injury with weights up to 140 lb. We agree with investigators who encourage reduction as soon as possible after spinal injury.[5,8,10,11] It was suggested that up to 50 lb of weight could be used reasonably to reduced the dislocated spine nonoperatively.[3,4] From

Table 2. Changes in Neurologic Status from Admission to 3-Month Follow-up.

A	Complete: all motor and sensory function is absent below the zone of partial preservation
B	Incomplete: preserved sensation only, preservation of any demonstrable, reproducible sensation, excluding phantom sensations; voluntary motor functions absent
C	Incomplete: preserved motor nonfunctional, preservation of voluntary motor function, which is minimal and performs no useful purpose; minimal defined as preserved voluntary motor ability below the level of injury where the majority of the key muscles test at less than a grade of 3
D	Incomplete: preserved motor functional, preservation of voluntary motor function, which is useful functionally; defined as preserved voluntary motor ability below the level of injury where the majority of the key muscles tests at least a grade of 3
E	Complete: return of all motor and sensory function, but one may still have abnormal reflexes

the current prospective study, it appears that up to 140 lb of weight can be used to achieve closed reduction under controlled circumstances with no risk to the subject. The importance of this finding is that cervical reduction could be achieved shortly after admission to the spinal cord injury center, where the patient's neurologic status, including both motor power and sensation, can be evaluated frequently, as in the current study. After the closed reduction is accomplished, subsequent surgical fusion can be scheduled on an elective basis.

In summary, to the authors' knowledge, this is the first report in the literature of safe effective early closed reduction of traumatic facet dislocations involving C4–C7 using traction weights up to 140 lb. The success of the closed reduction using bigger weights and careful monitoring, with dedicated equipment handled by experienced personnel provided sufficient preliminary data to justify further consideration by other experts in spinal cord injury centers.

■ Acknowledgments

The authors thank Barbara Wolff for her help in conducting this study and Patricia Williams for preparing the manuscript.

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