ORIGINAL ARTICLE

Traumatic central cord syndrome: neurological and functional outcome at 3 years

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Study design: Retrospective cohort analysis with prospective follow-up.

Objectives: To evaluate neurological and functional recovery following central cord syndrome.

Setting: Northern Ireland, population 1.8 million.

Methods: Twenty-seven cords were identified in 1 year. Five managed conservatively and 22 with surgery. American Spinal Injury Association (ASIA) motor scores (AMS) were calculated to assess neurological recovery. Rotterdam scores assessed functional independence at 3 years.

Results: Average age was 62 years. Mechanism of injury was a fall with neck hyperextension in 81% patients. Average AMS in surgical patients improved from injury, preoperatively, postoperatively, 6 months and 3 years from 51, 81, 83, 90 to 96, respectively. Conservative patients improved from time of injury to day 10 from 57 to 86 and then fell to 84 at 6 months. By 3 years, this had recovered to 91. There was no statistical significant difference in AMS ($P=0.15$)/change in AMS (Δ AMS) ($P=0.92$) or percentage of motor deficit resolution ($P=0.23$) between groups at 3 years. Two patients underwent surgery within 48 h and achieved full motor recovery by 3 years, but this was not significant ($P=0.2$). ASIA score improvement had a positive correlation with age at injury. Patients treated with surgery had better Rotterdam scores at 3 years than those managed conservatively ($P=0.05$).

Conclusions: This study confirms the natural history of central cord syndrome. Although it demonstrates equivocal neurological recovery for both groups, patients treated with surgery regained a greater degree of functional independence.

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INTRODUCTION

Central cord syndrome is the most common incomplete acute spinal cord injury (SCI) accounting for approximately 70% of incomplete injuries.¹ Schneider *et al.*² first described the condition in 1954 as ‘disproportionately more motor impairment of the upper than the lower extremities, bladder dysfunction, usually urinary retention and varying degrees of sensory loss below the level of the lesion’. The syndrome results from a hyperextension injury causing cord compression and injury to the central portion of the spinal cord, sparing the lateral tracts to the sacrum and lower limbs.^{3–5} It has been noted that this clinical picture occurs in a bimodal distribution with young and elderly patients. Injury in the younger patient occurs following high-energy trauma with or without congenital cervical stenosis; however, in the older patient, this syndrome develops as a result of a hyperextension injury in a preexisting stenotic canal. The pathophysiology is thought to result from pinching of the spinal cord between a buckled hypertrophied ligamentum flavum posteriorly and bulging disc osteophyte complex anteriorly.⁶

Schneider initially advocated surgery for the treatment of this condition but with limited success. One of the patients in his initial case series became quadriplegic from surgery. He subsequently managed the remaining patients conservatively and noted that the natural history of this condition was for spontaneous neurological improvement. That study concluded that surgical decompression was

unnecessary and detrimental and shaped the management of this condition for many years to come.

Most patients do improve initially; however, recovery is often incomplete and not sustained. Bosch *et al.*⁷ and Bose *et al.*⁸ reported that many conservatively managed patients experience late-onset neurological deterioration and only 60% remained functional despite a period of initial improvement. This deterioration can have severe functional limitation on basic activities of daily living. It could mean the difference between assisted living and functional independence.

There have been many developments in the management of acute traumatic SCI in the past 50 years. The involvement of the multi-disciplinary team improved surgical technique and early mobilization with focused rehabilitation has revolutionized patient care. A number of studies have been published reporting favorable results for surgical intervention and early decompression,^{9–12} and more recently, in 2013, a systematic review of 22 trials examining the timing of surgery in SCI found a significant improvement in neurological outcomes and length of hospital stay with early decompression.¹³ Yet it can be difficult to predict the neurological recovery to be expected. Some patients experience a rapid improvement, whereas others have continued to have significant residual neurodisability. Central cord syndrome remains controversial with widespread variability between centers in both treatment and outcome.

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The primary aim of this study was to evaluate whether surgical decompression improved neurological recovery compared with conservative management. The secondary aim was to evaluate whether surgery within 48 h led to better neurological outcome than late decompression. The third aim was to assess whether surgery improved functional independence at 3 years.

METHODS

Design and setting

Between April 2011 and April 2012, 27 consecutive patients who presented to the Royal Victoria Hospital, Belfast, UK with traumatic central cord syndrome were included in this study. Patients were identified using the regional trauma database cross referenced with the spinal multi-disciplinary team register.

Participant selection criteria

Neurological exam and imaging confirmed the diagnosis. An inclusion criterion was a primary diagnosis of TCCS (defined as a cervical SCI producing disproportionately greater weakness in the upper limbs than the lower limbs with varying degrees of sensory loss and bladder dysfunction). Magnetic resonance imaging was the modality of choice, or computed tomography if magnetic resonance imaging was contra-indicated. Information gathered included demographics, mechanism of injury, length of hospital stay and functional status.

Treatment selection criteria

Five patients were managed conservatively and 22 with surgical intervention. There were six Consultant Spinal surgeons working in this unit and treatment was decided on an individual case basis, as there is no consensus in the literature or national guideline to dictate management. Absolute indication for surgery included deteriorating neurology with evidence of radiological compression and spinal instability. The timing of surgical intervention was based on evolving neurology, theater availability, suitability for general anesthesia and anticipation of recovery based on radiological diagnosis.

The choice of surgical approach was dependent on the number of levels involved and whether the compression was anterior or posterior. Single-level disease from anterior disc osteophyte complex at C5/6 would be treated with anterior cervical discectomy and fusion at C5/6, whereas multi-level stenosis would be treated with posterior instrumentation and decompression. Other patient factors were also taken into consideration such as patient positioning, that is, the ability to prone under general anesthesia.

Zero patients received steroids in keeping with hospital protocol. One of the surgical patients passed away prior to follow-up at 6 months owing to gastric lymphoma and was therefore excluded from analysis. A second surgical patient passed away prior to final follow-up and was excluded from the 3-year analysis.

Assessment tools

The American Spinal Injury Association (ASIA) motor scores (AMS)¹⁴ were obtained in the operative group from the time of injury, preoperatively, postoperatively and at follow-up. The ASIA scores were collected at time of injury, day 10 and at follow-up in the conservative group. Follow-up for both groups was at 6 months and 3 years. AMS were further subclassified according to age for analysis: group 1 (<50 years), group 2 (50–70 years), and group 3 (70+ years).

Change in motor score (Δ AMS) and the motor percentage deficit resolution (motor %DR), were calculated for each time interval.

Deficit resolution was calculated using the formula described by Ishida and Tominaga¹⁵: $(\text{Review AMS} - \text{initial AMS}) / (100 - \text{initial AMS}) \times 100\%$.

Mobility aid requirements at follow-up were compared with pre-morbid mobility. The Rotterdam nine-item handicap scale¹⁶ was used at 3 years to assess nine parameters: mobility indoors, mobility outdoors, kitchen tasks, domestic tasks indoors, domestic tasks outdoors, leisure activities indoors, leisure activities outdoors, ability to drive, and finally return to occupation. Bladder and bowel control was also assessed at 3-year review.

Statistical analysis

Continuous variables were described as mean $\pm$ s.d. Mann–Whitney *U* and Kruskal–Wallis tests were used to compare non-parametric data sets. Data analysis and visualization was aided by the QIMacros for excel (KnowWare International Inc., Denver, CO, USA), Daniel's XL Toolbox add in for Excel, version 6.60 (Daniel Kraus, Würzburg, Germany) and Microsoft Excel (2010), (Microsoft corporation, Redmond, WA, USA) software packages. Statistical significance was set at $P < 0.05$.

RESULTS

Demographics

Twenty-seven patients with central cord syndrome were identified in 1 year. Five were managed conservatively and 22 with surgery. Average age of patient was 62 years (range 33–85). Twenty-two (81%) were male. In 22 patients (81%), the mechanism of injury was a simple fall with neck hyperextension. Two surgical patients had passed away before completion of follow-up at 3 years. Twenty of the surviving 25 patients (80%) completed follow-up at 3 years. This comprises 16 of the 20 (76%) managed operatively and 4 of the 5 (80%) non-operatively. A further patient from the surgical cohort was excluded from the 3-year analysis as he had suffered a cerebral vascular event that left him with a hemiplegia and would therefore confound results.

Imaging and surgical approach

Twenty-one (78%) had preexisting cervical stenosis on imaging. The most common level of injury was C5/6, occurring in 11 (41%) patients. Thirteen patients underwent a posterior approach, of which 11 had multi-level decompression and stabilization. Eight patients had a single-level anterior cervical discectomy and fusion. One patient had an anterior cervical discectomy and fusion followed by multi-level posterior decompression and stabilization at a later date. Average time to surgery was 24 days (1–120).

Figure 1 Average ASIA motor scores in surgical patients. A full color version of this figure is available at the *Spinal Cord* journal online.

Figure 2 Average ASIA motor scores in conservative patients. A full color version of this figure is available at the *Spinal Cord* journal online.

Neurological assessment

The average ASM in the surgical cohort improved from injury, preoperatively, postoperatively, 6 months and at 3 years follow-up from 51, 81, 83, 90 to 96, respectively (Figure 1). The average ASM in the conservative group improved from time of injury to day 10 from 57 to 86 but then fell to 84 at 6 months. Interestingly at 3-year follow-up this had improved to 91 (Figure 2).

Despite the average AMS at 3 years in the surgical group being higher than that of the non-operative group, 96 vs 90, this did not reach statistical significance ($P=0.15$). Neither did Δ AMS ($P=0.92$) or motor %DR ($P=0.23$).

Neurological assessment subclassified for age

Patients were subclassified according to age for a more detailed analysis. Group 1 (<50 years) consisted of 7 patients with a mean age

of 42.8 years (33–50). Group 2 (50–70 years) consisted of 6 patients with a mean age of 57 years (51–63) and group 3 had 8 patients with a mean age of 77 years (71–85). All patients demonstrate a rapid initial improvement in AMS (Table 1), but younger patients at the time of injury did better overall (Table 2). Not only did they have ultimately better AMS at follow-up, they had greater change in AMS and better %DR when compared with patients in groups 2 and 3. This supports Penrod's finding that patients aged <50 years have ultimately better ASIA motor scores and therefore better potential to regain functional independence.¹⁷

Of the eight surgical patients in group 3, two were deceased, one had a cerebrovascular event, one had advanced dementia and one had terminal lung cancer by 3-year review. This highlights the frailty of the population intended to treat and the need for appropriate management to ensure maximum quality of remaining life.

Table 1 Effect of surgery and conservative management on mean AMS

Surgery	Initial to preop (n = 21 ^a)	Preop to postop (n = 21)	Postop to 6 months (n = 21)	6 months to 3 years (n = 21 to n = 15 ^b)	Initial to 3 years (n = 21 to n = 15 ^b)
Δ AMS	30.4 $\pm$ 34.8 ^c	1.5 $\pm$ 9.5	6.7 $\pm$ 8.9	6.1 $\pm$ 10.3	41.1 $\pm$ 37.6
Motor %DR	39.4% $\pm$ 106.2	-29.3% $\pm$ 166.5	32.6% $\pm$ 86.4	58.3% $\pm$ 191.7	87.2% $\pm$ 26.2
Conservative	Initial to day 10 (n = 5)	Day 10 to 6 months (n = 5)		6 months to 3 years (n = 5 to n = 4)	Initial to 3 years (n = 5 to n = 4)
Δ AMS	28.2 $\pm$ 30.7	-1.4 $\pm$ 8.0		8.8 $\pm$ 30.1	40.8 $\pm$ 34.0
Motor %DR	68.5% $\pm$ 23.6	-0.9% $\pm$ 10.6		14.2% $\pm$ 36.5	83.8% $\pm$ 16.0

Abbreviations: AMS, Asia Motor Score; Δ AMS, change in motor score; %DR, percentage of deficit resolution.

^aExcludes patient number 22 (deceased prior to 6-month follow-up).

^bExcludes patient numbers 22 and 14 who have deceased, patient number 10 who had suffered a severe stroke resulting in hemiplegia and patient numbers 3, 9, 13 and 15 who were lost to follow-up.

^cValues are expressed as mean $\pm$ s.d.

Table 2 Effect of age on mean AMS, change in AMS and the percentage of deficit resolution for the surgical cohort

Age categories (years)	Initial (n = 21 ^a)	Pre-op (n = 21)	Post-op (n = 21)	6 months (n = 21)	3 years (n = 15 ^b)
AMS					
<50 (n = 6)	42.8 $\pm$ 39.2 ^c	83.8 $\pm$ 19.1	90.7 $\pm$ 14.6	97.7 $\pm$ 2.3	99.2 $\pm$ 1.1
50–70 (n = 7)	69.0 $\pm$ 33.0	82.1 $\pm$ 20.0	87.0 $\pm$ 16.3	90.7 $\pm$ 13.9	98.8 $\pm$ 1.8
>70 (n = 8)	42.5 $\pm$ 46.5	80.0 $\pm$ 15.2	74.6 $\pm$ 18.3	83.6 $\pm$ 14.1	92.0 $\pm$ 9.1
					KW $P=0.26$
	Initial to pre-op (n = 21)	Pre-op to post-op (n = 21)	Post-op to 6 months (n = 21)	Initial to 6 months (n = 21)	Initial to 3 years (n = 15 ^b)
ΔAMS					
<50	41.0 $\pm$ 42.3	6.8 $\pm$ 5.7	7.0 $\pm$ 13.4	54.8 $\pm$ 38.5	66.6 $\pm$ 33.9
50–70	13.1 $\pm$ 21.3	4.9 $\pm$ 9.4	3.7 $\pm$ 5.7	21.7 $\pm$ 19.5	27.8 $\pm$ 36.0
>70	37.5 $\pm$ 36.5	-5.4 $\pm$ 8.5	9.0 $\pm$ 7.5	41.1 $\pm$ 40.7	29.5 $\pm$ 35.6
					KW $P=0.14$
Motor %DR					
<50	64.1% $\pm$ 34.1	14.9% $\pm$ 15.2	12.6% $\pm$ 26.0	91.6% $\pm$ 12.6	98.6% $\pm$ 1.9
50–70	54.8% $\pm$ 47.2	14.5% $\pm$ 26.1	10.9% $\pm$ 15.4	80.2% $\pm$ 19.5	93.6% $\pm$ 11.6
>70	7.4 $\pm$ 166.0	-100.0% $\pm$ 262.8 ^d	66.5% $\pm$ 136.1	-26.8% $\pm$ 292.8	63.2% $\pm$ 43.7
					KW $P=0.50$

Abbreviations: KW, Kruskal–Wallis test; Δ AMS, change in ASIA motor score; Motor %DR, motor percentage of deficit resolution.

^aExcludes patient number 22 (deceased prior to 6-month follow-up).

^bExcludes patient numbers 22 and 14 who have deceased, patient number 10 who had suffered a severe stroke resulting in hemiplegia and patients 3, 9, 13 and 15 who were lost to follow-up.

^cValues are expressed as mean $\pm$ s.d.

^dPatient number 18 experienced a motor deterioration after surgery but recovered.

Table 3 Demographics, diagnosis, treatment and outcome scores

Pt.	Age and gender	PES	Injury level	Imaging diagnosis	Operation	Days to op	LOS	Motor score injury/preop/postop/ 6 months/3 years	R'dam% 3 years	Mobility preinjury/6 months/ 3 years
1	54, M	Y	C5/6	Interspinous ligament disruption, facet subluxation	Post stab C5/6	2	14	90/100/100/100/100	100	Unaided throughout
2	43, M	Y	C5/6	C5/6 disc osteophyte complex	ACDF C5/6	10	4	0/100/100/100/100	100	Unaided throughout
3	85 M	Y	C3/4	OPLL C2-7, contusion C3/4, ALL injury	Post S&D C3-7	30	70	0/58/57/60/—	—	Stick/W'chair/stick
4	56, M	Y	C4/5	C4/5 disc osteophyte complex	ACDF C4/5	16	10	88/100/100/100/100	100	Unaided throughout
5	63, F	Y	C5/6	Disc C5/6 severe canal stenosis, ALL injury	C6 corpectomy+graft	28	5	92/100/100/100/100	100	Unaided throughout
6	84, M	Y	C6/7	Disc protrusion C5/6	ACDF C5/6	6	27	63/75/59/80/90	59	Stick/frame/stick
7	33, M	N	C4/5	Central disc bulge C4/5 and C6/7	ACDF C4/5	120	6	79/92/100/100/100	100	Unaided throughout
8	48, F	N	C5/6	C5/6 disc osteophyte complex with multi-level stenosis	Post S&D C3-6	3	16	48/48/62/96/98	86	Unaided throughout
9	57, M	Y	C3/4	Multi-level stenosis C3-6 with effacement C3/4 and C5/6	Post decom C3-7	7	40	57/55/74/90/—	—	Unaided throughout
10	75, M	Y	C5/6	C5/6 paracentral DOC, LF hypertrophy	ACDF C5/6	5	30	89/94/94/98/76 ^a	38 ^a	Stick/frame/stick
11	61, M	Y	C3/4	C3/4 DOC, gross ant. and post. cord encroachment	Post S&D C2-5	9	14	86/90/90/94/96	40	UA/frame/UA
12	78, M	Y	C4/5	C4/5 post. disc bulge, spinal stenosis, LF hypertrophy	Post S&D C2-5	12	49	0/60/52/69/80	44	UA/frame/UA
13	75, M	Y	C5/6	Post. disc bulge C3/4, C4/5, C5/6, cord compression C5/6	Post C4-7 fusion &D.	12	11	0/82/90/95/—	—	Unaided throughout
14	71, M	Y	C4/5	Anterolisthesis C4/5, widened left facet joint, interspinous ligament disruption	Post S&D C3-5	40	60	0/81/70/84/D	—	W'chair/D
15	46, M	N	C5/6	C5/6 annular tear, disc herniation	ACDF C5/6	35	7	94/98/98/98/—	—	Unaided throughout
16	72, M	Y	C4/5	#C4 lamina, multi-level stenosis	Post stab C3-7	4	31	98/90/75/83/98	93	Unaided throughout
17	34 F	N	C2/3	Displaced peg #	Post S&D C1-3	1	31	0/81/90/94/100	100	Unaided throughout
18	51, M	Y	C6/7	Ank spond, anterolisthesis C5/6	Post S&D C2-T3	28	36	0/60/57/61/100	100	UAW'chair/UA
19	50, M	N	C4/5	C2-C6 bulges, #C5 endplate	Post S&D C2-6	30	21	70/70/88/90/97	88	Unaided throughout
20	83, M	Y	C5/6	#Spinous process C5, multi-level stenosis, interspinous ligament injury	ACDF C5/6, then post stab C3-7	8	24	90/100/100/100/100	88	Unaided throughout
21	46, M	Y	Multiple	Degenerative multi-level central canal stenosis	Post S&D C2-6	90	10	36/84/94/98/98	88	UA/stick/UA
22	71, M	Y	C5/6	#C6, ALL disruption (imaged via CT owing to pacemaker)	C6 corpectomy+graft	14	60	59/66/81/D/D	—	Unaided/D/D
Pt.	Age and gender	PES	Injury level	Imaging diagnosis			LOS	Motor score injury/day 10/ 6 months/3 years	R'dam% 3 years	Mobility preinjury/6 months/ 3 years
23	66, M	Y	C5/6	OPLL, C7 endplate#	—	485	28	74/86/88/92	86	Rollator/frame/frame
24	62, M	Y	C3/4	Interspinous ligament edema, C4 cord edema	—	—	7	11/88/94/74	40	Unaided throughout
25	75, F	N	C4/5	ALL tear, degenerative narrowing C4-6	—	—	4	94/100/100/100	79	Unaided throughout
26	79, M	Y	C4/5	Degenerative, pinching C5/6, no signal change	—	—	42	20/60/45/96	75	Stick/W'chair/w chair
27	46, M	Y	C5/6	Degenerative disc, foraminal stenosis C5/6	—	—	3	90/96/96/—	—	Unaided throughout

Abbreviations: ACDF, anterior cervical decompression and fusion; ALL, anterior longitudinal ligament; ank spond, ankylosing spondylitis; D, deceased; DOC, disc osteophyte complex; Frame, walking frame; LF, ligamentum flavum; LOS, length of hospital stay in days; op, operation; OPLL, ossification of posterior longitudinal ligament; PES, preexisting stenosis; postop, postoperative; preop, preoperative; Post decom, posterior decompression; Post stab, posterior stabilization; Post S&D, posterior stabilization and decompression; Pt., patient; R'dam, Rotterdam score at 3 years; SP, spinous process; Stick, walking stick; UA, unaided mobility; W'chair, wheelchair; #, fracture.

^a Patient number 10 who had suffered a cerebrovascular event prior to a 3-year follow-up resulting in a dense hemiplegia and was excluded from final analysis.

Functional assessment

Mean Rotterdam scores at 3 years were 83% s.d. ± 23 in the surgical group ($n = 15$) vs 70% s.d. ± 21 in the conservative group ($n = 4$). This difference was found to be statistically significant ($P = 0.05$).

Complications

No intra-operative complications were observed. One superficial wound infection occurred. In all, 14% of the surgical cohort developed chest sepsis in comparison with 40% in the conservatively managed group.

Bladder/bowel

At 3 years, only 2 patients from each group reported bladder/bowel dysfunction. The 4 patients with deficits were numbers 8, 12, 24 and 26 (Table 3).

Mobility

At 6 months, 67% of surgical patients reached their premorbid mobility status, compared with 60% of patients managed conservatively. However, when subclassified for age, 86% of surgical patients in group 1 (< 50 yrs) were mobile unaided compared with 67% in group 2 and 38% in group 3. At 3 years, 100% of the surgical cohort had reached baseline mobility (Table 3) as compared with 50% of the conservative cohort.

Crossover

One patient (patient number 23) was initially managed conservatively owing to intra-abdominal sepsis at the time of injury. He transferred to the spinal rehabilitation unit and his motor score improved from injury, day 10 to 6 months from 74, 86 to 88. However, he plateaued and further imaging confirmed persistent compression. He underwent decompression on day 485, and at 3-year review, his motor score had improved to 92.

DISCUSSION

The classic paper on central cord syndrome by Schneider *et al.*² in 1954 described the spontaneous neurological recovery experienced by these patients. The paper set a trend in the subsequent literature for these patients to be managed conservatively, and it was only when Bosch *et al.*⁷ and Bose *et al.*⁸ evaluated the long-term neurological status of these patients was it suggested that their management could be improved. Newey *et al.*¹ in 2000 studied 32 patients with central cord syndrome managed conservatively and found that, after a mean of 8.6 years of follow-up, ASIA score was usually maintained but patients who were > 70 years of age did poorly. Brodkey *et al.*¹⁸ in 1980 further supported this finding and demonstrated a decline in function in their conservative cohort. Cervical myelography was performed in these patients that showed persistent cord compression. These patients proceeded to have surgery and improve. This was similar to the result of patient number 23 in our study who was initially managed conservatively but, when his neurological recovery plateaued, further imaging revealed persistent compression. He went on to have surgery and his motor function continued to improve.

The initial study by Schneider was a single-surgeon case series of 8 patients that influenced the management of central cord for a further 30 years. Since then, dramatic improvements have been made in the management of acute SCI but a lack of robust peer-reviewed data leads to the controversy surrounding its management. This study highlights that, even within a tertiary referral center for 1.8 million patients, no consensus exists among surgeons regarding the timing of

surgical decompression. Although the average time taken to theater was 24 days, this ranged from anywhere between 24 h and 120 days.

Lenahan *et al.*¹⁹ and Guest *et al.*²⁰ have reported that early surgery (< 24 h) is safe and cost-effective compared with late surgery.

In our study, only two patients were operated on within 48 h but they went on to achieve a full motor and functional recovery.

Chen *et al.*²¹ in 2009 claimed that surgical intervention can be safely undertaken in patients with traumatic central cord syndrome. The Surgical Timing in Acute Spinal Cord Injury Study⁹ demonstrated recovery by ≥ 2 ASIA grades in an additional 10% of cervical spinal cord injuries with surgery < 24 h from injury. However, motor incomplete grade 'D' can only improve by one category.

There is convincing evidence in the literature to suggest that surgery provides two potential advantages over conservative treatment. First, improved neurological recovery achieved after early decompression of the cord and nerve roots may permit earlier rehabilitation; second, stable spinal fixation may prevent further SCI and subsequent neurological deterioration. Although we failed to demonstrate a statistical difference in neurological recovery between groups, patients treated with surgery did have significantly improved mobility and functional independence at 3 years.

Our study has a few limitations. First, the cohort had few patients treated conservatively. This was a result of the study design in that it was retrospective and not randomized. However, this study is a snapshot and is therefore reflective of the practice in Northern Ireland. Second, owing to small numbers, the groups were not matched to eliminate selection bias.

In conclusion, this study confirms the natural history of central cord syndrome by showing that the majority of patients are males, aged > 75 years presenting following a simple fall with neck hyperextension with preexisting stenosis. It has demonstrated that the majority of recovery does happen spontaneously in the first few weeks after injury and that the younger patient does better. This study also suggests that early surgical intervention (< 48 h) will produce ultimately better motor ASIA scores at follow-up as compared with conservatively managed patients. Patients treated with surgery regained a greater level of functional independence. Controversy persists in the literature and no clear consensus can be proposed because of the lack of prospective controlled studies. Further research in this area is required.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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