



# Post-Traumatic Cervical Myelopathy without Traumatic Bony Lesions in Spondylosis Patients Physiopathology, Clinical Picture and Therapeutical Options

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## Abstract

**Objectives:** Cervical Spondylosis (CS) is the first cause of myelopathy in adulthood. The concept that the acquired narrowing of the canal may represent a risk factor for cord lesions also for moderate trauma is not new; hyperextension of the neck was considered an important mechanism of cord damage also in absence of bony lesions. Neurological compromising is usually severe with central cord syndrome as the most common picture. Recently, a better understanding of the path genetic mechanism of spondylotic disease contributed to the theory that the traumatic damage of spinal cord could be re conducted to the combined effect of stress and shear with out of plane forces over a condition of abnormal spinal mobility more than to the narrowness of the spinal canal.

**Materials and Methods:** The 20 consecutive patients with traumatic cervical cord injuries, whose radiological examination showed only spondylosis changes in absence of traumatic bony lesions, were admitted to the Neurosurgical Units of Mestre Hospital (Group A - eight patients) and Caserta Hospital (Group B - twelve patients) during a two years period. On admission patients were classified according to JOA classification scale; score ranged from 6 to 13. Grade 3 JOA impairment was found out in six out of twenty patients (30%), Grade 2 compromising was found in ten patients (50%) and Grade 1 one resulted in 4 patients (20%). Group A patients were treated conservatively while group B was splitted into two different subgroups; six patients with single level contusion area underwent decompression and stabilization while a conservative treatment was chosen for patients harboring wider contusions (four patients).

**Results:** Regardless of treatment, a moderate to discrete neurological deficits persisted for all patients but one who remained unchanged. No patient recovered completely. Conservatively managed patients showed a mean increase in JOA score consisting of one point. Surgically treated patients improved 2.25 JOA points (mean values) showing a mild tendency towards a better outcome for surgically treated patients.

**Discussion:** Altered spinal motion in spondylosis patients can produce cord damages also after mild trauma due to abnormal forces and stresses acting over a cord almost tethered by spondylotic modifications of the spine. There are not clear evidences suggesting which the best treatment is. Surgical option could be taken into account for patients affected by focal lesions with incomplete neurological compromising and ligamentous damages. In these cases surgery should be not limited to decompression but must comprehend surgical stabilization too. Prevention of secondary cord damage also in case of further traumatic events, facilitation of earlier mobilization, shorter hospital stays, and reduction of medical complications due to bed rest are possible advantages.

**Keywords:** Cervical cord trauma; Cervical spondylosis; SCIWORET; Spondylosis complication; Central cord syndrome

## Abbreviations

ALL: Anterior Longitudinal Ligament; CCS: Central Cord Syndrome; SCI: Spinal Cord Injury; SCIWORET: Spinal Cord Injury with-Out Evidence of Trauma

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## Introduction

Cervical spondylosis represents the first cause of myelopathy in adulthood and is considered the commonest pre-existing spinal abnormality in SCI patients with a prevalence as high as 10% in some series [1-3]. The concept that a spondylosis condition may represent a risk factor for cord lesions also after mild trauma is not new. In fact, previous reports considered hyperextension of the neck a possible mechanism of cord damage in spondylosis patients also in absence of bony lesions [1,4]. Cord compression from bony spurs anteriorly and/or the buckling yellow ligaments posteriorly have been considered the cause of the nervous lesion [5-11]. More recently, new theories coming from a better and more complete understanding of the pathogenesis of the spondylosis disease itself contributed to the concept of dynamic cord damage in spondylosis patients probably due to the combination of stress and shear forces more than to a static compression from a narrow spinal canal [12-14].

Guidelines concerning the management of spondylosis patients suffering from traumatic cervical cord lesions are lacking. The aim of this preliminary study was to identify the best therapeutical options.

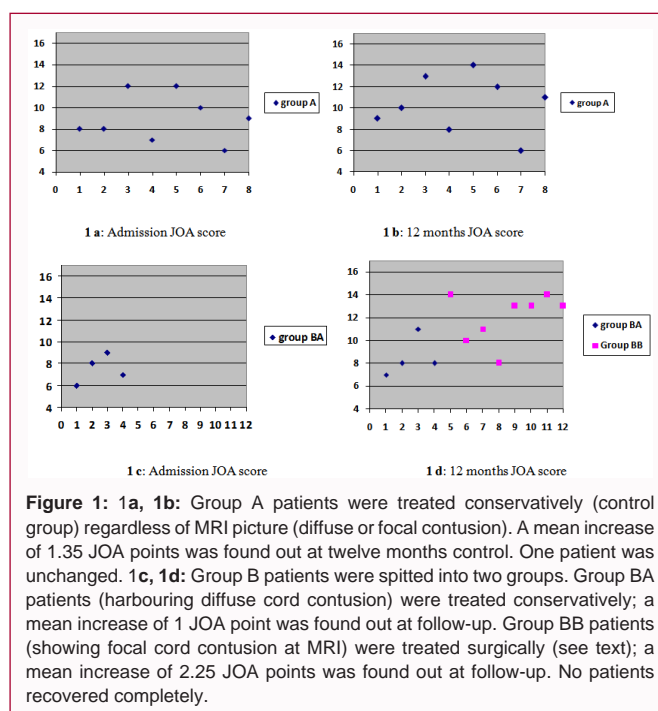
## Materials and Methods

From January 2013 to December 2014, 20 consecutive patients with cervical spinal cord traumatic injuries without radiological anomalies other than spondylosis were admitted to the Neurosurgical Units of Mestre Hospital (Group A - eight patients) and Caserta Hospital (Group B - twelve patients). There were fourteen males (70%) and six females (30%). Mean age was 62.8 years (range: 42 to 70 years). Falls of any type including job-related trauma was the first cause followed by traffic accidents and sport trauma.

On admission all patients were evaluated according to JOA classification [15]. A more than discrete to severe neurological compromising was present in all cases with the Central Cord Syndrome (CCS) as the most frequent finding. Six patients presented a Grade 3 (points 0 to 7) JOA impairment, a Grade 2 compromising (points 8 to 11) was found out in ten patients and Grade 1 (points 12 to 15) resulted in 4 patients (Figure 1).

Basal clinical conditions were thoroughly investigated; previous signs and/or symptoms of myelopathy or a clinical history suggesting a cord disease were exclusion criteria while previous history of cervical pain and/or signs of cervical radicular impingement were not considered exclusion criteria. Complete tetraplegic was considered exclusion criteria.

All patients underwent a thorough neuroradiological examination (static X-ray, CT scan and MRI) [16-20]. Traumatic bony lesions and/or dislocations were exclusion criteria; flexion-extension X-ray was not carried out routinely in the acute settings for the risk of further cord damage. All patients presented degenerative changes of the cervical spine and cord contusion spreading at one or more spinal levels. Patients harboring clear disc herniation were excluded from the study and received a targeted treatment. MRI examination also included sequences for softy tissues. In particular, a prevertebral hyperintensity on T2 weighted sagittal images correlating with Anterior Longitudinal Ligament (ALL) injuries was researched [21-23]. Radiological signs of ALL damage were taken into account as a possible segmental instability possibly requiring a proper treatment. Patients not suspected to have ligamentous injuries underwent routine flexion-extension X-ray study after four weeks in order to



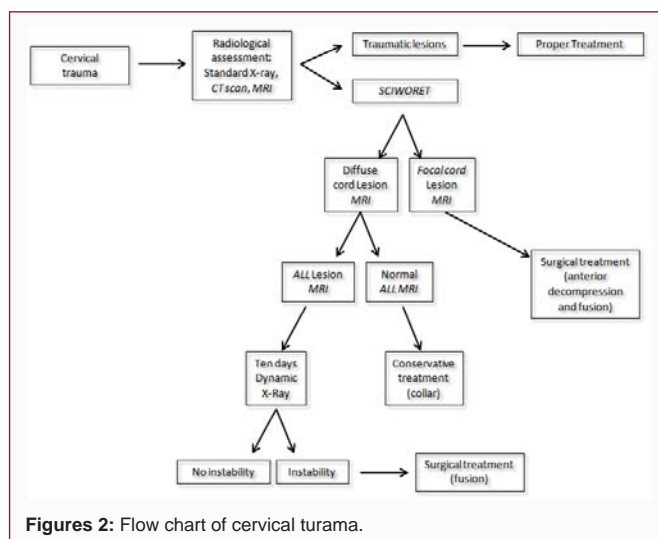
**Figure 1:** 1a, 1b: Group A patients were treated conservatively (control group) regardless of MRI picture (diffuse or focal contusion). A mean increase of 1.35 JOA points was found out at twelve months control. One patient was unchanged. 1c, 1d: Group B patients were splitted into two groups. Group BA patients (harbouring diffuse cord contusion) were treated conservatively; a mean increase of 1 JOA point was found out at follow-up. Group BB patients (showing focal cord contusion at MRI) were treated surgically (see text); a mean increase of 2.25 JOA points was found out at follow-up. No patients recovered completely.

exclude a hidden instability.

All patients received high dosage methylprednisolone according to NASCIS protocol [4]. Group A patients, regardless of MR findings, were treated conservatively and constituted the control group while group B was splitted into two different subgroups according to MRI findings; patients with diffuse lesions were managed conservatively (4 pts) while the resting eight, affected by traumatic cord lesions confined at a single level, were operated on within the first two weeks (range: 8 to 15) if they met all the following criteria: Presence of spondylosis changes affecting the cervical spine, MR finding of spotty cord contusion or cord lesions involving a single segment congruent with the clinical picture (Figure 2).

In all cases surgery consisted of an anterior decompression by means of single level omentectomy and arthrodesis with a titanium mesh filled with autologous bone graft and anterior plating.

All patients received a minimum follow-up period of twelve



**Figures 2:** Flow chart of cervical trauma.

**Table 1:** Group A. All patients were treated conservatively. The outcome has to be intended improved if the score improved at least 2 points respect to the admission. The mean increase was 1.35 JOA points within this group. One patient remained almost unchanged while no patients recovered completely.

Patient	JOA Admission Grade	JOA Admission Score	Neurimaging (T2, Diffusion)	Lesion Aspect	Treatment	12 Months JOA Score	Outcome
1	2	8/17	Spondylosis + contusion	Diffuse	Conservative	9/17	Unchanged
2	2	8/17	Spondylosis + contusion	Focal	Conservative	10/17	Improved
3	1	12/17	Spondylosis + contusion	Focal	Conservative	13/17	Improved
4	3	7/17	Spondylosis + contusion	Diffuse	Conservative	8/17	unchanged
5	1	12/17	Spondylosis + contusion	Focal	Conservative	14/17	Improved
6	2	10/17	Spondylosis + contusion	Focal	Conservative	12/17	Improved
7	3	6/17	Spondylosis + contusion	Diffuse	Conservative	6/17	Inchanged
8	2	9/17	Spondylosis + contusion	Focal	Conservative	11/17	Improved

months consisting of both clinical and MRI examinations.

Patients recovering at least two JOA points were considered improved while a single point progression was considered not suggestive for clinical amelioration.

## Results

Five out of eight (63%) group - A patients (managed conservatively) improved at least two JOA points while two improved only one point and were considered unchanged (Table 1). The mean improvement relative to the conservatively treated group was 1.35 points. No patients recovered completely.

In group B seven out of eight surgically treated patients improved clinically (almost two JOA points); one patient remained almost unchanged while two patients improved significantly with an increase in JOA score of three points (Table 2) with a mean value among this group of 2.25 JOA points. Conservatively managed patients of group B (harboring diffuse cord lesions) showed a mean improvement of one JOA point and three out of four were considered almost unchanged. No patient deteriorated either there were complications related to the surgical procedure [24,25].

## Discussion

Hughes described in 1963 the occurrence of cord injuries in spondylosis patients after minor trauma thus suggesting that spondylosis may predispose cord to traumatic lesions [15].

### Epidemiology of traumatic cord lesions in spondylosis

The risk of a traumatic cord lesion in spondylosis patients should always be kept in mind mostly if we consider that spondylosis affects about 75% to 95% of people aging more than 65 and up to 10% of all SCI patients presents some degenerative changes [7,10,26]. Furthermore, spondylosis modifications are visible in 52% to 56% of patients with traumatic cord lesions whose radiological examination is negative for vertebral fracture and/or dislocation [15,21]. The social and economical impact of such a condition has not been defined yet though it has been reported that the incidence of Spinal Cord Injury With-Out Evidence of Trauma (the so-called SCIWORET according to the definition of American Association of Neurological Surgeons) ranges from 5% to 16% of all spinal cord injury [20,25].

### Pathophysiology of traumatic cord lesions in spondylosis

The observations that the site of cord damage usually does not correspond to the site of maximal spondylosis compression (bony spurs are usually located at lower cervical spine while cord damage is usually at C3 to C5) together with the finding of typical histopathological lesions not reflecting the distribution of areas

of maximal compression, contributed to the hypothesis that the narrowness of the spinal canal could not be the only pathological mechanism of such a complex condition [12]. Physiological evidences clearly demonstrated that spinal cord can function normally despite deformation from static compression while it is poorly tolerant of dynamic compression [2,14,27]. Physiological neck motion results in cord dislocation and elongation within the spinal canal. During flexion and extension, cord's viscoelastic properties, distributes the strain over its entire length thus reducing the local stress [12].

Spondylosis disease affects spine motion entirely; segments with impaired motility alternate with segments with normal or abnormal motility [28]. Degenerative changes mainly involve the lower cervical spine (C5 to C7); reduction of regional motility (so-called "autofusion") protects cord from stresses and trauma. Contrariwise, upper and middle cervical spines, having an almost normal or more than normal motility are more vulnerable to trauma [15,28].

Osteophytic spurs, buckling yellow ligaments and protruding discs, severely interferes with the normal displacement and elongation of the cord within the spinal canal (*tethering effect*). As a consequence, cord elongation concentrates within a limited area more than along its entire length; thus, also mild trauma can be able to produce local shear and stresses forces strong enough to cause mechanical cord damage [17]. As maximal strain concentrates between the distracting force and the tethering point (usually at lower cervical spine), the nervous lesion is more frequently located in the middle and upper cervical cord [17].

In addition, cord deformation from compression by buckling yellow ligaments during neck extension and cord stretching over osteophytic and/or protruding discs during neck flexion produce "out of plane forces" that further increase the local stress [12].

As a result, in such group of patients, a traumatic flexion extension movement, is possible to cause severe cord injuries also in absence of bony fractures and/or dislocations [12,14,16].

### Clinical picture

Central Cord Syndrome (CCS) is a recurrent finding after minor cervical trauma without bony injuries in spondylosis patients; a disproportionately predominant deficit of the upper limbs (mostly distal) compared with the lower limbs, bladder dysfunction and a variable sensory impairment below the level of the lesion is the classic clinical picture [8].

Our experience confirms previous findings; neurological involvement was present in all cases with the CCS as the most frequent picture. Some neurological improvement is frequent within

**Table 2:** Group B. Patients harbouring diffuse cord lesions at MRI (eg. extending over more than one segment) were treated conservatively, while patients with focal lesion were operated on (see text for more details). The outcome has to be intended improved if the score improved at least 2 points respect to the admission. The mean increase was 1.0 JOA points within the conservatively managed group and 2.25 for the surgically treated group. No patients recovered completely.

Patient	JOA Admission Grade	JOA Admission Score	Neuroimaging 2 (T2, diffusion)	Lesion Aspect	Treatment	12 Months JOA Score	Outcome
BA 1	3	6/17	Spondylosis + contusion	Diffuse	Conservative	7/17	Unchanged
BA 2	2	8/17	Spondylosis + contusion	Diffuse	Conservative	8/17	Unchanged
BA 3	2	9/17	Spondylosis + contusion	Diffuse	Conservative	11/17	Improved
BA 4	3	7/17	Spondylosis + contusion	Diffuse	Conservative	8/17	Unchanged
BB 5	1	12/17	Spondylosis + contusion	Focal	Surgical	14/17	Improved
BB 6	3	7/17	Spondylosis + contusion	Focal	Surgical	10/17	Improved
BB 7	2	8/17	Spondylosis + contusion	Focal	Surgical	11/17	Improved
BB 8	3	6/17	Spondylosis + contusion	Focal	Surgical	8/17	Improved
BB 9	2	10/17	Spondylosis + contusion	Focal	Surgical	13/17	Improved
BB 10	2	11/17	Spondylosis + contusion	Focal	Surgical	13/17	improved
BB 11	1	13/17	Spondylosis + contusion	Focal	Surgical	14/17	unchanged
BB 12	2	11/17	Spondylosis + contusion	Focal	Surgical	13/17	improved

the first days; nevertheless, *restitution ad integrum* is exceptional and a moderate to severe disability usually persists. All patients but one presented at follow-up a moderate to severe residual deficit mostly affecting the upper limbs and in particular hand's motility.

#### Treatment of traumatic cord lesions in spondylosis

There are not guidelines for management of SCIWORET. The absence of traumatic vertebral lesions and/or dislocations might be the *rationale* for a conservative treatment; nevertheless, surgery for incomplete cord injuries still remains a valid option [5,11,18,19,22].

Cord lesion is the result of a complex mechanism involving both dynamic compression and abnormal spine motion. Traumatic instability has also been invoked by some authors as some damage of Anterior Longitudinal Ligament (ALL) is sometimes visible at MRI and is a common finding at operation [6,22]. We routinely explore prevertebral softy tissue with MRI in order to detect any ALL lesions. A clear high signal intensity on T2 weighted images in the prevertebral space was visible at preoperative MRI in about 68% of cases and a moderate to severe ALL damage was confirmed at operation in all patients treated surgically.

Prevention of secondary cord injury (abnormal motion can further damage the already injured cord) and facilitation of neurological recovery especially in the hands has been proposed as valid reasons for surgical treatment [11,22].

Anterior decompression and fusion was preferred to posterior approaches as it was considered more suitable for single level lesions mostly when a damage of ALL is suspected preoperatively. Furthermore, a reported incidence as high as 12.9% (Ref Day) of C5 nerve paresis due to stretching of rootlets from posterior cord migration following posterior decompression represented a significant concern to posterior approaches; shoulder motility impairment, though frequently resolves with time, is bad tolerated by these patients already complaining of moderate to severe deficit affecting both upper limbs (mostly hand's motility).

In particular, laminectomy was not considered for treatment of this condition as decompression without fusion could further contribute to spine deformity and instability. On the other hand, posterior decompression and instrumentation or laminoplasty could

be suggested in the future if benefits from surgical treatment will be demonstrated for multilevel lesions by further studies.

#### Analysis of results

The pre-selection of treatment modality on the basis of cord lesion features (e.g. diffuse or focal), and the limited cohort of patients does not allow to delineate statistically significant differences in outcome between different groups of treatment; nevertheless, some aspects could merit further attention.

Patients with diffuse cord injuries presented a worse outcome with an overall improvement of 1 JOA point at one year for both groups (Table 1 and 2). The one year outcome of patients with focal lesions was considerably better (Figure 1 and 2); a mean improvement of 2.25 JOA points was reported with three out of eight patients improving three points and only one patient improving one single point (considered unchanged).

The small number of cases does not allow us to draw definitive conclusion, but it appears evident that, regardless of treatment, the extension of the contusive area over more than one segment represent an unfavorable prognostic factor.

#### Conclusion

A complex combination of stress and shear forces with out-of-plane forces more than the narrowness of the spinal canal is the more likely pathogenetic mechanism of cord lesion in SCIWORET.

A detailed MRI examination of prevertebral space should be included in these patients as the finding of a prevertebral hyperintensity on sagittal images correlates with the Anterior Longitudinal Ligament (ALL) damage that may represent a further reason for a surgical stabilization.

Under this aspect, though the limited number of cases does not allows us to draw definite conclusions, it is possible to suggest for selected cases (e.g. patients with incomplete deficit harboring single level cord lesions at MRI and prevertebral hyperintensity signal) anterior decompression and fusion as a valid treatment whose *rationale* is to restore the normal sagittal alignment and reduce abnormal motion at the site of the lesion, thus eliminating cord deformation and stretching responsible for further cord damage.

Posterior approach with instrumentation could be suggested if a benefit from surgical treatment of multilevel lesions will be demonstrated by further studies.

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