

ORIGINAL PAPERS

Anterior approach for traumatic lesions of the lower cervical spine: long-term results

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KEYWORDS

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Abstract

Purpose: The purpose of this study is to assess the long-term results obtained by surgical treatment of severe lower cervical spine injuries by means of an anterior approach. We also carry out a review of the literature on the subject.

Materials and methods: Retrospective study of 32 patients with traumatic injuries in their low cervical spine, treated by means of anterior arthrodesis with a tricortical graft and locking plate fixation. Mean age was 33.7 years (range: 13-54). The most frequent mechanism of injury was fall from height in 13 cases, road accident in 18 and one case of an accident in the course of water sports practice. Mean follow-up was 10.2 years (range: 4.3-19.5).

Results: In all but one of our patients we obtained solid fusion at 3 to 6 months. Radiologically we observed 100% height restoration, recovery of physiologic cervical lordosis ($>20^\circ$) in 70% of patients and anatomic reduction in 87%. Resumption of previous occupation was possible for 23 patients (71.87%); the same number of patients was capable of performing basic activities of daily living without feeling any symptoms.

Conclusions: Although there is no unanimity as regards the best treatment for traumatic injury to the lower cervical spine, anterior decompression, accompanied by the use of a structural autologous tricortical graft and stabilization by locking plates, is considered the best option for most of these lesions.

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PALABRAS CLAVE

Columna cervical;
Fractura;
Estabilización anterior;
Placa

Abordaje anterior para lesiones traumáticas de la columna cervical baja. Resultados a largo plazo**Resumen**

Objetivo: El objetivo de este estudio es evaluar los resultados a largo plazo obtenidos en el tratamiento quirúrgico de lesiones traumáticas graves de la columna cervical baja mediante la práctica de un abordaje anterior así como la revisión de la literatura médica al respecto.

Material y método: Estudio retrospectivo de 32 pacientes con lesiones traumáticas en la columna cervical baja tratadas mediante artrodesis por vía anterior con injerto tricortical y fijación con placa autoestable. La media de edad fue de 33,7 años (rango: 13-54). La etiología más frecuente fue tras caída de altura en 13 casos, accidente de tráfico en 18 casos y accidente durante la práctica de deporte acuático en un caso. La media de seguimiento fue de 10,2 años (rango: 4,3-19,5).

Resultados: En todos los pacientes estudiados, a excepción de uno, obtuvimos una sólida fusión en un plazo de 3 a 6 meses. Radiológicamente, observamos el 100% de restauración de la altura, y se recuperó la lordosis cervical fisiológica ($>20^\circ$) en un 70% y la reducción anatómica en un 87%. La incorporación laboral a sus antiguos puestos de trabajo fue posible en el 71,87% (23 pacientes), al igual que la capacidad de realizar actividades básicas de la vida diaria sin presencia de síntomas.

Conclusiones: Aunque no existe unanimidad en el tratamiento de las lesiones traumáticas de la columna cervical baja, la descompresión anterior, unida al uso de injerto tricortical autólogo estructural y estabilización mediante sistema de placas autoestables, se considera la mejor opción terapéutica para la mayoría de estas lesiones.

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Fractures and dislocation-fractures of the lower cervical column constitute a special group of fractures not only due to the fracture itself, but also, more importantly, the deleterious consequences that it can lead to.

The treatment objective for these fractures is based on spinal decompression in order to immediately minimize neurological damage and stabilization of the spinal column in order to start an adequate rehabilitation programme as soon as possible. These objectives can utilize an anterior, posterior, or combined approach.

The posterior technique, according to its proponents, is favourable due to the relative ease of the approach and the ability to obtain optimal results for spinal decompression when necessary.

On the other hand, many surgeons state that the anterior approach is preferable for spinal decompression due to several advantages. Namely, high rates of fusion and fewer complications arising from the use of cervical locking plates and autologous tricortical iliac crest grafts are claimed to make this approach preferable over others.

Here we present a retrospective study of 32 patients with lower cervical column injuries that were treated by means of anterior arthrodesis with bone autografts and cervical plates; the surgical technique included anterior decompression, recovery of vertebral body height, the use of tricortical autografts to achieve fusion, and stabilization by locking plates.

Objectives

Present the advantages of the anterior approach in the treatment of severe traumatic injuries to the lower

cervical column using the results obtained in the present study, as well as through a revision of the pertinent medical literature.

Material and methods

Retrospective evaluation of 32 patients with injuries to the lower cervical column. The average age was 33.7 years old (range: 13-54). The aetiology was fall from height in 13 cases, road accident in 18, and one case of an accident in the course of water sports practice. Mean follow-up was 10.2 years (range: 4.3-19.5).

Classification

We used the classification system proposed by Allen⁴ et al., which proves easy to use by researchers and provides an accurate picture of the mechanism of fracture (fig. 1).

Neurological damage

Physical examination prior to surgery showed an absence of neurological symptoms in 14 patients, all of whom showed radiological parameters of instability.

Three patients presented with a complete spinal cord injury, 3 others with central cord syndrome, and radiculopathy was detected in 12 (one case of motor deficit due to a traumatic herniated disc in addition to a bone lesion and 11 cases with some type of sensory disorder).

Instability criteria

Along with assessment of the neurological state and its progressive deficit, we used the White and Panjabi classification system (table 1) as a patient treatment guide, even in the absence of a neurological damage. The 14 patients assessed in the study that did not present with neurological lesions had more than 5 points under the instability scale proposed by White and Panjabi (fig. 3).

Surgical methods

Each of the 32 patients was operated on lying in a supine position and using a single right side anterolateral approach.

Each patient received a prophylactic dose of intravenous cefazoline. In all cases where deemed necessary, a complete anterior decompression was performed. This decompression included the extirpation of all retropulsed disc and bony

elements that were causing the compression until the affected spinal segment was left completely free of them.

The patient lies in supine position with a pillow beneath the shoulders and traction through both arms using two straps joined to the surgical table. The incision is made in the skin at the level of the right pre-esternocleidomastoid and follows the standard anterior approach for surgeries of the lower cervical spine.

A single-level arthrodesis can be considered when the integrity of at least one third of the vertebral body is affected, and following the decompression of the disc and bony elements. When the affected segment reaches two thirds of the vertebral body, a subtotal corpectomy is performed to remove the fragments provoking the compression through a discectomy of the superior and inferior discs of the affected vertebra.

A rectangular tricortical graft is extracted from the right iliac crest for the arthrodesis. Finally, the locking cervical plate with the chosen and adequate measurements is inserted under fluoroscopic control.

A careful haemostasis then follows along with the placement of suction drainage. Closing is performed in layers using reabsorbable sutures, and a Philadelphia collar is placed in most cases. The suction drainage is removed after 48 hrs.

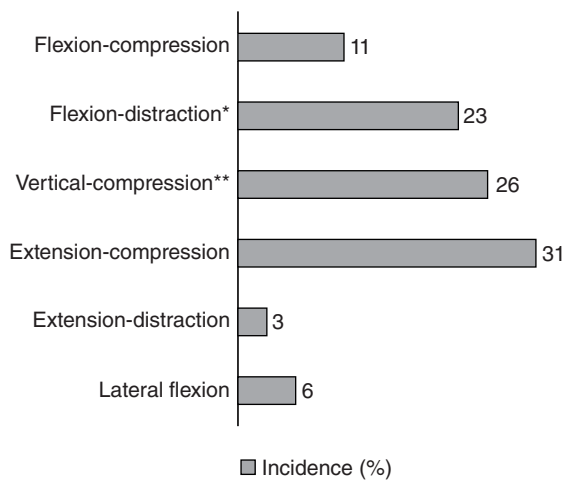


Figure 1 Allen classification applied to our study.

Table 1 White and Panjabi classification system for lower cervical column instability

Element	Points
Anterior elements destroyed	2
Posterior elements destroyed	2
Sagittal plane translation > 3.5mm	2
Sagittal plane rotation > 11°	2
Spinal cord damage	2
Nerve root damage	1
Abnormal disc narrowing	1
Total: 5 or more = unstable	

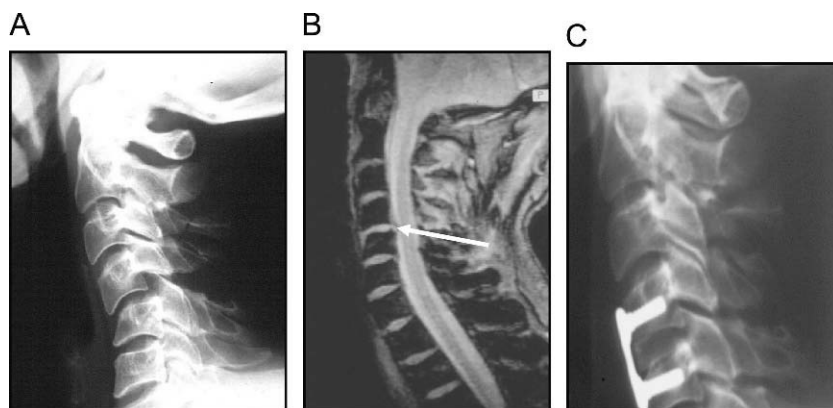


Figure 2 Flexion-distraction fracture. A) Radiograph of a C4-C5 injury. B) NMR image in which the traumatic herniated disc that produces sensorimotor radiculopathy can be observed. C) Postoperative radiograph following extirpation of the herniated disc, discectomy, and intersomatic C4-C5 fusion with an autologous tricortical iliac crest graft stabilized with locking plates.

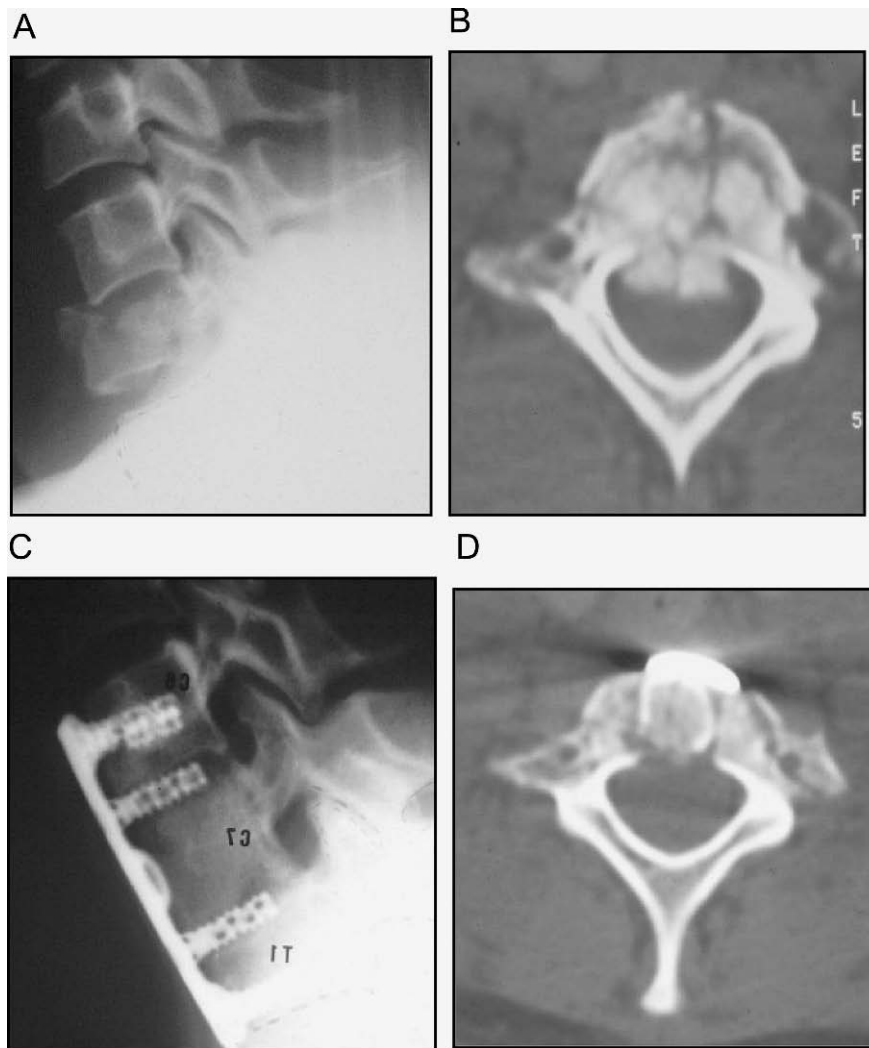


Figure 3 Vertical compression fracture of C7. A) Preoperative radiograph. B) Preoperative CT scan. C) Postoperative radiograph following a subtotal corpectomy of C7, fusion using an autologous graft, and fixation with locking plates of C6-T1. D) Postoperative CT scan.

The average time of hospitalization is 6 days, which may be prolonged by neurological complications as well as other concomitant non-vertebral injuries sustained.

Results

All of the patients, except for one, obtained a solid fusion in a period of 3 to 6 months.

2 types of surgical complications were identified.

- Early complications were observed in 5 patients: one cervical haematoma that was resolved through open surgical drainage, one transient neuropraxia of the inframandibular branch of the facial nerve, one hypoglossal neuropraxia with Horner's syndrome, 2 cases of odynophagia and one dysphagia.
- Late complications were observed in two patients: one pseudoarthrosis in a patient that showed no neurological

symptoms that was resolved through rearthrodesis using the same surgical technique and, in the second case, a persistent radiculalgia without motor deficit, which was alleviated by a second posterior foraminotomy.

In the radiological assessment, we observed height restoration in 100% of patients, recovery of physiological cervical lordosis ($> 20^\circ$) in 70% of patients and anatomical reduction in 87%.

The neurological state of the patients one year following surgery is described below.

Out of the entire study group, 23 patients presented no neurological deficit. 3 central cord syndromes persisted but evolved to various states of improvement, one of which showed significant functional recovery, allowing resumption of previous occupation, though this was a position of little physical demand. 3 patients exhibited persistent quadriplegias, and the remaining 3 maintained some degree of spinal root damage.

One case involved a sensorimotor radiculopathy with significant improvement, although residual deficit remained following surgery, and 2 cases involved persistent radiculopathy, one of which improved following the aforementioned posterior foraminotomy.

From an occupational point of view, the following results were obtained.

Resumption of previous occupation was possible for 23 patients (71.87%), along with resumption of basic daily physical activities without feeling any symptoms.

Conversely, 4 patients (12.5%) were left incapacitated to perform their habitual occupations, although they were able to gain active employment in less physically demanding jobs.

The remaining 5 patients (15.62%) were left with a degree of incapacitation that negated any type of occupational activity.

Discussion

Fractures of the lower cervical column are among the most difficult to propose optimal treatment for; they generally occur in young patients and are induced by traffic accidents, falls from height while at work, or during water sport activity.

The consequences can be especially serious economically and, more importantly, due to the deleterious ensuing conditions.

This type of fracture requires two treatment objectives.

The *first* consists of an assessment of the lesion through a meticulous physical exam including tests for the presence of accompanying neurological deficit. At this point it is essential to determine if the spinal cord injury is complete or incomplete.

A complete lesion is that in which the patient presents no sensory or voluntary motor function below the level of injury following the spinal shock phase that tends to last 24 hrs in most cases. This phase is identical in patients with complete or incomplete spinal cord injuries; in other words, during the spinal shock phase, it is impossible to distinguish between the two. The final phase of spinal shock is marked by the return of spinal reflexes, beginning with the bulbocavernosus reflex.

Incomplete spinal cord injuries are those in which the patient retains sensory or voluntary motor function in some area anatomically distal to the spinal cord injury. This classification is important from the prognostic point of view: while incomplete injuries are potentially reversible, complete injuries are irreversible.

The classification of complete or incomplete spinal cord injuries following these criteria can be somewhat complex, making clinical indicators useful in predicting what type of injury will be presented in the patient.

If during the course of initial evaluation the patient presents some sign of retained sacral function (voluntary contraction of the anal sphincter, perianal sensitivity, or active big toe flexion), we can affirm that the patient has an incomplete injury.

Incomplete injuries can be further classified into 5 syndromes, each of which implicates a distinct prognosis:

- *Central cord syndrome.* The syndrome most frequently presented, and chances of functional recovery can be as high as 75%. This syndrome appeared in 3 of our patients, one of which showed sufficient favourable functional recovery to allow resumption of previous occupation.
- *Anterior cord syndrome.* Associated with complete motor deficit. The probability of neurological recovery is 10%.
- *Posterior cord syndrome.* Very infrequently presented.
- *Brown-Séquard syndrome.* Recovery can be expected in 90% of cases.
- *Radicular syndrome.* Frequent. Functional recovery varies between 30 and 100% of patients. One of our patients presented with this syndrome and showed a partial functional recovery following surgery.

Finally there is an infrequent subgroup of incomplete spinal cord injuries, the accurate diagnosis of which is of crucial importance to the prognosis of the patient. These are incomplete spinal injuries that may negatively evolve as the neurological deficit worsens in the hours or days following the trauma. When mechanical instability or neurological compression is observed in this type of injury, immediate surgical treatment is required in order to reduce the risk of neurological aggravation. This treatment must be complete and avoid partial or total decompression manoeuvres unless accompanied by sufficient stabilization.

The *second* objective consists of decompression and stabilization of the injury, followed by a rehabilitation programme as early as possible.

This decompression and stabilization will be especially urgent in cases of neurological deterioration or following the appearance of neurological signs in patients that were previously intact.

In complete or established spinal cord injuries, surgical intervention can be delayed as necessary until the patient is medically stabilized. Surgical repair of the lesion will permit an early rehabilitation, which is desirable in this type of spinal cord injury.

Anterior versus posterior approach.

The proponents of the anterior approach defend its various and important advantages:

- Better results for spinal cord decompression. Due to the anterior location of the body and the disc causing the compression, it seems reasonable to work from the anterior approach in order to achieve a complete decompression and thus increase the chances of recovery in a greater number of cases.
- Lower incidence of pseudoarthrosis. The tricortical graft is placed in an ample and heavily vascularised area, the cervical vertebral body, and thus guarantees a high rate of consolidation.
- Less haemorrhaging during surgery. The surgeon enters through an anatomical dissection using an anterior approach.

Proponents of the posterior approach:

- Greater safety in the approach due to the avoidance of important structures such as vessels, nerves, the trachea, and the oesophagus.

- Greater stability is attained with posterior methods than in the anterior approach.

In light of Glaser¹² et al.'s exposition in a study published in 1998, on the lack of unanimity, or at least wide acceptance of a concrete procedure for the treatment of these injuries, we will attempt to summarize the tendencies found in the medical literature and present our own criteria, based on the positive results obtained in a study with a minimum follow-up of 51 months.

An objective review of the medical literature reveals no significant differences between the different approaches when the parameters used for evaluation refer to recovery from incomplete neurological deficit.

Lambiris¹⁶ et al. (2003) reviewed the results obtained from the treatment of 53 patients with lower cervical injury using anterior decompression, bone grafts, and anterior cervical instrumentation using plates and screws. No neurological complications were reported, and the incomplete spinal cord injuries improved by one Frankel grade following surgery.

Another important point of controversy between posterior and anterior approaches centres around an assessment of the quality and stability of instrumentation.

In 1977, Stauffer²¹ et al. insisted on the necessity of identification of the location of the principal injury in order to prevent posterior deformity, and proposed that, in spite of the fact that anterior fusion is a reasonable option for the treatment of certain fractures with anterior instability, it is not always applicable.

Aebi et al.² (1986) published their results on 100 patients with cervical fractures following surgical treatment and concluded that the optimal approach depends more on the type of fracture than the neurological lesion.

Kalff¹⁵ et al. (1993) published their results on 124 patients with cervical injuries, 79 of which were treated using an anterior approach. In their literature review, they advocate against posterior decompression in patients with neurological damage due to the greater instability it provokes; although they write in favour of anterior fusions, they still maintain that posterior fusions can play an important role in these complicated injuries.

In the medical literature since then, the tendency has arisen that the decision regarding the type of surgical approach does not depend on the type of fracture. On the other hand, the combined approach remains rarely used, although some authors defend it, such as McAfee¹⁷ et al. (1995), who presented their results on 100 patients treated with anterior decompression and posterior stabilization. These authors maintain that a true decompression can only be obtained through an anterior approach and claim that posterior instrumentation is superior to the anterior approach in terms of stabilization, at least in the laboratory. Although this is a minute study, it encompasses patients with different afflictions.

Aebi³ et al. (1991) published a study on 86 patients who were treated using an anterior approach independent of the type of fracture, with positive results.

Ripa¹⁹ et al. (1990) published their results on 92 patients with cervical fractures treated using anterior decompression, autografts, and AO plates. They concluded that only facet

dislocations and dislocation fractures that cannot be manually reduced should be treated through a posterior approach.

Garvey¹¹ et al. (1992) published their results on initial treatment of 14 patients with cervical fractures. They concluded that when an anterior decompression is required, anterior Caspar plates with bone grafts are sufficient, precluding the need for posterior stabilization.

In 1994, the first author of this article⁸ published the results obtained using an anterior approach for treatment of cervical fractures in a revision of 35 patients with a minimum 3-months follow-up. The article includes cases of fractures and dislocation fractures, among other afflictions, and all patients were treated using arthrodesis.

Wiseman²² et al. (2003) concluded that the new stable systems available for anterior instrumentation have increased the use of this approach in comparison with treatment using a posterior approach.

As Aebi et al.² summarized, the advantages of using a system of anterior plates for lower cervical column injuries are the supine lying position of the body, the less traumatic nature of the approach, the dynamic compression of the bone graft that acts as a tension band and support to physiological lordosis of the cervical column, and the convenience of anterior decompression.

In spite of all that has been presented, there is still a lack of consensus in the field. Roy-Camille et al.²⁰ (1992) published a study in which 90% of the 221 traumatic injuries presented at the level of the lower cervical spine were treated using posterior approach with plates, yielding very positive results with a low incidence of complications.

Various authors have compared the stability obtained in vitro through posterior versus anterior fixation. The results from posterior fixation are more favourable in terms of stability than anterior fixations.

Do Koh¹⁰ et al. (2001) communicated their results obtained from a series of comparative biomechanical studies of fixations using anterior and posterior plates on cervical column lesions on a cadaver. The results indicated a significantly higher stability when using posterior stabilization with lateral mass plates than with anterior locking plates for flexion-distraction or burst fracture injuries.

Differences exist among the posterior stabilizations used by surgical practitioners with regard to the use of lateral mass plates, wires, or cervical pedicle screws. Abumi¹ et al. preferred the use of pedicle screw for injuries to the lower and middle cervical spine. In 1994, these authors evaluated 13 patients with lower cervical fractures treated with posterior fusion using only cervical pedicle screws; they maintained that the stability offered by pedicle screws is far superior to other posterior techniques, such as wires or lateral mass plates. The surgeon must have a profound familiarity with the anatomy of the area in order to minimize the risks associated with this surgical procedure, which is still recommended for use in some circumstances due to the high stability it affords.

However, more recent cases exist, such as that of Bozkus et al.⁶ who carried out a biomechanical analysis of 14 cadavers with lower cervical lesions affecting the 3 columns. They exhibited a minimal difference in stability between fixations using screws and bars in lateral masses

and those that used only pedicle screws, at least immediately post-operation.

In our literature review we have found a randomized study published in 2003 by Brodke⁷ et al., in which they present a comparison between anterior and posterior approaches in 47 patients with lower cervical injuries using closed reduction methods. It is interesting to note that 75% of the patients treated using an anterior approach showed improvement of at least one Frankel grade in comparison with the group treated using a posterior approach, where only 57% of patients showed appreciable improvement. No differences existed in terms of fusion or in the correction of kyphosis.

In our opinion, some indications do exist currently for the use of posterior and combined approaches.⁹ The principal

examples of situations for posterior approach are unilateral and bilateral facet dislocations irreducible by orthopaedic methods, as well as some rare cases of posterior lesions with neurological damage (laminar fractures with canal fragment incarceration, apophyseal fractures with radicular damage, etc.). Allred et al.⁵ (2001) described their technique in 4 patients who presented with irreducible cervical subluxation from a prolapsed disc. The surgical procedure consisted of an anterior discectomy with a structural graft and fixation using plates screwed only to the superior body and supported by a posterior fusion using wires.

We believe that a combined approach (figs. 5 and 6) does maintain a principal indication in the treatment of symptoms or residual biomechanical defects following an anterior or posterior intervention. Furthermore, posterior decompression

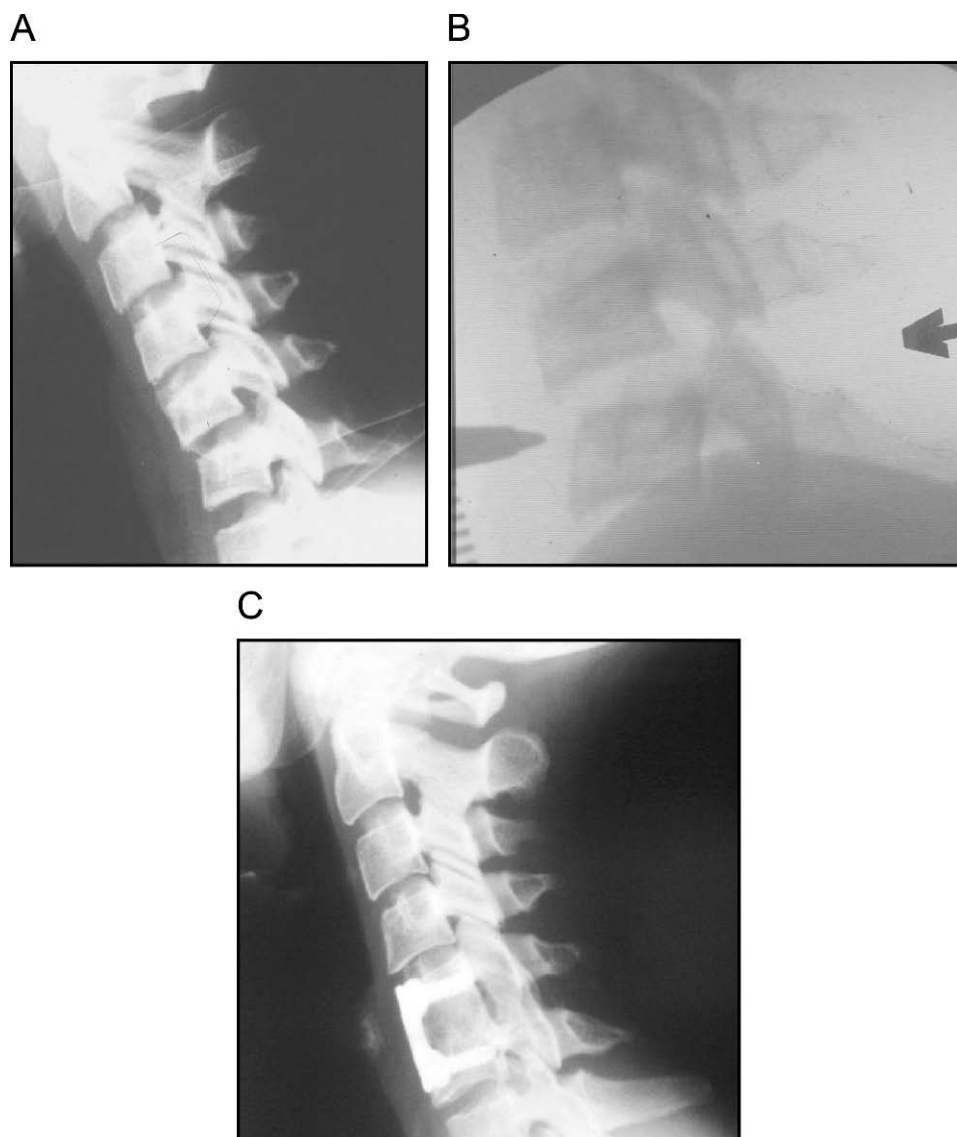


Figure 4 Traumatic injury of the C5-C6 posterior ligament complex. A) Increase in the interspinous distance in a dynamic radiograph. B) A fluoroscopic image obtained immediately pre-operation that clearly displays instability through a mild flexion manoeuvre. C) Follow-up radiograph 12 years post-operation following an anterior surgical stabilization.

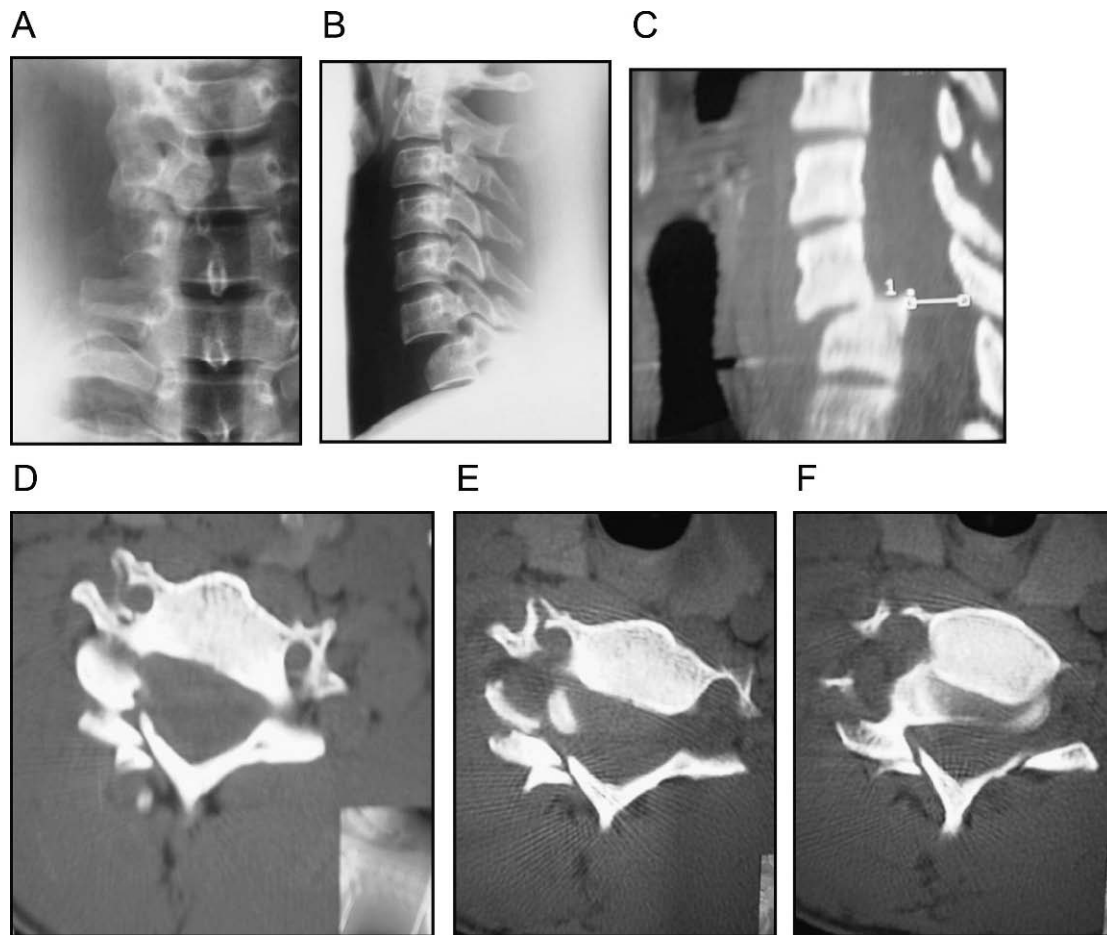


Figure 5 Preoperative C6-C7 subluxation producing a right C7 sensorimotor radiculopathy. A) Anteroposterior radiograph. B) Lateral radiograph. C) CT scan. D, E, and F) CT displaying a right laminar C6-C7 fracture, an inferior articular fracture of C6 and superior C7 fracture with facet dislocation, right transverse apophyseal fracture at C6 with damage to the transverse foramen, transverse apophyseal fracture at C7, compression fracture of the C7 vertebral body, and a C6-C7 subluxation.

of some infrequent but severe injuries to solid joints, with damage to the corresponding nerve root could implicate the total or partial loss of the joint, as well as complicating stabilization through the same approach. These cases could be treated with anterior fusion and stabilization and posterior decompression in a single surgical procedure, although we do recognize that few clinical situations exist in which a combined approach in a single operation would be preferable.

Given the lack of randomized clinical studies (and it is highly improbable that such studies will be carried out in coming years), we focus on the conceptual analysis and evaluation of our own clinical experience (both surgical cases and publications in the biomedical literature) to reach the conclusion that the anterior approach is preferable in the majority of cases.

Regarding the presence of complications, the Cervical Spine Research Society¹³ carried out an important study evaluating 5,356 patients with cervical traumas. The appearance of neurological complications was 0.64% using an anterior approach, compared to 2.18% when using a posterior approach. Instrumentation failures using an anterior approach reached 35% but did not cause relevant damage. Oral extrusion of the graft or implants is underrepresented in the

medical literature. Riley et al.¹⁸ observed a 30% prevalence of dysphagia in 454 patients within 3 months following decompression and anterior cervical fusion. Dysphagia persisted for 6 months in 21.5% of patients and reached 24 months in 21.3%.

Heller et al.¹⁴ evaluated the placement of 654 posterior screws and observed nervous lesions in 6% of cases and facet violations in 0.2% of cases.

In our study, only 3 residual radiculopathies persisted. These were the aforementioned case in which a second posterior foraminotomy was performed, one that presented with sensorimotor deficit, probably attributable to an incompletely healed traumatic herniated disc (fig. 2), and one persistent brachial pain without deficit that did not require further surgical interventions.

Considering this as a study with long-term follow-up, anterior stabilizations have functioned very well, with complete resolution or partial improvement of the radicular symptoms, variable improvement of the central spinal cord syndromes and, logically, persistence of complete spinal injuries, without the appearance of explanted material nor residual deformities, even in purely posterior (fig. 4) or combined (fig. 7) lesions.

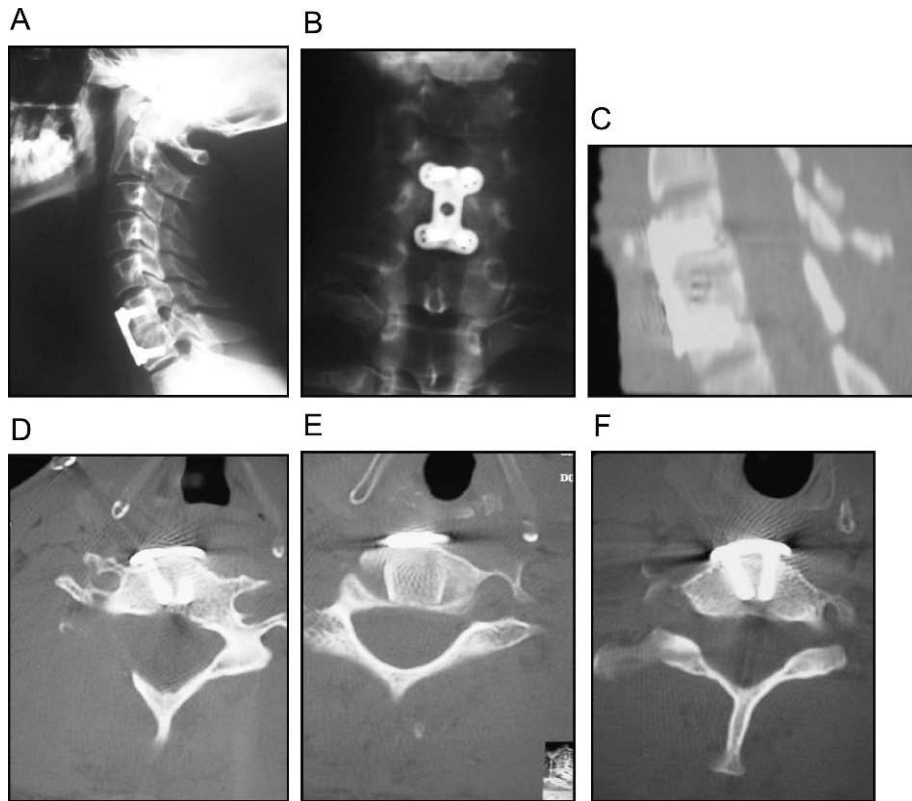


Figure 6 Evolution of a C6-C7 subluxation 12 months after a combined approach surgery. A) Lateral radiograph. B) Anteroposterior radiograph. C) CT scan. D, E, and F) Postoperative CT scan.

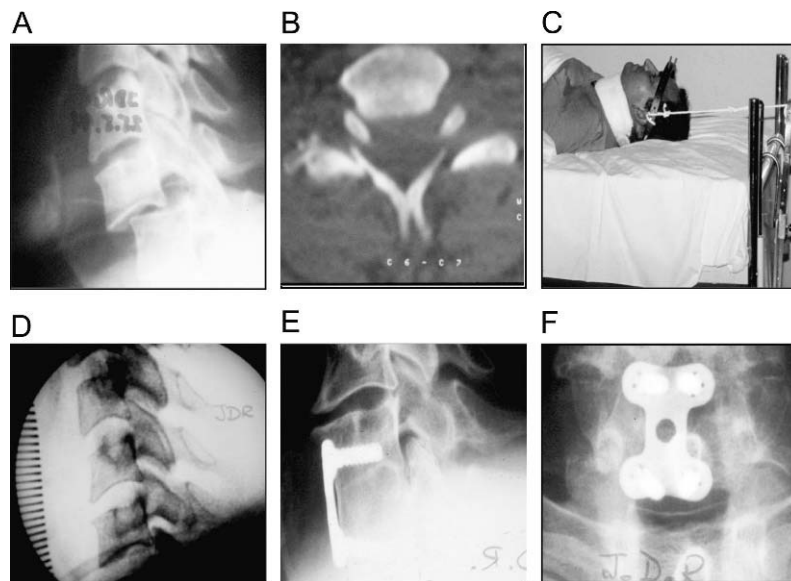


Figure 7 Complete C6-C7 bilateral facet dislocation. A) Preoperative radiograph. B) Axial CT scan displaying dislocation. C) Progressive halo-traction for reduction. D) Fluoroscopic image during operation that shows the reduction obtained using a halo. E) and F) 7 years postoperative radiograph of intersomatic fusion.

As we have shown, the controversy remains unresolved even today. Following analysis and study of the medical literature and review of our own clinical experience in recent years, the following points stand out:

- Optimal spinal decompression is best obtained using an anterior approach.
- In spite of the increased stability observed in in vitro studies using posterior instrumentation and the biomechanical

analyses that indicate that the use of anterior plates does not provide sufficient stability for supporting the forces applied to them, results obtained from various studies, including ours, clearly show that the use of locking plates and structural autologous tricortical iliac crest grafts is much more favourable than biomechanical studies would indicate.

- Less complications arise from anterior approaches than posterior approaches.

Conclusions

Following a review of the medical literature and our experience of long-term results, we conclude that, although there is no unanimity as regards the best treatment for traumatic injury to the lower cervical spine, anterior decompression accompanied by the use of a structural autologous tricortical graft and stabilization by locking plates is considered the best option for most of these lesions.

Combined approaches continue to have few indications and posterior techniques are reserved for those situations in which closed reduction or open anterior reduction are not feasible.

An anatomical approach with reduced haemorrhaging and the possibility of an excellent decompression of neurological structures, along with a low rate of complications and good clinical results, form the principal foundation for our recommendation of the use of this technique.

Conflict of interest

The authors affirm that they have no conflicts of interest.

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