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# Cotrel-Dubousset Instrumentation in Thoracolumbar Seat Belt–Type and Flexion-Distraction Injuries

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**Summary:** For many years, all the internal fixation devices available for the surgical treatment of thoracolumbar fractures [Harrington rods (HR); Luque rods (LR); Hartshill rectangle (HTR); Roy Camille plates (RCP)] were not always able to distribute all the reductive strains (distraction, compression, derotation), or to guarantee solid stabilization without external supports. In some cases (with HR), only distraction forces might be applied, but stability of the assembly was very poor. Otherwise (with LR, HTR, or RCP), stability was well achieved using segmental fixation systems (with SSW, screws), but reduction was possible only by deflecting the spine towards the rods (or plates), by winging the sublaminar wires (or screws). Restoration of normal sagittal alignment was also very difficult to obtain. The use of internal fixation systems for reduction of thoracolumbar fractures when distraction or compression forces are needed are essential for the spinal surgeon and the patient. In some cases of thoracolumbar fractures (seat belt; flexion-distraction), in fact, the use of distraction forces is not suitable, leading only to overdistraction, not to reduction. The introduction of Cotrel-Dubousset instrumentation (CDI) in 1983, and its subsequent use in spinal traumatology, seems to answer all these unresolved questions. **Key Words:** Thoracolumbar fractures—Cotrel-Dubousset instrumentation—Flexion-distraction injuries—Seat belt–type injuries.

## METHODS AND MATERIALS

From May 1985 to September 1992, 121 thoracolumbar injuries were operated by CDI at the Spinal Surgery Unit of the Orthopaedic Department of the Padova University School of Medicine. The cases were classified following Francis Denis criteria (Table 1) (7).

In this series, nine cases are seat belt–type injuries (7.7% of all the operated cases) (six men, three women), with an average age of 34.6 ± 3 years; 11 cases are flexion-distraction injuries (9%) (nine men, two women), with an average age of 29 ± 6 years.

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The level of trauma was always at the thoracolumbar junction (Table 2). In a high percentage of cases (90%) neurological involvement was present (Table 3).

The patients were operated in emergency or delayed surgery. When neurological impairment was present at admission (18 cases), the patients underwent immediate open reduction and CD stabilization (12 cases). If concomitant chest and/or abdominal injuries or very compromised general conditions were present (six cases), open reduction was scheduled later (2–12 days after admission). Two patients did not present with neurological involvement; one was operated 3 days after hospitalization; one had orthopaedic treatment (see Fig. 2 below). In all the operated cases, a focal posterior spinal fusion was performed.

The patient without neurological involvement,

**TABLE 1.** *Thoracolumbar fractures (general series 1985–1992)*[a]

| | | |
|---|---|---|
| Burst fr. | a | 39 |
| | b | 26 |
| | c | 10 |
| Seat belt–type | One level[b] | 7 |
| | Two levels | 2 |
| Fractures-dislocations | Flexion-rotation | 22 |
| | Shear | 4 |
| | Flexion-distraction | 11 |

[a] Concerns the classification of 121 thoracolumbar fractures observed and treated from 1985 to 1991. The seat belt type injuries are subdivided into two subgroups in order to simplify the table and stress the involvement of one or two motor segments.
[b] Two Chance fractures; five at one level through the disc.

**TABLE 2.** *Level of lesion*[a]

| Level | Seat belt-type (9 cases = 7.7%) | Flexion-distraction (11 cases = 9%) |
|---|---|---|
| T9–T10 | 2 | |
| T11–T12 | 3 | 3 |
| T12–L1 | 3 | 5 |
| L1–L2 | 1 | 3 |

[a] Concerns the different levels of location of seat belt–type and flexion-distraction injuries.

who underwent surgery, was discharged after 15 days, without any external support. The patients with complete or incomplete paraplegia were admitted to the Spinal Rehabilitation Unit, after the immediate postoperative period (8–10 days).

**TABLE 3.** *Frankel scale*[a]

| | A | B | C | D | E |
|---|---|---|---|---|---|
| A | 7 | 1 | — | 1 | — |
| B | — | 2 | 1 | 2 | — |
| C | — | — | 1 | 1 | 1 |
| D | — | — | — | — | 1 |
| E | — | — | — | — | 2 |

[a] Frankel scale, representing the comparative preoperative and follow-up evaluation of neurological involvement. Owing to the poor specificness of this method, from 3 years up to now, we evaluated the neurological impairment following the Sunnybrook scale.

Follow-up was carried out 1 year after surgery with clinical and roentgenographic examination.

The neurological impairment was evaluated using the Frankel scale. From a roentgenographic point of view, kyphosis and amount of angulation and translation were estimated in preoperative, postoperative, and follow-up x-rays.

## RESULTS

A satisfactory reduction and good stabilization was achieved in all cases, without any significant loss of reduction (Table 4). The average values of kyphotic deformity of the motion segments involved appear well improved in all cases, except for the slight loss of lumbar lordosis (L1–L2) (from $-3 \pm 4$ to $1 \pm 5$), without any statistic significance. The reduction of angulation and translation values were very stable.

**TABLE 4.** *Evaluation data*

| Level (cases) | Angle (normal)[b] | Kyphosis (degrees, M ± SD) | Angulation (degrees, M ± SD) | Translation (mm) |
|---|---|---|---|---|
| Preoperative values | | | | |
| T9–T10 (2) | 6 | 19 ± 11 | — | 10 ± 5 |
| T11–T12 (6) | 7 | 12 ± 5 | 9 ± 4 | 18 ± 11 |
| T12–L1 (8) | 5 | 9 ± 8 | 16 ± 7 | 9 ± 13 |
| L1–L2 (4) | 0 | 21 ± 6 | 9 ± 8 | 5 ± 4 |
| Postoperative values | | | | |
| T9–T10 (2) | 6 | 3 ± 4 | — | 3 ± 2 |
| T11–T12 (6) | 7 | 4 ± 1 | 1 ± 3 | 2 ± 3 |
| T12–L1 (8) | 5 | 3 ± 6 | 0 ± 5 | 4 ± 2 |
| L1–L2 (4) | 0 | −3 ± 4 | 4 ± 5 | 2 ± 1 |
| Follow-up values | | | | |
| T9–T10 (2) | 6 | 5 ± 2 | — | 4 ± 2 |
| T11–T12 (6) | 7 | 5 ± 3 | 3 ± 2 | 3 ± 5 |
| T12–L1 (8) | 5 | 5 ± 4 | 2 ± 5 | 5 ± 3 |
| L1–L2 (4) | 0 | 1 ± 5 | 5 ± 3 | 2 ± 4 |

[a] Table representing the evaluation of intervertebral kyphosis, angulation and translation at motor segment involved, compared with postoperative and follow-up values. Normal intervertebral angles are drawn by studies of Stagnara et al. (6). Student *t* test performed between preoperative and postoperative (or follow-up) values demonstrated high significance ($p < 0.001$). No significance between postoperative and follow-up data. The difference between postoperative and follow-up values of kyphosis, in our opinion, is related to the loss of a hypercorrection of the discal space, due to posttraumatic disc degeneration.
[b] The normal value of intervertebral angles is desumed by Stagnara et al. (6).

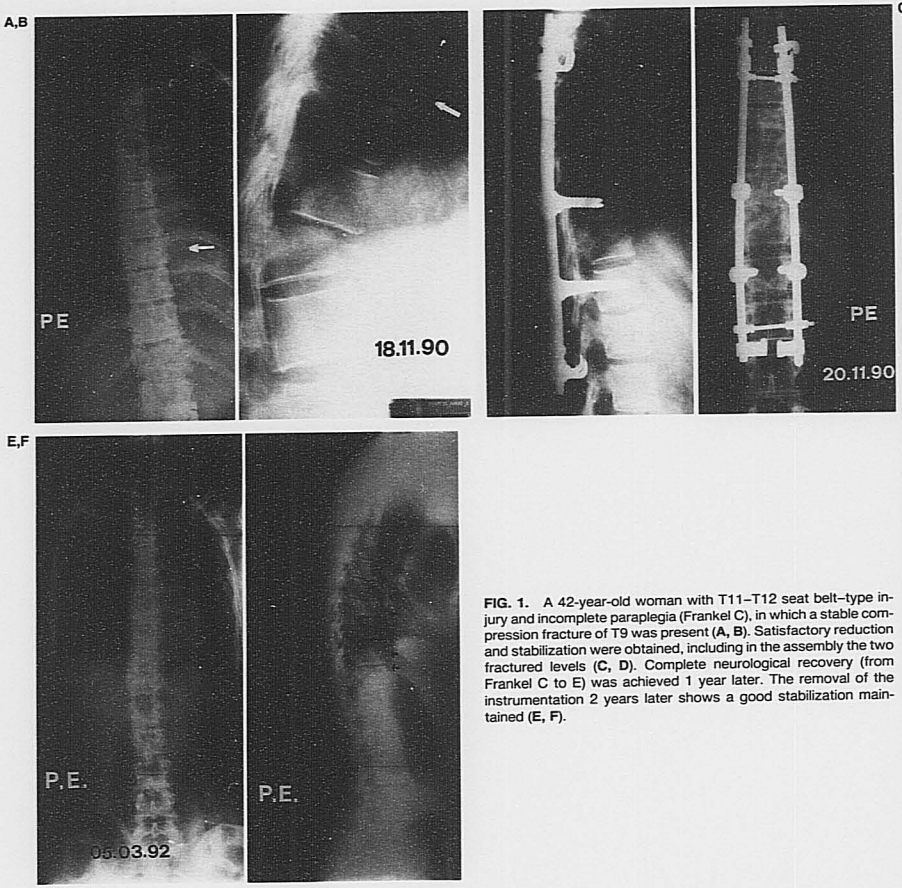


**FIG. 1.** A 42-year-old woman with T11–T12 seat belt–type injury and incomplete paraplegia (Frankel C), in which a stable compression fracture of T9 was present (**A, B**). Satisfactory reduction and stabilization were obtained, including in the assembly the two fractured levels (**C, D**). Complete neurological recovery (from Frankel C to E) was achieved 1 year later. The removal of the instrumentation 2 years later shows a good stabilization maintained (**E, F**).

Neurological recovery was satisfactory in incomplete lesions of the spinal cord. When complete paraplegia was present, an incomplete recovery but a fairly good improvement was achieved in only two cases (Table 3). When a major bladder impairment was present at admission, it remained unchanged at follow-up (intermittent catheterization). In some cases with incomplete neurologic deficit, the bladder function improved (urination without intermittent catheterization), further urodynamic studies were not included in follow-up.

## DISCUSSION

From a pathomechanical point of view, among the traumatic vectors involved in this particular type of spinal injury, the most important one is represented by distraction (8,11,15,18). In seat belt–type injuries, this traumatic vector acts on posterior and middle columns, with the anterior column as a hinge; on the other hand, in flexion-distraction injuries, all the three columns are involved by distraction loads. The reducing forces that must be applied in these two

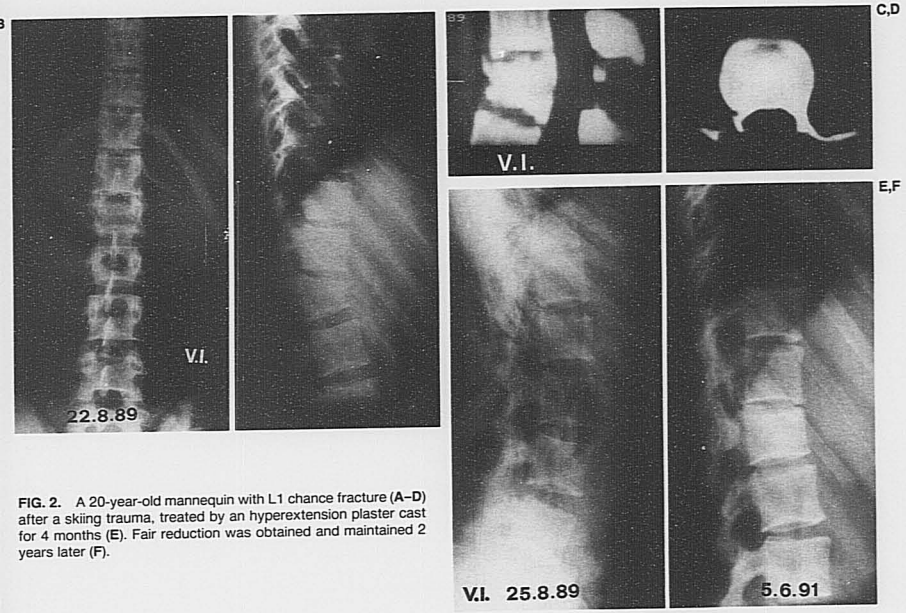


**FIG. 2.** A 20-year-old mannequin with L1 chance fracture (**A–D**) after a skiing trauma, treated by an hyperextension plaster cast for 4 months (**E**). Fair reduction was obtained and maintained 2 years later (**F**).

kinds of injuries by the internal fixation system are posterior compression (of the motor segment involved) and extension (of the spine).

The choice of the different possible CDI assembly and the extension of the instrumentation depend on the level of the injury and the presence of associated traumatic lesions of neighboring vertebrae or neural arches (Fig. 1) (1,10–12,22).

Among the two most common types of seat belt–type injuries, Chance fracture represents a good example of acute bone instability, that may, in some cases, be treated by orthopedic means (Fig. 2).

The other types of seat belt–type injuries (one level/two levels through the disc) recall the traumatic ligamentous instabilities of the cervical spine, well described by Roy Camille, in which surgical treatment is mandatory.

Pathomechanics of seat belt injuries are very similar to flexion-distraction injuries (2,8,12,17). The two groups differ for the fulcrum site and the amount of trauma to the anterior column. A primary "seat belt–type" injury may become a "flexion-distraction" injury due to inappropriate first aid maneuvers or during transport from the site of the trauma to the hospital. In other words, the final radiographic findings may differ, but the pathomechanics of the lesions are the same. For this reason, we combine the two different types of lesions (even if in Francis Denis' classification these two types are considered as different groups) (8).

In 1985, we began using CDI surgical treatment for thoracolumbar fractures. At this time, there was not a general consensus or systematic approach for use of CDI for different types of injuries and levels of spinal involvement. At the thoracolumbar junction, we often used long rods, short fusion, sublaminar wires (in order to subdivide the flexional vector loads), and the removal of instrumentation 1 year later (Fig. 3). This approach was discontinued in 1988 due to the inconvenience of the multilevel instrumentation and the requirement for a second surgery for removal.

Normally in this kind of injury the assembly may be really short, when only a single motion segment is involved (Fig. 4). When the vertebral body appears free from fracture (one level through the disc lesions), the pure ligamentous instability may be adequately

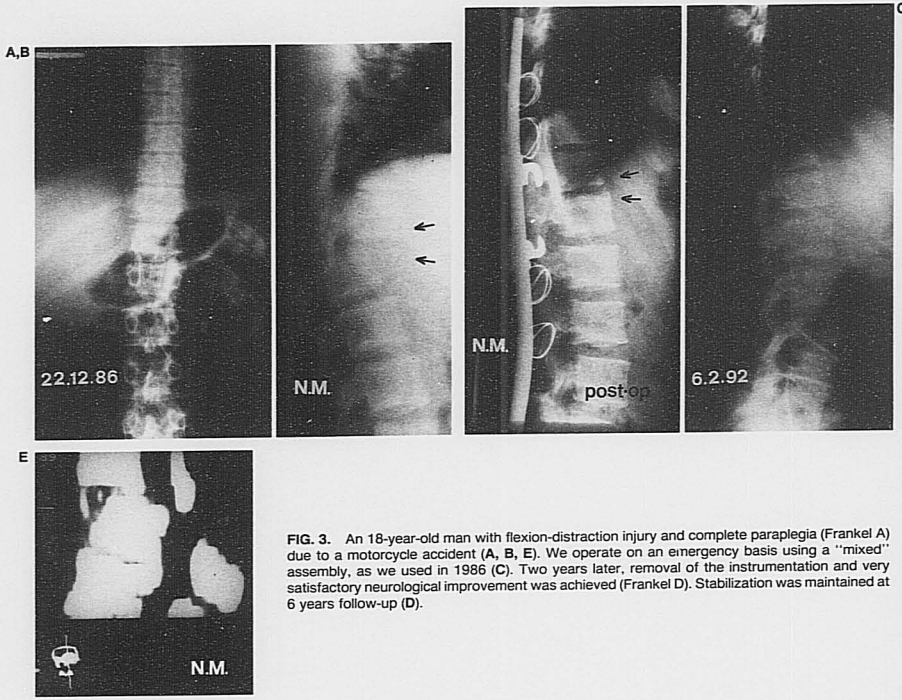


**FIG. 3.** An 18-year-old man with flexion-distraction injury and complete paraplegia (Frankel A) due to a motorcycle accident (**A, B, E**). We operate on an emergency basis using a "mixed" assembly, as we used in 1986 (**C**). Two years later, removal of the instrumentation and very satisfactory neurological improvement was achieved (Frankel D). Stabilization was maintained at 6 years follow-up (**D**).

stabilized by fixation and fusion of a single motor segment. A second anterior surgical procedure is often necessary in burst discosomatic fractures, in order to decompress the spinal cord and avoid anterior chronical progressive bone instability. A fracture of the bony elements may be present in seat belt–type and flexion-distraction injuries, as reported by Smith and Kaufer (20) and by Begeman et al. (4) due to axial loading associated with deceleration forces. In our opinion, the presence of the associated wedge compression or burst fracture is related to the amount of axial load more than to the priority of application of traumatic vectors (distraction and axial load).

The neurological improvement observed at follow-up in a fair percentage of cases is in our opinion related to the short period of time elapsed between trauma and surgical reduction. Within the last 2 years, we began to routinely use high doses of methylprednisolone, as recommended by Bracken et al. (5). It is well known that the best results for recovery from neurological impairment is when therapy starts within 6 h of the initial trauma (5).

It may appear very uncommon and hardly credible that a Frankel A, before surgery, became Frankel D 1 year later. One might reply that the first clinical observation was incorrect, confusing a grade A with a B. We hope that Frankel grade A does not always represent a complete unrecoverable spinal cord lesion, but only the clinical feature of an acute interruption in neurotransmission. The velocity of restoring the normal alignment of the spine and removing compression may play, in our opinion, an important role in avoiding the start of free radicals reactions, eventually leading to a complete functional and anatomical lesion without the possibility of restoring any function at all.

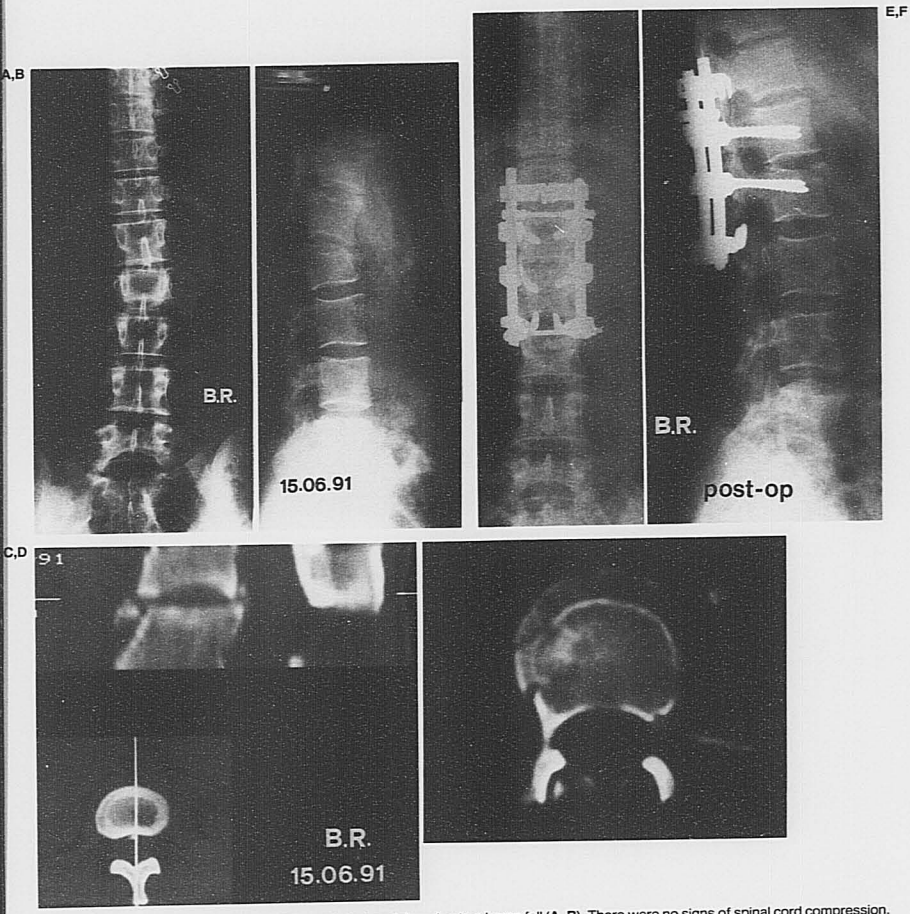


**FIG. 4.** A 40-year-old woman with L1–L2 seat belt–type injury due to a horse fall **(A, B)**. There were no signs of spinal cord compression. Note on CT scan **(C, D)** the disappearance of counterposed zigoaphophyseal lumbar joints. Short assembly with double screwhook claws was carried out, and no external support was needed **(E, F)** for postoperative treatment.

CDI allows a lot of different assemblies (using screws, hooks and claws, both in distraction or compression), in order to act with different forces and achieve segmental correction, and stabilize different traumatic lesions, in the different parts of the spine (thoracic spine; thoracolumbar junction; lumbar spine). This is particularly true in cases of multiple spinal fractures at different levels (Fig. 1), in which all the fractured vertebrae must be included in the instrumented area (even if stable compression fractures are present). The level of the spine involved led the surgeon to different assemblies owing to the different anatomical features of the neural arches and pedicles, and the different physiological kinematics in thoracic,

thoracolumbar, and lumbar spine. For this reason, if some other devices as the internal fixator may well be used in lumbar area, at the thoracic levels hooks (and above all the claws made by hooks) are more useful than pedicular screws, even because of the little size of the thoracic pedicles. On the other hand, the need for saving, with a short instrumentation, as many motion segments as possible, appears much more mandatory at thoracolumbar junction and lumbar level than in the thoracic area.

In conclusion, the use of CDI in seat belt–type or in flexion-distraction injuries demonstrated good results, allowed early mobilization and easy nursing of the patients, without any external support. Complications were small in number and importance. The practical difficulties that may be observed during the assembly of this complex device decrease with the increased experience of the surgeon, and represent the normal learning scale; the medium operative time (ranging from 3.5–2 h) is not so far from that of the other devices used in this very particular surgery.

The opportunity to use an internal fixation system, which allows short, different, but nonetheless stable assemblies, improves the results and appears very important for the patient and the surgeon.

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