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Original article

Surgery in vertebral fracture: Epidemiology and functional and radiological results in a prospective series of 518 patients at 1 year's follow-up



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ABSTRACT

Introduction: Recent epidemiological data for spinal trauma in France are sparse. However, increased knowledge of sagittal balance and the development of minimally invasive techniques have greatly improved surgical management.

Objectives: To describe the epidemiology and management of traumatic vertebral fracture, and to analyze evolution and risk factors for poor functional outcome at 1 year's follow-up.

Materials and methods: A prospective multicenter French cohort study was performed over a 6-month period in 2011, including all cases of vertebral fracture surgery. Data were collected by online questionnaire over the Internet. Demographic characteristics, lesion type and surgical procedures were collected. Clinical, functional and radiological assessment was carried out at 1 year.

Results: Five hundred and eighteen patients, with a mean age of 47 years, were included. Sixty-seven percent of fractures involved the thoracic or lumbar segment. Thirty percent of patients had multiple fractures and 28% neurological impairment. A minimally invasive technique was performed in 20% of cases and neurological decompression in 25%. Dural tear was observed in 42 patients (8%). Seventy percent of patients were followed up at 1 year. Functionally, SF-36 scores decreased on all dimensions, significantly associated with age, persistent neurological deficit and previous spine imbalance. Thirty-eight percent of working patients had returned to work. Radiologically, sagittal balance was good in 74% of cases, with fracture consolidation in 70%.

Discussion: Despite progress in management, spinal trauma was still a source of significant morbidity in 2011, with pronounced decrease in quality of life. Conserved sagittal balance appeared to be associated with better functional outcome.

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1. Introduction

The spine is a complex dynamic structure that is stable under physiological conditions. Spine trauma surgery seeks to restore the integrity of the spinal axis while conserving these characteristics as well as possible. Certain factors affected management

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over the last two decades. Population aging and improved prevention of serious accidents have altered the epidemiology of spine trauma, with increased incidence of osteoporotic fracture [1–3]. In parallel, multiple technical progresses in instrumentation and improved knowledge of spinal biomechanics and sagittal balance have changed surgical strategies [4].

The 1995 symposium of the French Society of Orthopedic and Traumatologic Surgery (SoFCOT) [5] introduced the concept of regional traumatic angulation (RTA), stressing the importance of sagittal balance. Since then, there have been few prospective reports of functional impact and quality of life and there is no consensus on the management of these fractures.

A multicenter prospective study was designed to:

- determine the epidemiological characteristics of operated patients;
- assess their clinical and functional evolution;
- analyze 1-year radiological data;
- and determine risk factors for poor clinical and radiological outcome.

2. Material and method

All patients operated on in 10 university hospital centers for spinal fracture or recent (< 3 months) severe sprain between February 1 and July 31, 2011 were prospectively included. Pediatric trauma (< 15 years) was excluded. All data were centralized on one computer database. Data were collected by each center by Internet-based questionnaire.

2.1. Patients

Inclusion data per patient were the following:

- demographic data: age, gender, body-mass index and comorbidity on the ASA classification [6];
- cause, mechanism and date of trauma;
- type of fracture on the Magerl classification for thoracic and lumbar fracture [7] and the Argenson classification for the lower cervical spine [8];
- associated neurological disorder or lesion, assessed on the American Spinal Injury Association Impairment Scale (AIS) [9];
- treatment duration and pathway.

2.2. Surgical procedure

Inclusion data per procedure were the following:

- approach and technique;
- osteosynthesis length and arthrodesis;
- procedural complications.

2.3. Follow-up

Patients were assessed at 3 months and 1 year.

Both assessments included clinical examination with visual analog scale (VAS) pain assessment. At 1 year, functional assessment used self-assessment on the Oswestry Disability Index (ODI) [10] for the thoracolumbar spine and the Neck Disability Index (NDI) [11] for the cervical spine, and the SF-36 quality of life questionnaire [12].

Any redo surgery was noted, with date and indication.

AP and lateral plain radiographs were taken postoperatively and at both follow-up consultations.

Table 1
Modified Youkilis classification.

Categories	Pedicle screw
Grade 1	Perfect alignment/in-out-in
Grade 2	Medial cortical violation < 2 mm
Grade 3	Medial cortical violation > 2 mm
Grade 4A	Cortical violation > 6 mm (intra-canal)
Grade 4B	Cortical violation > 6 mm (extra-canal)

Table 2
Patient characteristics at inclusion.

Age	46.9 (19.6)
Male	354 (68%)
BMI	24.8 (4.5)
ASA	
1	286 (56%)
2	161 (32%)
3	57 (11%)
4	4 (1%)
Cause of trauma	
Road accident	184 (36%)
Fall	162 (31%)
Home	113 (22%)
Sport	37 (7%)
Other	22 (4%)
Associated lesions	
Cranial trauma	50 (10%)
Visceral	93 (18%)
Peripheral	109 (21%)
Neurological deficit (Frankel score)	
A	55 (11%)
B	25 (5%)
C	24 (5%)
D	39 (7%)
E	363 (70%)
No data	12 (2%)

CT scan and large-format AP and lateral weight-bearing radiographs were taken at 1 year.

The following parameters were measured by two blinded investigators using KEOPS software (SMAIO: <https://www.keops-spine.fr>):

- vertebral and regional kyphosis and RTA, calculated from Stagnara's reference data [13];
- sagittal posture, with anterior sagittal imbalance defined by vertical projection of C7 forward of the femoral heads;
- vertebral body fusion, posterior arch status and possible arthrodesis, assessed on spinal CT as [1] consolidated (stable), [2] certain non-union, or [3] doubtful non-union;
- pedicular implant positioning on the Youkilis modified classification [14] (Table 1).

2.4. Analysis

Statistical analysis used STATA v12 software for Macintosh (Stata Corporation, College Station, TX, USA) for non-parametric tests, with Spearman correlation coefficient for continuous variables and Wilcoxon or Kruskal-Wallis test for categorical variables.

3. Results

3.1. Epidemiological data at inclusion (n = 518)

In all, 518 patients were included. Table 2 shows baseline data. Fifty-one percent were managed by the orthopedic team and 49% by the neurosurgery team. ASA score was 1 or 2 in most cases (88%).

Sixty-seven percent (n = 347) of fractures involved the thoracic or lumbar segments. Fig. 1 shows the distribution of levels.

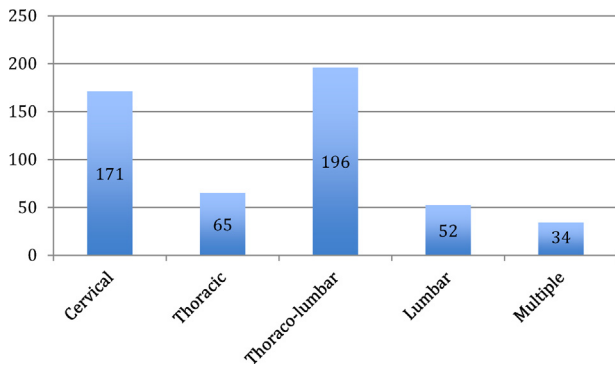


Fig. 1. Vertebral fracture distribution according to the level of injury. Cervical: C1 to C7; Thoracic: T1 to T10; Thoraco-lumbar: T11 to L2; Lumbar: L3 to L5.

Fifty-seven percent of lower cervical spine fractures were Argensson A or B and 89% of thoracic or lumbar spine fractures were Magerl A or B. Fracture distribution on the AO classification for thoracic or lumbar involvement and the Argensson classification for cervical involvement is shown in Fig. 2.

3.2. Surgery

Seventy-five percent of operations on the cervical segment used an anterior approach; 97% of thoracic, thoracolumbar and lumbar procedures used a posterior approach. Osteosynthesis was percutaneous in 97 cases, and vertebral expansion techniques were used in 45 cases. In all, 102 patients (20%) were managed by minimally invasive procedures. In the 375 patients operated on by a posterior approach, neurological decompression was performed in 126 cases, including 78 in which neurological deficit was found. Arthrodesis was performed in 333 cases: 148 cervical and 185 thoracic or lumbar (respectively 84% and 54% of procedures at these levels). Complementary arthrodesis on an anterior approach was performed in 25 patients with thoracic or lumbar fracture.

3.3. Follow-up

3.3.1. One-year clinical and functional assessment

Three hundred and sixty-one patients (70%) were assessed at 1 year. Among patients lost to follow-up, there were larger proportions of women, total neurological deficit and ASA score > 2.

Seventy-one percent of patients with neurological deficit showed improvement, with a mean gain of 1 AIS grade. Nineteen patients were still in hospital at 1 year, including 4 in intensive care.

Table 3
Variables associated with impaired quality of life at 1 year.

Variables	BP	PF	RP	VT	SF	RE	MH	GH	PCS	MCS
Patient-related										
Age		*				*		*	*	
ASA	*	*	*	*		*		*	*	
Trauma-related										
Neurological deficit	*	*	*	*	*	*	*	*	*	*
Associated lesions	*	*	*	*	*	*	*	*	*	*
Work accident	*		*	*	*			*	*	
Surgery-related										
Number of vertebrae treated										*
Anterior imbalance		*	*		*					

BP: bodily pain; PF: physical function; RP: role-physical; VT: vitality; SF: social functioning; RE: role-emotional; GH: general health; PCS: physical component summary; MCS: mental component summary; *: significant (5%) association with impaired quality of life.

Sixty percent of patients in work before trauma had returned to work by 1 year.

3.3.2. Quality of life

Two hundred and fifty-two patients filled out the quality of life questionnaire (Fig. 3). All SF-36 dimensions showed impairment with respect to general population scores. Table 3 presents factors associated with impaired quality of life. Persistent neurological deficit at 1 year was the strongest factor of impairment. Surgical revisions for surgery site infection or mechanical failure were not associated with impaired quality of life. Multivariate analysis was not performed, due to the small sample size and multiplicity of quality-of-life assessment criteria.

3.4. 1-year radiologic assessment (n = 162)

One hundred and sixty-two of the 246 patients with thoracic or lumbar fracture (66%) were assessed at 1 year on CT and large-format radiographs. Vertebral deformity correction was maximal at immediate postoperative assessment; Fig. 4 shows the evolution of correction. At 1 year, spinal posture showed anterior imbalance in 40 patients (26%), significantly associated with age ($P < 0.01$) and lumbar involvement ($P = 0.03$). Seventy-four percent of fractures were stable at 1 year: 69% with complete vertebral body fusion and 5% with solid posterior arthrodesis.

3.5. Complications

There were 42 peroperative dural tears (8%). Forty-six patients underwent surgical revision for complications: 24 for surgical site

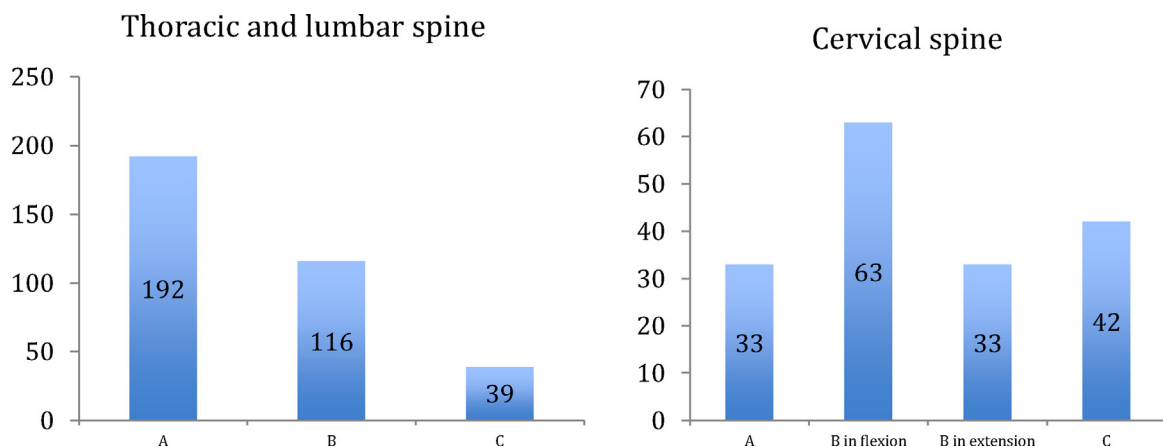


Fig. 2. Vertebral fracture distribution according to the AO (thoracic and lumbar fracture) or Argensson classification (cervical fracture).

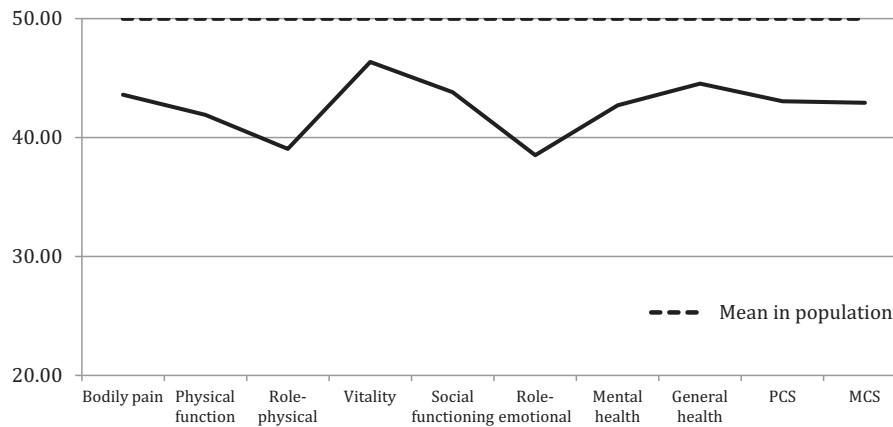


Fig. 3. SF-36 score after 1 year's follow-up.

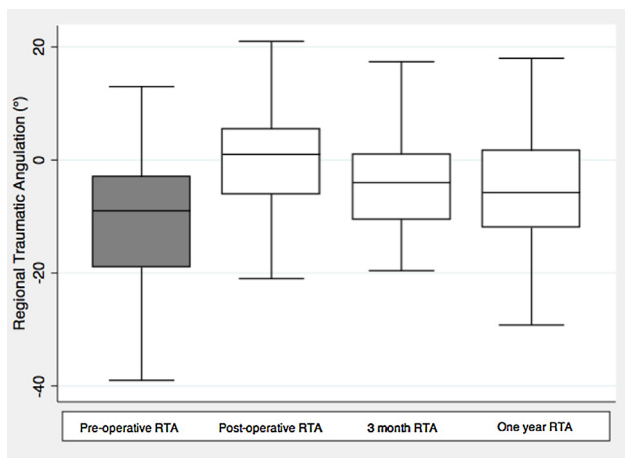


Fig. 4. Regional traumatic angulation variation according to time after trauma.

infection, (19 early), 6 for postoperative neurological deficit and 16 for mechanical failure. Nine patients died during follow-up, including 5 during primary hospitalization.

4. Discussion

The present study assessed spine trauma surgical practice in France, disclosing certain patterns of evolution. Over the last 15 years, patient age and the proportion of home accidents have increased. This is to be explained by the increased number of osteoporotic fractures secondary to population aging in the developed world [1,2]. There was also a reduction in the rate of neurological lesions (24% vs. 30%), in agreement with Oliver et al. [15].

The study testifies to the development of “minimally invasive” surgery. These procedures, which did not exist in 1995, now feature strongly, representing 20% of operations in the present data. Williams et al. reported a rate of 25% in a retrospective series of 6706 patients [16]. There was also a reduction in the rates of arthrodesis (54% vs. 75%) and of neurological decompression (31% vs. 65%). These changes in technique, however, did not significantly affect the radiologic results, in agreement with previous reports [17,18]. Durable reduction showed no significant association with posterior arthrodesis or anterior column reconstruction.

Few studies have focused on functional outcome in spinal fracture [19–21]. As in previous reports, late functional impact (at 1 year) was considerable, with significantly impaired quality of life as compared to the general population on SF-36 [22]. This

deterioration was also visible occupationally, 40% of patients not having returned to work by 1 year.

Factors predating treatment, and thus difficult or impossible to modify, had a strong influence. Several studies stressed the benefit of global management in patient groups at high risk of poor functional outcome, notably the elderly and patients with medullar involvement [23,24].

The study had several limitations. Firstly, the number of patients lost to follow-up hindered interpretation [25], although the present 30% rate was comparable to those reported elsewhere [26,27]. Interpretation was further hindered by the heterogeneity of the patients, traumas and treatments and the large number of assessment criteria. Despite an initial sample of more than 500 patients, statistical power was probably insufficient, and the strength of certain associations was probably underestimated. Finally, despite follow-up exceeding 1 year, fusion at last follow-up was uncertain in a non-negligible number of cases (26%), especially in case of associated limb trauma or neurological lesion. Thus, the factors for stable functional results may in fact be quite different from those highlighted here at 1 year.

5. Conclusion

The present study reports current practice in surgical management of spinal fracture in France, and functional and radiological results. Significant epidemiological and technical changes have occurred in the last decade. However, long-term results continue to show significant functional impact, underlining the gravity of such trauma.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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