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Isolated unstable burst fractures of the fifth lumbar vertebra: functional and radiological outcome after posterior stabilization with reconstruction of the anterior column: About 6 cases and literature review



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ABSTRACT

Introduction: L5 burst fractures represent a small percentage of all spine fractures. Treatment strategy has not yet been standardized. Anatomical features and their biomechanical characteristics create fracture patterns which differ from those at the thoracolumbar junction. The objective of this study was to evaluate L5 burst fracture surgical treatment outcomes after posterior stabilization and reconstruction of the anterior column.

Patients and methods: Six patients with fifth lumbar isolated unstable burst fractures were analyzed. Medical records, radiographs, and clinical scores were obtained. The results were evaluated based on restoration of vertebral body height, spinal lordosis/kyphosis, canal compromise and sagittal alignment at several phases of treatment.

Results: No patient showed neurologic deterioration, regardless of treatment. The median preoperative anterior vertebral height was 41 mm and postoperative was 48 mm. The median preoperative kyphotic angle as measured by Cobb angle (local and regional) was 21.5 degrees and 33 degrees which improved respectively by 7.5 and 5.5 degrees following instrumentation. The median amount of backward protrusion of bony fragment into the canal was measured at 67% preoperatively and at 35% postoperatively. There were no pseudarthrosis and anterior arthrodesis solid fusion was visible in all cases. There were a sagittal alignment restoration. At one year of follow up, fusion was obtained in all the cases, all patients had minimal to moderate disability using Oswestry Disability Index. The ability to return to work revealed a good-to-excellent long-term result.

Discussion: The results of treatment of 5th lumbar unstable burst fractures with posterior stabilization and reconstruction of the anterior column show benefit on durable functional outcome, spine stabilization and radiologic parameters.

Level of evidence: IV, retrospective study.

1. Introduction

Burst fractures of the fifth lumbar vertebra are a rare occurrence, accounting for 1.2% to 2% of all spinal injuries [1,2]. The largest published series of isolated burst fracture of the fifth lumbar vertebra concerned 14 cases [3]. This lack of available data has

been attributed both to their unique anatomical and biomechanical characteristics.

Therefore, treatment strategy of isolated L5 unstable burst fractures has not been standardized yet. In view of the reported data in the literature, isolated L4-S1 posterior fixation cannot be recommended as a reference treatment because neither functional nor radiological benefits have been noted especially, in comparison with conservative treatment [3–5].

Lumbar lordosis, which is maximal at this level, is difficult to restore durably with an isolated posterior fixation. Furthermore, anterior vertebral collapse and loss of lordosis with non-union are

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Table 1
patient population.

Patient	Age	Sex	Magerl classification	Neurologic status
1	16	M	A 3.3	S1 deficit
2	20	M	A 3.3	Intact
3	21	M	A 3.3	L5 deficit
4	29	F	A 3.2	Intact
5	33	F	A 3.3	L5 deficit
6	23	M	A 3.3	L5 deficit

frequent, leading to severe impairment and a loss of sagittal alignment of the spine with chronic low back pain and reduced level of activities. In neurologically intact patient, most of the literature recommends non-operative management, including bed rest followed by thoraco-lumbar brace for 3 months, especially in patients with moderate bone deformity and minimal canal compromise [3,5–7].

It can, therefore, seem logical to restore both the height of the anterior column and the lordosis at this level in order to prevent durably the secondary loss of lordosis. Similarly to burst fractures of the thoracolumbar junction, the anterior reconstruction of the vertebral body could avoid this evolution but remains technically challenging, especially because of the projection of the aortic bifurcation and ilio-cava confluence. Results from the literature are lacking in terms of anterior column support except for individual patients case reports [8,9].

The aim of this study was to evaluate treatment outcomes in a series of 6 patients managed for an isolated unstable L5 burst fracture treated by circumferential fusion including short posterior L4–S1 fixation followed by anterior reconstruction using expandable vertebral body prosthesis. We retrospectively analyzed functional and radiographic outcomes including vertebral body height restoration and correction of the traumatic kyphosis.

2. Methods

2.1. Patient population

This is a retrospective study of 6 patients (2 females, 4 males) managed between May 2011 and July 2015 for an isolated unstable L5 burst fracture in our institution (Table 1). Mean age at surgery was 24 years [range 16–33]. The fractures were classified according to Magerl's Classification [2]. The mechanism of injury was always related to a motor vehicle accident.

2.1.1. Inclusion criteria

All patients managed for an isolated L5 unstable <http://www.sciencedirect.com/science/article/pii/S0303846714004223-200005260> burst fracture and treated with posterior and anterior approach were included in this study. Radiological instability was defined by at least one of the following criteria: 50% or more loss of vertebral body height as measured on lateral radiography, more than 20 degree of kyphosis and more than 40% of canal compromise as seen on axial CT scan.

2.2. Surgery description:

Operative strategy always included a circumferential fusion by a posterior L4–S1 fixation followed by an anterior column reconstruction during a second procedure. First step was performed via percutaneous access for 2 patients without neurologic deficit, and via an open approach when L5 laminectomy was necessary (4 patients with neurological deficit).

The second surgical step was performed on average one week after the posterior fixation. Decision for anterior reconstruction was made based on immediate postoperative CT-scan based on the Load Sharing Classification as reported by Ould-Slimane et al. [10]. All

patients were positioned in « French position » and a left retroperitoneal approach was conducted. Segmental vessels and especially the ilio-lumbar vein was systematically ligated and cut in order to mobilize safely the great vessels. The left iliac vein was then mobilized towards the midline allowing the exposure of the L4–L5 disc and complementary access between both iliac veins allowed access to L5–S1 disc. The disc above and below the fracture was removed, then a subtotal corporectomy of the fractured vertebra body was performed, leaving the right lateral and anterior vertebral body wall in place. A hollow expandable cage (V-LIFT, Stryker SA) with lordotic endplates (8° or 14°) was filled with cancellous bone from the corporectomy associated with BMP2 and inserted into the corporectomy defect under lateral and anteroposterior fluoroscopic control and progressively distracted.

2.3. Radiographic analysis

Preoperative radiologic assessment systematically included x-rays, MRI and an angio-CT scan in order to visualize abdominal vessels before the anterior approach. The following parameters were measured:

The amount of kyphotic deformity that included the regional Cobb Angle (defined as the angle between a line drawn parallel to the superior endplate of L4 and a line drawn parallel to the inferior endplate of S1) and the Cobb vertebral angle (defined as the angle formed between a line drawn parallel to the inferior endplate of L4 and a line drawn parallel to the superior endplate of S1).

The percentage of canal compromise defined as a ratio between the canal stenosis at the level of injury and the estimated normal canal dimensions [11].

The loss of vertebral body height evaluated by the distance between the antero-inferior endplate of L4 and the anterosuperior endplate of S1.

2.3.1. Data collection

Electronic medical records, operative notes, follow-up clinical notes and radiographic studies were obtained retrospectively. Data on age, gender, body mass index (BMI), level of injury, kyphotic deformity pre and postoperatively, intraoperative blood loss, neurological function (preoperatively and at final follow up), fusion rate, complications, pain level on the VAS and the analgesics consumption; functional outcome evaluated by the Oswestry Disability Index (ODI) [12] and ability to work and the delay before return to work were obtained.

2.4. Postoperative evaluation

Patients were seen at 3 months, 6 months and 1-year postoperative period. In all the cases, clinical assessment and low-dose full-spine radiographs (EOS) were obtained. At one-year of follow-up, a CT scan was also performed in order to evaluate bony fusion. Vertebral body height, kyphotic deformity, bone fusion and spinal balance parameters (PT, PI, LL₁) were evaluated at 3 months postoperatively. For each patient the theoretical value of lumbar lordosis is calculated [13] and compared to the measured values on the full spine.

3. Results

3.1. Clinical outcomes

Overall, all patients were satisfied with the surgical results, with a minimal to moderate disability (average ODI score at 13). At one year follow up mean back VAS was 2.5 and painkillers were used occasionally by 4 patients and never by two patients. Physical therapy was still performed by 2 patients.

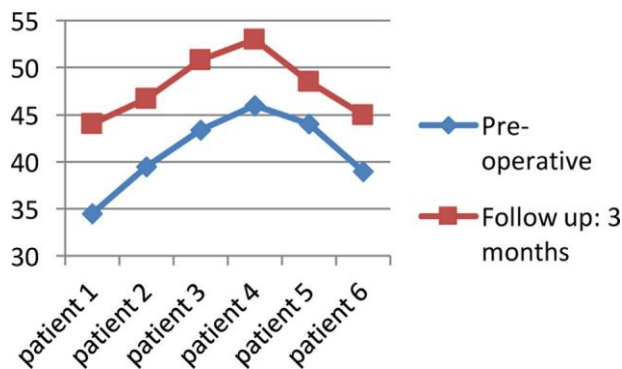


Fig. 1. Changes in vertebral body height form pre to post-operative evaluation (mm).

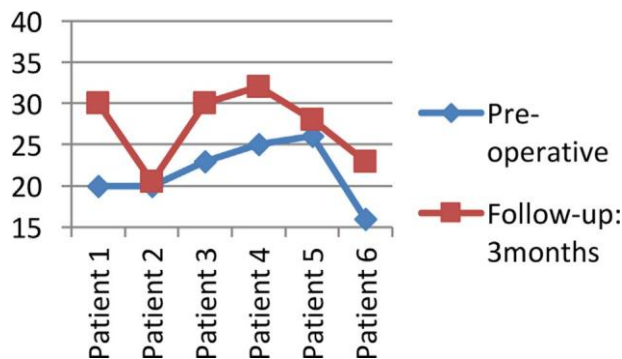


Fig. 2. Changes in vertebral Cobb angle form pre to post-operative evaluation (°).

There were no cases of postoperative neurological deterioration. The two patients without neurologic deficits remained intact after surgery. Among the four patients with incomplete nerve root injuries (motor deficit 3/5, no sphincter disorders), all of them showed complete recovery by the time of discharge from the hospital. At latest follow-up none of the patients developed neurological deterioration and there were no new onset of neurological deficits.

3.2. Return to work

The ability of patients to return to their previous levels of employment was 83% for the entire group at one year. One patient could not return to work because of an associated lower limb injury.

3.3. Radiological outcomes

All the radiographic parameters were measured pre and post-operatively.

The pre and post-operative median vertebral body height was respectively 41.45 [34.4;46] and 47.6 mm [44;53] (Fig. 1).

The pre and post-operative average vertebral Cobb angle was respectively 21.5 [16;26] and 29° [20.5;32] (Fig. 2).

The pre and post-operative average regional Cobb angle was respectively 33 [28; 39] and 38.5° [30;43] (Fig. 3).

The pre and post-operative average vertebral canal compromise was respectively 67 [39; 78] and 35% [0;54] (Fig. 4).

Based on evaluation criteria, a solid bony fusion defined as absence of progressive kyphosis, absence of hardware failure and absence of radiolucency around the screws was found in all patients on the one-year follow-up CT-scan (Fig. 5).

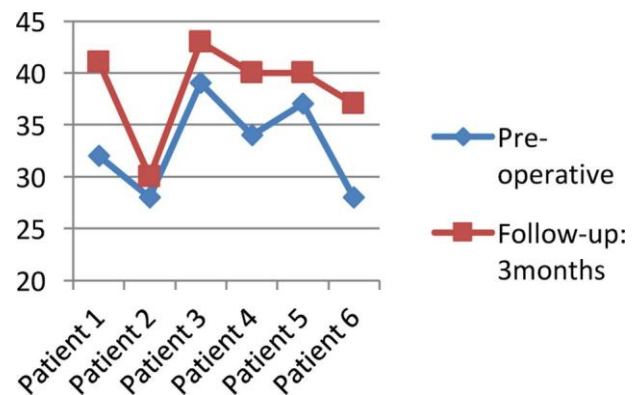


Fig. 3. Changes in vertebral regional Cobb angle form pre to post-operative evaluation (°).

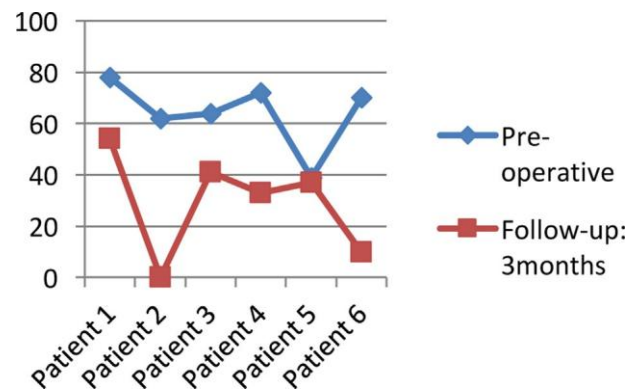


Fig. 4. Changes in canal occlusion form pre to post-operative evaluation (%).

3.4. Surgical results

The mean surgical duration for the posterior approach was 56 minutes and 115 minutes for anterior approach. Estimated blood losses were on average below 200 mL for the posterior approach and below 500 mL for the anterior approach. No perioperative complications were observed from the posterior and anterior approaches in the whole series. On the whole series, no case of vascular injury was observed during the anterior approach.

3.5. Postoperative sagittal alignment measurements

The geometric parameters of sagittal spinal and pelvic alignment was measured (Table 2, Fig. 6). The correlation between sagittal spine parameters and the pelvic measurements was improved especially the restoration of distal lumbar lordosis in a majority of patients.

4. Discussion

Fracture of the fifth lumbar vertebra are uncommon. Among them, burst fractures are the result of an axial compressive force which can be responsible for backward protrusion of bony fragments into the spinal canal [14], as well as kyphotic deformity.

Anatomical features of the lower lumbar spine and their biomechanical characteristics create fracture patterns which differ from those at the thoracolumbar junction [15]. The location of the vertebral bodies below the pelvic rim and the iliolumbar ligaments stabilize the L5 vertebrae resulting in less post traumatic instability than injuries elsewhere. Injuries in the lower lumbar spine involve the transfer of high amount energy. A significantly compression of



Fig. 5. Example of L5 unstable burst fracture after posterior fixation (left), after anterior reconstruction (middle) and bone fusion on one-year CT-scan (right).

Table 2
Postoperative sagittal alignment parameters measurements.

Patient	Lumbar Lordosis (°)	L4-S1 Lordosis (°)	Pelvis Tilt (°)	Pelvic incidence (°)	Theoretical L1-S1 lordosis (°)	Theoretical L4-S1 lordosis (°)
1	48	29	6	40	48	32
2	46	28	23	54	55	37
3	61	37	24	77	66	44
4	60	36	13	55	56	37
5	51	31	8	43	50	33
6	31	19	23	51	54	36

the trapezoidal body of L5 can alter the biomechanics at L4-L5 and L5-S1.

At L5 level, the spinal canal is wide and the nerve roots are more resistant to compressive forces than is the conus medullaris [16]. Cauda equina's nerve roots are similar to peripheral nerve lesions and the recovery prognostic is attractive [7]. For this reason neurologic deficits are less common in L5 fractures and recommendations for treatment are controversial.

According to various authors burst fractures are defined as unstable in the presence of a neurological deficit, in case of loss of vertebral body height, if there is more than 20 degree of kyphosis, more than 40% of canal compromise or significant posterior element lesion [17,18].

Optimal management of these fractures will therefore include an optimal decompression of neural structures in case of neurological impairment and a complete and stable in time kyphosis correction.

The treatment of L5 burst fractures remains controversial for various reasons: for fracture with normal neurologic status, conservative management can be conducted and satisfactory clinical outcomes and pain status were reported [3,5-7]; radiological outcomes were comparable between patients managed operatively (posterior instrumentation) and non-operatively at three months follow-up [3]. Conversely, Mick et al. [19] described a significant loss of height of the anterior column in patients treated conservatively when an increase of vertebral height was reported for patients that underwent posterior stabilization. A loss of lordosis was also noted in fractures treated operatively with posterior instrumentation and fusion [4].

However, despite the significant loss of lordosis, functional outcomes did not show any correlation with the radiological parameters [1,14,19].

On the other hand, when an isolated nerve root deficit is present the benefit of surgical decompression is uncertain when compared to the potential for spontaneous recovery at this level [1,7,20].

It can therefore be advocated that anterior approach is a valuable option when decompression and reconstruction is needed. In

such cases, a corpectomy with reconstruction using a vertebral body cage can be performed similarly to thoracolumbar junction fractures [21]. While several studies have reported comparison between surgical and non-operative treatment for L5 burst fractures, none of the surgical procedures evaluated in the literature are describing an anterior column support except for some individual cases reports [8,9].

The posterior only approach is unable to restore lumbar lordosis, and even carries a risk of kyphosis aggravation when isolated posterior distraction is performed. Finally, an important corporeal comminution is at high risk of non-union and posterior rods fracture, especially in A.3.3 burst fractures.

As for other level fractures, the optimal strategy should take care to preserve or improve neurological function and to obtain a stable stabilization of the spine.

According to the fact that the maximal amount of lordosis is located between L4 and S1 and that lumbar kyphosis can lead to severe impairment of sagittal alignment, it can therefore seems logical to restore not only the height of the anterior column but also the lordosis at this level.

The normal alignment between L4 and S1 is evaluated around 49.2 degrees of lordosis [22]. As a consequence, an injury that leads to a neutral alignment of the L5 vertebra significantly alters the overall alignment of the spine and dramatically affects the patient's sagittal balance. Although the long-term effects of this altered alignment have not been extensively reported in the spine trauma literature, a pelvic incidence-lumbar lordosis mismatch leads to significantly inferior health-related quality-of-life outcome measures [23], and sagittal balance parameters study is necessary for the optimal management [24].

Further studies evaluating sagittal alignment of patients with low lumbar burst fractures are needed as it is unclear if this alignment is improved with acute surgical intervention in comparison with non-operative care [3,5].

Most studies about thoracolumbar burst fracture revealed that combined anterior and posterior approaches were more likely to restore and maintain lordosis in patients [25,26]. Results of this

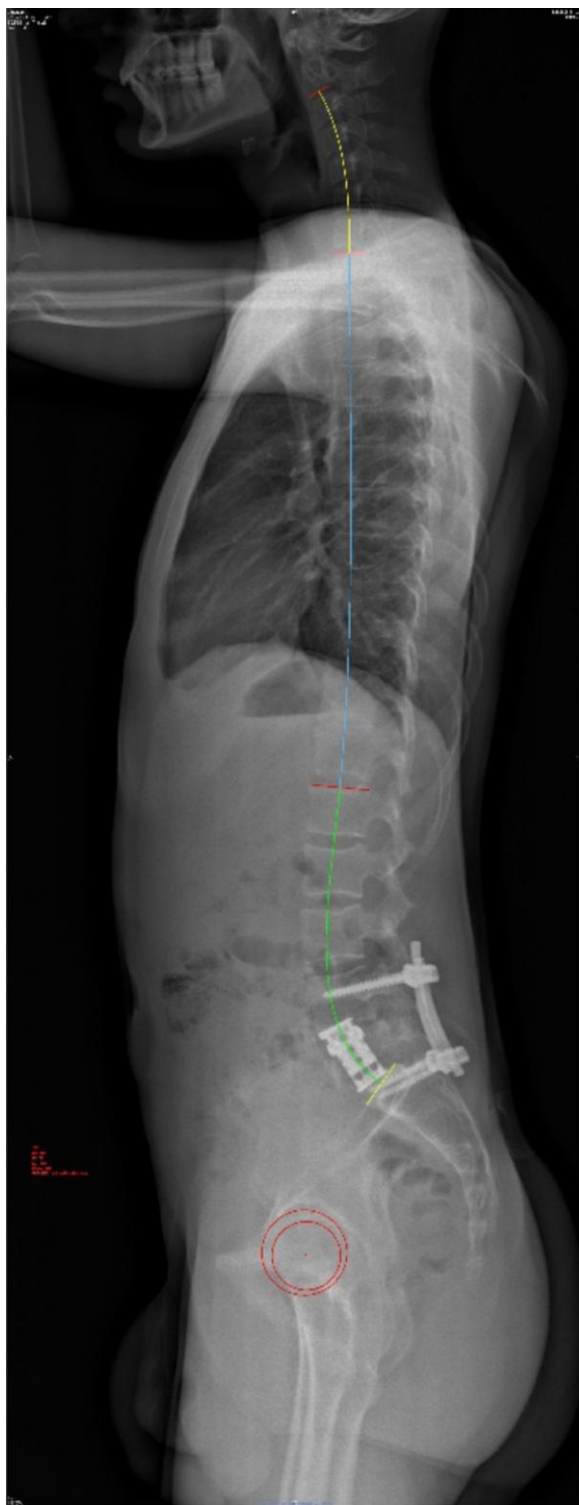


Fig. 6. Post-operative full spine.

study are in line with previously reported data as a improvement of local kyphosis and vertebral collapse were noted while having satisfactory functional results.

This study also contains limitation related to its retrospective design and the small amount of patients. We didn't encountered major complications. Blood loss was below 500 mL for the anterior approach without any vessels injury during the approach. Thus, we didn't evaluate the dread hypogastric plexus injury in young adults. No case of retrograde ejaculation or vaginal dryness with

dyspareunia was reported by patients but the question was not specifically asked to the patients.

However, as reported by Pflugmacher et al. [27] we believe that global maintenance of the initial kyphosis correction is due to the use of expandable titanium corpectomy vertebral body cages in association with posterior transpedicular fixation.

To prepare for the anterior surgical procedure and reduce the risk of intraoperative complications, preoperative CT angiography is important to locate the vessels, and if needed a vascular surgeon can be asked for assistance [28,29].

5. Conclusion

Posterior transpedicular fixation and staged anterior approach with reconstruction of the anterior column can be an alternative in the management of unstable L5 fracture. The advantages of this combined technique are: kyphosis correction, immediate stability, maintenance of kyphosis correction, and a better spinal canal decompression. These advantages have to be carefully weighed against the double approach morbidity. Further studies will be needed in order to confirm these results.

Disclosure of interest

The authors declare that they have no competing interest.

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Author contribution

Mikael Meyer, Solène Prost, Thomas Graillon and Kaissar Farah have written the manuscript

Rémy Noudel, Benjamin Blondel and Stéphane Fuentes have operated the patients and collected the data.

Benjamin Blondel, Solène Prost and Stéphane Fuentes have read and revised the manuscript

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