

# Roy-Camille Type 3 suicidal jumper's fractures: Case series and review of the literature

## ABSTRACT

**Background:** Roy-Camille reported only three patients in their Type 3 posttraumatic transverse sacral fracture (TSF) classification. A modified Roy-Camille classification has been already proposed by other authors suggesting further categorization of the TSFs as partially displaced or completely displaced to predict the rate of neurological recovery following lumbopelvic fixation.

**Materials and Methods:** We reported three adult cases of surgical fixation of fracture–dislocation (3A and 3B) of the sacrum due to traumatic injuries and submitted to lumbopelvic posterior reconstruction. A case of a 15-year-old male patient affected by Type 3C with vascular pelvic injury was also reported. A comprehensive literature search was performed on evaluation and management of Type 3 TSFs.

**Results:** In Type 3A, there is a minimal anterior dislocation and the reduction is feasible with good chance of recovery. In Type 3B, the anterior dislocation is severe, neurological deficits are present, reduction is difficult, and there is a risk of vascular injury both at the trauma and during the surgical reduction. In Type 3C, the anterior dislocation is massive, and the risk of vascular injury is very high requiring prompt vascular or endovascular treatment. Open reduction and posterior instrumentation are technically feasible in patients affected by Type 3 high TSFs.

**Conclusions:** In our opinion, a modified Roy-Camille classification could be useful in the assessment of prognostic and therapeutic aspects of such fractures. In our opinion, a modified Roy-Camille classification could help assess the prognostic and therapeutic aspects of such fractures, in which the severity of the dislocation affects the surgical technique, the chance of neurological recovery, and the patient's life expectancy.

**Keywords:** Lumbopelvic fixation, posterior fusion, sacral dislocation, sacral fractures, vascular injury

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## INTRODUCTION

Sacral fractures and lumbosacral junction trauma are rare but serious lesions, often presented to the emergency room as a polytraumatism. Neurologic and vascular injuries are frequently associated, and neural (spinal nerve or cauda equina roots) release may be required, with reduction and stabilization of the fracture. Transverse sacral fractures (TSFs) were first described in 1985.<sup>[1]</sup> Fracture–dislocation of the sacrum can be associated with serious and highly unstable pelvic injuries, specifically the

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so-called “spinopelvic dissociation” or “suicidal jumper’s fracture.”<sup>[2,3]</sup>

This rare injury represents 3%–5% of sacral fractures and is caused by high-energy accidents, for example, road accidents with multidirectional dynamics or falls from great height.<sup>[4]</sup> Spinopelvic dissociation is a transverse fracture of the sacrum with a longitudinal transforaminal bilateral fracture that causes a dislocation of the upper body of the sacrum from the pelvis and of the sacral wings from the spine.<sup>[3]</sup>

Thus, the upper body of the sacrum and the lumbar section of the spine can rotate and flex due to the action of gravity and of the psoas muscle.<sup>[5]</sup> This condition involves a sacral hyperkyphotic deformity,<sup>[6]</sup> often associated with severe neurologic injuries, such as radicular, plexus, or cauda equina injuries.<sup>[3]</sup> According to the Roy-Camille *et al.* classification, high TSFs and their displacement are grouped into three types.<sup>[1]</sup> Subsequently, Strange-Vognsen and Lebech<sup>[2]</sup> described another type of fracture, Type 4, characterized by a segmental comminution of the S1 vertebral body. Lindahl *et al.*<sup>[7]</sup> further subclassified Type 3 fractures in 3A and 3B depending on the degree of the dislocation. Treatment of these fractures consists in restoring and fixing the connection between the lumbar spine and the pelvis, after the pelvis is stabilized provisionally with external fixators, and if necessary, angiographic embolization is performed on arterial lesions.<sup>[8]</sup> Herewith, the authors present four peculiar cases of Type 3 TSFs along with a review of the existing literature. A modification of the Roy-Camille classification is also proposed, in order to better evaluate the prognostic and therapeutic aspects of different grades of spinopelvic dissociations.

## MATERIALS AND METHODS

Three adult cases of surgical fixation of fracture–dislocation (3A and 3B) of the sacrum due to traumatic injuries and submitted to lumbopelvic posterior reconstruction were retrospectively reported. A case of a 15-year-old male patient affected by Type 3C with vascular pelvic injury was also reported. A comprehensive literature search was performed on PubMed, MEDLINE, and Google Scholar databases on evaluation and management of Type 3 TSFs, and 9 papers including 63 patients were analyzed. We included only article in English and case series relative to traumatic sacral fracture Roy-Camille Type 3. Case series were analyzed to select only the very rare Type 3 Roy-Camille fractures. We analyzed only papers that reported cases classified based on the Roy-Camille classification. Article not in English, letters to the editor, and other sacral fracture types were excluded.

The characteristics of the patients included in this review as well as those concerning our four patients are summarized in Table 1.<sup>[1,3,7,9-14]</sup>

## RESULTS

### Case series

#### Case 1 (Type 3A)

A 37-year-old male was brought to our Trauma Center after a high-speed fall from a motorcycle, with an uneventful medical history. He presented with unstable hemodynamic, intubated on the scene after resuscitation, with a chest drain, floating right femur, a dislocated left shoulder, and distended abdomen. A thoraco-lumbosacral computed tomography (CT) scan revealed a Type 3 3A TSF [Figure 1a] with a vertical shear fracture of the pelvis, right femoral shaft fracture, anterior left glenohumeral dislocation with scapular fracture, hemothorax and no vascular injury was documented on abdominal CT angiogram.

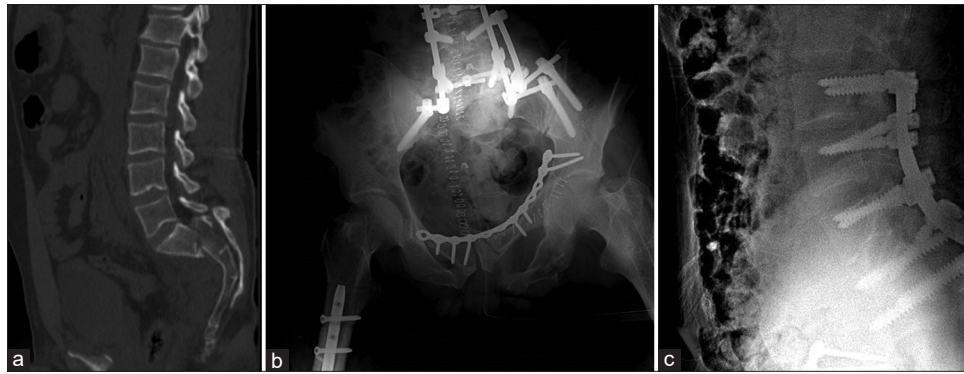
Reduction of the shoulder and external fixation of the pelvis and of the right femur with traction on the same by a distal femoral supracondylar pin with 8 kg (10% of body weight) were provided emergently and resulted in reduction of the vertical shear component of the sacral and pelvic injuries. At a later stage, posterior lumbopelvic reduction and fixation along with reduction and fixation of the pubic symphysis provided sound stability of the pelvic ring [Figure 1b and c]. Four years after trauma, the patient is ambulant without supports and has intact bowel and bladder function.

#### Case 2 (Type 3B)

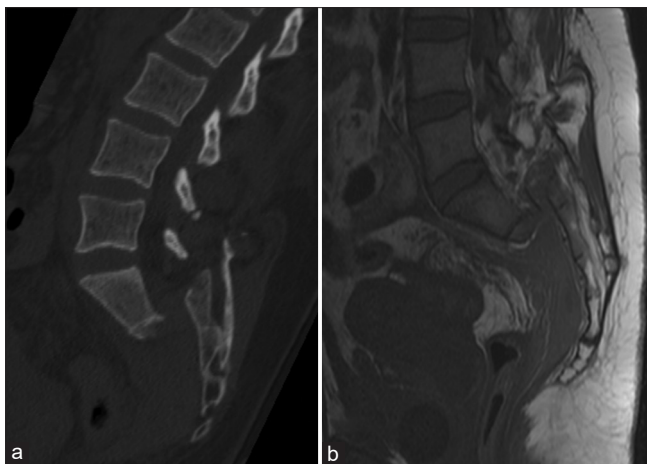
A 19-year-old female patient was referred to the emergency department of our Unit after a motorcycle accident that led to a polytrauma. She presented with a Glasgow Coma Scale score of 15/15, cauda equina syndrome, with stable hemodynamics. She was complaining of severe lumbosacral pain. Physical examination showed an incomplete cauda equine syndrome with mild motor lower-limb deficits, bilateral hyposthenia of plantar flexion, perineal hypoesthesia, S1 bilateral sensory deficits, hypoelicibility of Achilles reflexes, and rectal and bladder dysfunction.

A spine magnetic resonance imaging and a CT scan with axial, sagittal, coronal, and three-dimensional reconstruction were performed and showed an S1–S2 Roy-Camille Type 3B fracture–dislocation [Figure 2]. Lumbopelvic reduction and fixation was accomplished.

The patient presented progressive recovery, and she was discharged 4 days after surgery. Postoperative imaging studies were satisfactory, and no neurological deficits were recorded by the day she was discharged [Figure 3]. She managed to



**Figure 1:** Sagittal lumbosacral computed tomography scan showing a Type 3A transverse sacral fracture (a). Postoperative anteroposterior (b) and laterolateral (c) view of spinopelvic reconstruction with iliac screw on the right and double-rod/double iliac screw on the left-hand side



**Figure 2:** Preoperative sagittal lumbosacral computed tomography scan (a) and magnetic resonance imaging (b) showing transverse sacral fracture at S1–S2 with anterior translation (Type 3B)

walk using two crutches on the 2<sup>nd</sup> postoperative day. She had a full recovery of the sphincteric functions on postoperative day 2. One year following her injury, the wound had healed nicely, and she remained neurologically intact with good control of her bowel and bladder functions. Occasionally, she suffers from a burning sensation over the plantar surfaces of her feet, but other than that she remains asymptomatic. Radiographs are entirely satisfactory [Figure 4], and she returned to her job as a supervisor.

### Case 3 (Type 3C)

A 15-year-old male patient was referred to our Trauma Center after a fall from 10 m of height, with a history of multiple suicidal attempts, with lung contusions and hypovolemic shock due to suspected injury of the iliac arteries. The patient was hemodynamically unstable, and he was sedated and intubated and showed early development of bilateral mydriasis. A lumbosacral CT scan revealed a sacral Type 3C TSF, associated with fracture of the pelvis and acetabulum [Figure 5]. The patient died the same day, despite several invasive resuscitation maneuvers.

### Modified Roy-Camille Type 3 classification

In the literature, few modifications of the original classification are reported,<sup>[15,16]</sup> in which a Grade IV is added to define a fracture comminution of sacrum and a subtype 3A and 3B characterized by partial (A) or complete (B) anterior displacement >1 cm that present a significant prediction rate of neurological recovery following lumbopelvic fixation.<sup>[7]</sup> Since the classification of Roy-Camille presented 13 patients to define the entire classification with 3 grades, with only 3 patients affected by Type 3 fracture, and given the small series of patients with Type 3 subclassification as well as the absence of reported cases with massive anterior dislocation in literature, we reported four patients, thus creating a more detailed subclassification of Type 3 TSF with a focus on Type 3C characterized by extreme anterior dislocation and associated vascular damage. The classification proposed may help the surgeon not only for the treatment but also for the general management of the patient and for prognostic purposes. It includes also a patient who died due to massive internal bleeding caused by lesion of iliac vessels, in which no spinal surgical intervention was possible to be done. We think that in case of great anterior dislocation, more emphasis must be given to prompt vascular and/or endovascular treatment of highly possible vascular pelvic lesions as the first step. Moreover, we suggest modifying the existing subclassification 3A and 3B – which focuses on the possible surgical difficulties, required techniques, and chances of clinical recovery, and in which 1 cm dislocation is suggested as a cutoff– into a classification that focuses on the risk of life-threatening vascular injuries based on the severity of the anterior dislocation. The classification would be revised as follows:

Type 3A, partial anterior dislocation, unstable, most frequent type, reducible, good prognosis, high possibility of deficit recovery (if present) [Figure 6a].



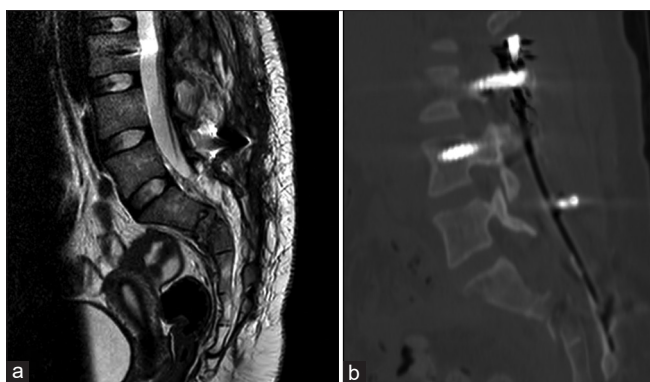


Figure 3: Postoperative sagittal lumbosacral magnetic resonance imaging (a) and computed tomography scan (b) showing satisfactory implant positioning and sagittal plane alignment

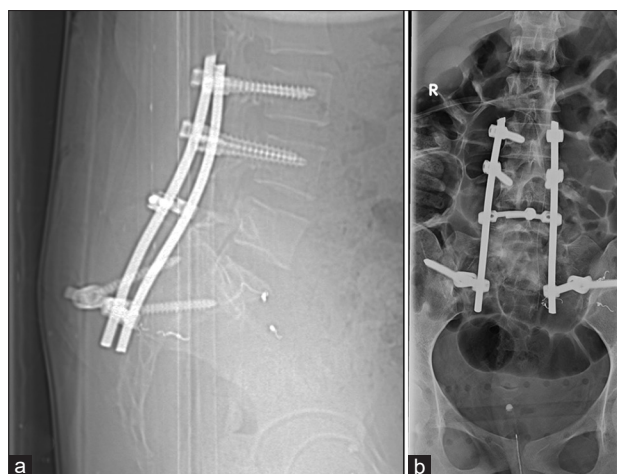


Figure 4: One-year postoperative standing radiographs showing the maintenance of correct alignment in both the lateral (a) and anteroposterior (b) projections

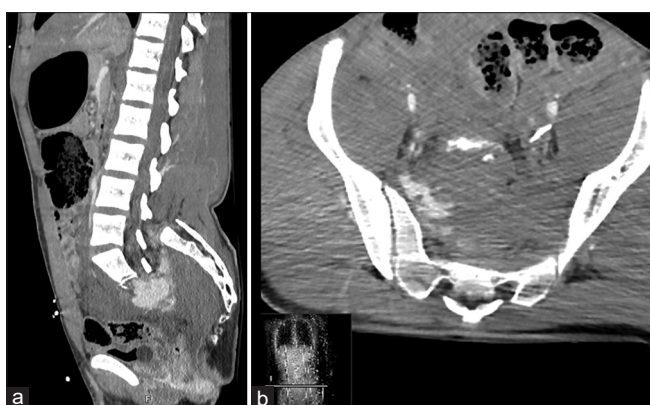


Figure 5: Sagittal (a) and axial (b) lumbosacral angio-computed tomography scan documenting a sacral Type 3C Roy-Camille fracture with spinopelvic dissociation, responsible for vascular lesions that caused massive bleeding

Type 3B, complete anterior dislocation, unstable, rare, open reduction needed, good prognosis, deficit recovery possible, possible risk of vascular injury [Figure 6b].

Type 3C, massive anterior dissociation >2 cm, unstable, very rare, open reduction needed and difficult, but rarely feasible early due to trauma severity, no deficit recovery, poor prognosis with high mortality rate due to high risk of vascular injury (with life-threatening bleeding or associated multi-organ traumatism) [Figure 6c].

### Diagnosis and treatment

A severe anterior dislocation >2 cm of the sacral fracture is detected by CT scan, so a diagnosis of Type 3C is done. We strongly recommend performing urgent CT scan with angiogram reconstruction. If vascular pelvic injury is suspected, immediate consultation of both endovascular and vascular surgeons is mandatory to decide the best treatment option. In this setting, vascular injury takes priority over spine instability. After the management of vascular lesion and if a hypovolemic shock is avoided, the patient will be evaluated by spine surgeons about the sacral fracture. We suggest

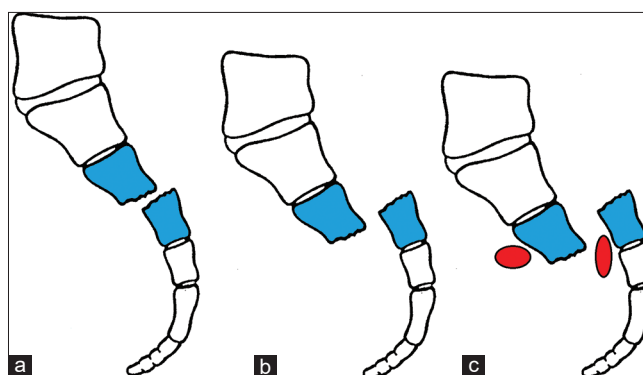


Figure 6: Modified Roy-Camille Type 3 classification: 3A partial anterior dislocation (a), 3B complete anterior dislocation <2 cm (b), 3C massive anterior dissociation >2 cm (c)

performing fracture reduction and spinopelvic fixation after alerting the vascular-endovascular team that must be ready to treat eventual sudden vessel's injury during the spine procedure.

### DISCUSSION

The severity of anterior sacral dislocation affects both the therapeutic and prognostic aspects. As a matter of fact, the greater the anterior dislocation, the greater the risk of vascular injury and neurological deficit with low chances of recovery,<sup>[7]</sup> the harder is the surgical reduction, and the higher is the risk of life-threatening internal bleeding. Therefore, we felt the need to try to identify further subtypes of Type 3 of the Roy-Camille classification likewise already reported in the literature.<sup>[7,15,16]</sup> In Type 3A, the anterior dislocation is minimal, and the reduction is feasible; neurological deficits may be present but have good chance of recovery. In Type 3B, the anterior dislocation is severe, neurological deficits are present, reduction is difficult but possible, and there is a risk of vascular injury both at the

**Table 1: Summary of the characteristics of the patients with Roy-Camille Type 3 fractures relating literature review and our case series**

Authors	Number of patients	Mechanism	Fracture type	Time to diagnosis	Neurologic deficits	Surgical treatment	Radicular involvement	Peripheral neurological recovery	Neurogenic bladder and bowel recovery
Roy-Camille et al., 1985 <sup>(1)</sup>	3	Fall (2 patients) + 1 car accident (1 patient)	3	45 days (1 patient), same day of the trauma (2 patients)	1: L5 incomplete, 2: L4-S1 perineal, 3: L5-S1 left	1 bone block resection, 2 Harrington, 3 1 reduction+plates L 2 laminectomy	1 R: S1-S2 torn 2 R: S2-S3-S4 torn L stretched, 3 L5 compression S1 torn	1 + ; 2 and 3 not reported	1 0; 2 and 3 not reported
Taguchi et al., 1999 <sup>(9)</sup>	3	Fall	3	Not reported	Sensory, motor, bladder deficits	Reduction and fixation with plates	Not specified for fracture subtype	Not specified for fracture subtype	Not specified for fracture subtype
Nork et al., 2001 <sup>(10)</sup>	4	Not specified for fracture subtype	3	24 h	Not specified for fracture subtype	Percutaneous iliosacral screw fixation	Not specified for fracture subtype	Not specified for fracture subtype	Not specified for fracture subtype
Lindahl et al., 2014 <sup>(7)</sup>	21	Not specified for fracture subtype	3 (A, B)	8 days	Not specified for fracture subtype	Anterior pelvic ring fixation followed by segmental lumbopelvic fixation or lumbopelvic fixation alone, but not specified for fracture's subtype	Not reported	Not specified for fracture subtype	Not specified for fracture subtype
Schildhauer et al., 2006 <sup>(8)</sup>	6	Fall (3 patients) and accident (3 patients)	3	Same day of the accident	All patients presented loss of anal sphincter tone; 3 patients presented complete sacral root deficits whereas 3 patients had incomplete cauda equina dysfunction	Lumbopelvic fixation	Not specified for fracture subtype	Not specified for fracture subtype	83% bowel and bladder recovery, but not specified for fracture subtype
Starantzis et al., 2014 <sup>(11)</sup>	1	Car accident	3	Same day of the accident	None	Lumbar-iliac fixation	None	Not reported	Not reported
Matar et al., 2016 <sup>(12)</sup>	1	Osteoporosis	3	4 weeks	Sensory deficit L5-S4, motor deficit L5-S1 and diminished S1 reflex	Conservative	-	-	-
Nonne et al., 2018 <sup>(13)</sup>	2	Fall, car accident	3	1: 17 days to treatment 2: 12 days to treatment	Cauda equina syndrome and bilateral radicular L5-S1 deficit	1 lumbar-iliac fixation, 2 lumbar-iliac fixation and ilium-sacral	Not reported	0	0
He et al., 2019 <sup>(14)</sup>	18	Not specified for fracture subtype	3 (A, B)	Not reported	Not specified for fracture subtype	Less invasive lumbopelvic fixation was conducted in patients with a displacement <1 cm and no neurological symptoms, whereas patients with noticeably displaced fractures underwent open reduction and decompression	Not specified for fracture subtype	Not specified for fracture subtype	Not specified for Fracture subtype
Our case series	4	1 car accident	3A	Same day of the accident	Lower extremity motor deficit; incomplete bowel/bladder dysfunction	Posterior lumbopelvic reduction and fixation along with reduction and fixation of the pubic symphysis provided sound stability of the pelvic ring	Bilateral S1-S2 compression	Full recovery	Full recovery

Contd...

Table 1: Contd...

Authors	Number of patients	Mechanism	Fracture type	Time to diagnosis	Neurologic deficits	Surgical treatment	Radicular involvement	Peripheral neurological recovery	Neurogenic bladder and bowel recovery
	1	car accident	3B	Same day of the accident	Incomplete cauda equine syndrome with mild motor lower-limb deficits, bilateral hyposthenia of plantar flexion, perineal hypoesthesia, S1 bilateral sensory deficits, hypoelectricity of Achilles reflexes, rectal and bladder dysfunction	Lumbopelvic reduction and fixation	Bilateral S2-S3-S4 torn and stretched, right S1 compression	Full recovery	Full recovery
	1	suicidal attempt	3B	Same day of the accident	Right lower limbs generalized strength deficit	Lumbopelvic reconstruction	Right S1 stretched and compressed	Full recovery	Full recovery
	1	fall	3C	Same day of the trauma	Coma GCS 3/15	Not feasible due the hemodynamic instability and death the same day	.	.	.

GCS - Glasgow Coma Scale

moment of trauma and during the surgical reduction, but it can be faced with multidisciplinary collaboration with endovascular radiologists and vascular surgeons. In Type 3C, the anterior dislocation is massive, and the risk of vascular injury is very high and is the first element of concern. Moreover, patients are more likely to present severe multi-organ traumatism. In our series, the patients affected by Type 3A and 3B fracture fully recovered, while the patient affected by Type 3C (a 15-year-old male) fracture died the same day due to massive internal bleeding.

The treatment of Type 3 TSFs remains challenging in both reduction and fixation. Traditionally, these fractures have been addressed using different surgical procedures and techniques.<sup>[1,2,15-17]</sup>

In the literature, Type 3 Roy-Camille classification is mentioned, but there are only a few references to the grade of anterior dislocation.<sup>[7,15-17]</sup> According to Lindahl *et al.*,<sup>[7]</sup> the greater the dislocation, the worse the neurological recovery.

Since Type 3 fractures are almost always associated with neurological deficits, the most performed procedure is an extensive laminectomy for decompression.<sup>[2,3,18]</sup> Although transected or avulsed nerve roots cannot recover, the goal of surgery is to achieve decompression, allowing potentially viable nerve roots to recover.<sup>[1]</sup> Vaccaro *et al.*<sup>[8]</sup> stated that, if there was full bilateral neurologic damage or radicular avulsion, chances of healing are low. Indirect closed reduction is almost impossible in Type 3 injuries because of the fracture overlapping.<sup>[19]</sup> In terms of stabilization, various tools have been used, including plating,<sup>[16]</sup> Harrington rods,<sup>[2,16]</sup> Luque wiring,<sup>[17]</sup> lumbosacral pedicle screws,<sup>[6]</sup> and lumbopelvic constructs. Surgical recommendations and the timing of decompression are still questionable. The literature suggests that spinopelvic fixation represents the best surgical treatment of these lesions. In 1994, Käch and Trentz<sup>[20]</sup> first proposed an open-surgery approach to reduce and stabilize the lumbar spine and pelvis, with pedicle and ilium-sacrum screws (or posterior transiliac plates), which are linked with bars or cross-linked. This technique allows for the equal distribution of forces to the acetabulum and lumbar spine, leaving out the fracture area, and permits the early mobilization of the patient.<sup>[16]</sup> Better results regarding neurologic healing can be achieved only if the treatment is performed within 24–72 h. However, in polytraumatized patients, the concurrent severe systemic inflammatory response does not always allow the performance of early surgery.<sup>[8,16]</sup> Yi and Hak<sup>[16]</sup> stated that late decompression could be hard, because of fibrous scar tissue, and it could worsen the neurological deficits. Schildhauer *et al.*<sup>[3]</sup> published the only study on patients

treated with a specific stabilization method: the lumbopelvic stabilization. Moreover, Schildhauer *et al.*<sup>[3]</sup> and Yi and Hak<sup>[16]</sup> demonstrated an improvement of the neurologic deficit in 80% of surgically treated patients, unrelated to the kind of treatment. In 86% of patients with radicular compression, a partial recovery of sphincter function was appreciated after surgery with decompression and lumbopelvic fixation; in the case of complete lesion or radicular avulsion, only 36% of patients showed partial healing.<sup>[16]</sup> Schildhauer *et al.*<sup>[3]</sup> also reported deep infection in 16% of patients, which developed into chronic osteomyelitis in 47% of cases. Symptomatic breakage of implants without loss of reduction and stability was reported in 33% of cases.<sup>[3]</sup>

In order to control such inherent instability of the fracture even in the absence of any neurological deficits, surgical treatment is to be considered. Further justification for reducing the anterior translation is the restoration of normal biomechanics, to reduce the risk of nonunion and hopefully the resulting chronic pain, as well as to prevent skin breakdown due to the tethering and dimpling of the skin as a result of severe anterior translation. This procedure carries the standard risks of a common lumbopelvic posterior instrumentation. Intraoperative neuromonitoring is a well-established methodology for the early detection of neurological deficits resulting from the surgical intervention; it can be performed with high sensitivity and specificity but with certain limitations, which are beyond the scope of this paper.<sup>[6,20]</sup> In our experience, the structures at risk, mainly during the reduction maneuver, included the L4 to S4 nerve roots. *In situ* stabilization without full restoration of sagittal alignment is the solution in cases in which neuromonitoring remains problematic. Nevertheless, S2–S4 nerve roots are difficult, if not impossible, to assess even with aggressive neuromonitoring methods.

## CONCLUSIONS

In our experience, we confirm that open reduction and posterior instrumentation of Type 3 high TSF-dislocations is a technically feasible, although demanding, procedure with specific indications and limitations. Our proposal of a modified Roy-Camille classification could be useful in the assessment of prognostic and therapeutic aspects of such fractures, in which dislocation grade, related to the impact injury, influence the surgical technique, recovery rate and patient's life expectancy.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other

clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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