Minimally invasive triangular lumboiliac and iliosacral fixation of posterior pelvic ring injuries with vertical instability: Technical note

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To date, no strong consensus exists on the best way to treat posterior pelvic ring injuries when there is no neurological deficit. Various fixation methods have been described; more recently, constructs that combine lumboiliac and iliosacral fixation have been introduced. This type of fixation is mainly indicated in cases of spinopelvic dissociation with large displacement of fracture fragments in the sagittal plane. However, these techniques are associated with postoperative complications, particularly infections and severe skin complications. This led us to propose a minimally invasive lumboiliac and iliosacral fixation technique for posterior pelvic ring injuries. The procedure is done with the patient prone. It consists of pedicle screw insertion into L4 or L5 and screw fixation of the ilium with fluoroscopy guidance; intra- operative distraction can be done depending on the amount of displacement. An iliosacral screw is then inserted percutaneously to allow reduction in the transverse plane and yield a triangular construct. In the five patients that we have operated using this technique, the mean preoperative vertical displacement was 11.9 ± 6.9 mm (SD) (min 1.3, max 19.7) versus 3.7 ± 3.2 mm (min 0.3, max 6.7) postoperatively and the mean preoperative frontal displacement was 7.5 ± 3.7 mm (min 4.2, max 12.4) versus 2.5 ± 2.0 mm (min 0.3, max 4.3) postoperatively. Minimally invasive iliosacral and lumboiliac fixation is an option for treating posterior pelvic ring fractures free of neurological deficit and especially spinopelvic dissociation.

1. Introduction

Posterior pelvic ring injuries are rare lesions that mainly occur due to high-energy trauma in younger adults [1] or because of a fall in older adults with osteoporosis. These injuries are often associated with other fractures or internal organ damage that can be life threatening [2]. These fractures have been extensively described in the literature; however, there is no consensus as to how to best treat them when no neurological deficit is present.

Pelvic fractures can be classified as outlined by Tile [3] to capture the instability caused by the fracture; however posterior pelvic ring injuries also combine U and H fractures of the sacrum along with sacroiliac dislocation. H fractures of the sacrum have been described and classified by Roy-Camille et al. [4] and Denis et al. [5]. They are defined by the combination of a transverse perpendicular fracture line in the sacral canal and two vertical fracture lines through the sacral alae. These fractures can create a spinopelvic dissociation and generally lead to kyphosis. These posterior injuries can occur simultaneously with anterior injuries such as fracture of the obturator ring or pubic separation, which increases the fracture's instability vertically and rotationally.

Historically, these lesions have been treated conservatively [6], in part due to the lack of appropriate fixation tools and in part because of the difficulty with approaching the fracture site and its increased risk of infection [7]. However, better surgical techniques and the increasingly frequent diagnosis of these lesions thanks to CT scans being done routinely in polytrauma patients [8] has led to the development of several surgical techniques: percutaneous iliosacral screw fixation [9], plate fixation or transiliac or transacral bar fixation [10–12] and more recently, constructs that combine lumboiliac and iliosacral fixation [13–15]. The latter fixation methods are mainly indicated for spinopelvic dissociation since they provide a reduction in all three planes and better restore the original pelvic incidence and acetabular orientation. This technique, which was described by Schildhauer et al. [16,17], produces good radiographic results but the skin complication rate is 3% to 13% and the postoperative infection rate is 5% to 10%.

The development of minimally invasive techniques combining iliosacral screw fixation and a hybrid lumboiliac construct may be relevant for Tile type C, B, A3.3 [3], Roy Camille type 1, 2 and 3 [4] and Denis type 1, 2, 3 [5] fractures. The aim of the surgery is to restore the balance between pelvic incidence and lumbar parameters by reducing the sacral kyphosis and the vertical and/or rotational displacement of the fractured hemi-pelvis, and to make the orientation of the two acetabula symmetric to prevent gait disturbances and improve the long-term clinical outcomes. The aim of this study was to present a lumboiliac and iliosacral fixation technique that produces a minimally invasive triangular construct for posterior pelvic ring injuries.

2. Surgical technique

Before the surgery, it is crucial to detect any internal organ injuries. Under general anesthesia, patients are positioned prone on a carbon radiotransparent table with chest and iliac rolls. Once the patient is in position, a preoperative fluoroscopy scan is done to locate the pedicles of the L4, L5 and S1 vertebrae on AP and lateral views, the superior endplate of S1 on AP view by tilting the unit along the patient's pelvic incidence (inlet view described by Pennal et al. [18]) and the body of the sacrum in an AP view to identify the sacral holes (outlet view).

The first step consists of conventional percutaneous pedicle screw fixation at one or two levels, typically L4 and/or L5. Determining which vertebra to instrument mainly depends on the degree of lumbar lordosis once the patient is positioned on the table, to make it easier to pass the rod percutaneously. The screw(s) is(are) inserted using the conventional technique (ES2, Stryker, Kalamazoo, Michigan, USA).

For the second step, a small (2 cm) incision is made over the posterior iliac crest; the aponeurosis is opened longitudinally, the posterosuperior iliac spine is resected with rongeurs, then an iliac screw (PassLP, Medicrea, Rieux-la-pape, France) is inserted with fluoroscopy guidance. The fixation is unilateral or bilateral, depending on the type of fracture.

A 6-mm diameter rod precurved into lordosis is then slipped between the lumbar and iliac screw percutaneously. The first locking is done on the lumbar pedicle screws, with in situ percutaneous distraction for Tile type C or B3 fractures with more than 1 cm elevation of the hemi-pelvis on preoperative CT scan or in cases of fracture-induced sacral kyphosis (Roy Camille type > 2); traction is applied intraoperatively on the lower limb by a circulating (nonsterile) surgical assistant. The iliac screws are then locked to the rod after distraction to reduce the hemipelvis under fluoroscopy guidance (Fig. 1).

Closure is done layer by layer by covering the head of the iliac screw with fascia to prevent discomfort related to protuberance of the screw head as best possible.

The final surgical step is done in the same position while focusing on the lateral projection of the S1 body located by fluoroscopy. A skin incision about 1 cm long is made. A 2.8-cm diameter guide wire is inserted with fluoroscopy guidance into the S1 vertebral body as described by Ruatti et al. [9]. This screw must go beyond the sacral fracture line and reach the center of the sacrum's body. A 7.3-mm diameter, short thread cannulated screw with washer (DePuy Synthes, New Brunswick, New Jersey, USA) is inserted next to compress the transverse fracture of the sacrum ala (Figs. 2–4).

Preoperative detection of lumbosacral dysplasia is done routinely as stated by Tonetti et al. [19]. In fact, iliosacral screw fixation can only be considered below the final mobile disc.

Postoperatively, partial weight bearing at 30% for 6 weeks is allowed immediately if there are no other injuries, especially in the lower limbs. Unrestricted hip and trunk motion is done as pain allows. A CT scan is always taken immediately postoperative to ensure the implants are in the correct position and the reduction is good in all three planes. The fixation hardware is removed after 1-year postoperative once fracture union has been confirmed on another CT scan.

Fig. 1. Insertion of the 6-mm diameter curved rod from the lumbar screw towards the iliac screw.

Along with the complications inherent to this type of fracture, various complications can occur intra- and postoperatively: incorrect screw position, failure of instrumentation due to rod breakage or screw pullout, early or late infections, mainly over the head of the iliac screw. The possibility of these complications must be explored at each follow-up visit.

3. Results

Our initial, retrospective, single-center cohort (6 months minimum follow-up) consisted of 5 patients who received a minimally invasive triangular construct for a posterior pelvic ring injury. The characteristics of the cohort are summarized in Table 1. All the associated lesions were treated either at the same time or during a subsequent surgery.

The mean preoperative displacement in the frontal plane was 7.5 ±3.7 mm (±SD) (min 4.2, max 12.4) and in the vertical plane it was 11.9 ±6.9 mm (min 1.3, max 19.7) (Table 2). No patients had postoperative infectious or neurological complications. One patient had urinary bladder overdistension upon removal of his urinary catheter that required implantation of a urethral catheter. The mean postoperative frontal displacement was 2.6 ± 2 mm (min 0.3, max 4.3) and the mean vertical displacement was 3.7 ± 3.2 mm (min 0.3, max 6.7) (Table 2).

4. Discussion

There is no consensus about how to treat posterior pelvic ring injuries without neurological deficit. Analysis of the fracture using the typical classification systems (Tile, Roy-Camille or Denis) helps to guide which reduction-fixation technique to use. Based on the literature review by Yi and Hak [20], the functional prognosis after spinopelvic dissociation is related to the success of the fracture reduction. This reduction must be done as early as possible since the large hematoma that accompanies this type of fracture induces rapid bone union, making it difficult to reduce later on [9].

Isolated iliosacral screw fixation provides reduction in the transverse plane and compresses a vertical fracture of the sacral ala but does not provide distraction in the vertical plane in case of elevation or rotation of the hemi-pelvis. Doing the initial lumboiliac fixation

Fig. 2. Posterior pelvic injury with elevation of the right hemi-pelvis (Tile C); preoperative CT scan (above) and postoperative radiographs showing the minimally invasive lumboiliac and iliosacral fixation (below).

Fig. 3. Posterior pelvic injury with superior S1 fracture on the left side (Tile C); preoperative CT scan (above) and postoperative radiographs showing the minimally invasive lumboiliac and iliosacral fixation (below).

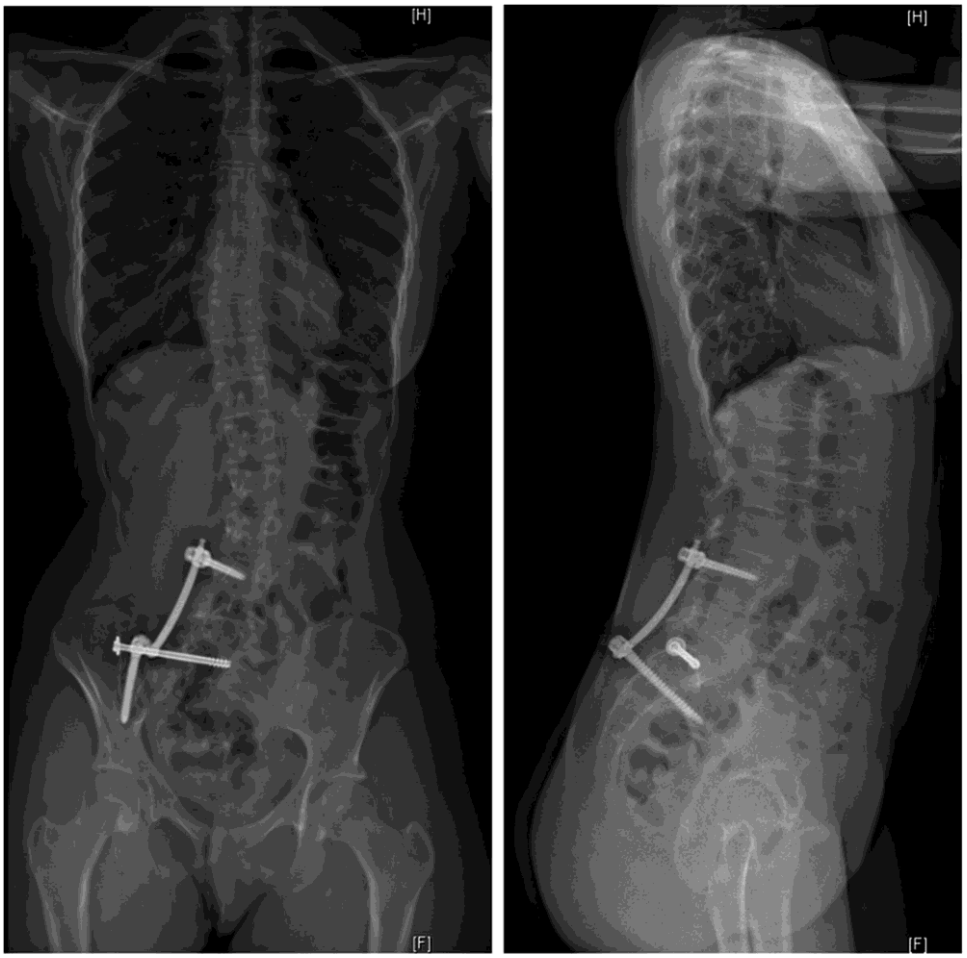

Fig. 4. Postoperative stereoradiographs (AP, lateral views) showing the triangular construct.

Table 1
Demographic data.

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Mean	SD
Age	27	35	18	50	25	31	12.3
Sex	W	W	W	M	W		
Other injuries	L1 type C fracture L both-column fracture of the acetabulum, L pneumothorax	None	R anterior column of acetabulum	Rupture of fibrous capsule of testis, pubic separation	T11 fracture		
Trauma	Defenestration	MVA	MVA	MVA	Defenestration		
Construct	Unilateral L	Unilateral R	Unilateral R	Unilateral L	Unilateral R		
Classification Tile [3]	C	C	C	C	C		
Roy Camille et al. [4]	Type 1 zone 2	Type 2 zone 2	Type 1 zone 1	Type 2 zone 2	Type 1 zone 2		
Denis et al. [5]	2	2	1	2	2		
Time to surgery (days)	9	2	3	7	2	4.6	3.2
Operative time (min)	140	175	120	140	110	139	22.5

SD: standard deviation; W: woman; M: man, MVA: motor vehicle accident; L: left, R: right.

Table 2
Pre- and postoperative radiological data.

	Preoperative		Postoperative	
	Displacement frontal (mm)	Displacement vertical (mm)	Displacement frontal (mm)	Displacement vertical (mm)
Patient 1	10.3	19.7	−1.2	6.7
Patient 2	4.6	1.3	−4.2	0.3
Patient 3	4.2	9.3	−4.3	6.2
Patient 4	5.8	14.3	0.3	0.3
Patient 5	12.4	14.9	−3.4	5.2
Mean	7.5	11.9	−2.6	3.74
SD	3.7	6.9	2	3.2

SD: standard deviation.

provides vertical reduction and stabilizes the fracture in the various planes, allowing early return to weightbearing.

Reduction using solely closed maneuvers in traction as described by Ruatti et al. [9] in their article on iliosacral screw fixation does not always provide satisfactory reduction, especially in overweight patients or in cases of kyphotic sacrum fracture. Reduction in the vertical plane is particularly important functionally. In fact, in case of hemipelvis elevation or elevation–rotation, asymmetry in acetabular orientation or indirect leg length difference are not particularly well tolerated functionally. Also, in case of unilateral or bilateral involvement of the L5-S1 joints, lumboiliac fixation helps to prevent destabilization of the lumbosacral hinge upon weightbearing. Furthermore, in case of spinopelvic dissociation, like in the cases of H-fractures of the sacrum, sacral kyphosis induces an alteration to the patient's native pelvic incidence, which has long-term consequences on the sagittal balance and may be the cause of early aging of the last mobile disc. Reduction of this fracture kyphosis must be one of the goals of the surgical treatment [17,21].

One of the drawbacks of traditional open lumboiliac fixation is the 16% rate of surgical site infections [22]. A minimally invasive approach can theoretically help to reduce the infection rate due to cutaneous, muscular and blood sparing, but also because of a reduction in the average operating time [23–25]. These parameters are particularly relevant for the treatment of polytrauma patients who may be hemodynamically unstable but also for the treatment of more fragile older patients [13,14,26,27]. Thus a transverse construct was proposed by Tempelaere et al. [28] and Okuda et al. [22], combining an L5 pedicle hold to create a crab-shaped lumboiliac construct. Shah et al. [29] recently described a minimally invasive lumboiliac fixation with distal fixation at S2. Our technique resembles theirs but with fixation in the posterior wing of the ilium. This allows us to extend the indications to Tile C fractures, Denis zone 1 fractures and sacroiliac dislocation for which S2 fixation is not possible or not needed.

The approach that we describe here appears to be adapted to the treatment of injuries without neurological deficit. Like in spinal trauma, this minimally invasive technique can be done early in the management of polytrauma patients [30]. In our experience, removing the instrumentation is possible once bone union is confirmed on CT scan. In fact, the instrumentation can cause discomfort because of the thin muscle layer covering the implants, especially the head of the iliac screw and because of the long-term risk of implant fracture since no bone graft is used.

However, our study is limited by the short follow-up and small number of patients reviewed. A longer follow-up of more patients is needed to confirm our results.

5. Conclusion

Minimally invasive iliosacral and lumboiliac fixation is an option for treating posterior pelvic ring injuries free of neurological deficit and especially spinopelvic dissociation. Beyond the theoretical advantages of a minimally invasive approach, this type of triangular fixation provides good reduction and stabilization of the fracture zones that are subjected to high loads when weightbearing resumes.

Disclosure of interest

Conflicts of interest related to this study: J. Tonetti and B. Blondel are Associate Editors of Orthopaedics & Traumatology: Surgery & Research. Conflicts of interest not related to this study: B Blondel: Consultant for Medicrea, Vexim-Stryker, Implanet, 3M. S. Prost: Travel paid by Zimmer Biomet and Stryker M. Boudissa: Consultant for Surgivisio. S. Fuentes: Consultant for Medicrea, Medtronic, Stryker. J. Tonetti: Consultant for Surgivisio and SpineArt. P. Tropiano: Consultant for LDR-Zimmer, DePuy-Synthes, France Rachis.

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