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Tile Type C Pelvic Fractures: Initial Management, Surgery and Rehabilitation Results of 12 Cases with Literature Review

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ABSTRACT

We report the results of 12 patients followed for Tile type C pelvic fractures treated with percutaneous sacroiliac screwing combined to anterior ring reduction and fixation provided by plate or external fixator during the last 4 years. this study was carried out in the light of literature review to focus on the therapeutic principles of the initial management, the different surgical techniques described for the definitive treatment of bone lesions, the current attitude regarding the rehabilitation of patients and the perspectives under development.

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Introduction

Unstable pelvic ring disruptions result from high-energy trauma and are often associated with multiple concomitant injuries responsible for high mortality rates [1-6]. The immediate goals of treatment include Advanced Trauma Life Support (ATLS) and temporary stabilization of the pelvic ring [7-10]. Biomechanical studies have shown that the best stability in unstable pelvic ring fractures can be achieved by reduction and fixation of both anterior and posterior pelvic ring structures [11,12]. For this, several techniques are available and the choice of the most appropriate fixation technique remains a challenging problem for almost all surgeons [13]. We report through this article, our experience and functional outcomes of 12 patients with Tile type C pelvic ring injuries who had been treated with percutaneous sacroiliac (SI) screwing combined to anterior ring reduction and fixation provided by plate or definitive external fixator during the last 4 years from January 2017 to December 2020.

Materials and Methods

Between January 2017 and Decembre 2020, 12 patients with Tile type C injuries of the pelvic ring were treated with percutaneous iliosacral screws combined to anterior ring reduction and fixation provided by plate or definitive external fixator. In all patients, the pelvis was evaluated on preoperative radiography (Figure 1) (including anteroposterior, inlet, and outlet views) and Computed tomography (CT) (Figure 2). The imaging fracture were classifed using the Tile's classification system (Figure 3) [12]. All displaced posterior pelvic ring injuries including sacral fracture, dislocation or fracture dislocation of the sacroiliac joint (SIJ) and fracture of the ilium were regarded for operatively treatment. Displaced fractures of the pubic rami, total disruption of the symphysis pubis and concomitant displaced acetabular fracture were also treated surgically. Postoperatively, rehabilitation of patients was started in the intensive care unit after stabilization of the general condition. It was based on ideomotor, resistance and weight training exercises in addition of electrical neurostimulation. The mean follow-up in our series was 24 (12–40) months. We measured the functional outcome using the Short Form-36 Physical Component Summary (SF-36 PCS) (Figure 4) [14].

Figure 1: Anteroposterior X ray View Showing Tile C1 Type Fracture

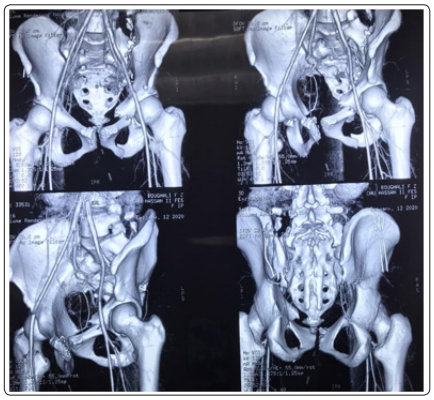


Figure 2: Coronal Pelvic Computed Tomography in 3D Reconstruction of Tile C1 Type Fracture

Figure 3: Tile Classification of pelvic ring fractures

Type A : Pelvic ring stable

A1 : fractures not involving the ring (avulsions, iliac wing or crest fractures)

A2 : stable minimally displaced fractures of the pelvic ring

Type B : Pelvic ring ratationally unstable and vertically stable

B1 : open book

B2 : lateral compression (ipsilateral)

B3 : lateral compression (contralateral or bucket handle type injury)

Type C : pelvic ring rotationally and vertically unstable

C1 : unilateral

C2 : bilateral

C3 associated with acetabular fracture

Figure 4: the Short Form-36 Physical Component Summary (SF-36 PCS) [94]

GENERAL HEALTH:

In general, would you say your health is:

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

Compared to one year ago, how would you rate your health in general now?

☐ Much better now than one year ago ☐ Somewhat better now than one year ago
☐ About the same ☐ Somewhat worse now than one year ago ☐ Much worse than one year ago

LIMITATIONS OF ACTIVITIES:

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.

Yes, Limited a lot Yes, Limited a Little No, Not Limited at all

Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf

☐ Yes, Limited a Lot ☐ Yes, Limited a Little ☐ No, Not Limited at all

Lifting or carrying groceries

☐ Yes, Limited a Lot ☐ Yes, Limited a Little ☐ No, Not Limited at all

Climbing several flights of stairs

☐ Yes, Limited a Lot ☐ Yes, Limited a Little ☐ No, Not Limited at all

Climbing one flight of stairs

☐ Yes, Limited a Lot ☐ Yes, Limited a Little ☐ No, Not Limited at all

Bending, kneeling, or stooping

EMOTIONAL HEALTH PROBLEMS:

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

Cut down the amount of time you spent on work or other activities ☐ Yes ☐ No

Accomplished less than you would like ☐ Yes ☐ No

Didn't do work or other activities as carefully asusual ☐ Yes ☐ No

SOCIAL ACTIVITIES:

Emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

☐ Not at all ☐ Slightly ☐ Moderately ☐ Severe ☐ Very Severe

PAIN:

How much bodily pain have you had during the past 4 weeks?

☐ Not at all ☐ Slightly ☐ Moderately ☐ Severe ☐ Very Severe

During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and house work)?

☐ Not at all ☐ Slightly ☐ Moderately ☐ Severe ☐ Very Severe

ENERGY AND EMOTIONS:

These questions are about how you feel and how things have been with you during the last 4 weeks. For each question, please give the answer that comes closest to the way you have been feeling.

Did you feel full of pep?

☐ All of the time ☐ Most of the time ☐ A good Bit of the Time ☐ Some of the time ☐ A little bit of the time ☐ None of the Time

SOCIAL ACTIVITIES:

During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

☐ All of the time ☐ Most of the time ☐ A good Bit of the Time ☐ Some of the time ☐ A little bit of the time ☐ None of the Time

GENERAL HEALTH:

How true or false is each of the following statements for you?

I seem to get sick a little easier than other people

☐ Definitely true ☐ Mostly true ☐ Don't know ☐ Mostly false ☐ Definitely false

I am as healthy as anybody I know

☐ Definitely true ☐ Mostly true ☐ Don't know ☐ Mostly false ☐ Definitely false

I expect my health to get worse

☐ Definitely true ☐ Mostly true ☐ Don't know ☐ Mostly false ☐ Definitely false

My health is excellent

☐ Definitely true ☐ Mostly true ☐ Don't know ☐ Mostly false ☐ Definitely false

Results

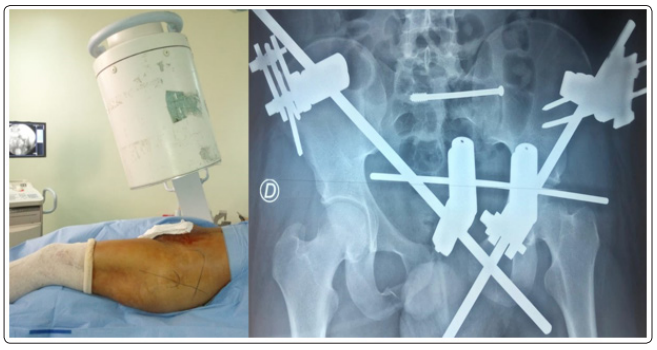
The mean age of patients was 36.3 (range : 19–58 years). All of them were males. All injuries resulted from high-speed road accidents. In this study we included Tile type C fractures. There were 9 type C1 and 3 type C2. Associated injuries were present in all patients : 2 pneumothoraces, 6 soft tissue injuries (4 open pelvic fractures and 2 Morel-Lavalle lesions [15]), associated fractures in 7 patients (1 distal radial fracture, 2 tibial fractures, 2 elbow fractures/dislocations and 2 thoracic vertebrae stable fractures) and bladder rupture in 2 cases with urethra rupture in one patient. In our series, we did not note any associated lumbosacral plexus injury. The mean Injury Severity Score (ISS) was 29 (range : 10–56) (Figure 5) [16].

Figure 5: Injury Severity Score (ISS) : Calculate Abbreviated Injury Scale (AIS) for most severely injured body part in each region. ISS is calculated as a sum of square of AIS for the most 3 injured body regions. Maximum score is 75. If any bady region is assigned a 6, the overall ISS is automatically 75.

Regions	Abbreviated Injury Scale (AIS)	AIS meaning
Head, neck and C-spine	1	Minor
Face including nose, mouth, eyes, ears	2	Moderate
Thorax, thoracic spine, diaphragm	3	Serious
Abdomen and lumbar spine	4	Severe
Extremities including pelvis	5	Critical
External soft tissue injury	6	Maximal (untreatable)

All patients were treated surgically once they were hemodynamically stable with defenitive fixation in 7.4 days on average after admission (range : 3–16 days). Posterior and anterior fixations were done in all patients who were operated by the same senior surgeon. Percutaneous SI screwing was chosen for posterior ring fxation. On the anterior side, we used external fixator in 8 patients (Figure 6) and pelvic plates in 4 cases. The mean follow-up of the 12 patients was 2 years (range : 12-40 months). Using the Short Form-36 Physical Component Summary, the average physical and mental component scores were respectively 68.3 and 70. One of 12 patients had to change his job after trauma but was still professionally active.

Figure 6: patient installation, surgical landmarks and post-operative radiograph of a left percutaneous sacroiliac screwing associated to anterior external fixation



Discussion

The rate of pelvic fractures in cases of polytrauma ranges from 20% to 52% [17,18]. In the same context, severe multisystem injuries varies from 35% to 70% [6,19]. During the first hours after the injury, the life saving actions shall dominate [20,21]. After stabilizing the vital functions, the pelvic ring injury shall be treated using the most appropriate approach [22,23].

The two most commonly used classification systems for pelvic ring injuries are those described by Young–Burgess and Tile [5,24]. These classifications make it possible to distinguish stable fractures from unstable ones in order to guide the therapeutic strategy. Based on the Tile classification, vertical Shear (VS) fractures that are resulting from a complete disruption of both anterior and posterior ring and whose incidence varies from 5.6 to 20.5% of pelvic ring fracture (PRF), are categorized as Type C and characterized by rotational and vertical instability [5,6,25].

Anatomic and radiologic studies describe the pelvic anterior ring injury when it sits in the pubic symphysis, the superior and inferior pubic ramus, or through the acetabulum. Posteriorly, variants include sacral and iliac fractures in addition to sacroiliac joint (SIJ) disruption which are intimately associated with the internal iliac vessels and lumbosacral plexus. The instability of these associated anterior and posterior ring injuries makes stabilization and definitive treatment a real challenge [26,27].

In practice, classification of VS injuries is based first on standard anteroposterior (AP), inlet and outlet pelvis radiographs. This radiological views which are a static images, inform about a dynamic process responsible at the time of impact of more severe injury and deformity. It is in this context, that Computed tomography (CT) is of crucial importance for a better lesionnal characterization espacially for posterior injuries. It is also essential to preoperative planning of definitive reduction and fixation [26,28-30].

Taking into account varying results in the inter-observer agreement in pelvic radiograph interpretations reported by numerous studies, we systematically realizing in our daily practice the CT to improve lesion classification[31,32].

The Tile type C fractures were more commonly associated with high-energy mechanisms [33]. Several authors associated VS fractures with closed head injuries, pneumothorax, retroperitoneal haematoma, bowel, urological, vascular and lumbosacral plexus injury. Open pelvic fractures constitute one of the most devastating injuries in musculoskeletal trauma. Their rate ranges from 3.6% to 4.2% with an associated mortality rate of 42% to 50% according to several authors [1,5,34-38].

Several classifcations of open pelvic fractures exist, especially that of Faringer et al. [39] taking into consideration the localization of the wounds, and that of Jones et al. [40] based on the pelvic ring stability, perineal and rectal injury.

The Morel-Lavallée lesions (MLL) can be expected in 2 to 12% after pelvic ring injuries. In a systematic review of 204 MLL, the main locations were the greater trochanteric area in 30.4%, the thigh in 20.1% and the pelvis in 18.6% [41-43]. Early diagnosed (<2 days), MLL can suffciently be treated using a percutaneous approach to evacuate hematoma with accompanying fracture stabilization. Open debridement of all necrotic material, injection of sclerosing agents and dead space closure are proposed for lesions diagnosed after 2 days [15,42,44].

In our series, associated injuries were present in all patients. We report in this context 2 pneumothoraces, 6 soft tissue injuries, 7 associated limb and thoracic vertebrae fractures, 2 cases of bladder rupture with urethra rupture in one patient. We have no cases of associated lumbosacral plexus injury.

The immediate goals of treatment include Advanced Trauma Life Support (ATLS) and temporary stabilization of the pelvic ring (Figure 7) [36,45]. To achieve haemodynamic stability in patients with unstable pelvic ring injuries, angioembolization (AE) and preperitoneal pelvic packing (PPP) are the two modalities that are frequently employed [46]. In the same context, some authors propose the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) to increase systolic blood pressure [47]. To contribute to haemostasis by reducing pelvic volume, the choice can be made between sheet, pelvic binder, C-clamps and supra-acetabular external fixation which act by a tamponade effect [48-50].

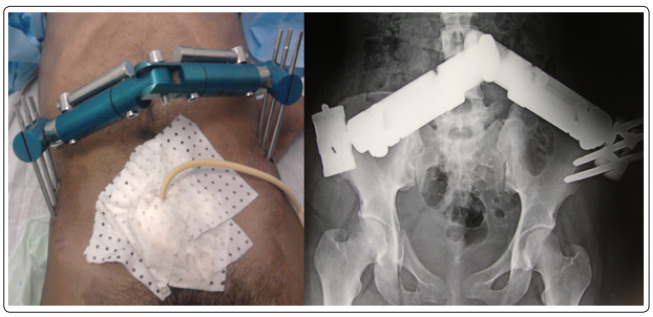


Figure 7: temporary stabilization of the pelvic ring using supra-acetabular external fixator in patient with hemodynamic instability and perineal laceration

In our team, we are used to systematically placing for Tile type C fractures a temporary anterior external fixator. This rapid and safe attitude allowed us to achieve haemodynamic stability of our patients and consequently spared us the use of angioembolization which is not always accessible in our context.

Due to the fact that the stability of the pelvic ring relies predominantly on the stability of sacroiliac joint and its strong interosseous ligaments, definitive fixation in unstable pelvic fractures must include the posterior pelvic structures that are the primary weight-bearing elements [51-54]. In general the posterior ring reduction and fixation is performed before approaching the anterior injury. The exception to this attitude is a symphyseal disruption without innominate bone fracture in which an initial anatomic reduction is often favorable to reducing the posterior displacement [55]. In the literature, several surgical options are descriped for the management of Tile type C fractures each having its advantages and inconvients.

On the posterior ring, we report first the sacroiliac (SI) screwing that can be placed percutaneously or by open posterior approach. It may be employed both for SI joint dislocations as well as sacral fractures. Screws can be inserted in two ways, first from the lateral iliac cortex into the ipsilateral upper sacral segment, or traversing the entire sacrum to exit through the contralateral iliac cortex. This second technique improve resistance to vertical shear forces especially in patients with osteoporosis [53,56]. Biomechanically, several studies showed that fully threaded screws are significantly stronger than partially threaded ones [53]. There was no difference in strength between an assembly with two screws inserted both in the S1 segment and a construct with the insertion of one screw in the S1 segment and the second in the S2 segment. In the same frame, no additional benefit to add second SI screw has been demonstrated [54]. In terms of complications related to SI screwing, several authors deplore the infection in the case of open posterior approach with rates of 3.4% and 10% reported respectively by Stover et al and Suzuki et al [57-58]. Percutaneous fixation, for its part, exposes, in non-expert hands, to the risk of damaging L5 and S1 nerve roots with in addition a higher rates of malunion [59]. At present, percutaneous SI screwing takes advantage of technological advances and can be performed using computer navigation which significantly reduces operation time, length of incision, the blood loss, the anesthesia time and radiation exposure during screw insertion [60-62]. In addition, assistance by the navigation system improves accuracy of screw placement which consequently decreases the SI screwing failure rate and nerve injury [63,64].

Then we descripe posterior plating considered as an alternative means for patients with sacral dysmorphism or in cases of significant sacral comminution, situations during which the risks of iatrogenic damage of neurovascular structures are highers with percutaneous SI screwing. This therapeutic option proccurs the advantage of safe hard-ware placement at the expense of extensive surgical dissection with higher rates of wound complication [65-67].

Lumbosacral fixation is a construct that connects the spine to the pelvis. It realizes a triangular osteosynthesis (TOS) by combining SI screws with lumbosacral fixation to achieve multiplanar stability [53,58]. Biomechanical testing showed that TOS in the cases of transforaminal sacral fractures, allows compared to screw fixation alone, to maintain reduction until healing in 95% of patients [68,69].

External fixation of posterior pelvic injuries can be accomplished when SI screwing seems to be diffcult and dangerous to practise, as in sacral dysmorphism and comminuted sacral fractures. In this context, the minimally invasive internal fixator (Infix) that has recently emerged as an alternative to conventional technique brings in addition of low soft tissue complication rates, suffcient biomechanical stability [70,71].

Regarding our attitude towards posterior injuries, SI screwing performed percutaneously has our preference taking into account its multiple technical and biomechanical advantages. We have performed it in all our patients without deploring any complications until the last follow-up.

Concerning anterior pelvic injuries, symphyseal diastasis were one of the earliest indications of pelvic internal fixation with plate. In this context, open approach and plating allows anatomic reduction, improved stability and facilitate posterior injuries fixation [72]. However, Fixation failure is quite common especially after symphyseal plating beacause of persistent mobility at the symphysis after ligamentous healing. In the literature, rates of this complication range from 12% to 75% and its incidence is significantly reduced by associating a posterior osteosynthesis [73-76,77]. Anterior pelvic plating can also be practiced using locking pelvic reconstruction plates, that can applied subcutaneously from the iliac crest to the pubic symphysis as descriped by Cole et al [78]. This osteosynthesis functions as an internal fixator and had according to his supporters a significantly lower incidence of complications and increased morbidity compared with anterior pelvic external fixator. Anterior pelvic subcutaneous locking plate is recommend in bilateral superior and inferior ramii fractures. However, it is contraindicated in pure symphyseal disruption.

The uses of triple dimension (3D) printing in orthopaedic surgery are growing rapidly and becoming most common in trauma. With its develpment, pelvic fractures as complex as they are can be reproduced in full size on the basis of CT scan data. Thereby, this tool provides better understanding of the three-dimensional fracture disposition. So the surgery can be planned meticulously with the possibility of pre-bending the plates that are going to be used [79].

Intramedullary superior ramus screwing which was popularized in its retrograde form by Routt in 1995, is useful for ramus fractures with minimal comminution and that may be reduced indirectelly by manual manipulation or directelly using Pfannenstiel approach [80]. Ramus screw sizing depends on the size and curvature of the osseous fixation pathway [81]. When retrograde screw insertion is difficult to achieve, especially in obese patients, in the case of a swollen perineum, or when there is an association with other pelvic or acetabular injuries necessitate prone approaches, the screwing is performed anterograde manner [80]. Technically, starting point for the retrograde screw lies just inferior to the pubic tubercle and just lateral to the symphysis. For anterograde screw, insertion lies just superior to the acetabulum in the gluteal pillar. Whatever the procedure adopted, the obturator outlet and inlet fluoroscopic views are necessary to confirm the trajectory within the superior ramus and the acetabular dom [80,82,83].

Recently, the photodynamic stabilization system (IlluminOss™) was described as a form of augmentation in patients with osteoporosis.The IlluminOss™ system consists of a light activated monomer which is inserted in a small diameter expandable balloon catheter that can be introduced percutaneously in the intramedullary canal of the superior pubic ramus. Once the monomer is cured, it remains within the balloon and conforms to the anatomic contours providing thanks to its flexibility sufficient longitudinal and rotational stability [84].

The external fixator is an effective tool for anterior ring fixation and has been widely used from 1950s. However, it is associated with many complications, such as pin-track infection, aseptic loosening and loss of reduction [85-87]. In the literature the comparison between different configurations of the anterior external pelvic fxation construct argue in favor of the use of two parallel connecting rods for external pelvic ring fxation that provides the highest translational and rotational stability [88]. Technically, the choice is made between anterosuperior (above the iliac crest) or anteroinferior assemblies (supra-acetabular). The latter is more stable and longer lasting as reported by several authors such as Guimarães R P et al [89].

In 2009, Kuttner et al first reported the use of internal fixator system (INFIX) to stabilize anterior ring fractures. Vaidya et al demonstrated that INFIX system, whose use is appropriate in the case of less displacement fracture in patients with obesity or urethral injury, achieves a better outcome in reducing the symphyseal widening [90-91]. The main complication reported with INFIX system was the lateral femoral cutaneous nerve (LFCN) paresthesia in the anterolateral side of the afected thigh that can be prevented by avoiding deep placement of pedicle screws. Asymptomatic heterotopic ossifcation is the second most common complication descriped by previous studies and which must be the subject of a prophylactic treatment based on radiation therapy or Non-Steroidal Anti-infammatory Drugs (NSAIDs) [92].

For the definitive management of anterior pelvic ring fractures, in order to reduce the operating time, extensive surgical dissection, blood loss and higher rates of wound complication reported with internal osteosynthesis, we opt for the external fixator in supra-acetabular assembly, especially with the frequent association in our context of soft tissue injuries which were present in 50% of our patients. We reserve the anterior plate in open approach for symphyseal diastasis when the local and general conditions are favorable.

In the literature, there is a lack of adequate long-term followup studies on pelvic ring fractures Tile type C. The available reports have described the results of different types of Tile C injuries without distinguishing between fracture location and treatment modalities. Several nonvalidated and validated outcome instruments are used in describing the long-term results after pelvic ring injuries. Most authors use the validated Short Form-36 Physical Component Summary (SF-36 PCS) [14] or the Short Musculoskeletal Function Assessment (SMFA) [93]. which are a subjective self-assessment of mental health, physical, and social aspects. Approximately 30 to 50% in patient with Tile type C injuries suffer from signifcant persistent pain and have sexual or urogenital disturbances. An excellent or good overall functional result can be expected in 70 to 80% [94].

In our series and using the Short Form-36 Physical Component Summary, the average of physical and mental component scores were respectively 68.3 and 70 which agrees with the literature data. In the literature, little attention appears to have been paid to the issue of postoperative weight-bearing protocols after pelvic fracture surgery. A systematic review of the English language literature from 1990 to 2016 highlights a very little published scientific data that focus on the subject with no randomized trials and only 1 paper out of 122 stating this as a primary aim [95]. Tradition dictates that the majority of patients following pelvic fracture surgery are kept nonweight-bearing for a mean of 9.5 weeks. Restricted weight-bearing and immobility are associated with a number of deleterious effects most notably bone loss, muscle loss, and joint stiffness [95]. Therefore the current trend of most authors is to adopt early weight-bearing in order to recover a satisfactory quality of life [95,96].

At our structure, rehabilitation of patients is started in the intensive care unit usually arround the 3rd day after the general condition stabilization and bone fixation. To restore the function of the lower extremities, we make patients practice first ideomotor exercises, then isometric tension of leg muscles and finally active movements of flexion and extension. When conditions are favorable, sessions are supplemented with resistance-weight training exercises and electrical neurorostimulation in the perspective of shortening bed rest and preparing the patients for walking first with crutches.

Conclusion

The Tile type C fractures that are serious injuries, are often described in the context of high-energy mechanisms usually in young adults and are generally associated to severe multisystem injuries. In the near future, the population with unstable pelvic fractures will getting older. Therefore we will soon have to manage in addition to young patients, osteoporotic low energy pelvic fractures. The immediate goals of initial treatment relies on Advanced Trauma Life Support (ATLS) and temporary stabilization of the pelvic ring. The definitive fixation must include the posterior pelvic structures. For this, percutaneous SI screwing and anterior external fixator in supra-acetabular assemblie have our preference taking into account their technical and biomechanical advantages. Post-operatively, early weight-bearing represents When conditions are favorable our motto.

With great conviction, we plan to constitute a multi-disciplinary teams comprising orthopedic surgeon, trauma anesthesiologist, interventional radiologists and rehabilitation physician to optimize our unstable pelvic fractures management and consequently improving our clinical outcomes with a view to a prospective study with longer following up and a greater number of patients.

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