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Management and surgical options of Tile C pelvic ring fractures: a narrative review of the literature

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Summary

Tile C pelvic ring fractures are complex and dangerous for patients. It is mandatory to know guidelines and algorithms for pelvic trauma to promptly and carefully treat it. Tile C pelvic fractures require temporary treatment. The aim of surgical fixation is to obtain mechanical and haemodynamic stability. The pelvic ring can be divided in two parts, the anterior arch and posterior arch: it is important to know where to start. According to the pattern of fractures, there are different ways to treat a Tile C pelvic ring fracture: plates, percutaneous screws, and external fixator. regarding outcomes, Tile C pelvic fractures are characterized by poor functional outcomes, with only 30% of patients with excellent or good outcomes.

Key words: pelvic ring, Tile classification, Tile C, surgical fixation, temporary treatment

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Introduction

Pelvic ring fractures are infrequent, representing about 1% or less of all fractures [1]. They are often linked to high-energy trauma and are associated with a high rate of mortality compared to other fractures [2,3]. The most widely used classification of pelvic ring fractures is the Tile classification, in which three patterns are observed based on fracture stability [4]. A Tile C fracture is the most severe pattern with simultaneous rotational and vertical instability: both the anterior and posterior arches are disrupted, with concomitant bleeding of vascular structures [5]. This type of fracture demands operative treatment to provide pelvic ring stability. Due to the severity of the injury, orthopaedic damage control is often required: stabilisation of the pelvic ring provides not only mechanical but also haemodynamic stability, dramatically reducing active bleeding [6]. After patient resuscitation, the definitive fixation is planned with further imaging (i.e. 3D reconstruction of the pelvic ring) and a multidisciplinary approach. The aim of this article is to explain how to approach Tile C fractures, analysing the classification, anatomy, clinical evaluation, diagnostic tools, timing and surgical options.

Classification and pathoanatomy

Different classifications describing pelvic ring injuries exist. The most widely used

are the Tile and Young-Burgess classifications [4]. The Tile classification considers stability and fracture pathoanatomy. This classification is entirely based on the integrity and stability of the posterior arch. Stability can be defined as the ability of the pelvis to withstand physiologic force without deformation [7]. Three types are described, according to the stability of the pelvic ring (Tab. I). In the Young-Burgess classification, the direction force plays a key role: Anterior-Posterior Compression II and Vertical Shear correspond to Tile C (Tab. II). The most severe type is Tile C, in which a simultaneous disruption of the posterior and anterior arches is observed: in particular, there is the lesion of sacrospinous, sacrotuberous and posterior sacroiliac ligaments. These ligaments are among the strongest ligaments of the human body, and assure pelvic ring posterior stability. The structures of the posterior arch of the pelvic ring are in strict contact with vessels and nerves. In these fractures, there is a high risk of lesions to these structures, given pelvic ring rotational and vertical instability [8,9]. Regarding pelvic injury, the correlation between pelvic fractures and blood loss is well known: in over 60% of pelvic injuries, the cause of bleeding is directly related to the fracture of the pelvis [10, 11]. About 80% of blood loss is due to lesions of the venous plexuses, especially the pre-sacral and pre-bladder ones. Only 20% of bleeding has an arterial origin and is mainly linked, in decreasing percentage, to lesions of the anterior branches of the internal iliac, pudendal, obturator, and superior gluteal artery. Should the bleeding persist, patients can become haemodynamically unstable. Thus, in most cases, the pelvic ring must return to a condition of mechanical stability to stop the bleeding and consequently achieve haemodynamic stability.

Clinical and instrumental evaluations

For optimal management, it is very important to understand the kinematics and energy of the trauma; based on this, initial assessments are made on the possible type of injury and associated complications. Abrasions, contusions, haematomas, wounds, and anatomical deformities must therefore be sought in orthopaedic evaluation.

Regarding evaluation of pelvic ring stability, the palpatory-compressive manoeuvre of the pelvis is one of the most executed. It is performed by applying slight anteroposterior pressure with the palm of the hand on the pubic symphysis and contemporary palpating the two iliac crests. The pressure on the pubic symphysis can highlight a diastasis between the right and left hemipelvis, thus suggesting a fracture of the pelvic ring; palpation of the iliac crests may also show a preternatural movement. However, the role of this test is often questioned: although it has been shown to have a sensitivity and specificity of 86 and 92%, respectively, according to the recent literature, it is an operator-dependent method and does not provide further information other than that obtainable from first level X-ray diagnostics. In addition, incongruous mobilisation of the pelvic ring may result in a resumption or increase in both bleeding and pain perceived by the patient [12,13]. A relevant role is played by X-rays and then computed tomography (CT) scans. As the first evaluation, an anteroposterior X-ray of the pelvis helps to diagnose pelvic ring injury. The other two projections, inlet and outlet, may complete the first evaluation. In inlet projections, the posterior and anterior arches are well observed, so that eventual disruptions are detected; in outlet projections, the anterior face of the sacrum with its foramina is observed. Thanks to X-rays, orthopaedic surgeons understand if control of damage is necessary or not. As second-level imaging, CT scans are needed to better understand the fracture patterns and how to definitively treat them. Furthermore, with CT scans it is possible to perform a 3D reconstruction of the pelvic ring, which can be useful in some cases [14,15].

Damage control orthopaedics

Haemodynamic stability is what guides the orthopaedic surgeon on how to proceed. A pelvic binder should be applied as soon as possible, ideally at the scene of the trauma and only afterward the remaining evaluations will be carried out. The pelvic binder must be positioned at the level of the greater trochanters, without excessive compression on the abdomen. In the case of a haemodynamically stable patient, with symptoms and imaging that suggest pelvic ring fractures, it is recommended to keep the pelvic binder in place and subsequently evaluate possible therapeutic options. In the case of a haemodynamically unstable patient, with symptoms and imaging that suggest pelvic ring fractures, stabilisation of the pelvis is

Table I. Tile classification.

Tile pattern	1	2	3
A: Pelvic ring stable	Fractures not involving the ring (avulsion or iliac wing fracture)	Stable fractures with minimally or not displacement	Transvers sacral fracture
B: Pelvic ring rotationally unstable	Open Book	Lateral compression, ipsilateral	Lateral compression, contralateral
C: Pelvic ring rotationally and vertically unstable	Unilateral	Bilateral	Associated acetabular fracture

Table II. Young-Burgess classification.

Young Burgess pattern	1	2	3
Anterior-Posterior Compression (APC)	Symphysis widening < 2.5 cm	Symphysis widening > 2.5 cm with anterior SI joint diastasis	Disruption of anterior and posterior SI ligaments and/or association with vascular injury
Lateral Compression (LC)	Ramus fracture and anterior sacral ala compression fracture	Rami fracture and ipsilateral ilium fracture (i.e. Crescent fracture)	Ipsilateral LC and contralateral APC
Vertical Shear (VS)	Vertical displacement of hemipelvis		

required: firstly to reduce pelvic volume, secondary to limit post-traumatic blood loss, then to stabilise fracture fragments and finally to reduce pain. Alongside orthopaedic treatment, the patient has to be managed by the colleagues of the Trauma Team for evaluation of vital parameters and possible bleeding. It is not recommended to keep the pelvic binder in place for longer than 48 hours: if it is not possible to perform early definitive fixation, conversion to a different device is needed. An external fixator is the main device used as damage control orthopaedics in pelvic ring fractures. The aim of external fixator in emergency is to grant mechanical and haemodynamical stability. It is not necessary to obtain an anatomic reduction when external fixator is used as damage control orthopaedics. However, in some cases, an external fixator is definitive fixation for the anterior arch: when it happens, external fixator can be subject to change later.

Tile C patterns

In pelvic ring Tile C fractures, complete disruption of the pelvic ring is observed; however, the disruption can happen in various anatomical regions of the pelvic ring [16,17]. The anterior arch can be interrupted because of a diastasis of the pubic symphysis and pubic rami fractures (either monolateral or bilateral). The posterior arch can be interrupted because of diastasis of the sacro-iliac joint, fracture of the sacrum and fracture of the iliac wing (crescent fracture). In pelvic ring Tile C fractures, the disjunction of either one of the hemipelvis is observed: when both hemipelvis are involved, a spinopelvic disjunction is observed. A rare and severe condition is when there is an open Tile C fracture, with a major risk of lesion to the urogenital tract (Figs. 1-3).

Due to increasing life expectancy, fragility fractures of the pelvis are observed in the elderly population. In these fractures, different patterns are observed, and usual classifications are not optimal to describe them. They are caused by low energy trauma and characterized by minimal displacement with prevalent involvement of bony structures: in the elderly, the strength of bony structures is less than that of the ligaments due to osteoporosis. Fragility fractures of pelvis are well described by Rommens et al. [18].

Surgical options

Surgical treatment aims to obtain mechanical stability of the pelvic ring and restore the anterior and posterior arches [16]. According to the pattern of the Tile C fracture, different instruments can be used to obtain fixation of the pelvic ring. In open fractures, it is not possible to perform an internal fixation in the acute phase: in these cases, external fixation is mandatory to manage the anterior arch; for the posterior arch, a mini-invasive fixation (i.e. fixation with ileo-sacral screws) can be achieved. In these cases, it is necessary to also treat the open fractures: irrigation and debridement are performed, while antibiotic prophylaxis is administered according to literature guidelines [19].

For all other fractures, internal fixation is mandatory to rightly restore the continuity of the pelvic ring.

In the literature, there is discussion about the correct timing for the osteosynthesis of both arches. Previously it was necessary to reduce and fix the posterior arch first and then the anterior arch: as it is known, the posterior arch grants mechanical and haemodynamic stability to the pelvic ring. However, the pelvic ring is too stable after the stabilisation of the posterior arch, so that it is difficult to correctly reduce the anterior arch. Some authors prefer to treat the anterior arch first if it is possible to obtain an anatomical reduction of the pubic symphysis. If this is not possible or if there are pubic rami fractures, it is necessary to stabilise the posterior arch first [20].

For the anterior arch, surgical options comprise pubic plates, anterograde and retrograde screws, and an external fixator. For the posterior arch, surgical options include ileo-sacral screws, sacral or ileo-sacral plates and spinopelvic fixation (Fig. 4).

Anterior arch

Open reduction and internal fixation with a pubic plate is the gold standard when there is a diastasis of the pubic symphysis. There is still discussion if one or two plates need to be

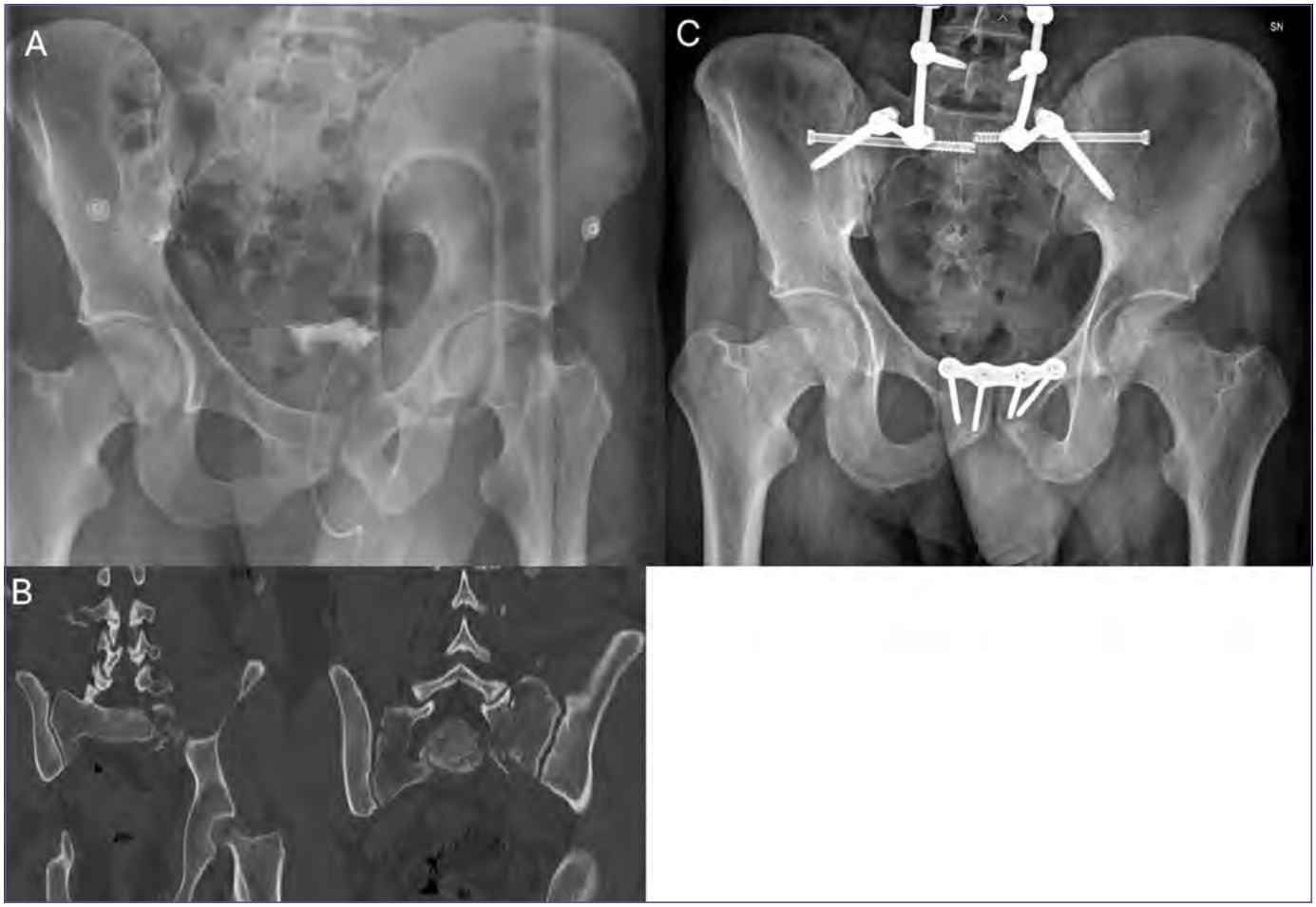

Figure 1. A) a Tile C1 fracture in shock room; B) a coronal reconstruction of CT scans where a right sacral ala fracture is observed; C) definitive treatment with pubic plate and two right sacro-iliac screws.

used: in the literature, several papers have studied the forces that develop in pubic symphysis and their biomechanics. The pubic plate can be applied anteriorly and/or superiorly, according to the patient's anatomy. Double pubic plates are characterised by major resistance to shear and vertical stresses [21,22]. Double plates represent a major discomfort for patients with higher risks of re-operation for implant removal. In case of an open fracture, an external fixator is preferred, so that there is no contamination of the surgical site: however, whenever possible, a conversion after a wash-out time is recommended [19]. A suprapubic approach according to Pfannenstiel is performed to implant a pubic plate [23].

In pubic rami fractures, anterograde and retrograde screws (5 mm, 6.5 mm and 7.3 mm) are recommended: there is no difference in terms of outcomes between anterograde and retrograde screws. Nonetheless, it is not always possible to perform such surgery: in some cases, the bone tunnel is too tight or there is not enough bone stock to grant appropriate fixation and stability. Retrograde screws are preferred when the pubic rami fractures are medial, while when they are lateral anterograde screws are preferred. To apply a retrograde screw, a stab incision is performed over the contralateral pubic tubercle and it is inserted from the homolateral pubic tubercle directly to the supracetabular rim. To apply an anterograde screw, a stab incision is performed cephalad to the hip joint, next to the supracetabular rim and it is inserted from the supracetabular rim to the pubic tubercle [24-26].

There are some cases where it is not possible to perform internal fixation: open fracture, patients with high surgical risk, low-demand patients, comminuted fractures, and cases when good bone stock is lacking. In all these cases, it is recommended to apply external fixation. Different configurations are available, according to pin positioning. The pins, in fact, can be positioned in the iliac crest and supracetabular rim. Possible configurations are an iliac configuration, with one or two pins in the iliac crests; supracetabular rim configuration, with one or two pins in the supracetabular rims; hybrid configuration, with one pin in the iliac crest and one pin in the supracetabular

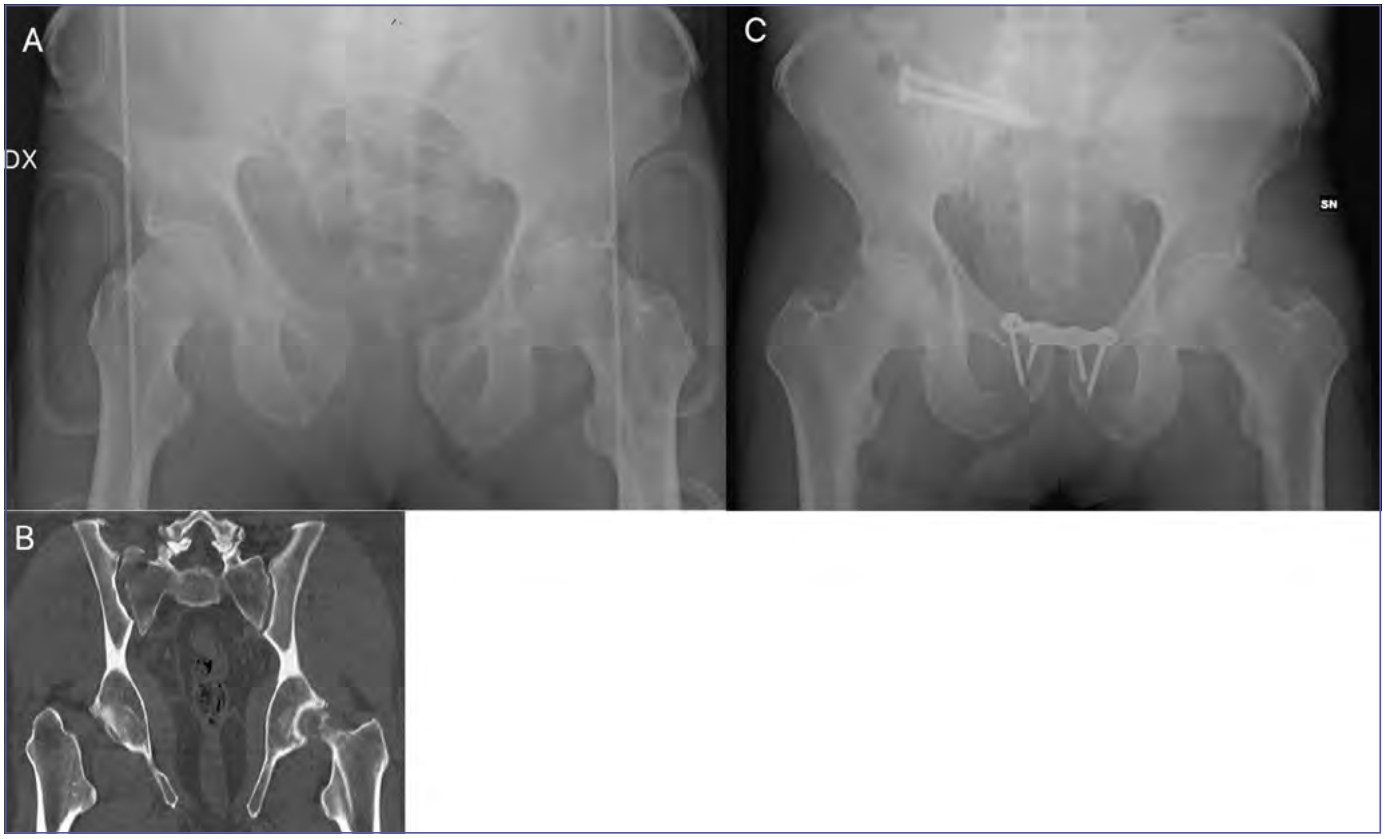

Figure 2. A) a Tile C2 fracture in shock room; B) a coronal reconstruction of CT scans where bilateral sacral ala fractures are observed; C) definitive treatment with pubic plate and bilateral sacro-iliac screws.

rims. An external fixator is a treatment that is both simple and fast and makes the management of patients easier during hospitalisation [27,28].

Posterior arch

The posterior arch is the anatomic region of the pelvic ring that grants the most stability: it is composed of bony and ligamentous structures, as mentioned above. In Tile C pelvic ring fractures, there is a combined rotational and vertical instability. In pelvic ring fractures with exclusive rotational instability (Tile B), lesion of anterior sacro-iliac ligaments or diastasis of sacro-iliac joint are observed (i.e. open book), while posterior structures of the posterior arch are not involved. To obtain a vertical instability, a conjunct disruption of bony and ligamentous structures is required: injuries of only bony structures are not sufficient to observe a vertical instability. Usually, the ligamentous structure whose lesion gives vertical instability is posterior sacro-iliac ligament. However, in some cases, the vertical instability is related to other lesions, such as sacral fractures. Treatment of these lesions depends on what structures are damaged: it is mandatory to know what structures are involved and how to correctly treat them.

Ileo-sacral screws are the most common way to fix an injury of the sacroiliac joint. Cannulated screws with a diameter of 6.5 mm or 7.3 mm are used, with different types of threads: when compression is needed, a ½ or 1/3 threaded screw is required; if stabilisation without compression is needed, a fully threaded screw is required. Ileo-sacral screws may be used both in diastasis of the sacroiliac joint and in sacral alar fractures. In diastasis of the sacroiliac joint, there is a disruption of posterior ligaments of the pelvic ring (sacroiliac, sacrotuberous and sacrospinous ligaments): a compression of diastasis with consequent stabilisation is mandatory, and thus one or two sacroiliac screws are needed [29,30].

In sacral fractures, the Denis classification is the most common and used to stage the fracture: in Denis II and Denis III, there is a sacral ala fracture with (Denis II) or without (Denis III) involvement of foramina. When a sacral alar fracture is observed, the use of a sacroiliac screw may be a solution; nevertheless, in this case, stabilisation of fracture without compression is required due to the increased risk of compressing nerve roots [31,32].

Another difference in the treatment of these two types of injuries is the length of the screws. In sacral alar fractures, it

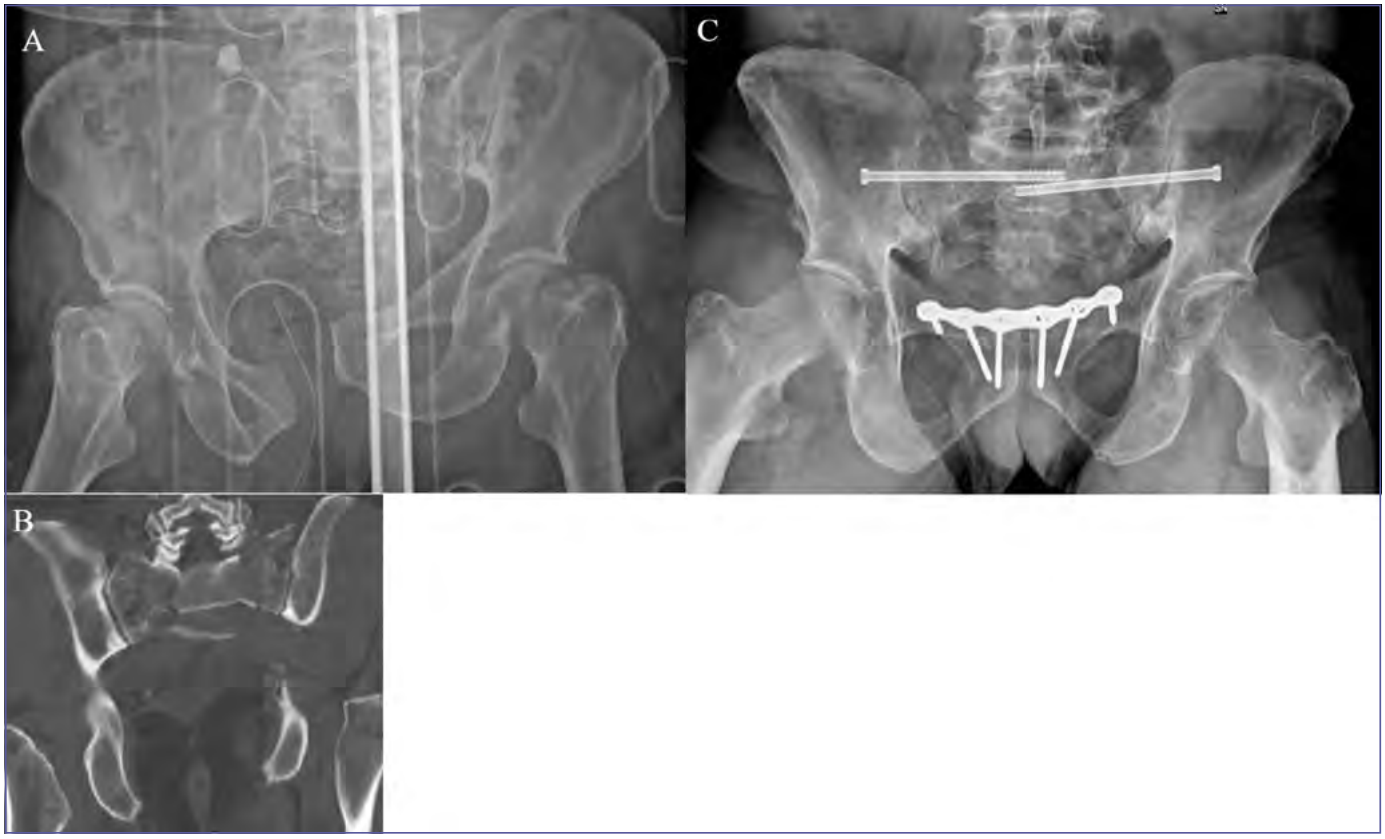

Figure 3. A) a Tile C3 fracture in shock room; B) coronal reconstructions of CT scans where a spino-pelvic disjunction is observed (sacral U-fracture); C) definitive treatment with pubic plate, bilateral sacro-iliac screws, and spino-pelvic fixation.

is possible to use bis-iliac screws: the bone stock of the sacrum may be reduced due to fractures, and therefore bicortical screws grant major resistance and stabilisation of the fracture. Ileo-sacral screws are directed to the body of the first sacral vertebra: if compression is desired, they are directed anteriorly and superiorly (perpendicular to the sacroiliac joint), otherwise they can be perpendicular to the fracture line. It is still debated if one or more screws are needed. If two ileo-sacral screws are placed, one is placed in the body of the first sacral vertebra and one in the body of the second sacral vertebra.

Crescent fractures are characterised by diastasis of sacro-iliac joint with fracture of the iliac bone, and there is no rupture of posterior sacroiliac ligaments. According to Crescent classification, different methods of fixation are possible. Type III is comparable to the diastasis of the sacro-iliac joint, and an ileo-sacral screw is used to fix it. In types I and II, the fracture is too anterior and there is no bone stock to insert an ileo-sacral screw. In these cases, it is recommended to perform an internal fixation with sacroiliac plates. If possible, one of the screws on the iliac bone should be directed superiorly and medially to the posterior fragment of the crescent fracture. A lateral AIP approach is performed to view the iliac bone and sacroiliac joint: in this approach, orthopaedic surgeons must be careful to nerve roots [33-35].

In sacral fractures with body involvement, ileo-sacral screws cannot provide enough stability due to poor bone stock and the difficulty to obtain a good reduction. In these cases, fixation with posterior approaches is preferred. The device used can change according to fracture pattern: in a simple fracture of the sacrum, posterior plates are preferred, similar to anterior plates in crescent fractures. However, in U-type or H-type fractures of the sacrum, posterior plates do not grant enough stability. In U-type or H-type fractures, a spinopelvic disjunction is observed, and the continuity between the vertebral column and the pelvic ring must be restored. In these cases, a spinopelvic fixation is recommended: it may be mono-lateral or bilateral, according to the fracture pattern. Spinopelvic fixation usually links the fourth and/or fifth lumbar vertebra to the iliac bones. Screws in iliac bones are placed next to the posterior-superior iliac spine and directed to the supracetabular rim (the same trajectory as the supracetabular pin in the external fixator). Spinopelvic fixation grants high resistance to every type of stress; however, it also provides high rigidity to the involved joint: in some cases, a second surgical procedure is necessary

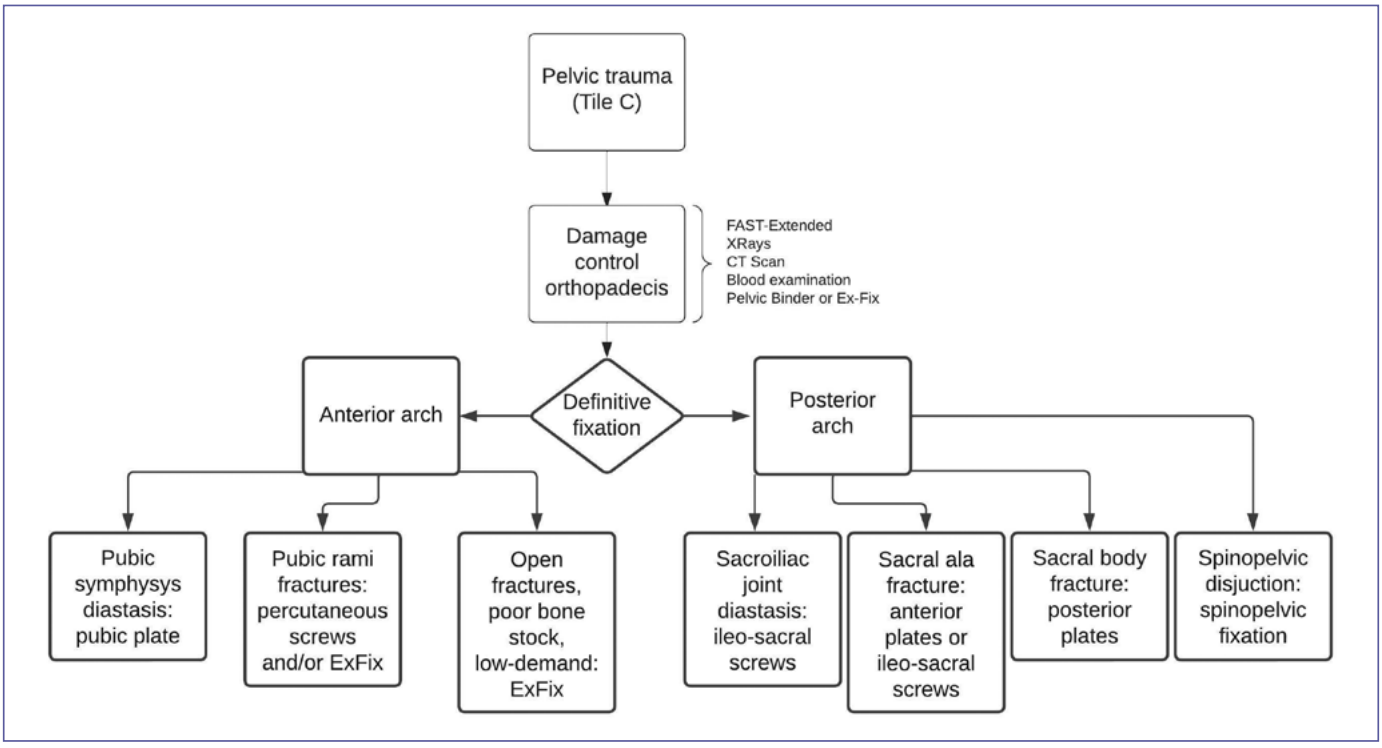

Figure 4. Flow chart for treatment of Tile C pelvic ring fractures.

to remove the implant and reduce the rigidity of the involved area [36-38].

Outcomes

Outcomes following treatment of pelvic ring fractures are strictly related to fracture reduction: displacement greater than 0.5-1 cm is a poor prognostic indicator for fracture healing [39]. However, in only about 30% of Tile C pelvic ring fracture is there a good or excellent outcome. Orthopaedic surgeons must be very clear with patients about the outcomes of these fractures, highlighting the strong risk of not being able to return to either functional or activity levels prior to the injury [40-43].

Pelvic ring Tile C fractures are characterised by several complications, due to the type of fracture, kinematics of trauma, and surgical procedures. The most frequent complications are chronic pelvic and low back pain, infections, malunion and/or nonunion, neurological injuries and urinary tract and sexual disorders. Chronic pain is reported in about 10% of patients and leads to severe discomfort [44].

In addition, urinary tract and sexual disorders are very frequent, with a reported rate of 50% in some papers [45,46]. Neurological injuries and infections are mostly linked to surgical procedures, and it is therefore important to follow guidelines in order to prevent them [19].

Conclusions

Tile C pelvic fractures are among the most complex and dangerous fractures and need to be treated correctly and promptly. It is necessary to follow literature guidelines and algorithms for pelvic trauma to perform damage control orthopaedics or definitive fixation. Orthopaedic surgeons must have a precise knowledge of pelvic ring anatomy and of the dynamics of the injury in order to properly classify the fracture and then choose the best treatment option. It is mandatory to know the entire variety of the available methods of fixation together with their indications and related risks. Accurate planning with imaging leads to better outcomes: CT scans are useful, although X-rays are the first imaging needed in this type of injury. Lastly, informed consent is paramount for educating patients about outcomes.

Conflict of interest statement

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Author contributions

CDF, PP: wrote the manuscript; AB, SC: collected data in literature; AA, KZ: reviewed the manuscript.

Ethical consideration

Not applicable

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