



Review Article

Osteoporotic Pelvic Ring Fractures

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Abstract

The pelvic ring is a complicated anatomical structure which consists of the sacral bone, the iliac, ischial and pubic compartments and the pubic symphysis. In the elderly, osteoporotic fractures of the pelvic ring are often caused by low energy trauma. They are very rarely accompanied by neurological, vascular or endopelvic organ injuries. There has been a rise in the incidence of such trauma due to the increase of life expectancy, population aging and improvement of diagnostic and evaluation techniques. Pelvic ring fractures are often missed or under evaluated, resulting in remaining pain and great disability. Thorough assessment of the clinical presentation and medical history of the patient along with the needed imaging tests are vital for choosing the suitable therapeutic approach. Pelvic ring fractures are classified according to many systems. The most popular one is Denis et al classification, which is slowly replaced by the Young-Burgess classification, based on the applied force's direction. FFP classification aids in the diagnosis and leads the treatment algorithm. The AO/OTA cooperative categorization can help improve common understanding of such pathologies. Treatment sequence can be conservative or surgical and aims to pain management and rapid mobilization. However, it must always include the suitable osteoporotic therapy.

Keywords: Fracture, Lesion, Osteoporosis, Pelvic ring, Sacrum

Introduction

The definition of osteoporosis describes the pathologic entity characterized by loss of bone mass and density and distortion of bone micro-architecture, predisposing patients to fragility fractures¹. World Health Organization defines fragility fracture as the one that results from low energy trauma, incapable of injuring healthy bone. Fragility fractures occur in bones that can no longer sustain compression and rotational forces. Osteoporotic fractures occur in as many as 40% of menopausal women and 30% of men of the same age^{2,3} causing important disabilities, whilst many patients never manage to fully recover and regain mobility after the trauma.

Pelvic ring osteoporotic fractures are a completely different pathology from pelvic fractures in patients with normal bone density. In young patients, high energy trauma is essential to cause such fractures in the pelvis. These injuries are often accompanied by neurological, vascular and ligamentous trauma. In contrast, osteoporotic fractures are caused by low energy trauma and sometimes patients even mention no history of trauma. Rarely do these fractures

present with vascular, neurological, ligamentous or other visceral organ injuries⁴.

The purpose of this paper is to thoroughly review the bibliography regarding osteoporotic pelvic fractures and the current status of management and treatment algorithm. Fragility fractures of the pelvic ring are rarely confronted, but when they do, they are usually missed, underdiagnosed and undertreated. For this reason, we need to spread awareness and raise knowledge for this unpopular clinical entity.

Etiology

The etiologic background behind fragility fractures is decreased bone mineral density (BMD). Osteoporosis is

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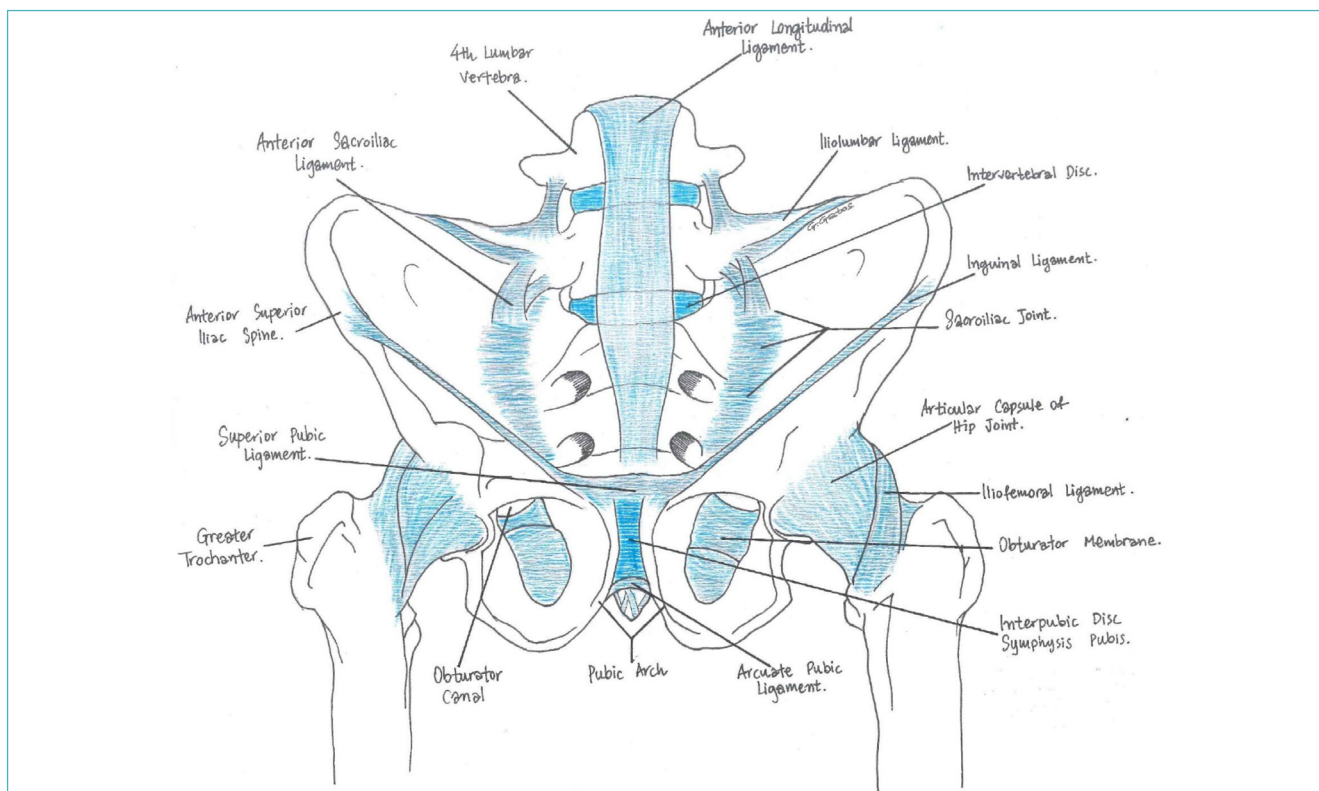


Figure 1. Pelvic ligaments - front view.

the most common underlying pathology, which leads to compromised bone strength and increased risk of bone fractures. There are also some less frequent predisposing factors that can lead to low energy bone injury, such as vitamin D deficiency, long term corticosteroid use, rheumatoid arthritis, prolonged immobilization and radiotherapy^{5,6}.

Epidemiology

The incidence of fragility fractures increases with age. As a result, in patients over 60 years old 94% of all fractures occurring are fragility fractures⁷. In the previous century, aging of population and increase of life expectancy have led to rapid growth of the elderly population with consequent rise of fragility fractures incidence. Pelvic ring fragility fractures constitute 7% of all osteoporotic bone injuries⁷. Although they are not as frequent as fractures of the extremities, they tend to appear more often, causing important clinical problems, as well as diagnostic and therapeutic challenges⁸. Their incidence in the general population is 20-37/100000 whereas in ages over 60 the number is increased to 92/100000 and for the age group over 85 peaks to 446/100000⁹. The most common site of occurring bone trauma is the pubic rami and such fractures are considered stable.

Injury Mechanism

Osteoporotic pelvic fractures are usually caused by simple falls, most of the times from the patient's height. High energy trauma is rarely mentioned in the patient's history in this age group. Falls are very common in the elderly due to malfunction of perception and motion systems. In addition, many concomitant diseases and their medication can contribute to the increase of such injuries.

In many cases, no history of trauma is mentioned. This is because the patient may have deteriorated mental function and memory, which leads to incapability of giving a detailed record of events. Sometimes, the injury is due to very low energy trauma that was not perceived by the patient as something harmful or worth mentioning.

Review Of Literature

Anatomy

True knowledge and understanding of pelvic ring anatomy and biomechanics are essential for the comprehension of the nature of pelvic trauma.

The pelvis consists of the two innominate bones and the sacrum forming a ring-like structure. Every innominate bone consists of the ischial, pubic and iliac compartments. The two

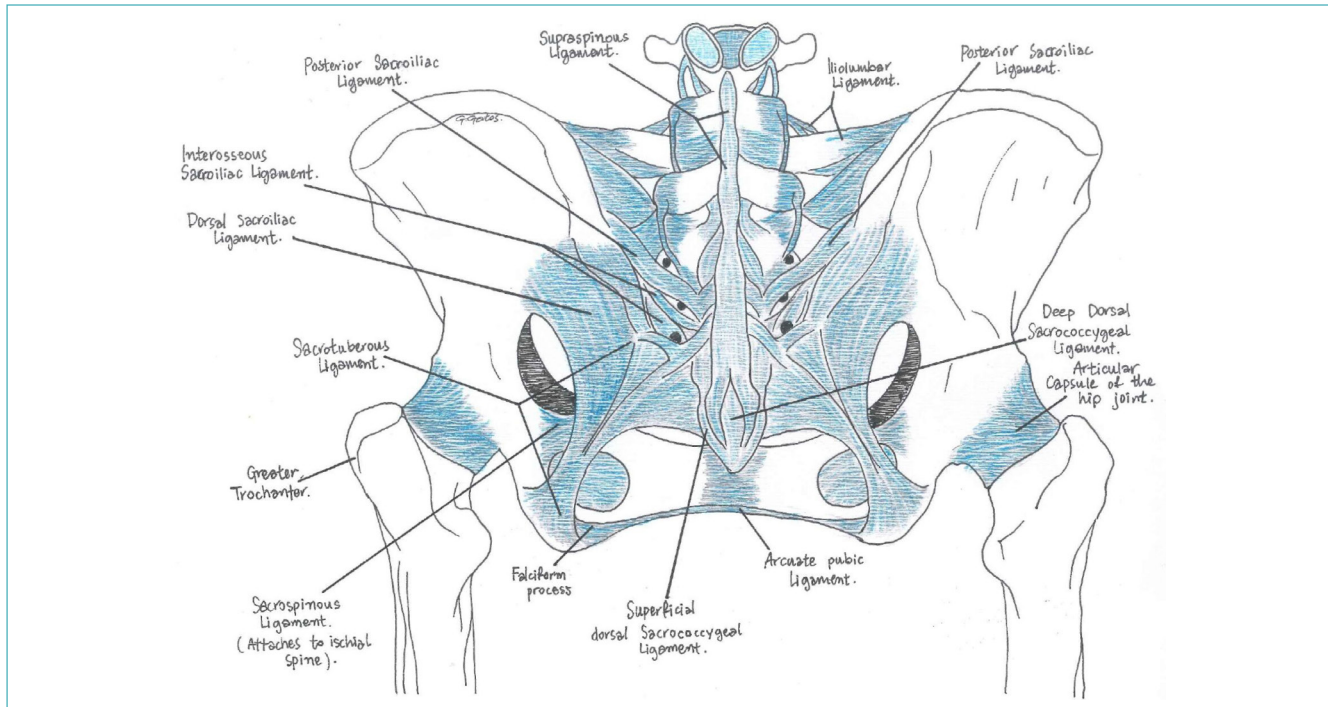


Figure 2. Pelvic ligaments - rear view.

innominate bones are joined together in the anterior part of the pelvic ring forming the pubic symphysis. In the posterior part, they merge with the sacral bone forming the sacroiliac (SI) joints.

Pelvic ring is made up of two arcs: a relatively weak anterior arc consisting of the pubic bones and pubic symphysis and a relatively strong posterior arc consisting of the posterior parts of iliac bones, the sacral bone and the SI joints¹⁰.

The pelvis is a very strong structure that can withstand high forces without distortion. The interosseous sacroiliac ligament is considered to be the strongest one and can be further divided into thin anterior fibers and thick posterior fibers. The anterior sacroiliac ligaments resist rotational distortion of the iliac towards the sacrum. The posterior sacroiliac ligaments are more powerful and resist vertical and rotational distortion. The sacrospinous ligament connects the posterior part of the sacrum with the ischial spine and offers rotational stability to the pelvic ring. The sacrotuberous ligament is located superficially to the sacrospinous and connects the sacrum to the ischial tuberosity, protecting the pelvis from vertical distortion and flexural movements. The iliolumbar ligaments extend from the posterior part of the iliac crest to the transverse process of lumbar vertebrae L4 and L5, connecting the pelvis to the spine^{11,12}. The pubic symphysis is stabilized by multiple ligaments; however,

it is considered to be the weakest joint of the pelvic ring contributing only by 15% to the stability of the pelvic ring¹³.

Embryology

The pelvis is a complicated anatomical structure, originating from the merging of the embryonic ischial, iliac and pubic bones during fetal development. The formation is called “Cartilago Ypsiloformis” and is ossified completely during the first years of puberty (12 years for girls and 14 years for boys)¹⁴.

Clinical Presentation

Osteoporotic ring fractures make up a clinical entity that is completely different from pelvic ring fractures in younger patients. Non-osteoporotic patients have normal bone density and mass. Therefore, pelvic fractures require a high force trauma and are usually accompanied by concomitant vascular, nerve, ligamentous and internal organ injuries, as well as other fractures.

On the contrary, pelvic ring fractures in osteoporotic patients are often due to low energy trauma. The patient with pelvic ring fracture is presented in the emergency unit with a pain of acute onset in the hip, groin or lumbar area, usually following minor trauma, or with a persisting pain that impedes mobilization and does not improve with time. The patient mentions a low energy injury, most frequently

a fall, or no trauma at all. Almost 60% of patients cannot give any history of injury⁷. This is due to the high dementia prevalence that is present in this age group, which can hinder the acquiring of a good medical history. Sometimes, the injury is downgraded by the patient himself misleading the clinician and delaying the course of diagnosis. In these cases, the bone is fractured due to low bone density and mass. As a rule, those lesions are not accompanied by neurovascular, internal organ or other bone injuries. Pelvic ring fractures generally cause great disability and deterioration of the patient's quality of life, and thus demand a fast and suitable treatment.

Patients with pelvic ring fractures are most of the times presented in the outpatient department complaining about pain and sensitivity in the hip and lower back area.

Pubic bone fractures are usually presented with pain in the ischial or pubic area and sensitivity during the palpation of the pubic symphysis¹⁵.

Sacral bone fractures are accompanied by lower back pain which reflects to the ischial or pubic area and intense sensitivity during the palpation of the sacrum. The symptom is aggravated by movement¹⁶. It is often accompanied by rhizopathy, myelopathy and cauda equina syndrome (CES)^{17,18}.

Pelvic ring fractures are rarely included in the clinician's differential diagnosis, mainly because of the unclear patient's medical history and the underestimation of symptoms due to the patient's poor overall condition. Most of the times, they are underdiagnosed and treated conservatively as lower back pain of no specific cause. Thus, patients are undertreated, leading to delay of rehabilitation, disability and increase of morbidity and mortality rates. In literature, cases have been reported of patients that were given the wrong surgical treatment following mistaken diagnosis (e.g., procedures for spinal cord decompression).

Diagnosis

The evaluation of a patient with an osteoporotic pelvic ring fracture starts, as any other diagnostic procedure, with a thorough assessment of the patient history, presenting complaint and medication. Medical history is always completed with the evaluation of the patient's pre-traumatic physical status, self-care capacity and nutritional status. All of the above are factors of paramount importance in decision making for the best suited therapeutic approach.

Clinical assessment is the next step of the diagnostic path of pelvic trauma and should begin with detailed observation of the area for deformities, ecchymoses, lacerations or hematomas. Clinical examination follows, with palpation of the pelvis in its anterior and posterior arc and stability check via compression of the iliac crest¹⁹. Light manual palpation along the iliac crests with the patient lying on his back can reveal crepitus from fractures. Mild compression of iliac crests can assist the clinician in detecting pelvic ring instability, but it must be undertaken carefully to avoid

harming the patient. Rotational instability suggests bilateral pelvic ring fractures. Sensitivity may be also found on the palpation of sacrum²⁰. Multiple tests can also be used during the examination, such as the FABER test or the Gaenslen's test, but do not show high specificity especially in patients experiencing intense pain.

Whenever a fracture is suspected from the clinician, imaging tests are requested to confirm and validate the diagnosis. The first evaluation is made with plain radiography, which is a simple anterior-posterior (AP) x-ray of the pelvis. Bibliography suggests the necessity of an additional computed tomography since 80% of fractures initially diagnosed as solitary are proved to be multiple after CT scanning^{21,22}.

In osteoporotic patients, fractures of the anterior part of pelvic ring are often accompanied by fractures of the posterior part, which are most of the times missed in plain radiography, leading to the underdiagnosis and undertreatment of unstable fractures. A significantly high percentage (reaching 80%) of fractures that were initially considered as single after plain radiography, were ultimately proved multiple after computed tomography. Thus, in osteoporotic patients that are diagnosed with pelvic ring fracture, computed tomography should always follow simple radiography. In addition, fragility fractures are often nondisplaced and, therefore, the only diagnostic tool can be magnetic resonance imaging scan. Undiagnosed persistent lower back pain should be assessed with an MRI whenever a CT scan fails to detect an injury¹².

Complications

Non-osteoporotic pelvic ring fractures are usually accompanied by multiple injuries in organs nearby, such as the bladder, internal genitals and adjacent nerves and vessels. On the contrary, osteoporotic pelvic ring fractures are almost always individual injuries since they are caused by low energy trauma. Hemodynamic instability is confronted in only 2-3% of fragility fractures of the pelvis, due to injury of internal iliac. In these cases, major hemorrhage and hypovolemic shock are common due to the widespread use of anticoagulant or antiplatelet agents in the elderly group²³⁻²⁵.

Nonetheless, the most important complications of osteoporotic pelvic ring fractures are iatrogenic, due to underdiagnosis and undertreatment, which lead to instability, disability and prolonged rehabilitation.

Classification

There are many classifications for pelvic ring injuries, but most of them apply better to high energy trauma. The "Tile Classification" is the precursor of the most contemporary ones. It takes into account stability and force direction. The integrity of the posterior arch determines the grade. Three basic stability descriptions are used, each with degrees of severity²⁶.

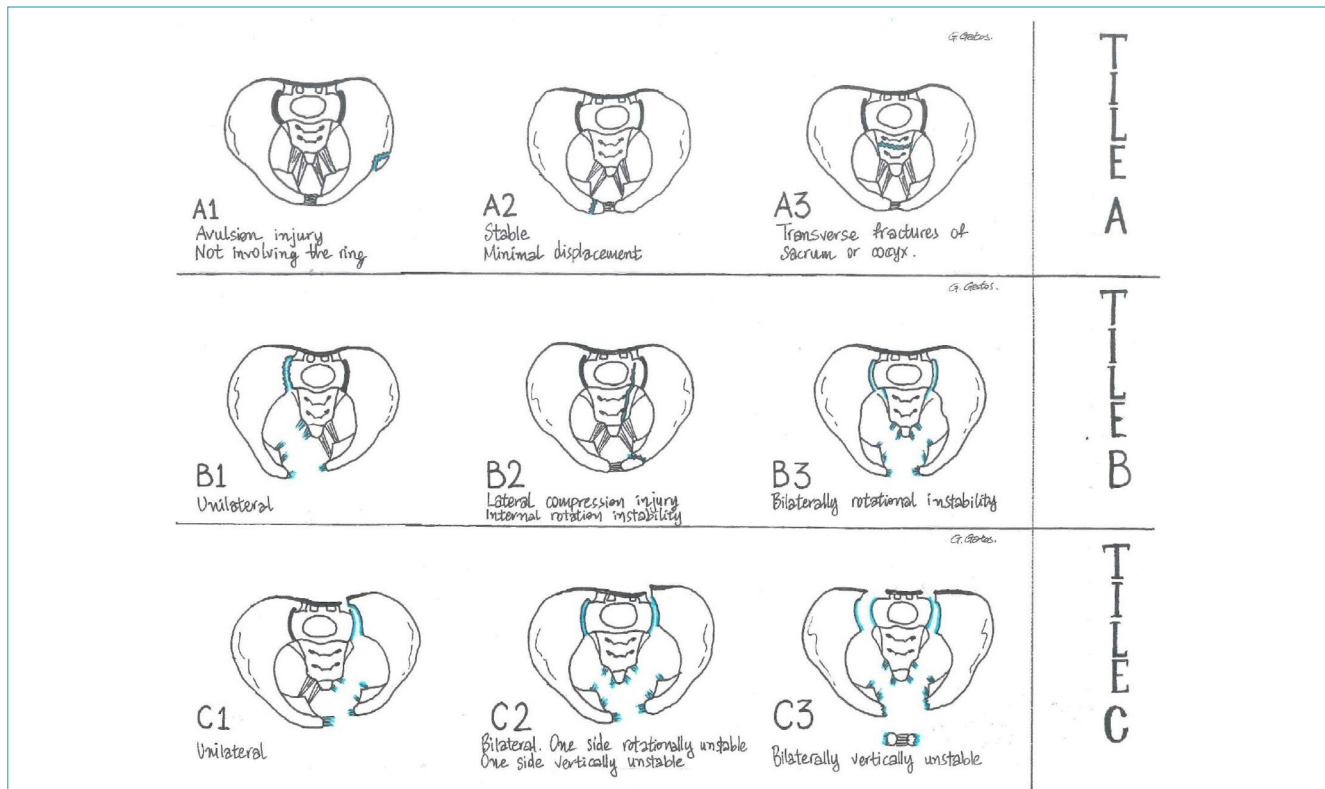


Figure 3. Tile classification of pelvic fractures.

Tile Classification

• Type A

Stable (posterior arch intact)

- A1: Avulsion injury
- A2: Iliac-wing or anterior-arch fracture due to a direct blow
- A3: Transverse sacrococcygeal fracture

• Type B

Partially stable (incomplete disruption of the posterior arch)

- B1: Open-book injury (external rotation)
- B2: Lateral-compression injury (internal rotation)
 - * B2.1: Ipsilateral anterior and posterior injuries
 - * B2.2: Contralateral (bucket-handle) injuries
- B3: Bilateral

• Type C

Unstable (complete disruption of the posterior arch)

- C1: Unilateral
 - * C1.1: Iliac fracture
 - * C1.2: Sacroiliac fracture-dislocation
 - * C1.3: Sacral fracture
- C2: Bilateral, with one side type B, one side type C
- C3: Bilateral

Nowadays, this classification tends to be replaced by a modified version, which takes into account force type,

severity and direction, as well as pelvic instability. This is the “Young and Burgess Classification” and constitutes the most widely used classification system for pelvic ring fractures. Three basic mechanistic descriptions are used, each with degrees of severity²⁷.

Young and Burgess Classification

• Anteroposterior compression (APC)

- APC I: stable
 - * pubic diastasis < 2.5 cm
- APC II: rotationally unstable, vertically stable
 - * pubic diastasis > 2.5 cm
 - * disruption and diastasis of the anterior part of the sacroiliac joint, with intact posterior sacroiliac joint ligaments
- APC III: equates to a complete hemipelvis separation (but without vertical displacement); unstable
 - * pubic diastasis > 2.5 cm
 - * disruption-diastasis of both anterior and posterior sacroiliac joint ligaments with dislocation

• Lateral compression (LC)

Most common type.

- LC I: stable
 - * oblique fracture of pubic rami
 - * ipsilateral anterior compression fracture of the sacral ala

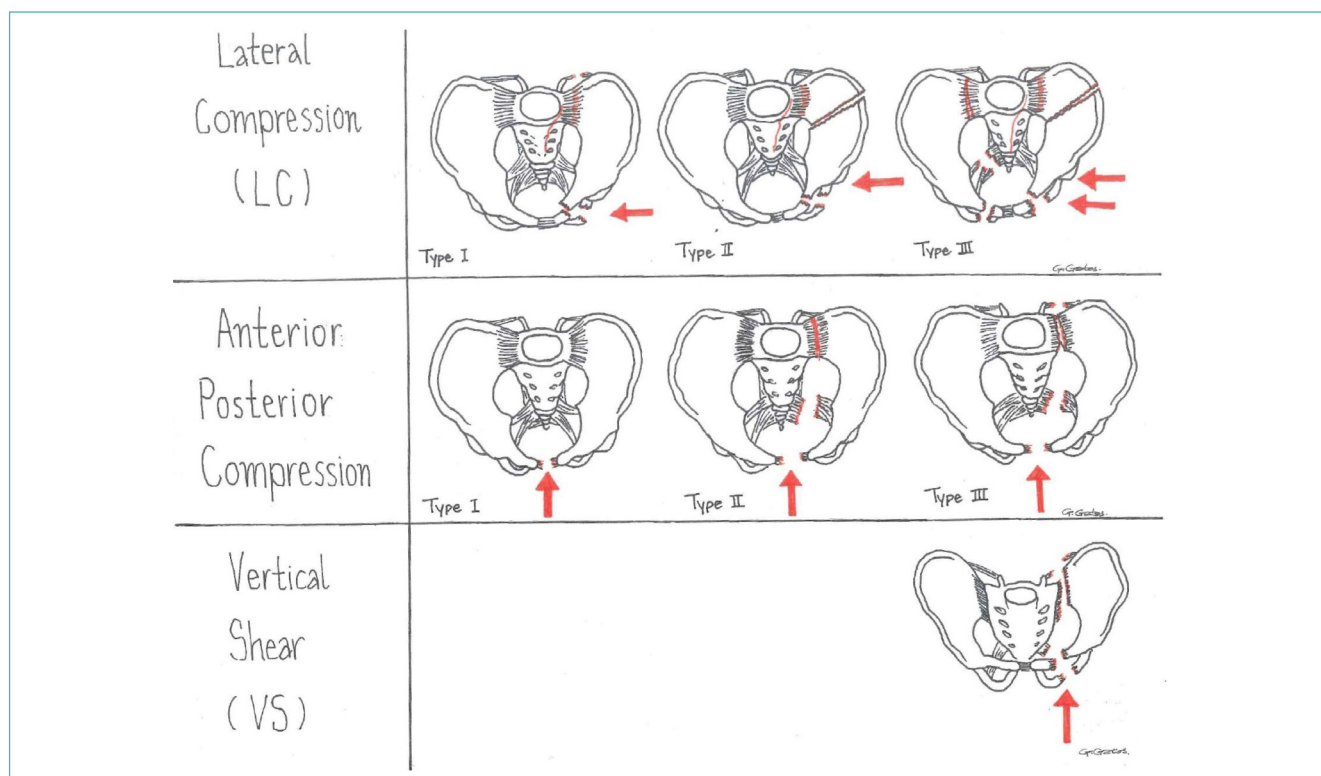


Figure 4. Young and Burgess Classification of pelvic fractures.

- LC II: rotationally unstable, vertically stable
 - * fracture of pubic rami
 - * posterior fracture with dislocation of the ipsilateral iliac wing (crescent fracture)
- LC III: unstable
 - * ipsilateral lateral compression (LC)
 - * contralateral anteroposterior compression (APC)

• Vertical shear (VS)

Most severe and unstable type with a high association of visceral injuries.

- vertical displacement of hemipelvis, pubic and sacroiliac joint fractures

• Combined

Stability depends on the individual components of this injury.

- complex fracture, including a combination of anteroposterior compression (APC), lateral compression (LC), and/or vertical shear (VS).

For sacral fractures there is a specified classification, which distinguishes the fractures depending on the part of sacrum involved. The "Denis et al Classification" described three different zones of injury²⁸.

Denis Classification

- **Zone I:** injuries located lateral to the neuroforamina

- **Zone II:** injuries that involve the neuroforamina, but not the spinal canal

- **Zone III:** injuries that extend into the spinal canal
They are often divided into four different types:

- (1) flexion fracture with anterior angulation
- (2) flexion fracture with anterior angulation and posterior displacement
- (3) extension fractures with anterior displacement
- (4) comminuted fracture of the upper segment of the sacrum without displaced alignment of sacrum

Denis et al found that injuries had a neurologic deficit in 5.9% of patients with Zone 1 fractures, 28.4% of patients with Zone 2 fractures and Zone 3 fractures had the highest incidence of neurological injury reaching a quota of 56,7%²⁹.

In 2013, a new classification was published, regarding only the fragility fractures of the pelvic ring (Fragility Fractures of the Pelvis-FFP). This classification assists in the better understanding of these fractures and can help determine the most suited therapeutic approach³⁰. According to the new categorization, osteoporotic pelvic ring fractures are sorted in four groups depending on pelvic instability, which is the most important factor when choosing the optimized treatment⁴.

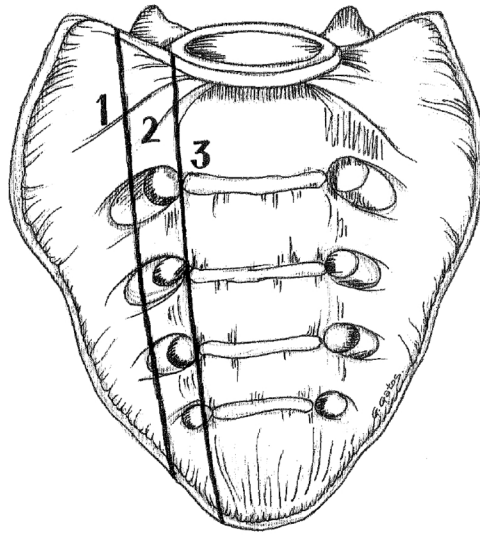


Figure 5. The three zones of "Denis et al Classification" of sacral fractures.

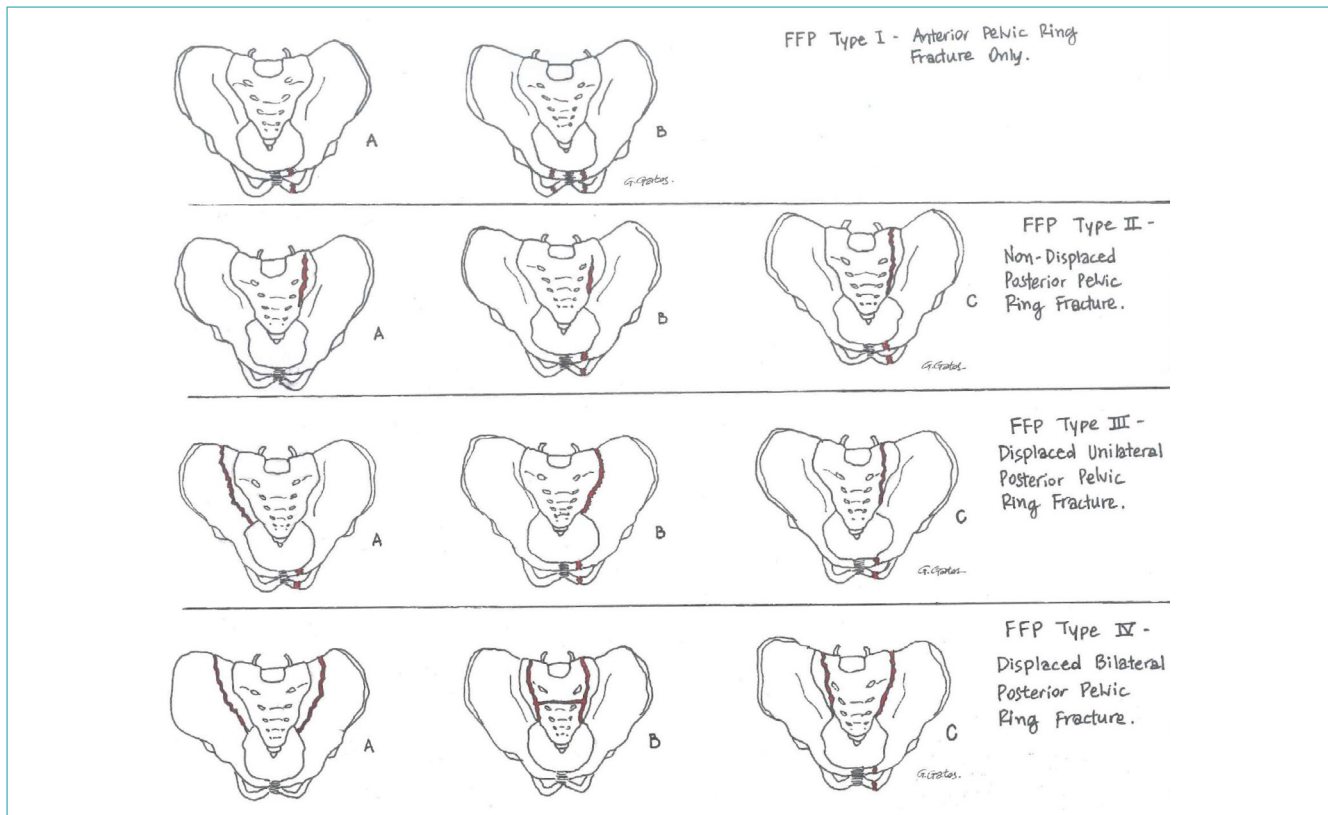


Figure 6. FFP Classification for fragility fractures of the pelvis.

FFP Classification

- **FFP type I:** Isolated anterior pelvic ring fractures without involvement of the posterior structures.
 - * Type Ia: Unilateral fractures
 - * Type Ib: Bilateral fractures
- **FFP type II:** Nondisplaced fractures of the posterior part of the pelvic ring.
 - * Type IIa: Isolated dorsal lesion
 - * Type IIb: Compression fracture of the anterior portion of the lateral mass of the sacrum associated with instability of the anterior pelvic ring
 - * Type IIc: Nondisplaced complete sacral, sacro-iliac or iliac fracture with accompanying instability of the anterior pelvic ring
- **FFP type III:** Displaced unilateral fractures of the posterior pelvic ring with simultaneous instability of the anterior pelvic ring.
 - * Type IIIa: Displaced fracture of the ilium.
 - * Type IIIb: Displaced unilateral iliosacral rupture
 - * Type IIIc: Displaced unilateral fracture of the sacrum
- **FFP type IV:** Bilateral displaced posterior pelvic ring fractures.
 - * Type IVa: Bilateral ilium fracture or bilateral iliosacral rupture
 - * Type IVb: Spinopelvic burst fracture with associated bilateral vertical lesions of the lateral mass of the sacrum and a simultaneous horizontal component connecting the two vertical lesions (U or H fracture of the sacrum)
 - * Type IVc: Combination of multiple displaced instabilities of the posterior pelvic ring

Treatment

The main parameter of fragility pelvic ring fractures is successful pain management and patient rehabilitation.

Hemorrhage is rare in this type of injuries, but the clinician should be alert in patients receiving anticoagulant or antiplatelet medication. Monitoring of patient's vitals for the first 24 hours after the trauma can assist in the fast diagnosis of blood loss and prevent hypovolemic shock. The treatment in such cases includes angiography and embolization of bleeding artery^{32,33}.

The therapeutic algorithm must be adjusted to every patient individually, depending on his pre-traumatic mobility status, concomitant diseases, severity of pain and fracture characteristics³⁴. There are no specific instructions for the management of fragility pelvic ring fractures and most of the times a conservative treatment is preferred. This tactic is suitable for stable fractures, such as FFP I and FFPII injuries. However, unstable fractures generally require surgical intervention. FFPIII and FFPIV fractures, as well as FFPII that failed to be treated conservatively, should be treated surgically. The advanced age and concomitant diseases of osteoporotic pelvic fracture patients make them unsuitable for complicated and prolonged procedures. Thus, minimally invasive

techniques are preferred when dealing with such injuries³¹.

More specifically, the suitable treatment depending on fracture type is analyzed below:

FFPI Fractures: Single anterior pelvic ring fractures are considered stable and can be treated conservatively. When the patient cannot bear the pain, hospitalization is required for analgesic treatment and mobilization under the supervision of a physiotherapist. The analgesic medication must include non-steroid anti-inflammatory agents and many times even opioids. Concomitant diseases of these patients and received medication are creating problem in providing adequate analgesia and drugs should be administered with caution so as to avoid contraindications.

Imaging reassessment is required when the pain does not meliorate, in order to exclude a secondary fracture or dislocation. In these cases, the classification of the fracture is reprocessed and the therapeutic approach may have to be altered.

FFPII Fractures: These injuries concern the posterior part of the pelvic ring and are very rarely dislocated. However, they are seldom single (FFPIIa) and they are usually accompanied by anterior pelvic ring fracture and compression fracture of the sacrum (FFPIIb). They can also be treated conservatively, but immobilization should be extended for a longer period of time. In cases that conservative treatment fails and the patient can not be mobilized, a surgical intervention is discussed. Percutaneous fixation of anterior and posterior parts of pelvic ring are preferred, in order to avoid multi-hour surgical procedures in a patient that has already many morbidities.

FFPIII Fractures: These are unstable fractures of the pelvic ring and can very rarely be treated conservatively. Percutaneous interventions are preferred, excluding cases with great dislocation.

FFPIV Fractures: These are unstable bilateral fractures and can only be confronted surgically. Fixation of posterior and anterior parts of pelvic ring are demanded in order to avoid further dislocation and secondary injuries.

Treatment, conservative or surgical, should always be followed by an assessment of the underlying osteoporosis. Prescription or alteration of patient's medication is vital so as to avoid a new fragility fracture in the future.

Surgical Procedures

Surgical Fixation Of Posterior Part Of Pelvic Ring

Fractures in the posterior part of pelvic ring and lateral parts of sacrum can be treated with percutaneous sacroiliac osteosynthesis with screws, which is a very popular technique in the management of high energy fractures^{35,36}. A 7-8 mm cannulated screw is inserted at S1 level and a second one can be inserted at S2 level if needed. In bilateral fractures, 2 sacroiliac screws can be inserted at the same level or a plate through the sacrum, in order to achieve adequate stability.

Stable incomplete fractures of the sacrum can be managed with sacroplasty, a technique that includes injecting bone

cement in the fragility fracture. On the other hand, unstable sacral fractures call for plate osteosynthesis to achieve the stability needed and allow rehabilitation³⁷.

Fragility fractures that necessitate surgical fixation are usually treated with one sacroiliac screw (48% of patients) or two sacroiliac screws (36% of patients)³⁸. Most screws cross a single sacroiliac joint; however, a quota of those patients need transsacral screws, passing through both sacroiliac joints. A smaller percentage of patients require screw augmentation with polymethylmethacrylate (PMMA) or other void fillers³⁹.

Surgical Fixation Of Anterior Part Of Pelvic Ring

Unstable anterior pelvic ring fractures can be fixated with external osteosynthesis for stabilization and pain management. Percutaneous techniques can also be applied depending on patient's overall status^{35,36} and are usually preferred in the elderly with fragility fractures.

Discussion

Loss of bone density and mass due to osteoporosis is the main factor predisposing the elderly to fractures of the pelvic ring. Fragility fractures can also be encountered in patients with vitamin D deficiency, rheumatoid arthritis, corticosteroid use, prolonged immobilization and people undergoing radiation therapy in the pelvis for numerous therapeutic reasons. However, all these cases are rare and thus fragility and osteoporotic fractures are two names describing the same clinical entity.

The therapeutic target is the mobilization of the patient, since prolonged bed rest can lead to a number of unwanted complications, such as osteopenia, pulmonary infections and thromboembolic incidents. Pain management can also be a very demanding subject in treating fragility pelvic fractures.

Anterior pelvic ring fractures are usually stable and can be managed conservatively. Posterior fractures may be treated conservatively but may also require surgical treatment depending on their stability. Whenever conservative treatment fails, with no improvement of pain and mobilization, an MRI scan should be scheduled to exclude the underdiagnosis and undertreatment of an unstable fracture. The suitable treatment is chosen after taking into consideration patient's overall status, comorbidities and physical condition.

In addition, fragility fracture patients require treatment of osteoporosis to help prevent future fractures. Sufficient calcium intake is of paramount importance, but there is a number of effective therapies and medications, which include antiresorptive agents, that help reduce bone turnover (bisphosphonates, estrogen or hormone therapy, SERMs, calcitonin and denosumab) and anabolic agents, that help the formation of new bone (Teriparatide)⁴⁰.

While pharmacological therapies are the main means for osteoporosis treatment, exercise and strategies to prevent falls are also important⁴⁰.

Conclusion

Osteoporotic pelvic ring fractures form a clinical entity, that often escapes diagnosis due to the low-energy trauma, the misleading clinical presentation and the incomplete patient's medical history. The clinician should be informed and alerted so as to provide the right diagnosis in time, since delayed diagnosis can lead to significant morbidity and disabilities. Treatment can be conservative or surgical but should always be accompanied by the correct management of the responsible underlying disease, osteoporosis.

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