



Pelvic ring fractures in the elderly

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- Pelvic ring fractures are rare injuries in the elderly though the incidence is increasing due to the increasing age of the population.
- Main goal of treatment is the quickest possible re-mobilization to prevent side-effects of immobilization such as osteopenia, pulmonary infections or thromboembolic events.
- Isolated anterior pelvic ring fractures are stable injuries and therefore they usually can be treated conservatively, while pelvic ring injuries with involvement of the posterior ring are considered unstable and should undergo surgical stabilization if the patient's condition allows for it.
- Conservative treatment includes adequate analgesia, guided mobilization with partial weight bearing if possible and osteoanabolic medication.
- The appropriate surgical procedure should be discussed in an interdisciplinary round considering patient's pre-injury condition, anaesthetic and surgical risks.

Keywords: geriatrics; insufficiency fractures; osteoporosis; pelvic ring fractures

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Introduction

Injuries of the pelvic ring are rare fractures compared with all other fractures and occur with two peaks regarding frequency and age. The first peak occurs between the second and third decades, the second peak occurs between the seventh and eighth decades. However, the incidence of pelvic ring fractures rises with increasing age. The immobilization associated with pelvic ring fractures has severe side effects, especially for the elderly, so the main focus within the treatment of these injuries must be on the mobilization of patients, which should happen as early as possible. This article gives an overview of epidemiology, diagnostic and therapeutic options and aftercare regarding pelvic ring injuries in the elderly.

Anatomy and biomechanics of the pelvic ring

The pelvic ring consists of the sacrum and the two hip bones (each one of them consisting of an ischium, ilium and pubic bone) which are connected by three joints, namely two sacroiliac (SI) joints between the sacral bone and the iliac wings, and the symphysis, which connects the two pubic rami. While the symphysis is composed of a combination of hyaline and fibrous cartilage,¹ the SI joints mainly consist of fibrous cartilage combined with a strong joint capsule and strong ligaments.²⁻⁴

In the orthopaedic trauma context, the pelvic ring is divided into a posterior and an anterior part.⁵ The posterior pelvic ring is defined as the part between the two SI joints including the two SI joints and the sacral bone. The anterior part reaches from the anterior columns of the acetabula along the pubic rami to the symphysis. Between the anterior and the posterior parts of the pelvic ring, the two acetabula are located within the iliopectineal lines and the quadrilateral plates, which function as a bony connection between the anterior and the posterior pelvic ring. The anterior pelvic ring mainly consists of the pubic bone. Beginning at the symphysis it divides into two branches, the superior and inferior pubic rami. Laterally, the superior pubic rami pass into the anterior columns of the acetabula, and the inferior pubic rami act as a bridge between the pubic and the ischial bones.

Functionally, the pelvic ring serves as a border for the intrapelvic organs on one hand and is the insertion point of the gluteal hamstrings, the abdominal muscles and the pelvic floor muscles on the other hand. Therefore, the pelvic ring plays a crucial role in the stabilization of the trunk as well as the mobility of the hip joints.⁶

Biomechanically, the pelvic ring and especially the superior pubic rami direct the muscle forces during upright walking dorsally towards the SI joints and via the symphysis towards the opposite side.² While the muscle forces are distributed evenly during normal walking, the superior pubic rami are especially stressed when there is

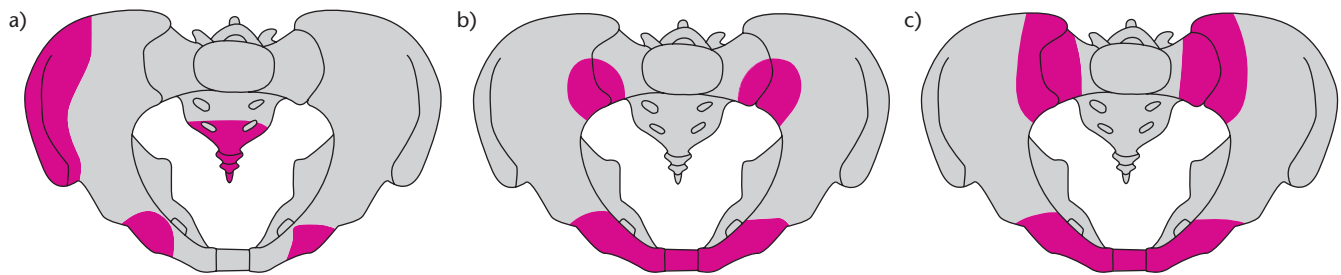


Fig. 1 Classification of pelvic ring fractures according to AO/CCF (Comprehensive Classification of Fracture). a) Type A fracture with injury of the anterior ring or the iliac crest or the sacral bone beneath the SI joints. b) Type B fracture with injury of the anterior ring and partial lesion of the posterior ring. c) Type C fracture with complete interruption of the posterior ring and possibly injury of the anterior ring.

strong pressure from the side. This is the typical mechanism of the lateral compression injury.^{2,3,7}

Classification of pelvic ring fractures

There are different classification systems for pelvic ring fractures. The most widely used system is the AO-classification which is based on the affected part of the pelvic ring and gives information regarding the stability of the pelvic ring (Fig. 1). For proper classification, a CT scan is necessary. Whilst isolated lesions of the anterior pelvic ring are classified as Type A injuries (Fig. 1a), isolated lesions of the posterior ring or combined anterior and posterior pelvic ring fractures are classified as Type B or Type C injuries. The difference between Type B and Type C injuries lies in the posterior lesion. While in Type B injuries the posterior pelvic ring fracture is incomplete (Fig. 1b), in Type C injuries the posterior pelvic ring is disrupted completely (Fig. 1c). Consequently, Type A injuries are considered as stable, while Type B and C injuries are considered as unstable fractures. A more exact classification is the CCF-classification (Comprehensive Classification of Fractures) which uses different qualifiers to describe the respective lesions more exactly.⁵

With respect to the increasing number of osteoporotic pelvic ring fractures, Rommens and Hofmann presented another classification for insufficiency fractures of the pelvic ring in 2013.⁸ The FFP classification (Fragility Fractures of the Pelvis) especially integrates osteoporotic insufficiency fractures into the categorization of the injury. While the FFP classification provides some advantages in the elderly, an evaluation of the benefit is under investigation.

Epidemiology of pelvic ring fractures

About 3% of all fractures affect the pelvic ring.^{9,10} However, a Swedish study in the early 1990s showed that the incidence of pelvic ring fractures notably increases in geriatric patients.¹¹ In particular, female patients over 80 years sustain pelvic ring injuries, with low-energy impact as the

main cause of these injuries. Osteoporosis is the most important risk factor for pelvic ring fractures.^{12–14} It has been shown that about 7% of all osteoporotic fractures affect the pelvic ring, and that in a group of patients over 60 years 94% of pelvic fractures are associated with osteoporosis.^{15–17}

We retrospectively analysed 1024 consecutive patients with pelvic injuries from our prospective single-centre database (from 2012–2017), and we found that 816 of 1024 patients had a pelvic ring injury. Of these 816 patients, 494 were > 65 years old. We routinely used CT scans in every patient with a pelvic injury. Among these elderly patients, 125/494 patients (25.3%) had an isolated fracture of the anterior pelvic ring (Type A), while the majority of the pelvic ring fractures were Type B (288/494, 58.3%) or Type C (81/494, 16.4%) fractures with injuries of the posterior pelvic ring (Fig. 2).

These numbers are in accordance with the literature, and it has been shown that the routine use of CT scans in pelvic ring fractures nearly doubles the detection of posterior pelvic ring lesions.^{18–21} Another entity in fractures of the pelvic ring are insufficiency fractures, which occur without significant trauma. Typically, these fractures affect the posterior pelvic ring with the sacrum and therefore are often missed by plain radiography. While dislocated pelvic ring fractures are best diagnosed with CT scans, insufficiency fractures mainly affect the bone marrow. Therefore, there is still underdiagnosis of osteoporotic insufficiency fractures of the posterior pelvic ring. They are usually better diagnosed using an MRI (which shows an oedema of the bone marrow). Other tools for diagnosing insufficiency fractures of the pelvic ring such as DECT (dual-energy CT) are still under investigation.²²

Complications of pelvic ring fractures

While it is the common consensus that Type B or Type C pelvic ring fractures are severe injuries with a high morbidity risk and mortality rates up to 20% (for Type C injuries), fractures of the anterior pelvic ring are often

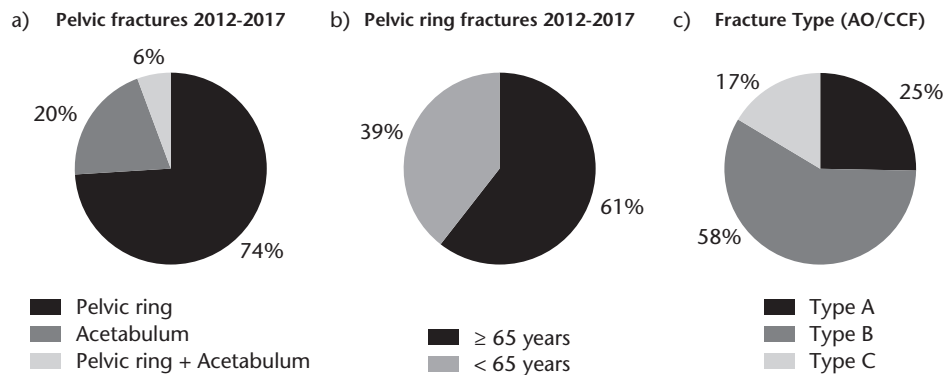


Fig. 2 Epidemiology of 1024 pelvic fractures in 2012–2017. a) The vast majority of the pelvic fractures were pelvic ring fractures (74%), followed by acetabular fractures (20%) and combined pelvic ring/acetabular fractures (6%). b) 61% of the patients with pelvic ring fractures were older than 65 years. c) The most common fracture type was Type B (58%), followed by Type A fractures (25%) and Type C fractures (17%). So, 75% of the pelvic ring fractures were classified as unstable fractures.

considered as minor injuries, especially if they are not displaced. However, even in Type A pelvic ring fractures severe or even life-threatening complications can occur and must be considered. In elderly patients, the risk of developing haemodynamically relevant bleeding from anterior pelvic ring injuries is about 2–3%. In particular, bleeding from branches of the internal iliac artery can cause severe haemorrhage.²³ The risk increases even more with atherosclerosis of the vessels, which causes a higher fragility of the vessels. With the rising number of patients on antithrombotic medication a significant blood loss can occur.^{24–26}

In general, pelvic ring injuries can be associated with some rare but severe complications, namely perforation of the urinary bladder by bony fragments with consequent intrapelvic abscess formation, injury of the obturator nerve, major haemorrhage of the genital organs, or open injuries with complicated infections. However, one of the most frequent complications is iatrogenic: when the primary misinterpretation of the pelvic ring fracture and its instability leads to a prolonged course of treatment.

Assessment of elderly patients with a suspected pelvic ring fracture

Besides the general considerations regarding the medical history of an injured patient, in the elderly, there are some special issues to be considered. Information is necessary about the patient's mobility prior to the accident, need for help prior to the accident, concomitant diseases and medications, and their cognitive and nutritional status. These factors play an important role in the decision-making and planning of the therapy together with the patient and the relatives.

Further assessments include the radiographic studies as well as CT scans. Firstly, a plain radiograph of the pelvis should be initiated. However, if there is no obvious sign of

fracture despite the clinical signs and symptoms of a pelvic ring injury, a CT scan should be performed. In particular, injuries of the posterior pelvic ring might only be detected using CT scans (Fig. 3). Furthermore, as there is a difference in the treatment algorithm between an isolated anterior pelvic ring injury and a combined injury of the anterior and posterior pelvic ring, a CT scan should be indicated usually in the elderly. CT scans can detect these types of injuries better than plain radiography. This is important as it has been shown in the past that the occurrence of pelvic ring fractures showed a shift from solely anterior pelvic ring injuries to combined injuries of the anterior and posterior pelvic ring.¹⁸

Another entity in pelvic ring fractures in the elderly, which must be taken into consideration in patients with a trivial or even no trauma, are insufficiency fractures of the pelvic ring. Despite the fact that most insufficiency fractures are located in the posterior pelvic ring with the sacrum or the SI joints, insufficiency fractures of the anterior pelvic ring can also occur. As these fractures are mostly not dislocated, some of them might only be detected using MRI or dual-energy CT scan.^{22,27}

Therapeutic options for pelvic ring fractures

The most important factor in the treatment of elderly patients with pelvic ring injuries is to sustain their mobility or to treat the consequences of immobility actively.^{28–30} Therefore, the aim of all treatment options – whether non-operative or surgical – must be the mobilization of the patients, as quickly as possible. To make the most appropriate decision, both the stability of the pelvic ring and the history regarding living conditions and mobility prior to the injury should be taken into consideration. Moreover, especially for the insufficiency fractures of the pelvic ring, the bone metabolism should also be assessed.^{8,31–34}

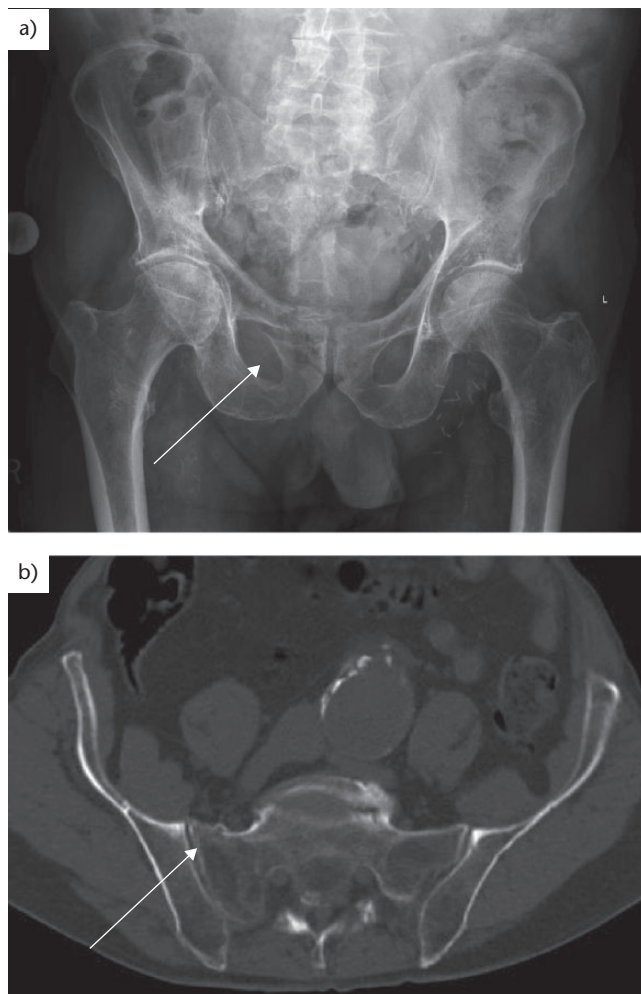


Fig. 3 Possibly missed unstable pelvic ring fracture without CT scan in a 91-year-old male patient. a) Plain pelvic radiography shows a dislocated fracture of the anterior pelvic ring. b) Additional CT scan reveals a ventral impression of the sacral bone on the same side. Classification must be changed from Type A to Type B fracture.

As the posterior pelvic ring is critical for pelvic ring stability, Type A fractures according to AO/CCF usually do not need surgical stabilization, while dislocated Type C fractures according to AO/CCF should undergo surgical stabilization. For the most frequent fractures, Type B or non-dislocated Type C fractures, decision-making can be difficult. If the mobilization of the patient is possible with acceptable pain, we would recommend choosing a non-operative treatment. On the other hand, if mobilization is not possible despite sufficient pain medication, we would recommend early stabilization of the pelvic ring. However, the general condition of the patient and concomitant disorders that may increase the peri-operative surgical or anaesthetic risk, play a crucial role in finding the best individual treatment option.

Our treatment algorithm for geriatric patients with pelvic ring fractures is shown in Figure 4.

Non-operative treatment

Non-operative treatment of pelvic ring fractures consists of three major pillars: Analgesia, mobilization and osteoporotic medication.

The aim of analgesia is to get the patient out of bed. The WHO analgesic step diagram should be followed in these patients. However, especially in geriatric patients, concomitant diseases such as chronic renal failure (avoid NSAIDs) or a chronic hepatic failure (avoid paracetamol) might reduce the choice of different pain medication, which is why opioids are more frequently needed to achieve sufficient analgesia. We recommend the use of tramadol or tilidine in these cases.

Regarding mobilization, the help of physiotherapists and auxiliary devices such as crutches or wheeled walkers are needed. The issue of weight-bearing is difficult. Usually, it depends on the stability of the pelvic ring whether the patients are allowed fully weight-bear or not. Type A fractures according to AO or CCF are stable due to the intact posterior ring, and therefore the patients can be mobilized with full weight-bearing. Patients with Type B fractures or non-dislocated Type C fractures should actually be mobilized with partial weight-bearing (PWB) on the affected side. However, in the geriatric context PWB is often not possible for the patients due to concomitant diseases or the patient's general condition.³⁵ Therefore, we usually allow the patients to mobilize with full weight-bearing according to their ability. A control CT scan after 10 to 12 days of mobilization should be performed to rule out secondary dislocation.

The third pillar of conservative treatment is osteoporotic medication. As the vast majority of pelvic ring fractures in the elderly follow low-energy trauma or insufficiency fractures, they are often associated with osteoporosis. According to the German guidelines for prophylaxis, diagnosis and treatment of osteoporosis we recommend starting a combined oral substitution of vitamin D3 (80IE to 1000IE per day) and calcium (1000mg per day) with the diagnosis of the pelvic ring fracture. As pelvic ring fractures in older patients, and especially insufficiency fractures of the pelvic ring, are a risk factor for further osteoporotic fractures, it is recommended that these patients receive a specific osteoporotic medication. Options are either anti-resorptive drugs such as the bisphosphonates (e.g. alendronate)³⁶ or osteoanabolic drugs such as teriparatide.^{37,38} Especially for teriparatide, it has been shown not only that the risk of new fractures can be reduced, but also that the time to healing in existing fractures is shortened.³⁸

Additionally, patients on antithrombotic medication should be treated as inpatients at least for the first 24 to 48

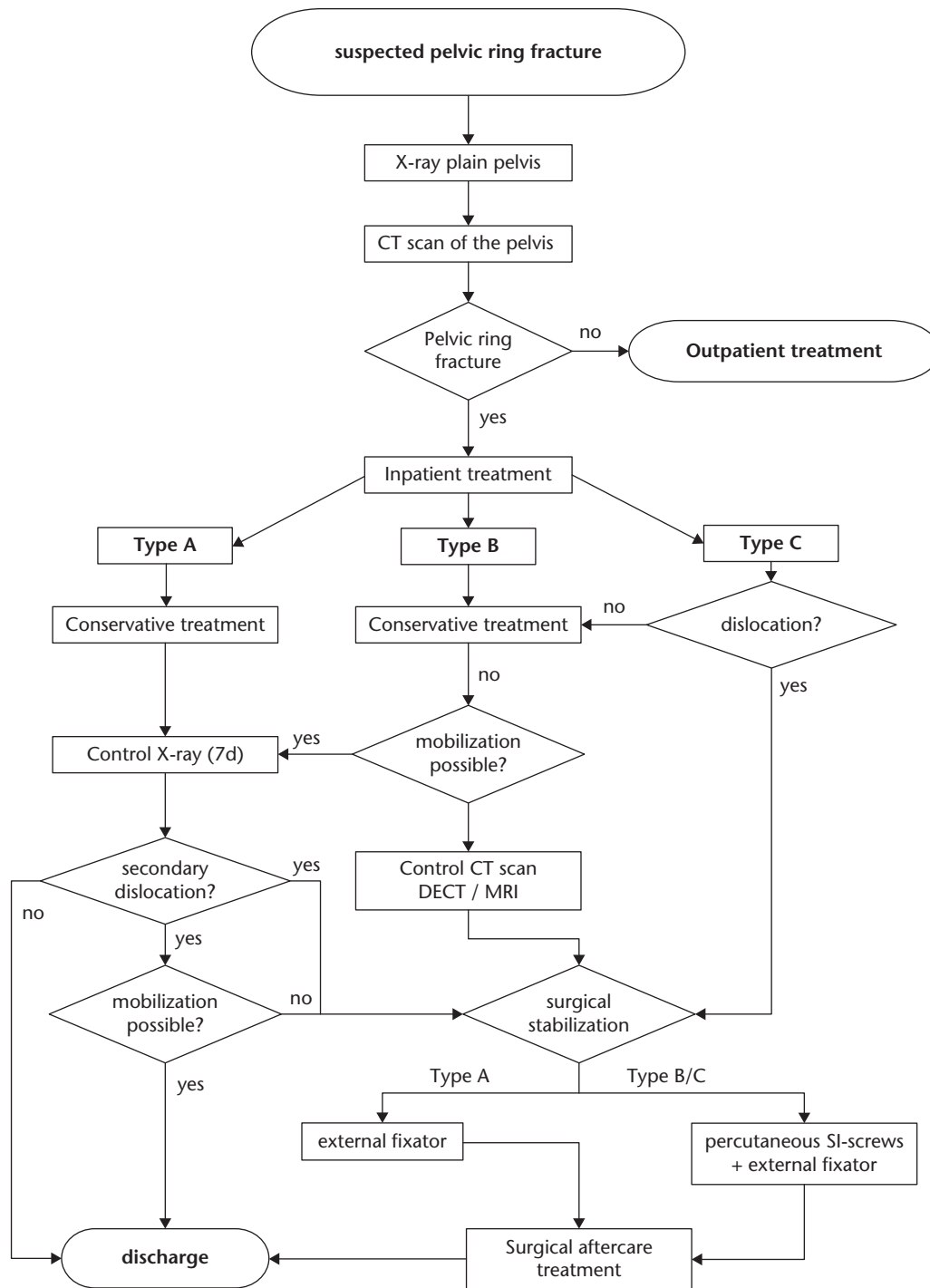


Fig. 4 Treatment algorithm for patients with suspected pelvic ring fracture.

hours with monitoring of vital signs and haemoglobin levels to detect severe haemorrhage.^{23,39} On the other hand, one should be aware of other complications such as thromboembolic events, secondary dislocation or constipation (due to opioid analgesics). That means that patients should be on thrombosis prophylaxis and laxative

medication. According to the 2018 American Society of Haematology (ASH) guideline for the prophylaxis of venous thromboembolism (VTE) we recommend a medical VTE prophylaxis for 6 weeks using unfractionated heparin (UFH) or low-molecular-weight heparins (LMWH) depending on concomitant diseases.⁴⁰ A plain radiograph

of the pelvis or, even better, a control CT scan should be taken after 10 to 12 days of mobilization.

Surgical treatment

The decision to operate on an older patient with a pelvic ring fracture should take several factors into consideration, as mentioned above, especially in Type B pelvic ring fractures or non-dislocated Type C pelvic ring fractures. The indication for surgical stabilization depends on the general condition and concomitant diseases of the patients. Although the conservative treatment is associated with fewer complications than the operative treatment in the short term, Höch et al showed that the mid-term survival rate after two years was significantly higher in patients with surgically stabilized fractures.⁴¹ Major problems associated with surgical treatment are approach-related complications which occur in up to 30% of cases, which is why there are aims to reduce the approach-related risk by minimizing surgical incisions.³²

As the posterior pelvic ring is critical for pelvic ring stability, stabilization of the posterior pelvic ring should be prioritized if stabilization is indicated. For stabilization of non-dislocated or minimally displaced SI-joint disruptions or sacral fractures, the unilateral or bilateral fluoroscopy-guided percutaneous SI screw osteosynthesis is the gold standard. In cases with severe osteoporosis, the screws can be cement-augmented, and intra-operative navigation by 3D-fluoroscopy or CT scan can improve safety and accuracy of the SI screws in the future. For severely displaced SI joint disruptions or sacral fractures, open reduction and internal fixation techniques (ORIF), either through anterior or posterior surgical approaches to the pelvis, are feasible. Stabilization of the anterior ring is not usually necessary in Type A pelvic ring fractures. However, in Type B or Type C pelvic ring fractures we recommend stabilizing the anterior pelvic ring together with the posterior pelvic ring to achieve the best possible stability of the whole pelvic ring in order to facilitate early mobilization of the patients.

A minimally invasive option to stabilize the anterior pelvic ring is the use of the external fixator. This procedure has been well investigated, carries a minimal surgical risk, and can be performed in a short period of time. However, disadvantages of the external fixator are obvious. As the bone healing, and therefore the treatment period, takes at least 6 weeks, discomfort for the patients and a more extensive nursing care (i.e. cleaning the fixator pins to prevent pin infections) must be taken into consideration. If the external fixator is chosen in geriatric patients, the pins should be positioned in the supraacetabular region which is more stable than the iliac crest.

Another surgical option for stabilization of the anterior pelvic ring is ORIF with screw or plate osteosynthesis. The most widely used surgical approaches for ORIF of the anterior pelvic ring include the Pfannenstiel approach or

the modified Stoppa (or intrapelvic) approach. Compared with screw osteosynthesis, ORIF with plate osteosynthesis usually provides better stability, especially in osteoporotic bones. On the other hand, it requires a more extensive surgical approach with an increased rate of approach-related complications.^{32,42} Screw osteosynthesis in pubic rami fractures is possible using one single screw (6.5 mm or 7.3 mm) or using two 3.5 mm screws.⁴² In terms of stability there is no difference between these two techniques in osteoporotic bones.

Less common alternatives to these three established procedures for stabilization of the anterior pelvic ring are the percutaneous cemented bone osteoplasty and the subcutaneous internal fixator, which can be performed minimally invasively.^{43–45} Regarding stability and complication rates, these procedures are under investigation at present.^{32,46,47}

Aftercare after surgical stabilization of pelvic ring fractures

Post-operatively, we actually recommend the same therapeutic regime for analgesia, mobilization and osteoporotic medication as in conservatively treated patients. That means adequate analgesia, according to the WHO analgesic step diagram with respect to concomitant renal or hepatic disorders. Mobilization should be started as early as possible under supervision of a physiotherapist. Ideally, the patients should be mobilized with partial weight-bearing on the affected side for 6 weeks. However, geriatric patients often are not capable of PWB. Therefore, we usually allow the patients to mobilize with weight-bearing according to their ability. Regarding osteoporotic medication, every patient > 65 years of age with a pelvic ring fracture should undergo an evaluation for osteoporosis and a specific treatment should be initiated in case of manifest osteoporosis,^{48–50} as this has been shown to equally improve the bone healing and reduce the risk of another fracture. Of course, if the patient was already put on osteoporotic medication prior to the pelvic ring fracture, this treatment should be continued.

VTE-prophylaxis using UFH or LMWH (depending on a concomitant renal disease with chronic renal failure) is recommended for 6 weeks, if the patient was not on anti-coagulant medication prior to the pelvic ring fracture.

Conclusions

Pelvic ring fractures in the elderly are rare injuries compared with all forms of fractures. However, with increasing age the risk of sustaining one of these fractures increases exponentially. The main goal of treatment is to start mobilization as soon as possible, as immobilization has severe side effects such as osteopenia, pulmonary infections or

thromboembolic events. Concomitant diseases as well as the activity level prior to the injury are decisive for planning the treatment. Whilst isolated anterior pelvic ring fractures in the majority of the cases can be treated conservatively, unstable pelvic ring injuries with injury to the posterior pelvic ring should be surgically stabilized if the patient's condition allows for it. Conservative treatment includes early mobilization under physiotherapeutic guidance, analgesia according to the WHO analgesic step diagram and specific osteoporotic medication. If surgical stabilization is indicated, the posterior pelvic ring usually can be stabilized using percutaneous SI screws, while ORIF with plate osteosynthesis is the more stable procedure for stabilization of the anterior pelvic ring, compared with an external fixator. However, ORIF carries a higher peri-operative risk compared with the external fixator. The decision regarding the appropriate procedure should be discussed at an interdisciplinary round considering pre-injury conditions, peri-operative anaesthetic and surgical risks. If the condition of the patients does not improve, an insufficiency fracture of the pelvic ring should be ruled out using extended imaging such as MRI or dual-energy-CT.

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