# Do We Need a Separate Classification for Fragility Fractures of the Pelvis?

*Pol Maria Rommens, MD, PhD,* Daniel Wagner, MD,* and Alexander Hofmann, MD, PhD†*

**Summary:** Fragility fractures of the pelvis are occurring with increasing frequency. These fractures, occurring in the geriatric patient population, are low-energy injuries and are dissimilar in many ways from those caused by high-energy trauma. For example, the mechanism of injury is different and emergency treatment is usually not necessary. Having diminished bone strength, fragility fracture lines follow areas of low bone mineral density and loss of pelvic stability may increase over time. Based on our clinical experience, we propose a comprehensive classification of pelvic fragility fractures separate from the existing pelvic ring injury classification to provide a framework for distinguishing the different fragility fracture types and their recommended treatment. This classification is derived first from the degree of fracture instability, followed by the location of the fracture. Anterior pelvic fractures are differentiated from posterior pelvic ring fractures, nondisplaced fractures from displaced, and unilateral from bilateral. It is our belief that this new in-depth analysis of these lesions will assist the clinician in identifying the specific patterns of fragility fracture instability and selecting the appropriate choice of treatment. Further investigation is required to determine the ultimate value of this proposed pelvic fragility fracture classification system.

**Key Words:** pelvis, fragility fracture, classification, instability, treatment, minimal invasive fixation

**Level of Evidence:** Diagnostic Level V.

(*J Orthop Trauma* 2019;33:S55–S60)



## INTRODUCTION

Fragility fracture of the pelvis (FFP) is an entity, mainly of the geriatric patient population, occurring with increasing frequency. Sullivan et al[1] looked at the discharge diagnosis of all Medicare patients, who were hospitalized between 1993 and 2010 in the United States. During this 18-year period, the annual incidence of traditional hip fractures peaked in 1996 but declined 25.7% by 2010. On the contrary, the annual incidence of geriatric pelvic ring fractures increased by 24% over the same period. A similar development has been shown to exist in several European countries. Kannus et al documented a decline in hip fractures with a sharp increase of pelvic ring fractures in the same period in Finland.[2,3] Likewise, a high incidence of geriatric pelvic ring fractures has also been seen in the Netherlands and in Germany.[4,5] It is hypothesized that the increase of FFP is related to the high life expectancy in our aging populations and due to better and more intensively used diagnostic tools such as computed tomography (CT) and magnetic resonance imaging (MRI).[6,7] Several risk factors have been identified: female gender, high age, osteoporosis, long-term cortisone intake, long-term immobilization, irradiation of the pelvis after surgical treatment of malignancies (prostate, bladder, ovaria, and uterus).[6–8] The clinical picture and natural course of geriatric patients with FFP are different than those of younger adults, who suffered a pelvic ring fracture.[9,10] In the following contribution, we highlight the differences between pelvic fractures in younger adults versus those occurring in the elderly. These differences form the rationale for the new proposed FFP classification, which will be presented and explained.

Accepted for publication November 7, 2018.

From the *Department for Orthopaedics and Traumatology, University Medical Center, Johannes Gutenberg-University, Mainz, Germany; and †Department for Traumatology and Orthopaedics, Westpfalz-Clinic Kaiserslautern, Kaiserslautern, Germany.

The authors report no conflict of interest.

Reprints: Pol Maria Rommens, MD, PhD, Department for Orthopaedics and Traumatology, University Medical Center, Johannes Gutenberg-University, Langenbeckstrasse 1, 55131 Mainz, Germany (e-mail: pol.rommens@unimedizin-mainz.de).



**DOI: 10.1097/BOT.0000000000001402**

## SPECIFIC CHARACTERISTICS OF HIGH-ENERGY VERSUS FRAGILITY FRACTURES OF THE PELVIS

Pelvic fractures in younger adults occur due to high-energy trauma, such as motorcycle or motorcar accidents, falls from great height, or crush injuries.[11,12] The trauma mechanism in elderly patients is of low energy: typically, a domestic fall from a standing or sitting position.[13,14] In some patients, repetitive small accidents occurred or the trauma event is not memorable.

### Clinical Picture

In high-energy pelvic trauma, the trauma itself and the displacement of fracture fragments lead to major soft tissue damage and physiologically important blood loss. Pelvic ring bony instability is combined with hemodynamic instability: the patients often arrive in hemodynamic shock or require blood transfusion. In contradistinction, patients with a fragility fracture present with intense, immobilizing pain in the groin, the pubic region, and/or the low back and the buttocks.[14,15] They have not sustained major injury to the soft tissues and are not hemodynamically unstable on arrival to the treating institution.

## Damage Control Measures

The preservation of airways, breathing and circulation (ABCs) of Advanced Trauma Life Support (ATLS) apply for high-energy pelvic trauma patients.[12,16] Additional measures, which have proven to diminish blood loss, are used to stabilize the pelvic ring, such as the application of a pelvic sheet or pelvic binder, of a C-clamp, or an external fixator.[17,18] All these treatment measures control the dimension of the bony pelvis and provisionally restore stability. Pelvic packing and angiography with selective embolization are additional measures, which are beneficial for nonresponders of the first damage control measures.[16,18,19] Although patients with FFP are not initially hemodynamically unstable, ongoing venous or arterial bleeding may occur, not from the magnitude of the traumatic event but due to the anticoagulant activity of preexisting drug therapies common to the geriatric population.[20,21] Hemodynamic instability then develops over time and can become life-threatening. It therefore is recommended to monitor geriatric patients with FFP for at least 24 hours in the hospital.[21] In case of hemodynamic instability, angiography and selective embolization are treatment of choice.[21,22] Otherwise, no damage control measures are needed.

## Early Versus Delayed Mortality

In high-energy trauma, there is a considerable risk to die early due to pelvic hemorrhage or concomitant injuries such as traumatic brain injury, thoracic or abdominal trauma.[9] This is also true for adults older than 65 years, who sustain high-energy pelvic trauma.[23] However, geriatric patients, who sustain low-energy pelvic trauma, do not die early but rather later due to their preexisting medical comorbidities.[24] Andrich et al[10] found an excess mortality in the first 8 months for inpatient treated older patients. van Dijk et al[25] showed that survival of patients with an isolated pubic ramus fracture was significantly lower than that of controls in a 10-year follow-up study of 99 patients with the age of 60 years or older. The mortality rates at 1, 5, and 10 years were 24.7%, 64.4%, and 93.8%, respectively. One-third of the mortality was due to cardiovascular events.[25] Therefore, it is evident that patients with high-energy pelvic trauma are more likely to die early due to the consequences of trauma and associated injuries, whereas geriatric patients with low-energy pelvic trauma die later due to their comorbidities.

## Diminished Bone Mineral Density

Patients with FFP exhibit a decreased bone mineral density in the pelvic bones.[26,27] The bone loss is not equally distributed but follows a consistent pattern. Wagner et al showed that excessive bone loss is situated in both sacral ala and in the sacral bodies at the transition of S1 to S2 and of S2 to S3.[26,27] In some patients, there is a complete loss of bone mass in the sacral ala, described as an alar void.[28]

## Different Fracture Morphology

Different vectors of traumatizing energy are responsible for typical fracture patterns in high-energy pelvic trauma. These vectors form the basis of the OTA/AO and Young–Burgess classifications.[11,29,30] Anteroposterior compression forces cause a diastasis in the anterior aspect of the pelvic ring and damage to the anterior sacroiliac ligaments with rotational instability of the injured hemipelvis. Lateral compression forces cause crush zones in the sacrum and overriding of fracture fragments in the anterior pelvis. Vertical shear forces give rise to complete disruption of the anterior and posterior pelvis with vertical displacement of the injured hemipelvis.

The specific and consistent decrease of bone mass throughout the sacrum explains the distinctive fracture morphology specific to fragility fractures of the sacrum. Linstrom et al[28] described the different patterns in a case study of 108 patients. Vertical sacral fractures typically occur

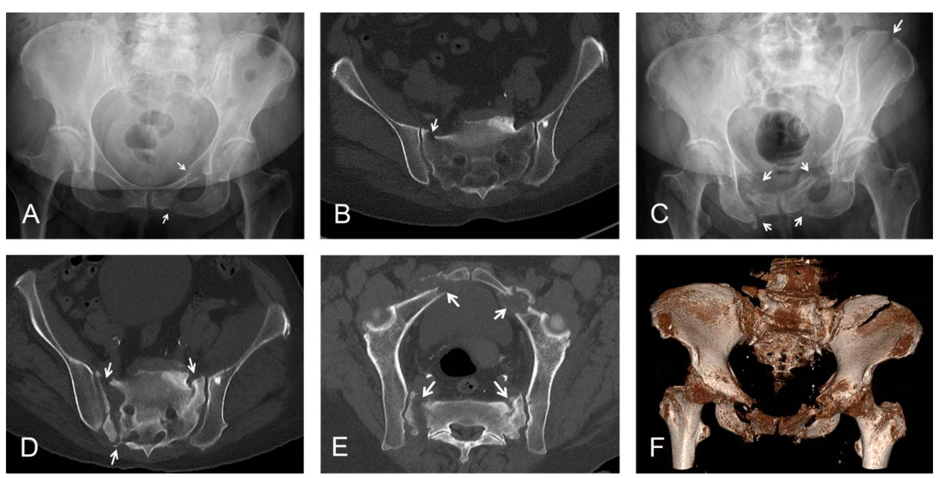


**FIGURE 1.** A–F, A 66-year-old woman sustained a domestic fall. A, AP pelvic radiograph at the time of injury shows left-sided superior and inferior pubic ramus fractures (arrows). B, An axial CT section through the posterior pelvis at that time reveals a fracture of the anterior cortex of the right sacral ala (arrow). This would be a type IIb lesion in the proposed FFP classification. The patient was treated conservatively and an active physiotherapy started. C, Six weeks later, the patient presented with immobilizing pain in the anterior and posterior pelvis. An AP pelvic radiograph at that time reveals bilateral fractures of both pubic rami with callus formation and a fracture of the left ilium (arrows). D, An axial CT section through the posterior pelvis at the same level as in (B) shows a complete fracture of the right and an incomplete fracture of the left sacral ala (arrows). The fracture of the left ilium is not visible at this level. E, An oblique CT reconstruction through the plane of the pelvic brim obtained at the same time as (C and D) shows bilateral fractures of the anterior and posterior pelvis (arrows). There also is a cortical interruption of the left ilium. F, Three-dimensional reconstruction of the whole pelvic ring shows the progression of the lesion from the original shown in (A and B). The FFP type IIb lesion has changed into a FFP type IVc lesion.

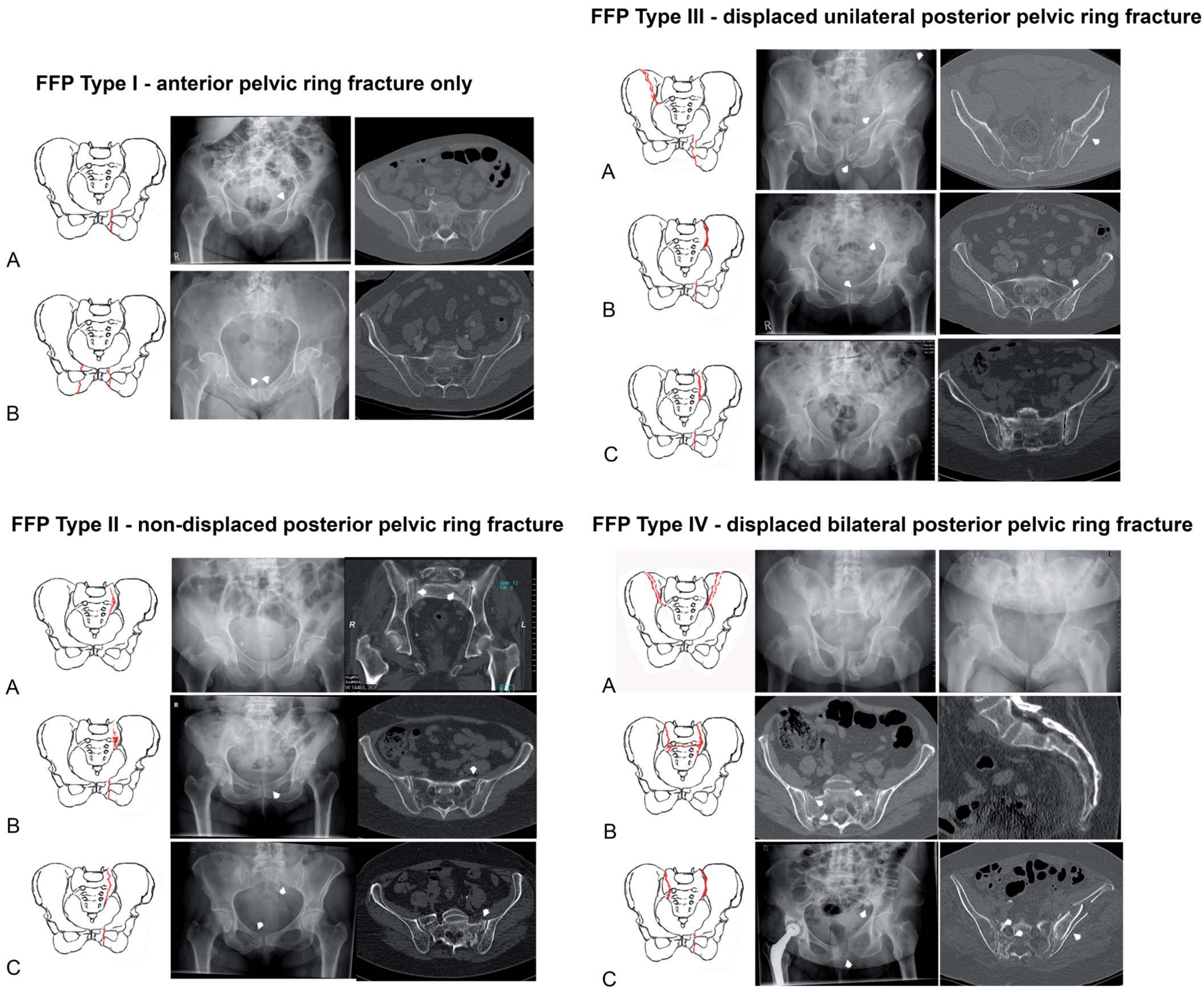


**FIGURE 2.** Comprehensive classification of fragility fractures of the pelvis. Reprinted with permission. Copyright 2013. Elsevier.[34]

through the sacral ala, leaving the neuroforamina intact. Frequently, bilateral sacral ala fractures with a horizontal connection between the left and the right fractures are seen. These H-type fractures technically are spinopelvic dissociations, but their clinical picture and degree of instability are not comparable with the suicide jumper's fracture of the younger adults.[31] The frequently observed bilateral pathology in FFP cannot be classified, when using the OTA/AO and Young–Burgess classification systems.

## Progress of Instability

Regularly, a progress of instability due to the occurrence and progression of additional fractures is observed in FFP.[7] Trauma history starts with a pubic ramus fracture due to low-energy injury, which is treated conservatively. Over time, due to recurrent falls or too aggressive mobilization or indeterminant causes, new fractures of the anterior and posterior pelvis occur and add to the existing ones. The instability of the pelvic ring increases in accordance with the increasing number of fractures. Instead of an explosion, which is seen after high-energy pelvic trauma, the evolution of FFP is similar to an implosion or collapse. Ligaments remain strong and become less elastic, whereas bone gets weaker due to decrease in bone mineral density due to the patient's age.[32] Pure dislocations and large displacements of fracture fragments are rare as the ligaments continue to form an envelope around the failed bone.[33] Continuing motion between fracture fragments in cases of chronic instability leads to bone resorption with destruction of the neighboring sacroiliac joint or pubic symphysis. In high-energy pelvic disruptions, the posttraumatic fracture morphology remains unchanged despite the type of treatment or occurrence of complications during treatment. The evolution to complete pelvic collapse is unique for FFP (Figs. 1A–F).

The above-mentioned differences are all arguments for a new classification system. It should provide a reliable

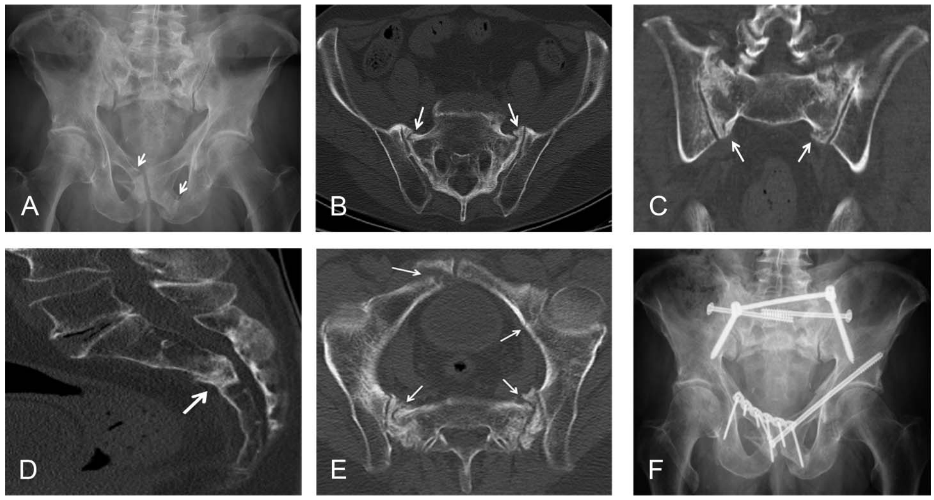


**FIGURE 3.** A–F, A 76-year-old man with a history of prostate cancer complained of immobilizing pain in the anterior and posterior pelvis 1.5 years after pelvic irradiation. A, AP pelvic radiograph at that time shows displaced fractures of the right superior and left inferior pubic ramus (arrows). B, An axial CT section through the posterior pelvis reveals bilateral sacral ala fractures near the iliosacral joints (arrows). C, A coronal CT section reveals bilateral complete fractures of the sacral ala (arrows). D, A sagittal CT section through the midline reveals a fracture between S2 and S3 with slight flexion deformity (arrow). E, A CT reconstruction in the plane of the pelvic brim gives an overview of all the fracture lines, consistent with a FFP type IVc injury. A fracture at the anterior lip of the left acetabulum is also identified (arrows). F, The postoperative AP radiograph shows a transiliac internal fixator and 2 iliosacral screws inserted into the posterior pelvis. A plate osteosynthesis and retrograde transpubic screw fixation were performed anteriorly.

framework for discriminating different FFP morphologies and support decision making.

## COMPREHENSIVE FFP CLASSIFICATION

The classification is based on the analysis of 245 patients aged 65 years or older, who have been admitted due to a FFP at the Department of Orthopaedics and Traumatology of the University Medical Centre of the Johannes Gutenberg-University of Mainz, Germany (Fig. 2).[34] Diagnosis was based on 3 conventional x-rays (anteroposterior pelvis, pelvic inlet, and pelvic outlet) and CT of the pelvic ring. MRI is of high value when fractures of the posterior pelvis cannot be identified in conventional x-rays and CT despite clear clinical signs of intensive pain in the lower back.[33,35] However, MRI was not used as a diagnostic tool as it was not available to us on short-term notice for acute fracture patients.

The first criterion of the classification is loss of stability in the pelvic ring. Loss of stability is responsible for clinical signs, such as pain, reduced mobility, and loss of independency. It is a major criterion in our treatment algorithm. The more unstable the pelvic ring is, the more there is a need for stabilization by surgical means.[15] The second criterion is the location of the instability (ilium vs. iliosacral joint vs. sacrum). The location has a decisive influence on the type of surgical treatment, if needed.

We distinguish 4 different categories of instability: slight, moderate, high, and highest loss of stability.[34] The first category represents a FFP with an instability in the anterior pelvis only. Type Ia is a unilateral pubic ramus fracture and type Ib is a bilateral pubic ramus fracture. In our series, FFP type I account for only 17.5% of the fractures. Consequently, more than 80% had a posterior pelvic instability. These data underline the importance of CT examination of the pelvis when a pubic ramus fracture is diagnosed. When only conventional x-rays are taken, there is a real risk of underestimating severity of instability and undertreatment.[33,35] FFP type II account for more than 50% of FFP. They are characterized by a nondisplaced posterior pelvic ring fracture, which are defined as a crush zone in the sacral ala or any fracture without deformation of anatomy. Conventional x-rays and CT images must be analyzed together, as CT images do not always clearly depict displacement. FFP type IIa fractures are nondisplaced posterior pelvic ring fractures without anterior pelvic ring fracture, FFP type IIb has a crush zone in the sacral ala (Fig. 1B), and FFP type IIc is a nondisplaced sacral, sacroiliac, or iliac fracture with an anterior pelvic ring fracture. FFP type III fractures are characterized by a unilaterally displaced posterior pelvic ring fracture with an anterior pelvic ring fracture. FFP type IIIa has a posterior fracture through the ilium, FFP type IIIb through the iliosacral joint, and FFP type IIIc through the sacrum. FFP type III accounts for 10% of FFP. Displacement in these cases does not mean translation or vertical displacement, as is the situation in high-energy pelvic fractures. In FFP, large displacements infrequently occur. As displacement is small, it may be difficult to

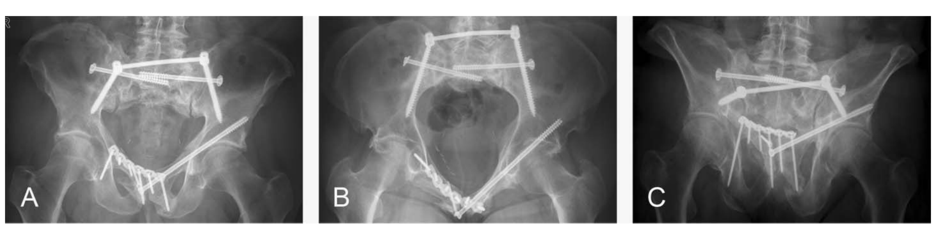


**FIGURE 4.** A–C, Six months after surgery, the patient described in Figure 3 was able to walk without crutches and with minimal pain with the fractures healed without further displacement, as shown in the (A) AP, (B) inlet, and (C) outlet pelvic radiographs.

 

distinguish an FFP type IIc from a FFP type IIIc lesion. The clinical picture with intensity of pain and loss of mobility helps to differentiate between the categories. As mentioned above, instability may also increase over time with FFP changing from a category of lower to a category of higher instability (Fig. 1F). FFP type IV is a bilaterally displaced posterior pelvic ring fracture with or without an anterior pelvic ring fracture. Type IVa fractures are characterized by a bilateral ilium fracture, type IVb are spinopelvic dissociations with an H-type sacral fracture, and type IVc are combinations of different types of posterior pelvic ring fractures. Surprisingly, the incidence of FFP type IV was almost 20% in our series. We estimate that many patients presenting to us with a FFP type IV initially had a lesser FFP type, which had a chronic progression of instability, ending in a complete collapse of the pelvic ring.[7,34]

## SIGNIFICANCE FOR MANAGEMENT

The comprehensive classification provides a framework for the choice of treatment. The ultimate goal is pain-free mobilization, which will enable the patient's full participation in activities of daily living. Our treatment regimen consists of pain therapy and physiotherapy. FFP type I are treated conservatively. We expect out-of-bed mobilization in less than 1 week after trauma.[36] FFP type II fractures are treated conservatively as well. As the posterior pelvic ring is also fractured, we expect a slower progression to pain-free mobilization. When the patient cannot be mobilized within 1 week or complaints get worse, a minimal invasive stabilization should be considered and discussed with the patient.[37,38] The surgical procedure aims at stabilizing the fracture and preventing further progression of instability, using minimally invasive surgical techniques.

For FFP types III and IV, the pelvic ring should be stabilized primarily by operative means. Different procedures such as iliosacral screw, transiliac, or transsacral bar osteosynthesis are available (Figs. 3A–H and Figs. 4A–C).[39–41] Lumbopelvic fixation is another procedure, which prevents protrusion of the lumbosacral segment into the small pelvis.[42] As displacement usually is small, percutaneous procedures can be used in FFP type III and IV as well. After surgery, patients are mobilized as soon as possible and as tolerated.

Surgical therapy and physiotherapy must be enhanced with therapy for osteoporosis in accordance with the recommendations of others. The use of teriparatide has proven to promote fracture healing of pubic rami fractures and should be considered.[43] Interdisciplinary management of geriatric patients with comorbidities is associated with improved outcome and diminishes hospital length of stay.[44] This is also an important part of our overall treatment.

## CONCLUSIONS

Fragility fractures of the pelvis are occurring with increasing frequency. These fractures are low-energy injuries and are dissimilar in many ways from those caused by high-energy trauma. Our proposed FFP comprehensive classification system provides a framework for differentiating different degrees of instability and identifying fracture progression. In addition, the categories can be linked to specific appropriate treatment plans. Further investigation is required to determine the ultimate value of this proposed pelvic fragility fracture classification system and the optimal treatment of each fracture type.

## REFERENCES


1. Sullivan MP, Baldwin KDJ. Donegan DJ, et al. Geriatric fractures about the hip: divergent patterns in the proximal femur, acetabulum, and pelvis. *Orthopedics*. 2014;37:151–157.
2. Kannus P, Niemi S, Parkkari J, et al. Continuously declining incidence of hip fracture in Finland: analysis of nationwide database in 1970–2016. *Arch Gerontol Geriatr.* 2018;77:64–67.
3. Kannus P, Parkkari J, Niemi S, et al. Low-trauma pelvic fractures in elderly Finns in 1970–2013. *Calcif Tissue Int.* 2015;97:577–580.
4. Nanninga GL, de Leur K, Panneman MJ, et al. Increasing rates of pelvic fractures among older adults: the Netherlands, 1986–2011. *Age Ageing*. 2014;43:648–653.
5. Andrich S, Haastert B, Neuhaus E, et al. Epidemiology of pelvic fractures in Germany: considerably high incidence rates among older people. *PLoS One.* 2015;10:e0139078.
6. Maier GS, Kolbow K, Lazovic D, et al. Risk factors for pelvic insufficiency fractures and outcome after conservative therapy. *Arch Gerontol Geriatr.* 2016;67:80–85.
7. Rommens PM, Wagner D, Hofmann A. Fragility fractures of the pelvis. *JBJS Rev.* 2017;5. pii: 01874474-201703000-00004 doi: 10.2106/JBJS.RVW.16.00057.
8. Breuil V, Roux CH, Carle GF. Pelvic fractures: epidemiology, consequences, and medical management. *Curr Opin Rheumatol.* 2016;28:442–447.
9. Pohlemann T, Stengel D, Tosounidis G, et al. Survival trends and predictors of mortality in severe pelvic trauma: estimates from the German Pelvic Trauma Registry Initiative. *Injury*. 2011;42:997–1002.
10. Andrich S, Haastert B, Neuhaus E, et al. Excess mortality after pelvic fractures among older people. *J Bone Miner Res.* 2017;32:1789–1801.
11. Dalal SA, Burgess AR, Siegel JH, et al. Pelvic fracture in multiple trauma: classification by mechanism is key to pattern of organ injury, resuscitative requirements, and outcome. *J Trauma.* 1989;29:981–1000.
12. McCormack R, Strauss EJ, Alwattar BJ, et al. Diagnosis and management of pelvic fractures. *Bull NYU Hosp Joint Dis.* 2010;68:281–291.
13. Krappinger D, Kammerlander C, Hak DJ, et al. Low-energy osteoporotic pelvic fractures. *Arch Orthop Trauma Surg.* 2010;130:1167–1175.
14. Finiels H, Finiels PJ, Jacquot JM, et al. Fractures of the sacrum caused by bone insufficiency: meta-analysis of 508 cases. *Presse Med.* 1997;26:1568–1573.
15. Oberkircher L, Ruchholtz S, Rommens PM, et al. Osteoporotic pelvic fractures. *Dtsch Arztebl Int.* 2018;115:70–80.
16. Rommens PM, Hofmann A, Hessmann MH. Management of acute hemorrhage in pelvic trauma: an overview. *Eur J Trauma Emerg Surg.* 2010;36:91–99.
17. Giannoudis PV, Pape HC. Damage control orthopaedics in unstable pelvic ring injuries. *Injury*. 2004;35:671–677.
18. Marzi I, Lustenberger T. Management of bleeding pelvic fractures. *Scand J Surg.* 2014;103:104–111.
19. Cothren CC, Osborn PM, Moore EE, et al. Preperitonal pelvic packing for hemodynamically unstable pelvic fractures: a paradigm shift. *J Trauma.* 2007;62:834–839.
20. Krappinger D, Zegg M, Jeske C, et al. Hemorrhage after low-energy pelvic trauma. *J Trauma.* 2012;72:437–442.
21. Dietz SO, Hofmann A, Rommens PM. Hemorrhage in fragility fractures of the pelvis. *Eur J Trauma Emerg Surg.* 2015;41:363–367.
22. Rommens PM, Kuhn S. Principles of damage control in the elderly. Chapter 23 In: *"Damage Control Management in the Polytrauma Patient"*, Pape HC, Peitzman AB, Rotondo MF, et al, eds. Springer International Publishing AG;2017:249–261.
23. Keil DS, Gross S, Seymour RB, et al. Mortality after high-energy pelvic fractures of age 65 years or older. *J Orthop Trauma.* 2018;32:124–128.
24. Schmitz P, Lüdeck S, Baumann F, et al. Patient-related quality of life after pelvic ring fractures in elderly. *Int Orthop.* 2018. doi: 10.1007/s00264-018-4030-8;[epub ahead of print].

25. van Dijk WA, Poeze M, van Helden SH, et al. Ten-year mortality among hospitalised patients with fractures of the pubic rami. *Injury*. 2010;41: 411–414.
26. Wagner D, Kamer L, Sawaguchi T, et al. Sacral bone mass distribution assessed by averaged three-dimensional CT models: implications for pathogenesis and treatment of fragility fractures of the sacrum. *J Bone Joint Surg Am.* 2016;98:584–590.
27. Wagner D, Hofmann A, Kamer L, et al. Fragility fractures of the sacrum occur in elderly patients with severe loss of sacral bone mass. *Arch Orthop Trauma Surg.* 2018;138:971–977.
28. Linstrom NJ, Heiserman JE, Kortman KE, et al. Anatomical and biomechanical analyses of the unique and consistent locations of sacral insufficiency fractures. *Spine (Phila Pa 1976).* 2009;34: 309–315.
29. Pennal GF, Tile M, Waddell JP, et al. Pelvic disruption: assessment and classification. *Clin Orthop.* 1980;151:12–21.
30. Fracture and dislocation compendium—2018. Orthopaedic Trauma Association and AO-Foundation. *J Orthop Trauma.* 2018;32.
31. Roy-Camille R, Saillant G, Gagna G, et al. Transverse fracture of the upper sacrum. Suicidal jumper's fracture. *Spine*. 1985;10:838–845.
32. Hammer N, Lingslebe U, Aust G, et al. Ultimate stress and age-dependent deformation characteristics of the iliotibial tract. *J Mech Behav Biomed Mater.* 2012;16:81–86.
33. Kreitner KF. Radiological assessment. Chapter 6 In: *"Fragility Fractures of the Pelvis."* Rommens PM, Hofmann A, eds. London, Great Britain: Springer International Publishing AG; 2017:55–65.
34. Rommens PM, Hofmann A. Comprehensive classification of fragility fractures of the pelvic ring: recommendations for surgical treatment. *Injury*. 2013;44:1733–1744.
35. Nüchtern JV, Hartel MJ, Henes FO, et al. Significance of clinical examination, CT and MRI scan in the diagnosis of posterior pelvic ring fractures. *Injury*. 2015;46:315–319.
36. Sato T, Shiota N, Sawaguchi T. Non-operative treatment. Chapter 8 In: *"Fragility Fractures of the Pelvis"*. Rommens P, Hofmann A, eds. London, Great Britain: Springer International Publishing AG; 2017:87–99.
37. Rommens PM, Wagner D, Hofmann A. Minimal invasive surgical treatment of fragility fractures of the pelvis. *Chirurgia (Bucur)*. 2017;112:524–537.
38. Wagner D, Ossendorf C, Gruszka D, et al. Fragility fractures of the sacrum: how to identify and when to treat surgically? *Eur J Trauma Emerg Surg.* 2015;41:349–362.
39. Hopf JC, Krieglstein CF, Müller LP, et al. Percutaneous iliosacral screw fixation after osteoporotic posterior ring fractures of the pelvis reduces pain significantly in elderly patients. *Injury*. 2015;46:1631–1636.
40. Dienstknecht T, Berner A, Lenich A, et al. A minimally invasive stabilizing system for dorsal pelvic ring injuries. *Clin Orthop Relat Res.* 2011; 469:3209–3217.
41. Mehling I, Hessmann MH, Rommens PM. Stabilization of fatigue fractures of the dorsal pelvis with a trans-sacral bar. Operative technique and outcome. *Injury*. 2012;43:446–451.
42. Schildhauer AT. Chapman JR. Triangular osteosynthesis and lumbopelvic fixation. Chapter 16 In: *"Fragility Fractures of the Pelvis"*. Rommens P, Hofmann A, eds. London, Great Britain: Springer International Publishing AG;2017:177–192.
43. Peichl P, Holzer LA, Maier R, et al. Parathyroid hormone 1-84 accelerates fracture-healing in pubic bones of elderly osteoporotic women. *J Bone Joint Surg Am.* 2011;93:1583–1587.
44. Kates SL, Mears SC. A guide to improving the care of patients with fragility fractures. *Geriatric Orthop Surg Rehabil.* 2015;6:58–120.