

Current consensus and clinical approach to fragility fractures of the pelvis: an international survey of expert opinion

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Introduction: Fragility fractures of the pelvis (FFP) in elderly patients are an underappreciated injury with a significant impact on mobility, independency, and mortality of affected patients and is a growing burden for society/health care. Given the lack of clinical practice guidelines for these injuries, the authors postulate there is heterogeneity in the current use of diagnostic modalities, treatment strategies (both operative and nonoperative), and follow-up of patients with FFP. The goal of this study was to assess international variation in the management of FFP.

Methods: All International Orthopaedic Trauma Association (IOTA) steering committee members were asked to select 15 to 20 experts in the field of pelvic surgery to complete a case-driven international survey. The survey addresses the definition of FFP, use of diagnostic modalities, timing of imaging, mobilization protocols, and indications for surgical management.

Results: In total, 143 experts within 16 IOTA societies responded to the survey. Among the experts, 86% have >10 years of experience and 80% works in a referral center for pelvic fractures. However, only 44% of experts reported having an institutional protocol for the management of FFP. More than 89% of experts feel the need for a (inter)national evidence-based guideline. Of all experts, 73% use both radiographs and computed tomography (CT) to diagnose FFP, of which 63% routinely use CT and 35% used CT imaging selectively. Treatment strategies of anterior ring fractures were compared with combined (anterior and posterior ring) fractures. Thirty-seven percent of patients with anterior ring fractures get admitted to the hospital compared with 75% of patients with combined fractures. Experts allow pain-guided mobilization in 72% after anterior ring fracture but propose restricted weight-bearing in case of a combined fracture in 44% of patients. Surgical indications are primarily based on the inability to mobilize during hospital admission (33%) or persistent pain after 2 weeks (25%). Over 92% plan outpatient follow-up independent of the type of fracture or treatment.

Conclusion: This study shows that there is a great worldwide heterogeneity in the current use of diagnostic modalities and both nonoperative and surgical management of FFP, emphasizing the need for a consensus meeting or guideline.

Key Words: fragility fractures of the pelvis, diagnostics, (non)operative treatment, follow-up strategies, osteoporosis

1. Introduction

Fragility fractures of the pelvis (FFP) in elderly patients are an underappreciated injury with a significant impact on patient mobility, independency, and mortality and is a growing burden on health care costs.¹⁻³ The incidence of this emerging pathology is increasing due to higher life expectancy and greater incidence of osteoporosis in the elderly population.^{1,4-6} Despite the current rise and further expected increase in the incidence of FFP, an international treatment guideline is currently lacking.

A fragility fracture is defined by the World Health Organization as “a fracture that is caused by an injury that would be insufficient to fracture normal bone; the result of reduced compressive and/or torsional strength of bone.”⁷ Consequently, characteristics of FFP are not comparable with those of pelvic fractures in younger patients. Not only are trauma mechanisms are completely different also clinical symptoms, fracture patterns, and natural course are distinct.⁸⁻¹⁰ These fractures are usually caused by low-energy mechanisms like a fall from standing

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position, resulting in specific fracture patterns as described by Rommens et al.⁸ Identification of these fractures remains challenging because studies have shown that conventional pelvic radiographs tend to underdiagnose FFP. Specifically, involvement of the posterior ring in pelvic fractures can only be assessed accurately on computed tomography (CT) or magnetic resonance imaging (MRI).^{3,11} Regarding treatment of FFP, current literature supports arguments for nonoperative and operative treatment.^{2,12,13} Most authors suggest that surgery can be considered after nonoperative treatment has failed.^{14,15} However, non-operative treatment strategies, such as mobilization protocols, differ between studies and is therefore often left to the discretion of the treating physician, leading to practice variation.

Decision-making around FFP is believed to vary between physicians, hospitals, and countries. Owing to the significant impact of this injury, there is a need to create more uniformity, address some key aspects in the management of FFP, and provide data that can be used as a first step toward a consensus of the best management of FFP. The goal of this study was to assess the current heterogeneity between experts within the definition of FFP, use of diagnostic modalities, conservative treatment options, surgical indications, and outpatient follow-up of patients with FFP using an international survey-based approach. The hypothesis is that there is meaningful international variation in the management of FFP.

2. Methods

A web-based survey was created with 52 questions regarding the definition of FFP, use of classification systems, diagnostic modalities, timing of imaging, treatment protocols (partially case driven), follow-up strategies, and the need for a protocol. The survey was distributed internationally through the International Orthopaedic Trauma Association (IOTA) network. All IOTA steering committee members were asked to send the survey to 15 to 20 experts in the field of pelvic surgery; the orthopaedic trauma surgeons received a reminder twice in case they did not respond.

The experts were only asked in which country they worked, if they were fellowship-trained in pelvic surgery, and on the number of years of experience. The data analyst was blinded to the characteristics of the participating experts.

The study was approved by the local medical ethics review committee of VU University Medical Center, Amsterdam, the Netherlands (2021.0562).

Categorical and ordinal variables are shown as count and percentages; no further statistical analysis was performed.

3. Results

Sixteen IOTA societies participated. In total, 143 orthopaedic trauma surgeons have responded; the distribution per society and continent are shown in Fig. 1. The major characteristics of the participating experts are presented in Table 1.

3.1. Definition of FFP

Of all experts, 77% defines FFP as fractures in patients with proven signs of osteoporosis independent of age. Furthermore, 83% added a low-energy fall as trauma mechanism to the definition, while other classify FFP irrespective of trauma mechanism.

3.2. Classification

Data showed a lot of variation with regard to classification systems used for FFP, with multiple options used. Forty percent uses the Tile/OTA classification,¹⁶ 37% the Young and Burgess classification,¹⁷ while 60% uses the Fragility Fracture Classification of the Pelvis by Rommens et al.⁸

3.3. Diagnostic Imaging

The standard imaging modality is a pelvic x-ray, followed by a CT scan in case of a proven anterior ring fracture (ramus inferior/

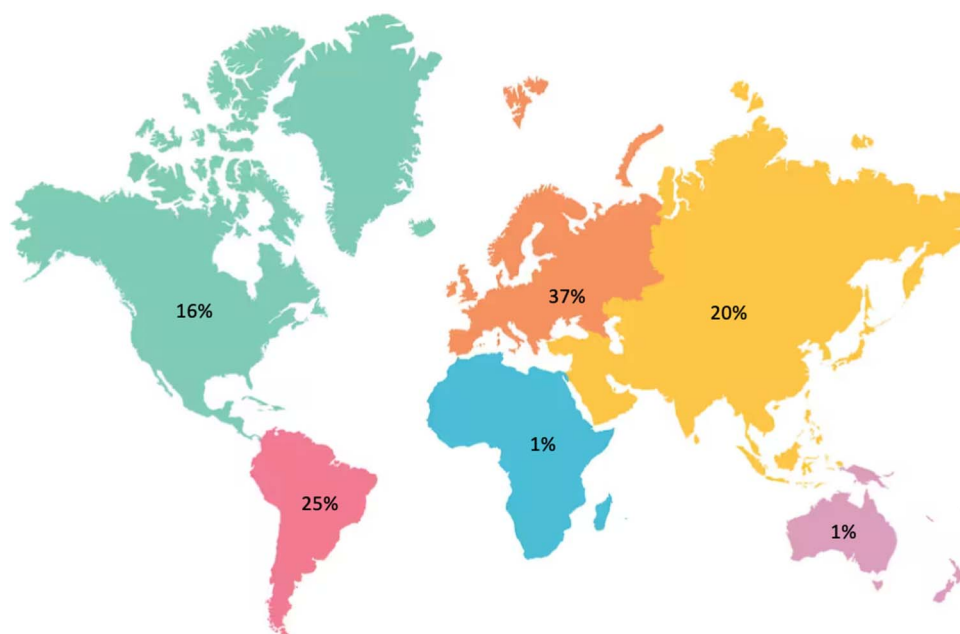


Figure 1. Participation of IOTA societies per continent. IOTA, International Orthopaedic Trauma Association.

TABLE 1**Characteristics of Participating Experts**

Fellowship in pelvis and acetabular surgery	59%
Working experience >10 years	86%
University/teaching/referral hospital	79%
Referral center for pelvic fractures	80%

superior fracture) on x-ray. Sixty-three percent of experts perform a CT scan routinely compared with 35% who base the need for advanced imaging on clinical presentation/symptoms (Table 2). Variability exists regarding the timing of the additional CT scan; 55% of respondents obtain it within 1 to 3 days after trauma, while 27% within 1 week and 12% in 2 to 6 weeks.

3.4. Treatment

A distinction was made regarding treatment of anterior ring versus combined fractures (anterior and posterior ring). Thirty seven percent of experts would admit patients with an isolated anterior ring fracture to the hospital compared with 75% of patients with combined fractures. Anterior ring fractures are often treated with a pain-guided mobilization protocol (72%), while 44% of experts manage combined fractures using a partial or non-weight-bearing protocol for usually 4 to 6 weeks. Among the experts, there was a lot of variation in what type of partial weight-bearing protocol they propose in case of a combined type II fracture: bed-chair (18%), non-weight-bearing (15%), 10% weight-bearing (7%), 50% weight-bearing (5%), and pain-guided mobilization (55%). If weight-bearing restrictions are applied, 65% (n = 93) would apply this for a period of 4 to 6 weeks. Although with increasing age, experts would allow a pain-guided mobilization protocol more frequently, even in case of a type III fracture.

There is considerable variability in the indications and timing for surgery of FFP according to experts as shown in Table 3. Most would stabilize both the anterior and posterior ring in case of a combined fracture, and 72% uses 2D fluoroscopy intraoperatively. Table 4 shows the techniques used by the experts for stabilization of the posterior ring. For unilateral sacral fractures, there is considerable variation in the choice of percutaneous fixation material. Two transiliac-transsacral screws are used in 36%, a single transiliac-transsacral screw in 27%, 2 unilateral sacro-iliac screws in 21%, and a single unilateral screw in 13%.

3.5. Follow-Up

Independent of the fracture type, over 92% of the experts schedule their patients for follow-up. Eighty-three percent plan the first follow-up between 2 and 4 weeks. The duration of follow-up varies. From the experts, 37% would follow-up until the patient is free of pain, 8% up to 1 year, 24% up to 6 months, 16% up to 3 months, and 9% up to 4 to 6 weeks. To follow-up on nonoperatively treated patients, pelvic radiographs are used in 94% in case of anterior ring fractures in comparison with 87% of combined fractures. A CT scan is obtained in the other 13%; however, this imaging modality is used more frequently in surgically treated patients (25%). In case there are no fractures seen on x-ray or CT but with persistent pain after 2 to 4 weeks, 39% of the respondents would perform an MRI, 24% would wait-and-see, 22% would repeat a CT scan, and 14% would repeat the x-ray.

3.6. Need for a Guideline

Only 44% of these international experts have a specific institutional protocol for the management of FFP. The vast majority agrees that there is a lot of international/regional variation. Consequently, 89% feel the need for an international treatment guideline for FFP.

4. Discussion

This study showed that there is considerable heterogeneity between experts within the definition of FFP, use of diagnostic modalities, conservative treatment options, surgical strategies, and the timing and imaging used in the outpatient follow-up of patients with FFP. This heterogeneity was expected as a consequence of the lack of (inter)national guidelines. This results in practice variation and potentially suboptimal quality of care for patients with FFP, and therefore, this heterogeneity needs to be addressed internationally.¹⁸ The lack of local, regional, or national guidelines is potentially the consequence of previous and historical underestimation of the significant impact of FFP. The relatively recent recognition in the past 5 to 10 years that FFP are a distinct entity that needs to be managed differently compared with other pelvic fractures, and the consequent relatively scarce high-quality evidence on the best management, obviates the need for further research and the development of an international evidence-based guideline. In line with the heterogeneity in this survey, there is currently ongoing discussion in the management of FFP concerning the definition and used classification for FFP, the best timing of the additional CT scan, and the timing and identification of the patient/fracture characteristics that would benefit from surgery. In addition, the phenomenon of fracture progression, which only recently has been described in the literature, also adds to the discussion and poses extra question mark on how to best follow-up patients with FFP.

4.1. Definition and Classification of FFP

A majority of experts agree that osteoporosis is the most frequent underlying cause of FFP. Bone loss within the sacrum generally follows a consistent pattern, with excess loss in the transitional zones between sacral levels and in the sacral ala. This leads to vertically oriented sacral fractures through the ala, not involving the neuroforamina, but in case of bilateral injury often joined by a horizontal fracture creating a H-type pattern.^{19,20} Owing to the difference in injury patterns after low-energy trauma, fracture classification is challenging according to the experts. However, full assessment of the fracture pattern is necessary to establish the best treatment plan. Although the traditional classification systems (Tile/OTA and Young and Burgess) are not covering the spectrum of observed injury, they are still used by 40% of experts. The specific FFP classification by Rommens et al is used

TABLE 2**Clinical Observations**

Inability to walk/mobilize	80%
Pain out of proportion to apparent injury	76%
Lower back pain	47%
Inability to roll over in bed within the first 2 days	37%
Anamnestic dorsal pain	33%
Radiating leg pain	14%

TABLE 3
Indications for Surgery

Inability to mobilize during hospital admission	33%
Persistent pain after 2 weeks (at outpatient clinic)	25%
Based on clinical symptoms or other reason	22%
Persistent pain after 6 weeks (at outpatient clinic)	14%
Only in case of nonunion or delayed union	7%

most frequently. However, this system showed moderate intra-observer and interobserver reliability, with comparable levels of agreement as with other pelvic classifications.^{21,22} Despite these limitations, it is currently the best available classification for FFP and should therefore, in our opinion, be recommended in future guidelines.

4.2. Diagnostic Imaging

It is known that conventional radiography underestimates the full extent of FFP. Scheyerer and Nüchtern et al have shown that up to 80% of patients with a proven anterior ring fracture have posterior disruption.^{11,23} Therefore, an additional CT is advised as the standard imaging modality.^{11,24}

The survey showed that 63% of experts routinely perform a CT scan in case of a proven or suspected anterior ring fracture and another 35% based on clinical symptoms, such as inability to mobilize, pain around the sacro-iliac joints, or pain out of proportion to apparent injury. It is interesting that still one-third of the experts obtain a CT scan based on clinical symptoms. The meta-analysis by Sauerland et al²⁵ described an overall sensitivity of 90% of clinical examination in detection of pelvic fractures, compared with conventional radiology. Another study showed that 83% of dorsal pelvic fractures could be detected by clinical examination.¹¹ It remains a topic of debate if routine additional CT scans should be performed because this may not always change treatment regimens. The ARTIFACT-study by Beelen et al²⁶ showed that additional CT changed the treatment strategy in almost 60% of patients.

Posterior pelvic pain had a positive predictive value of 79% for a possible change in management and a negative predictive value of 88%. Therefore, it is debatable whether routinely diagnosing every full fracture pattern is necessary. However, performing routine radiologic diagnostics in the workup in patients with high-energy trauma yield less significant routine changes in management, for example, a FAST scan in hemodynamically stable patients with blunt abdominal trauma is negative in up to 96% of the patients but remains recommended.²⁷ It is clear that to fully understand the fracture pattern, CT scanning is necessary. It is therefore recommendable to at least have a local protocol that either includes a routine additional CT scan or describe a set of indications for CT based on clinical symptoms. In addition, the timing of the CT scan is also disputable. Approximately half of the experts in this survey would obtain the CT within the first 3 days after trauma, another 27% within a week. The literature is, to our knowledge, not very clear about timing of additional imaging, although fracture patterns determine mobilization protocol (eg, non-/partial/full weight-bearing or pain-guided mobilization). Based on our data, 82% of the experts obtain the CT within the first week; therefore, early CT imaging seems to be a consensus opinion based on practice patterns identified by this survey. An additional argument for this could be that the most optimal window for early surgical intervention would be within 1 week after trauma.

4.3. Treatment

Conservative management is the primary approach for isolated nondisplaced sacral fractures with or without an additional (nondisplaced) fracture of the anterior pelvic ring.⁸ Mobilization protocols depend on a patient's preinjured walking ability, degree of pain, and severity of the fracture. In our survey, experts were asked for their mobilization strategies based on fracture type. Anterior ring fractures (type I) are treated with a pain-guided mobilization protocol, while combined fractures (type II, III, and IV) are more often treated with a partial or non-weight-bearing protocol if treated nonoperatively. This corresponds to what some authors advice in current literature.^{2,8} The variation in partial weight-bearing protocols among experts in case of a combined fracture shows the lack of evidence on what the best treatment strategy is. It is interesting that partial or non-weight-bearing protocols are used, despite the fact that to our knowledge no literature has shown that this would prevent nonunion or fracture progression in FFP. Therefore, this should be a topic in future studies because unnecessary weight-bearing restrictions lead to potential enhanced immobility with its known implications, especially in the elderly population.

Currently, more studies have been published on (early) surgical treatment of type III and IV fractures because these fracture types show distinct worse outcomes when treated nonoperatively compared with type I and II fractures.² Reported outcomes in the literature vary widely between studies, ranging from radiographic outcomes to functional measures and mortality rates. In addition, studies often represent mixed populations of injury and different surgical fixation methods and, therefore, are difficult to compare. However, some studies do show beneficial effects of early surgical intervention on pain, consequent mobility, and improved mortality rates, of course with surgery-related adverse events.

Our data showed that experts on pelvic surgery also use different surgical techniques for stabilization of the posterior ring, although percutaneous screws are most frequently used. Caution is necessary when considering this geriatric population for surgery because studies have reported high complication rates.^{13,14,28} Complication rates in open surgery are much higher than for percutaneous fixation, and therefore, if possible, this should be the method of choice.¹³ In our opinion, identification and best timing of surgical intervention should be the most important topic for future studies and guidelines to improve patient outcomes.

4.4. Follow-Up

There is also considerable variation in the standard duration of follow-up; only one-third of the experts routinely follow-up until the patient is free of pain. There is general consensus among experts to follow-up patients with additional radiographic imaging, mostly a pelvic x-ray. Based on the results of the survey, it seems rational to follow-up patients for at least 3 months or

TABLE 4
Stabilization of Posterior Ring Fractures

Transiliac-transsacral screw fixation	57%
Sacro-iliac screw fixation	54%
Plate fixation	10%
Spinopelvic fixation	10%
Other	7%

when free of pain because this is practice of 85% of the experts. Sufficient duration and intervals of follow-up seems indicated to either identify patients who are failing nonoperative management in type II-IV fractures because these still potentially benefit from surgery.²⁹ In addition, fracture progression has been identified as an important factor.^{30,31} This means progression to a higher grade type fracture with either greater displacement of additional anterior and/or posterior ring fractures that were not initially present on previous imaging. In some patients, this can lead to debilitating symptoms and conceivably benefit from surgical intervention. The phenomenon of fracture progression is found in a significant proportion (14%–30%) of patients with FFP.^{30,31} This means that in case of deterioration during the rehabilitation period, a low threshold for a CT scan could be advised when patients are a potential surgical candidate. To date, the time to fracture progression is not well-defined and should be assessed in future studies.

4.5. Recommendations

Although this survey shows that there is considerable variation on the management of FFP, there are some recommendations that can be suggested from this expert opinion survey. These could be implemented into local protocols to standardize treatment for patients with FFP until formal evidence-based guidelines are formed. Full assessment of fracture patterns is necessary to establish the best treatment plan. The fracture classification for FFP by Rommens et al is most frequently used and assesses the full spectrum of FFP fracture patterns. To fully classify a fracture pattern, a low threshold for an additional CT scan is necessary within a period of 3 days to 1 week. This could either be performed routinely or based on a set of well-defined indications, also depending on the local threshold and capabilities to perform pelvic surgery, taking patient characteristics into account. Surgery is preferably performed timely and percutaneous. Follow-up of patients is routinely advised for at least 3 months or until free of pain with some type of imaging and a low threshold for additional CT scanning in case of prolonged pain.

4.6. Limitations

This survey was conducted among experts in the field of pelvic surgery. However, the definition of an expert was broad, a member of the IOTA society and treated at least 30 cases of fragility fractures over the last 5 years, either nonsurgically or surgically. This survey was partially case-driven; however, some case-driven questions are difficult to generalize. Elderly patients with FFP require some form of tailor-made approach, standard formalized timing of surgery, or follow-up should be interpreted carefully because many factors have to be accounted for. Despite some limitations, this survey does provide a good overview on the current management of this significant injury and provides insight of the current high heterogeneity in areas in the management in FFP that should be addressed in further studies to improve the quality of care for these patients.

5. Conclusion

There is considerable variation in the management of FFP, especially in diagnostics and treatment strategies among experts in the field of pelvic surgery. According to experts, there is a need for an evidence-based guideline for the best management of FFP. In the meantime, there should be awareness of the significant

impact of FFP, and it requires a tailor-made approach until more high-quality studies are derived or guidelines are formed.

APPENDIX 1. PERFECT Study Group Collaborators

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REFERENCES

- Breuil V, Roux CH, Testa J, et al. Outcome of osteoporotic pelvic fractures: an underestimated severity. Survey of 60 cases. *Jt Bone Spine*. 2008;75:585–588.
- Omichi T, Takegami Y, Tokutake K, et al. Mortality and functional outcomes of fragility fractures of the pelvis by fracture type with conservative treatment: a retrospective, multicenter TRON study. *Eur J Trauma Emerg Surg*. 2022;48:2897–2904.
- Loggers SAL, Joosse P, Jan Ponsen K. Outcome of pubic rami fractures with or without concomitant involvement of the posterior ring in elderly patients. *Eur J Trauma Emerg Surg*. 2019;45:1021–1029.
- Burge R, Dawson-Hughes B, Solomon DH, et al. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005–2025. *J Bone Miner Res*. 2007;22:465–475.
- Kannus P, Palvanen M, Niemi S, et al. Epidemiology of osteoporotic pelvic fractures in elderly people in Finland: sharp increase in 1970–1997 and alarming projections for the new millennium. *Osteoporos Int*. 2000;11:443–448.
- Bernstein BP, Duma MTN, Or O, et al. Fragility fracture management and FLS models in South Africa and Israel. *OTA Int*. 2022;5:e171.
- World Health Organization. Guidelines for Preclinical Evaluation and Clinical Trials in Osteoporosis. Geneva, Switzerland: World Health Organization; 1998:59.
- Rommens PM, Hofmann A. Comprehensive classification of fragility fractures of the pelvic ring: recommendations for surgical treatment. *Injury*. 2013;44:1733–1744.
- Rommens PM, Ossendorf C, Pairen P, et al. Clinical pathways for fragility fractures of the pelvic ring: personal experience and review of the literature. *J Orthop Sci*. 2015;20:1–11.
- Rommens PM, Wagner D, Hofmann A. Fragility fractures of the pelvis. *JBJS Rev*. 2017;5:e3.
- 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.
- Oberkircher L, Lenz J, Bücking B, et al. Which factors influence treatment decision in fragility fractures of the pelvis?—results of a prospective study. *BMC Musculoskelet Disord*. 2021;22:690.
- Rommens PM, Hofmann A, Kraemer S, et al. Operative treatment of fragility fractures of the pelvis: a critical analysis of 140 patients. *Eur J Trauma Emerg Surg*. 2022;48:2881–2896.
- Osterhoff G, Noser J, Held U, et al. Early operative versus nonoperative treatment of fragility fractures of the pelvis: a propensity-matched multicenter study. *J Orthop Trauma*. 2019;33:e410–e415.
- Wilson DGG, Kelly J, Rickman M. Operative management of fragility fractures of the pelvis—a systematic review. *BMC Musculoskelet Disord*. 2021;22:717.
- Tile M. Pelvic ring fractures: should they be fixed? *J Bone Joint Surg Br*. 1988;70-B:1–12.
- 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.
- Tarrant SM, Kim JW, Matsushita T, et al. Fragility fracture systems: international perspectives - Asia & Australia. *OTA Int*. 2022;5(3 suppl):e195.
- Wagner D, Kamer L, Sawaguchi T, et al. Sacral bone mass distribution assessed by averaged three-dimensional CT models. *J Bone Joint Surg Am*. 2016;98:584–590.
- Hutchings L, Roffey DM, Lefavre KA. Fragility fractures of the pelvis: current practices and future directions. *Curr Osteoporos Rep*. 2022;20:469–477.
- Pieroh P, Höch A, Hohmann T, et al. Fragility fractures of the pelvis classification. *J Bone Joint Surg Am*. 2019;101:987–994.
- Berger-Groch J, Thiesen DM, Grossterlinden LG, et al. The intra- and interobserver reliability of the Tile AO, the Young and Burgess, and FFP classifications in pelvic trauma. *Arch Orthop Trauma Surg*. 2019;139:645–650.

23. Scheyerer MJ, Osterhoff G, Wehrle S, et al. Detection of posterior pelvic injuries in fractures of the pubic rami. *Injury*. 2012;43:1326–1329.
24. Rommens PM, Vanderschot PM, Broos PL. Conventional radiography and CT examination of pelvic ring fractures. A comparative study of 90 patients. *Unfallchirurg*. 1992;95:387–392.
25. Sauerland S, Bouillon B, Rixen D, et al. The reliability of clinical examination in detecting pelvic fractures in blunt trauma patients: a meta-analysis. *Arch Orthop Trauma Surg*. 2004;124:123–128.
26. Beelen GWCM, Loggers SAI, de Wit BWK, et al. Additional clinical value of routine CT imaging in fragility fractures of the pelvis: a prospective cohort study (ARTIFACT). *Eur J Trauma Emerg Surg*. 2022;48:4713–4718.
27. Dammers D, El Moumni M, Hoogland , II, et al. Should we perform a FAST exam in haemodynamically stable patients presenting after blunt abdominal injury: a retrospective cohort study. *Scand J Trauma Resusc Emerg Med*. 2017;25:1–8.
28. 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.
29. Höch A, Özkurtul O, Pieroh P, et al. Outcome and 2-year survival rate in elderly patients with lateral compression fractures of the pelvis. *Geriatr Orthop Surg Rehabil*. 2017;8:3–9.
30. Ueda Y, Inui T, Kurata Y, et al. Prolonged pain in patients with fragility fractures of the pelvis may be due to fracture progression. *Eur J Trauma Emerg Surg*. 2021;47:507–513.
31. Rommens PM, Arand C, Hopf JC, et al. Progress of instability in fragility fractures of the pelvis: an observational study. *Injury*. 2019;50:1966–1973.