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# Progress of instability in fragility fractures of the pelvis: An observational study

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ABSTRACT

Fragility fractures of the pelvis (FFP) are an increasing entity among elderly persons. Characteristics are different from high-energy pelvic trauma. Little is known about the natural course of FFP in conservative and after operative treatment.

*Materials and methods:* Medical charts and radiologic data of 148 patients with an FFP, who were admitted in a 3-year period, were analysed retrospectively. Incidence and characteristics of fracture progression (FP) were noted.

*Results:* Patients presenting early after a traumatic event had more often non-displaced fractures, fractures with lower FFP Type classification and were more frequently treated conservatively. FP was observed in 21 cases (14.2%), twenty times after conservative and once after operative treatment. FP under conservative treatment occurred in female patients only. Patients with FP were younger than patients without. FP occurred in all fracture types, most frequently in FFP Type I. A second CT scan was positive for FP in 39.2% of patients with prolonged pain or restricted mobility.

*Conclusion:* FP is a real phenomenon, occurring in a minority of FFP patients. Female patients are at highest risk. Repeated CT scan is positive in nearly 40% of patients with continuing pain or restricted mobility. Operative treatment is a good preventive measure of FP as FP does only exceptionally occur after operative fixation of FFP.



## Introduction

Fragility fractures of the pelvis (FFP) are an increasing entity. Due to high life expectancy, the proportion of old patients is steadily growing in high-income countries. Parallelly, the number of osteoporosis-related fractures is also rising. Whereas in some countries, the incidence of hip fractures is decreasing for more than two decades, the incidence of FFP is going up. This has been shown in long-term observational studies in USA and Finland [1,2]. Increasing numbers of FFP have also been described in the Netherlands and Germany [3,4]. Similar to vertebral compression fractures, hip fractures and distal radius fractures, FFP can be regarded as an indicator fracture for osteoporosis [5]. The characteristics of FFP are in several aspects different from pelvic fractures in younger adults. The injury mechanism typically is a simple fall in a domestic environment. Patients are hemodynamically stable and complain from disabling pain in the pelvic region. Mobility and independence for activities of daily life are considerably reduced [6,7]. Bone strength of the pelvic ring is diminished and bone mineral density of the sacrum is decreased following a consistent pattern [8]. Especially the sacral ala shows severe reduction of bone mass. The areas in which trabecular bone has completely disappeared are described as sacral voids. Fractures are localised in the areas of the lowest bone mineral density [9]. Fracture patterns differ from those of pelvic fractures in younger adults and are classified in a new, specific classification, which is connected with recommendations for treatment [10].

In some patients, a progress of instability has been observed. Due to evolving fracture displacement, fracture non-union or even the appearance of additional fractures, also called fracture progression (FP), the FFP Type can change to a higher degree of instability (Fig. 1a–d). This is usually not seen in high-energy trauma in younger adults: once a fracture has been created, its morphology is not changing, independent of the type of treatment

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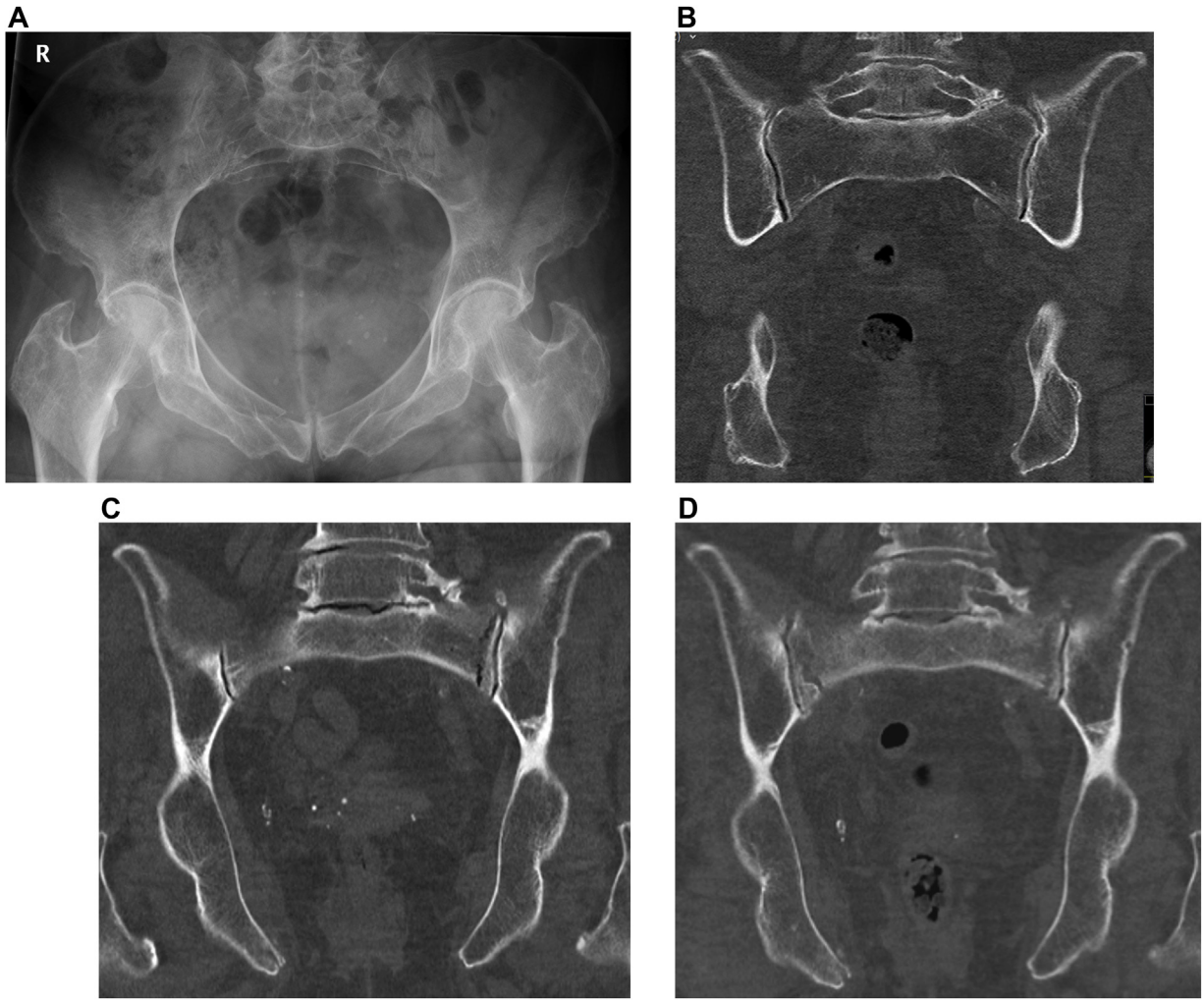


**Fig. 1.** A seventy-eight-year-old female suffered a domestic fall. The pelvic inlet **(a)** revealed a slightly displaced fracture of the right pubic ramus. A pelvic CT was taken to exclude fractures of the posterior pelvic ring. On the coronal reconstruction of the posterior pelvis **(b)**, no fracture can be detected. The fracture was classified as FFP Type Ia and conservative treatment initiated. Due to persisting pain, a second CT was taken one month later. On the coronal reconstruction of the posterior pelvis, a non-displaced fracture of the lateral mass of the sacrum on the left side was now visible **(c)**. Conservative treatment was continued. Because of persistent pain with restricted mobility, a third pelvic CT was taken one month after the second. The coronal reconstruction of the posterior pelvis revealed an additional fracture of the lateral mass of the sacrum on the right side **(d)**. The fracture progressed from FFP Type Ia to FFP Type IIc.

that follows. It is unknown how often and how quick FP occurs in FFP and if additional traumatic events are related to this phenomenon. In this study, we observed a patient population with FFP and investigated the frequency and nature of progress of instability, depending on the type of treatment.

## Materials and methods

The medical charts and radiological data of all patients with an FFP admitted to our Department in the years 2015–2017 (three-year period) have been reviewed. Approval for this retrospective study has been granted by the local ethics committee (837.140.17 (10974; Ethics Commission of the State Chamber of Medicine of Rhineland-Palatinate)). Demographic data were recorded. Conventional x-rays (pelvic a.-p., inlet and outlet overviews) and pelvic CT-scan (including axial, coronal and sagittal reconstructions) of all patients at the time of their primary presentation were analysed by the authors. Fractures were classified in accordance to the Rommens and Hofmann classification system [10]. Patients were treated conservatively or operatively in accordance to the protocol of our Department, which is similar to the recommendations for the different categories of the Rommens and Hofmann classification [10]. The Pelvic incidence (PI) was calculated according to Vrtovec et al. [11] using Surgimap® (Version 2.2.15.5. Nemaris Inc, New York, USA) after manual alignment of a digital rendered radiograph in an orthogonal perspective superimposing both femoral heads created with Sectra Workstation (IDS7, Version 20.2. Sectra AB, Linköping, Sweden). Patients with improvement of pain and mobility during follow-up received only conventional x-rays to control the healing process and rule out secondary dislocations of fractures or implants. Patients, with treatment complications during hospital stay or deterioration during follow-up with increase of pain or recurrent loss of mobility, received a second pelvic CT scan. A minority of patients received CT-examinations for other medical reasons. These data were also integrated in our observational study. The conventional x-rays at follow-up and the new CT-datasets were compared with those available at primary admission. The original FFP-classification type was confirmed or changed into another type, when additional fractures and/or displacement were observed. Time delay between the first and subsequent CT scans was calculated. If progress of instability was observed, the change in the FFP Type and the localisation of additional fractures were noted.

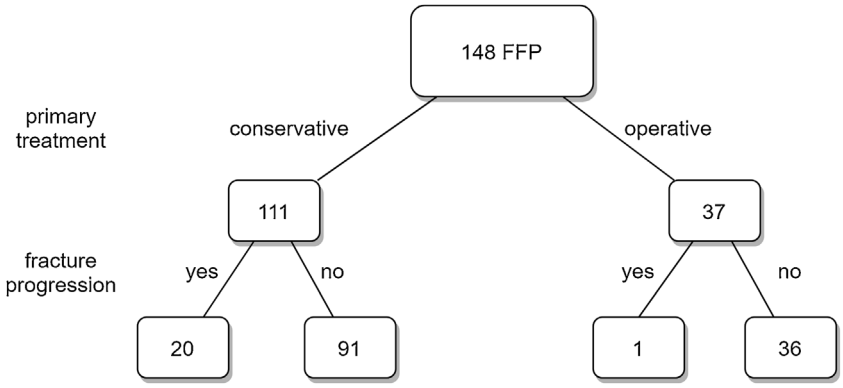


**Fig. 2.** Fracture progression among conservatively and operatively treated patients with FFP.

Descriptive statistics were performed. Continuous data was tested for normal distribution using the Kolmogorov–Smirnov-test. Only age was normally distributed. After confirming significant probability of normal distribution, metric data groups were compared using the unpaired t-test. In non-normally distributed data, the Mann–Whitney-U test was applied. Categorical data was compared using the Chi-square test and Kruskal Wallis test when multiple categories were tested. Analyses were carried out with SPSS (Version 23, IBM SPSS Statistics for Windows. Armonk, NY; IBM Corp). Statistical significance was defined as $p \leq 0.05$.draw.io (JGraph Ltd, Northampton, UK) was used to design diagrams.

## Results

One hundred and forty-eight patients with an FFP were admitted to our Department in this 3-year period. There were 129 women (87%) and 19 men (13%). The mean age was 79.2 years (+/− 9.9; 50–97 years), 78.9 +/− 10 years in females and 80.8 +/− 9.6 years in males (p 0.963).

Thirty of 148 fragility fractures were classified as FFP Type I (20.3%), 73 as Type II (49.3%), 9 as Type III (6.1%) and 36 as Type IV (24.3%). Primary treatment was conservative in 111 patients (75%), 37 were treated operatively (25%). Operative treatment was carried out primarily in 7% of FFP I (2 FFP Ib), 16% in FFP II (1 FFP IIa, 5 FFP IIb, 6 FFP IIc), 22% of FFP III (2 FFP IIIc) and 58% of FFP IV (20 FFP IVb, 1 FFP IVc). The conservatively treated group was older (80 +/−9.8 years vs 76.8 +/−10.0 years; p 0.093 t-test) with 74% of the females (96) and 79% of the males (15; p 0.670). Secondary operative treatment after failure of conservative treatment was carried out in 10 patients (9%). Two patients primary treated operatively had revision surgery (5.4%). One patient suffered FP (see below) and another had increased pain in the groin due to displacement of a primary non-displaced fracture of the anterior pelvic ring, which occurred after fixation of the posterior pelvic ring with a trans-sacral bar.

Patients who presented acutely (<7 days after trauma) had a lower FFP-Type (p 0.002), had more often non-displaced posterior pelvic ring fractures (FFP Type I and Type II, p 0.016) and underwent less often surgical treatment than when presenting later ($p < 0.001$). Time interval from the trauma/beginning of symptoms to presentation in our Department was higher in operatively treated patients (median 14 vs 1 day, p 0.062). In primary conservatively treated patients, there was no difference in the incidence of FP when presenting <7d compared to a longer time delay (p 0.754).

Time interval between first and last imaging (conventional x-rays and/or CT) had a median of 34 days (0–1488 days, IQR 7–218). This time interval was significantly larger in operatively treated patients (median 172 vs 12 days, $p < 0.001$) and such with FP (median 215 vs 16.5 days, $p < 0.001$).

Fifty-one patients (51/148 = 34.4%) had a second CT scan of the pelvis with 7 days or more time delay (median 123 days, IQR 35–375). Thirty-one of these patients had no FP (31/127 = 24.4%, median 106 days) and 20 had FP (20/21 = 95.2%, median 125 days) (p 0.923). Thirty-nine primary conservatively treated patients (39/111 = 35%) and 12 primary operatively treated patients (12/37 = 32%) received a second CT-scan (p 0.764).

FP was identified in 21 patients (14.2%), 20 with conservative treatment (20/111 = 18%) and one with operative treatment (1/37 = 2.7%) (Fig. 2). FP was observed in all categories of FFP classification. Six of 30 patients with FFP Type I suffered FP (20%), 10 of 73 patients with FFP Type II (13.7%), one patient of 9 with FFP Type III (11.1%) and 5 patients of 36 with FFP Type IV (13.9%). In 60% of FP, patients suffered increased instability leading to placement in a higher category of the FFP classification (Fig. 3). We observed a progress from non-displaced to displaced posterior fractures in seven cases (6/21 = 28.6%), in five cases (5/21 = 23.8%) the appearance of an additional posterior fracture to the already existing anterior fracture, in five cases (5/21 = 23.8%) the appearance of an additional contralateral fracture and in five cases (5/21 = 23.8%) the occurrence of additional fractures in patients who already had FFP IV, the most unstable fracture type. Patients with FP under conservative treatment were younger (76.1 +/−11.0 years vs. 80.8 +/−9.4 years; p 0.052) and all were female (p 0.051). Seven patients in the conservative group with FP (7/20 = 35%) went on to operative treatment (Fig. 4a–k) Three had operative treatment due

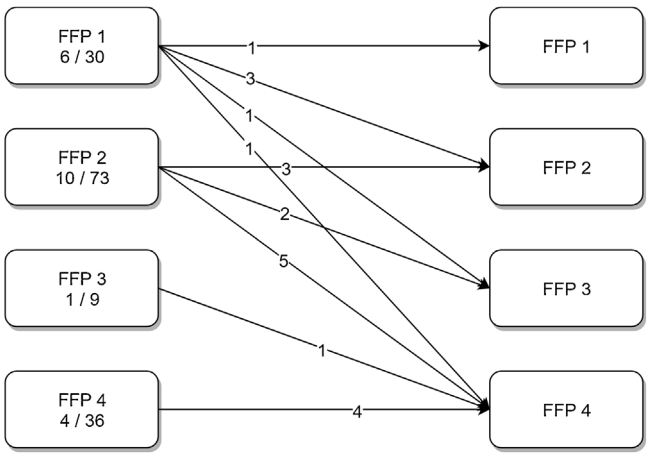


**Fig. 3.** Type and frequency of fracture progression among 148 patients with FFP.

to pain persistence without visible FP. In the primary operative treatment group (n = 37), one male went on to FP. After posterior unilateral stabilization, he suffered a contralateral sacral ala fracture, which was treated operatively (Fig. 5a–f).

The pelvic incidence in all patients had a median of 55.9° (range 28.0–97.4, IQR 48.3–65.1). The PI was significantly higher in females (median 56.8 vs. 48.8; p 0.003). PI was not different between patients with primary conservative (median 55.5) and operative treatment (median 59.1; p 0.772). The PI was not significantly different for the FFP types (median FFP 1 55.3, FFP 2 55.8, FFP 3 58.3, FFP 4 56.9; p 0.948). Also, non-displaced fractures (FFP 1 and FFP 2, median 55.4) and displaced (FFP 3 and FFP 4, median 56.9) did not differ in PI (p 0.704). In the conservative group, patients with FP had higher PI (median 57.9) than patients without FP (median 55.4, p 0.092 Mann–Whitney-U).

## Discussion

Fragility fractures of the pelvis (FFP) are an increasing entity among osteoporotic fractures. Although these fractures already have been described several decades ago [12], little is known about their natural course and outcome. Treatment has been


**Fig. 4.** An eighty-three-year-old female fell on her left side on the street. On the anteroposterior (a.- p.) pelvic overview left sided pubic rami fractures were seen **(a)**. The pelvic CT revealed a complete fracture of the left sacral ala. Axial view **(b)**, coronal view **(c)**, reconstruction at the level of the pelvic brim **(d)**. The fragility fractures were classified as FFP Type IIc. Treatment was conservative. After four months, the patient was still unable to walk independently and suffered pain at the lower back. A control conventional pelvic a.- p. overview revealed bilateral displaced pubic rami fractures and bilateral irregularities at the sacral ala **(e)**. The pelvic CT-scan showed bilateral complete and displaced fractures of the sacral ala. Axial view **(f)**, coronal view **(g)**, reconstruction at the level of the pelvic brim **(h)**. The fracture was now classified as FFP Type IVb. The lesion was treated operatively using a trans-sacral bar and two iliosacral screws at the level S1 in the posterior pelvic ring. Anteriorly, an open reduction and double plate osteosynthesis was performed. Note the long infra-acetabular screws to prevent loosening in the osteoporotic bone. A.-p. pelvic overview **(i)**, inlet (j) and outlet view **(k)**. Six months after operation, the patient has no pain and regained functional independency.

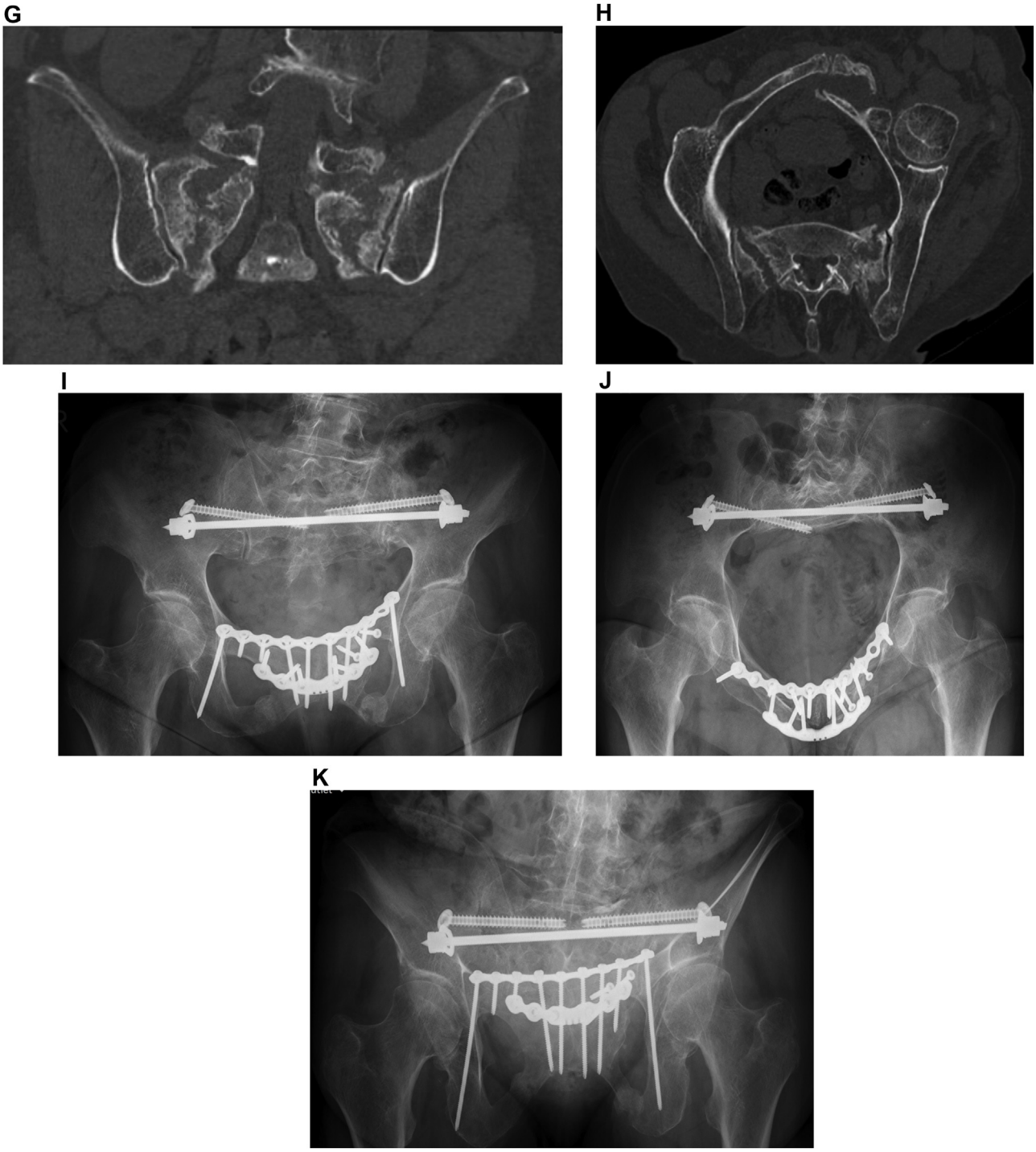


**Fig. 4.** (Continued)

conservative with bed rest, pain therapy, physiotherapy and mobilization as tolerated. In the last decade, there has been more attention to FFP. Several studies also state that operative stabilisation may be an alternative to conservative treatment [13,14]. It is hypothesized that surgical treatment may shorten immobilization time and prevent complications associated with it. Specific surgical techniques are developed and applied. They are minimal-invasive and use long bone corridors [15–17]. Some implants are augmented with cement to prevent early loosening [18,19]. Due to lack of evidence, it is not yet proven that short- and long-term outcomes of operative treatment of FFP are superior to conservative treatment. Schmitz et al. found in a cohort of 196 patients with FFP that length of hospital stays and complication rates duringhospitalization were significantly higher in operatively treated patients, whereas quality of life was not significantly better after one year [20]. Van Dyck et al. found mortality rates of 24.7, 64.4 and 93.8% one, five and ten years after pubic rami fractures, which all were treated conservatively [21]. Maier et al. described a mortality rate of 20% in 93 patients after an observation period of 34 months. Sixty-six percent of the surviving patients needed help for at least one activity of daily life [22]. All previously mentioned authors looked at FFP as being one group. On the contrary, we observed that

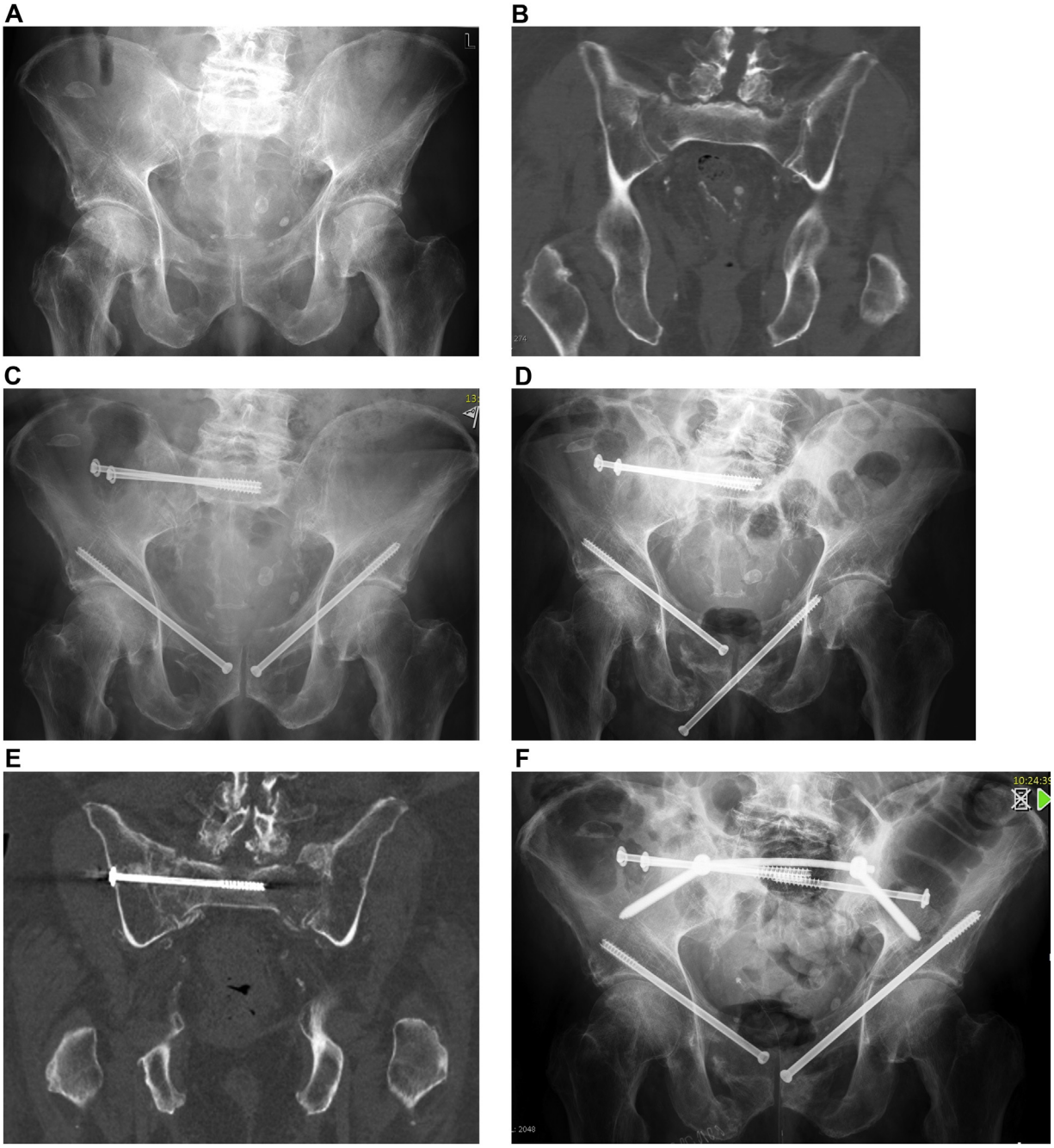


**Fig. 5.** A 66-year-old alcoholic male patient suffered an FFP Type IIc lesion after a domestic fall. On the a.- p. overview, bilateral pubic rami fractures were seen **(a)**. The coronal reconstruction of the pelvic CT revealed a complete fracture of the right sacral ala, the fractures were classified as FFP type IIc **(b)**. The patient was treated operatively: the sacral ala fracture was fixed with two iliosacral screws. The bilateral pubic rami fractures were stabilized with retrograde transpubic screws **(c)**. Three months later, the patient was readmitted after a recurrent fall. The new a.- p. pelvic overview showed loosening of the left retrograde transpubic screw **(d)**. The coronal reconstruction of the second pelvic CT revealed an additional left-sided sacral ala fracture **(e)**. The patient was treated operatively again. The postoperative a.- p. pelvic overview showed the placement of a posterior transiliac internal fixator and one iliosacral screw on the left. The loosened retrograde transpubic screw was replaced with a longer bicortical screw **(f)**. The postoperative course was uneventful.

FFP is a spectrum of fracture patterns and covers different degrees of instability [10]. Patients with pubic rami fractures only (FFP Type I) are not comparable with patients with bilateral displaced posterior and anterior fractures (FFP Type IV). As degree of instability is different, the need for surgical stabilisation and the outcome also may be different.

A specific phenomenon in FFP, which has been noted but not has been studied in detail earlier, is the fracture's dynamic and progress of instability over time. In adults, we observe that fracture morphology does not change after high-energy trauma. Stable fractures are treated conservatively, unstable fractures are operated on. In osteoporotic spine fractures, additional fractures may occur over time due to a new traumatic event or without known cause. The incidence of an adjacent fracture in the subsequent year after an osteoporotic spine fracture among 381 postmenopausal women was 19.2% [23]. Also after stabilization

procedures of the spine, new fatigue fractures near to the rigid fixation may occur, especially in the presence of osteoporosis [24].

In this retrospective study, several interesting observations have been made. When patients present early with an FFP after an acute traumatic event, the fractures on the posterior pelvic ring are mostly non-displaced, belong to the lower categories of the FFP classification and are more often treated conservatively. When patients present late, they have more often displaced fracture types, which need operative treatment. This supports the theory of a fracture dynamic over time: Patients presenting late may have had a non-displaced fracture treated conservatively and present later with now displaced, higher FFP Type fracture or persisting pain. Other, non-displaced fracture may have healed without presentation to the physician. The time delay between the first and last imaging was larger in patients, who have been treated operatively and patients who suffered FP. Also was a second CT-scan more often taken in patients with FP. Patients without FP may have healed and do not require further imaging.

We observed FP in 21 of 148 patients (14.2%). The FP occurred nearly exclusively in female patients, treated conservatively. The patients were younger than the patients without FP. This data suggests that female patients are at highest risk of FP after FFP. This may be due to higher degree of osteoporosis. This data underlines the importance of anti-osteoporotic therapy after the diagnosis of FFP to enhance fracture healing and prevent further fractures [7,25,26]. Whereas the incidence of FP was 14.2% for the whole patient population, this number raised up to 39.2% (20/51) in the patients, who received a second CT scan. The main reasons for the second CT scan were prolonged pain in the pelvic region and recurrent loss of mobility. Abovementioned clinical signs seem to be important predictive factors for FP. Ueda et al. found prolonged pain in 4 of 18 patients with FP, whereas only 2 of 61 patients without FP had prolonged pain. This difference was statistically significant. They considered prolonged pain being an indication for elective surgical stabilization [27].

We observed FP in all FFP Types, also in the most unstable fracture category FFP Type IV. This phenomenon confirms our hypothesis that FP in FFP is an insidious and continual process, which may lead to complete collapse of the pelvic ring [10,28]

Twenty patients, who have been treated conservatively (20/111 = 18.0%) showed FP and only one patient, who had been treated operatively (1/37 = 2.7%). Operative treatment seems to be a good preventive measure against FP. The only patient, who had FP after operative treatment, was stabilized in the posterior pelvic ring on one side only. A trans-sacral or a posterior bridging implant may prevent the occurrence of an additional contralateral fracture.

Pelvic incidence was somewhat higher in patients with FP than in those without, although the difference did not reach statistical difference. Further studies are needed to analyse the influence of sacral tilting on the occurrence of FFP.

This study has some weaknesses. It concerns a retrospective analysis; therefore, all clinical and radiological data of the patients may not have been available. MRI examinations have not been performed routinely in this patient group. We, therefore, may have missed signs of additional fractures, which were not visible in pelvic CT. However, the clinical consequence of bone bruise in MRI without correlate in CT remains questionable. In this study, the outcome of conservatively and operatively treated patients was not analysed systematically, neither the complications of operative treatment. Consequently, from the data of this study, no recommendations can be derived on which patients with FFP profit the most from operative treatment. As our department is a referral center for pelvic fracture, the number of complicated cases may be overestimated. In bilateral sacral fractures leading to a spinopelvic dissociation and kyhosing of the proximal fragment, PI may be overestimated.

## Conclusion

Fracture progression with progress of instability is a real phenomenon in fragility fractures of the pelvis. It is observed in nearly 15% of FFP patients and in all categories of the FFP classification. Female patients have a higher risk of FP than male. A thorough follow-up of all patients, who have been diagnosed with FFP, at least until pain subsidises and mobility is regained, is recommended. Suspicion of FP is based on clinical signs such as recurrent, steady or increasing pain in the pelvic region during mobilization, decrease of mobility or independency. In these patients, diagnosis is FP made in nearly 40% using further imaging. Progress of instability occurs much more often after conservative than after operative treatment. FP after conservative treatment indicates that treatment has not been successful and operative stabilization becomes necessary.

## Acknowledgements

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