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Progressive and subsequent instability in fragility fractures of the pelvis. Are the fracture type, pelvic incidence and pelvic morphology risk factors? A case control study

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Abstract

Purpose: Little is known about the progressive instability and risk of subsequent fractures in fragility fractures of the pelvis. Nothing is known about the influence of the fracture type, pelvic incidence (PI) and pelvic morphology.

Methods: We retrospectively analyzed radiological findings like the fracture type, PI, and pelvic ratio (PR) in patients with fragility fractures of the pelvis, who where readmitted with new or persistent pain after inpatient treatment and who received a follow up CT scan of the pelvis.

Results: In a cohort of 141 patients, only 6 female patients represented with new or persistent pain after 10,6 weeks on average after the inpatient treatment of a fragility fracture of the pelvis. The mean age was 82,67 years (xmed: 83 years, 78-89 years). The average PI in the progressive group was 60,83° (xmed: 62,5°). The average PR in the progressive group was 1,13 (xmed: 1,13). 4 patients (FFP type 4 fractures) demonstrated a progressive fracture dissociation. Two patients (FFP type 2 fractures) demonstrated a fracture type shift into a bilateral fracture (FFP type 4).

Conclusion: The clinical impact of subsequent and progressive instability in fragility fractures of the pelvis seems to be small. We could demonstrate two phenomenona: A fracture type shift of an unilateral into a bilateral fracture type and a progressive fracture dissociation. Female patients are at high risk for progressive instability and subsequent fragility fractures of the pelvis. The influence of PI and PR could not be clarified.

Keywords

fragility fractures of the pelvis; geriatric pelvic ring fracture; osteoporosis; subsequent pelvic ring fractures.

Abbreviations

PI: Pelvic Incidence; PR: Pelvic Ratio; DT/DS: transverse diameter / sagittal diameter; FFP: Fragility Fracture of the Pelvis; CT: Computed Tomography; MPR-CT: Multiplanar Reconstruction Computed Tomography; BMD: Bone Mineral Density.

Introduction

Osteoporosis is on of the major risk factors for fragility fractures of the pelvis [1-3]. Little is known about the incidence and risk of progressive instability in these kind of fractures. Studies could demonstrate the correlation of high-grade pelvic incidence and increased stress forces at the lumbosacral junction, but the impact on fragility fractures of the pelvis and its progression is not clear [4-6]. The circle-type morphology of the true pelvis is more related to fragility fractures of the pelvis than an ellipse-type, but there is no evidence about its influence on progressive instabilities and subsequent fractures [7]. The aim of this study was to examine the frequency of progressive and subsequent instabilities in fragility fractures of the pelvis and the influence of the fracture type, the pelvic incidence and the pelvic morphology (pelvic ratio).

Material and methods

We analyzed radiological findings of patients who were readmitted with new or persistent pain after the inpatient treatment of a fragility fracture of the pelvis. General patient data were obtained from the electronic patient files (sex, age, time of readmission). Pelvic CT scans were analized for fracture classification, according to the FFP-classification [8]. Pelvic and lumbar X ray examination was used for PI measurement [9]. We analyzed 3D-MPR-CT reconstructions of the pelvis to measure the DT/DS ratio (morphology of the true pelvis) according to Lee et al. to define the circle-type and the ellipse-type of the true pelvis [7].

Patients

FFP fractures: January 2017 – december 2019

Readmisson period: At least 4 weeks after dismission

Inclusion criterion: patients >65 years with FFP fracture

Exclusion criterion: new trauma

Fracture classification: according to FFP-classification [8].

Results

In total 141 patients (14 men = 9,93%, 127 women = 90,07 %) had to undergo inpatient treatment for a fragility fracture of the pelvis from january 2017 to december 2019 (Table 1). The mean age was 84,87 years (xmed:86 years, 65-102 years). Only 6 female patients were readmitted on average after 10,6 weeks (min 4, max 16, xmed:11 weeks) (Figure 1). The mean age was 82,67 years (xmed: 83 years, 78-89 years). 4 out of the 6 patients presented a FFP type IVb fracture (66,67%). One patient had a FFP type 2c fracture (16,67%) und one patient had a FFP type 2a fracture (16,67%). The patients with FFP type 4 fractures demonstrated a progressive fracture dissociation. The patients with FFP type 2 fractures demonstrated a

fracture type shift into a bilateral fracture (FFP type 4) (Figures 2,3).

Table 1: Fracture types in the overall collective (n=141).

Fracture type		1a	1b	2a	2b	2c	3a	3b	3c	4a	4b	4c	total
sex	men	4	1	0	3	1	0	0	2	0	3	0	14
	women	18	4	1	44	9	3	0	7	0	41	0	127
total		22	5	1	47	10	3	0	9	0	44	0	141

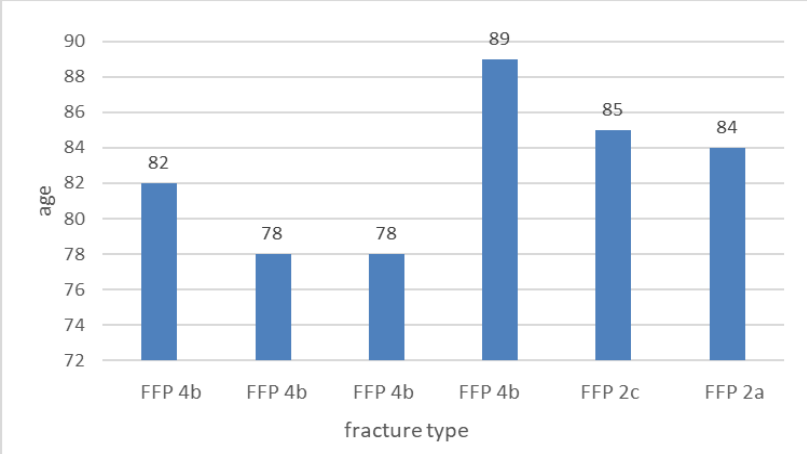

Figure 1: Fracture types in the progressive instability group (n=6).

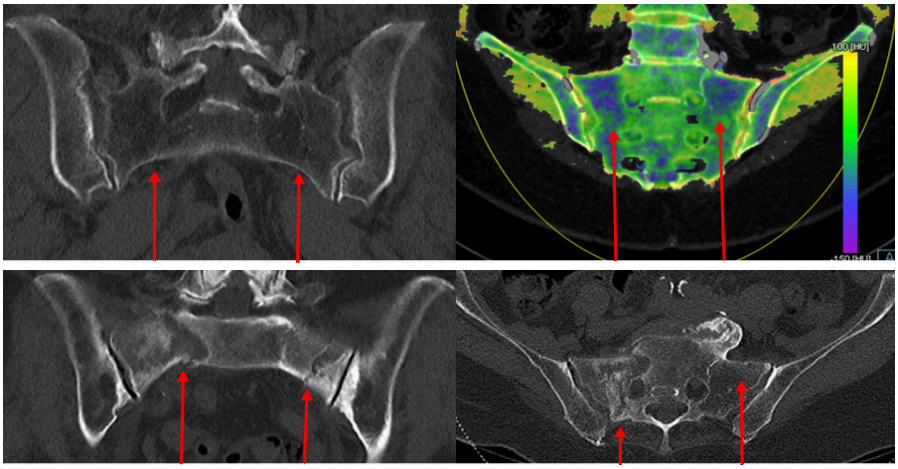

Figure 2: 79 years old female patient with bilateral non-displaced fracture of the sacrum.

Top row: July 2019

Left: Frontal CT scan: non displaced fracture lines in the sacrum (red arrow).

Right: Frontal CT scan (dual energy CT): bone marrow edema in the sacrum (red arrow).

Bottom row: September 2019

Left: Frontal CT scan: Bilateral displaced fracture of the sacrum (red arrow).

Right: Frontal CT scan: Displaced fracture of the sacrum (red arrow).

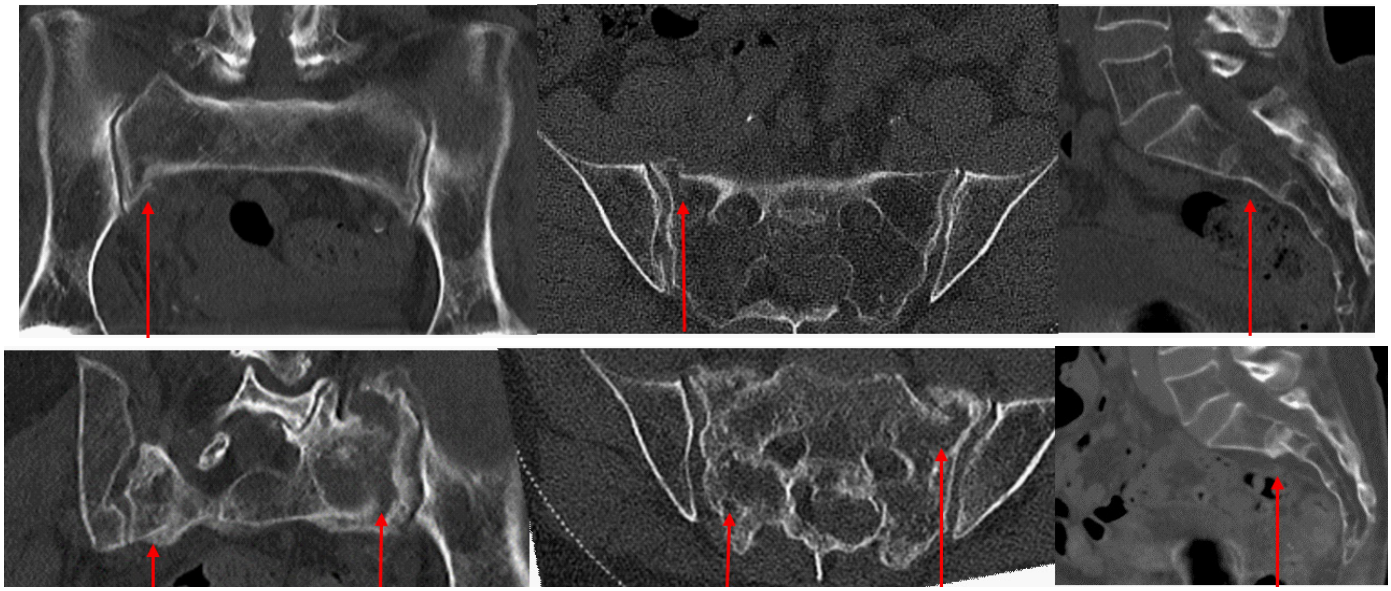

Figure 3: 90 years old female patient with unilateral fracture of the sacrum (FFP type 2a).

Top row: September 2018

Left: Frontal CT scan: Unilateral crush of the sacrum (red arrow).

Middle: Frontal CT scan: Unilateral crush of the sacrum (red arrow).

Right: Sagittal CT Scan: no fracture line at S1/S2 visible (red arrow).

Bottom row: January 2019

Left: Frontal CT scan: Bilateral displaced fracture of the sacrum (red arrow).

Middle: Frontal CT scan: Bilateral displaced fracture of the sacrum (red arrow).

Right: Sagittal CT Scan: Transverse component of H-type fracture at S2 (red arrow).

Pelvic Incidence in the female patients with progressive fractures

The average PI in the progressive group was 60,83° (xmed: 62,5°). Patients with FFP IVb type fractures demonstrated a mean PI of 57,5° (xmed: 60°). The patient with a FFP type 2a fracture demonstrated a PI of 70° and that with a FFP type 2c fracture a PI of 65° (Figure 4).

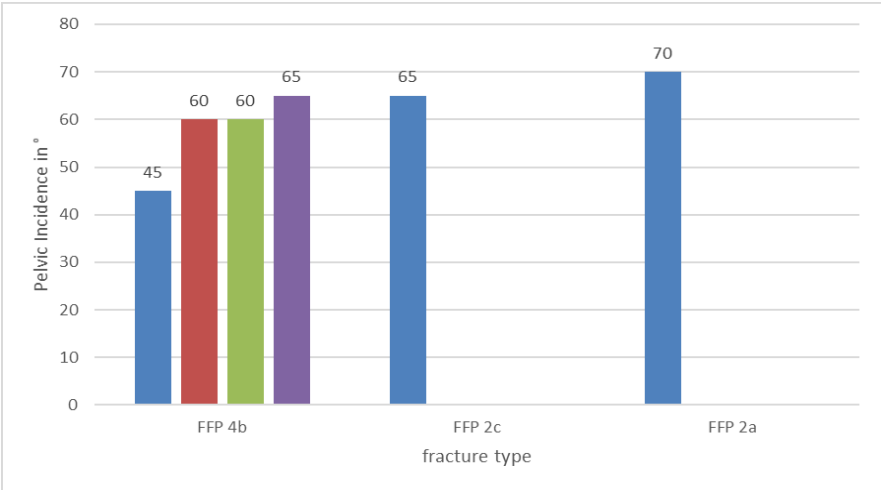

Figure 4: Pelvic Incidence and fracture types in the progressive group.

Pelvic morphology (DT/DS ratio) in female patients with progressive fractures

The average PR in the progressive group was 1,13 (xmed: 1,13). Patients with FFP IVb type fractures demonstrated a mean PR of 1,18 (1,14;1,12;1,28,1,21). Two of these demonstrated an ellipse-type morphology (PR ≥ 1,18). Both patients with FFP type 2 fractures demonstrated a PR of 1,04 corresponding to a circle-type morphology (Table 2, Figure 5).

Table 2: DT / DS ratio in the progressive group.

	FFP 2	FFP 4	
DT/DS 1,06	2	0	circle-type
DT/DS 1,18	0	2	ellipse-type
total	2	4	

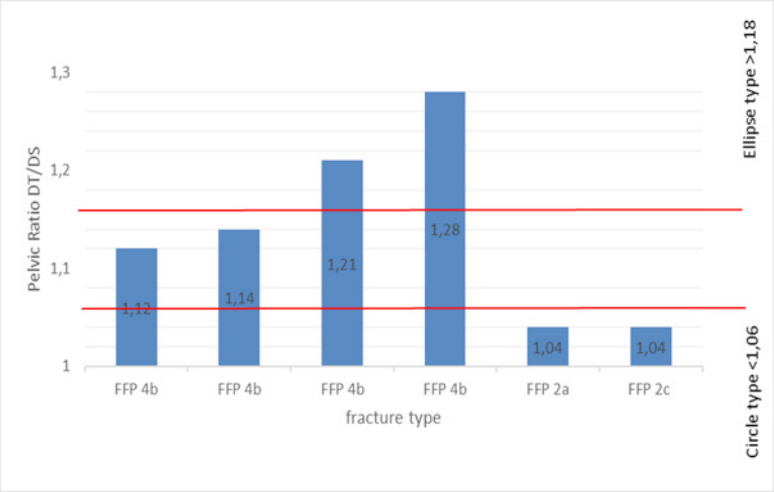

Figure 5: DT / DS ratio in the progressive group. The red lines mark the threshold of circle-type and ellipse-type.

Discussion

Fragility fractures of the pelvis are associated with reduced quality of life, functional impairment, restricted mobility and increased mortality. Osteoporosis is one of the major causes and women older than 65 years are mostly affected [2,10,11]. Little is known about the natural course of these fractures and the risk factors, that might be responsible for a progressive instability. In general, the reported risk of subsequent fractures in women aged 65 years and older is 10% within 1 year, 18% within 2 years and 31% within 5 years following an initial fracture [12]. There is a subsequent fracture risk of 34% at 5 years following a vertebral fracture in women ≥ 65 years [13]. The increased risk of subsequent fractures seems to be independent of the bone mineral density, because about 39% occur in patients with normal or low BMD [14]. The history of a previous fracture is a strong predictor of a future fracture. Women with prior fractures have a 1.4- to 2.0-fold greater risk of major osteoporotic fractures compared to women without [15-17]. The natural course of the aging spine is well known: reduction of LL, SS; increase of TK, PT, SVA [18,19]. These conditions lead to higher forward shear forces and increased stress forces at the lumbosacral junction. It could be demonstrated that high PI is a further risk factor for increased stress forces in this area [20-23]. The correlation of a high PI and a progressive instability of the posterior pelvic ring in osteoporotic conditions is suspected [23,24]. Higher PI leads to increased PT to keep the imbalanced spine balanced

in a comfort zone [25-28]. A pelvic retroversion leads to higher stress forces in the sacral plateau, the sacral ala and the S1/S1 intervall [29]. This might be a critical factor for fracture progression in fragility fractures of the sacrum. There is a correlation between osteoporosis, the global sagittal malalignment and compensatory pelvic retroversion [30]. In our small group of only 6 patients, all were female patients with a mean age of 82,67 years. Female sex, age and osteoporosis are major risk factors for fragility fractures [4]. We observed two different forms of progressive instabilities: 1. progressive dissociation of the bilateral fractures (FFP type 4) and 2. a fracture type shift from an unilateral (FFP type 2) into a bilateral (FFP type 4) pelvic ring fracture. The average PI in the progressive group was 60,83° (xmed: 62,5°). The mean pelvic incidence in the female population of the overall collective (n=127; 90,07%) was 59.37° (± 10,53°). Lee et al. examined the influence of the pelvic morphology of the true pelvis on the incidence of type 2 fragility fractures of the pelvis. The authors could demonstrate that a circle-type is more related to fractures than an ellipse-type shape due to greater bending moments and smaller moments of inertia [7]. The influence of the DT/DS ratio on the progressive instability of fragility fractures of the pelvis has not been examined yet. The average PR in our progressive group was 1,13 (xmed:1,13). The mean PR in the female population in the overall collective (n=127; 90,07%) was 1,09 (± 0,08). In our progressive group, 2 patients demonstrated a circle type (FFP 2) and two patients demomstrated an ellipse-type (FFP 4). In the overall collective, female patients with FFP type 2 fractures demonstrated a DT/DS ratio ≤ 1,06 in 35,19% (circle-type) and DT/DS ≥ 1,18 (ellipse-type) in 20,37%. In the overall group, female patients with FFP type 4 fractures demonstrated a DT/DS ratio ≤ 1,06 in 34,15% (circle-type) and DT/DS ≥ 1,18 (ellipse-type) in 12,20%. Due to the small number of patients in this studygroup a statistical statement is not possible.

Limitation

This is a retrospective case control study. We analyzed patients, who needed inpatient treatment for a fragility fracture of the pelvis (n=141). The number of patients, who were readmitted with new or persistent pain is small (n=6) and statistical analyzes and correlations are unfeasible. Prospective studies and follow-up series are necessary to evaluate essential risk factors to possibly prevent progressive instabilities and subsequent fractures in fragility fractures of the pelvis.

Conclusion

Fragility fractures of the pelvis are one of the major osteoporotic fractures with high morbidity and mortality rates. Women older than 65 years with osteoporosis are mostly affected and therefore an anti-osteoporotic drug therapy is indispensable. The risk of progressive instability and subsequent fractures seems to be small. Due to the small number of cases in this study, we could not clarify the influence of the FFP fracture type, the PI and the morphology of the true pelvis (PR) on the progressive and subsequent instability in fragility fractures of the pelvis. Further studies are necessary.

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