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What is the long-term clinical outcome after fragility fractures of the pelvis? - A CT-based cross-sectional study☆

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ABSTRACT

Background: Recently, Rommens and Hoffman introduced a CT-based classification system for fragility fractures of the pelvis (FFP). Although fracture characteristics have been described, the relationship with clinical outcome is lacking. The purpose of this study was to get insight into the type of treatment and subsequent clinical outcome after all types of FFP.

Methods: A cross-sectional cohort study was performed including all elderly patients (≥ 65 years) with a CT-diagnosed FFP, between 2007-2019 in two level 1 trauma centers. Data regarding treatment, mortality and clinical outcome was gathered from the electronic patient files. Patients were asked to complete patient-reported outcome measures (PROMs) regarding physical functioning (SMFA) and quality of life (EQ-5D). Additionally, a standardized multidisciplinary treatment algorithm was constructed.

Results: A total of 187 patients were diagnosed with an FFP of whom 117 patients were available for follow-up analysis and 58 patients responded. FFP type I was most common (60%), followed by type II (27%), type III (8%) and type IV (5%). Almost all injuries were treated non-operatively (98%). Mobility at six weeks ranged from 50% (type III) to 80% type II). Mortality at 1 year was respectively 16% (type I and II), 47% (type III) and 13% (type IV). Physical functioning (SMFA function index) ranged from 62 (type III and IV) to 69 (type II) and was significantly decreased (P=<0.001) compared to the age-matched general population. Quality of life was also significantly decreased, ranging from 0.26 (type III) to 0.69 (type IV).

Conclusions: FFP type I and II are most common. Treatment is mainly non-operative, resulting in good mobility after six weeks, especially for patients with FFP type I and II. Mortality rates at one year were substantial in all patients. Physical functioning and quality of life was about 20-30% decreased compared to the general population.

Introduction

Fragility fractures of the pelvis (FFPs) are fractures "caused by an injury that would be insufficient to fracture normal bone" [1], i.e. low-energy traumas. During recent years these low-energy fractures are gaining more attention due to its increased incidence within the growing elderly population. Seventy-three percent of all pelvic ring fractures occur in the elderly [2]. Rommens et al. re-

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cently introduced a classification system for FFP based on CT imaging of the pelvis [3]. It distinguishes different subtypes with increasing degrees of instability ranging from simple type I injuries, defined as isolated anterior pelvic ring fractures, to more complex type IV injuries consisting of bilateral displaced posterior pelvic fractures.

Additional CT imaging for distinction between different fracture subtypes was rarely performed. In line with the extensive work by Rommens et al. [4], more CT scans have been performed and radiological subtypes have been described. Traditionally, FFPs were treated non-operatively. Management goals of FFP may include pain control, early mobilization and bone health assessment, fracture union and personal independence. However, high morbidity and mortality rates may occur after FFPs. Unlike after high-energy traumas, with resultant damage to intrapelvic organs, soft tissues and substantial bleeding, the limited physical condition and coping mechanisms of the elderly influence outcomes. Besides, FFPs are thought to have a major impact on physical functioning and quality of life, as they may lead to pain, immobility and loss of independence [3].

Literature about CT based diagnosis of FFP subtypes, treatment strategies and their clinical and functional outcome is lacking. Moreover, a comprehensive treatment algorithm for these injuries is currently not available. Before subsequent clinical studies will be conducted in this frail patient population, insight is needed on the management of these injuries and the recovery of these patients following these injuries over the last decade. Therefore, the purpose of this study was to evaluate the treatment strategy and clinical outcome in terms of mobility, mortality, physical functioning and quality of life for all types of FFP over the last decade. The study was approved by the local Medical Ethical Review Boards (METc 2016.385 and 2018.181108).

Patients and methods

Participants

A cross-sectional cohort study was performed including all consecutive patients treated for an FFP at two level 1 trauma centers between 2007 and 2019. Included were elderly patients (age $\geq$ 65 years) after a low-energy trauma who sustained a FFP as diagnosed on a CT-scan. A low-energy trauma is defined as 'a fall below two-to-three times the body length, with an impact less than 20 km/h' [5]. Electronic medical records were reviewed in order to collect baseline characteristics. Two senior trauma surgeons reassessed all CT-scans and classified the FFPs according to the Rommens and Hoffman classification (Fig. 1) [3].

Treatment and outcome

Electronic medical and surgical records were reviewed. For each type of FFP it was recorded whether the patient had non-operative or operative treatment. Non-operative treatment consisted of early mobilization with weight bearing as tolerated or, in a few cases, bed-chair mobilization during the first six weeks in combination with appropriate pain medication. In case operative treatment was performed, surgical techniques were described. The Charlson Comorbidity Index score (CCI) [6] was determined to evaluate the patient's pre-injury physical condition. If a Dual energy X-ray Absorptiometry (DXA) scan was performed to evaluate the bone quality and presence of osteoporosis, the result of this scan was recorded. Medical records from the time the patient was admitted, as well as records from the outpatient clinic were reviewed to assess time to mobilization, either with or without walking aid.

The national population registry was contacted to verify whether patients were still alive at follow-up. For this study, the Short Musculoskeletal Function Assessment (SMFA) was used. The SMFA contains 46 items which are scored on a 5-item Likert scale. Two indices (function and bother) [7] and, additionally, four subscales (upper extremity dysfunction, lower extremity dysfunction, problems with daily activities, and mental and emotional problems) can be calculated [8]. Scores are calculated by summing up the individual items and transforming scores on a range from zero to 100, with higher scores indicating better function. Quality of life (QoL) was assessed with the EuroQol-5D (EQ-5D-5L) [9], which screens five health levels (mobility, self-care, daily activities, pain/inconvenience and fear/depression). The five-level version uses 5-item Likert scales per health level, from 1 (no problems) up to 5 (extreme problems, or 'unable to'). Based on the score given for each health level, utility scores can be calculated which range from -0.329 (worst condition) to 1 (best QoL). Both the scores on SMFA and EQ-5D were compared to normative data from the general Dutch population [10,11]. Because of the use of reliable and valid outcome measures, no risk of assessment bias was expected. However, due to inevitable loss to follow-up, some transfer bias might have been present. A multidisciplinary treatment algorithm for FFPs will be presented based on our experiences of the last decade and the available literature.

Statistical analysis

Descriptive statistics were used to describe the study population, using mean and standard deviation (SD) for normally distributed data and median and interquartile range (IQR) if data were not normally distributed. A pie chart was made to show the distribution of the different types of FFPs. A non-response analysis was performed by using a chi-square test for categorical variables and an independent samples t-test for numeric variables to identify possible differences between the responders and non-responders. Scores on physical functioning and QoL (SMFA and EQ-5D) were compared to the age-matched normative data of the general population using a one-sample T-test with pooled means and SDs. The level of significance was defined at $p < 0.05$. The data were analyzed using IBM SPSS software, version 23.0 for Windows (IBM Corporation, Armonk, NY).

Results

Between March 2007 and 2019, 1009 elderly patients with an FFP were treated. Of these, 781 were excluded because no CT-scan was available, another 38 were excluded because of concomitant acetabular fractures, and three more because of pathological fractures, leaving 187 patients with an FFP as diagnosed on a CT-scan available for follow-up analysis. Fig. 2 shows the distribution of the different types of FFPs in our study population. Median follow-up of the 187 patients was four (IQR 2-7) years, of which 70 patients had deceased at a median of four years (IQR 2-6) after the injury. As a result, 117 patients with a median of three years (IQR 2-6) after the injury were available for follow-up with patient-reported outcome measures (PROMs). These patients were contacted and asked to complete two questionnaires, of which 58 patients (response rate 50%) responded after a median follow-up of two (IQR 1-4) years. The non-response analysis showed no differences between responders and non-responders in age, sex, fracture type and follow-up duration.

FFP type I

All patients with FFP type I (N=112) were treated non-operatively. In 32 of these patients (29%) a DXA scan was

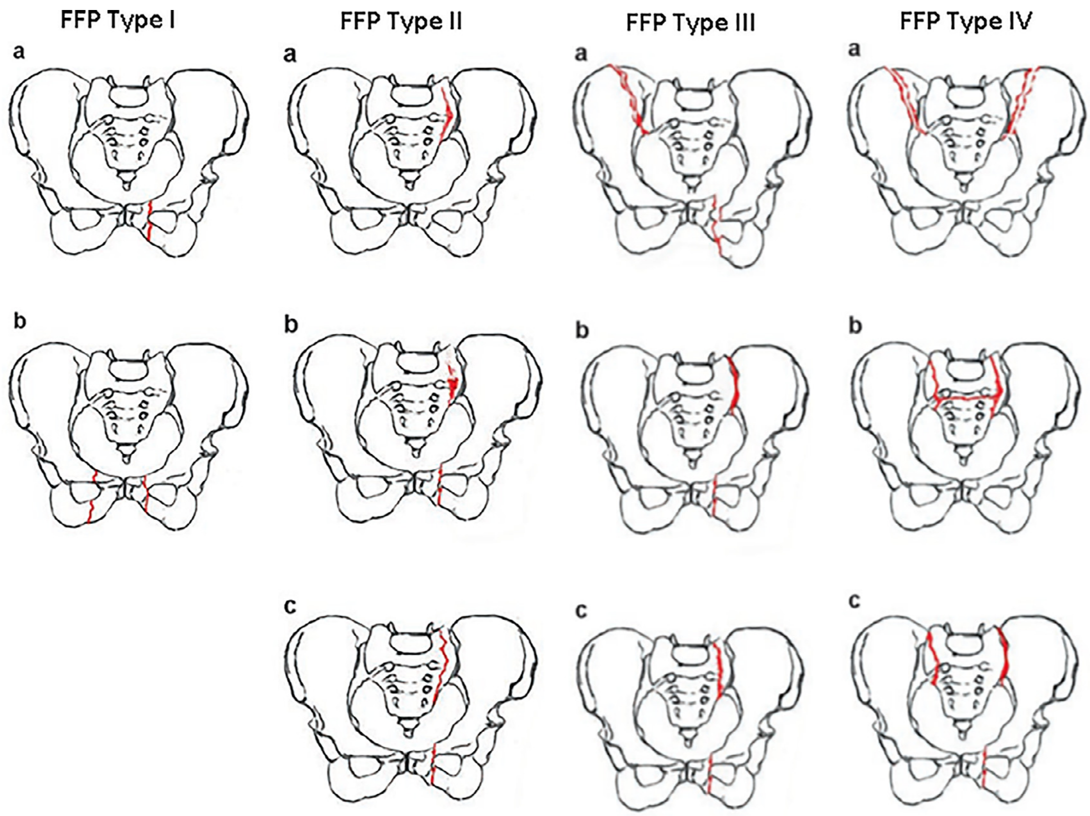

Fig. 1. Types I-IV with subtypes (a, b, c) of fragility fractures of the pelvic ring according to Rommens and Hofmann.
Type I: isolated anterior pelvic ring fractures, without involvement of the posterior part of the pelvis. Type II: non-displaced posterior lesions. Type III: displaced but unilateral posterior injuries combined with an anterior pelvic ring lesion. Type IV: displaced bilateral posterior injuries [19].

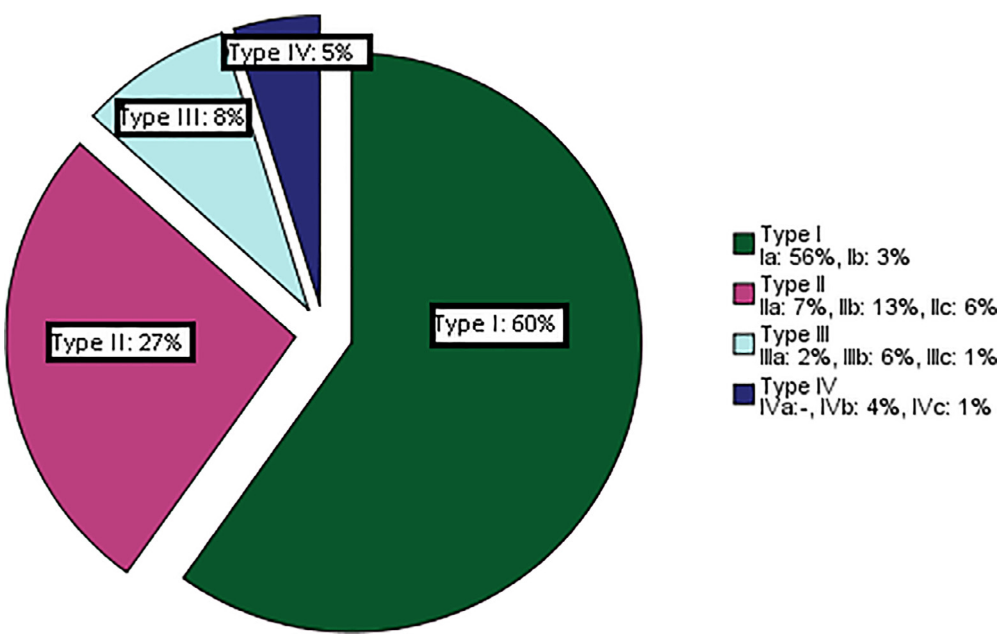

Fig. 2. FFPs divided by Rommens and Hofmann subclassification [18].

performed, all showing osteoporosis (66%) or osteopenia (34%). Seventy-seven patients (70%) were able to walk within six weeks, three patients between six weeks and three months after being restricted to only mobilize bed-chair in the first six weeks, one patient was not able to walk within six weeks, one other patient had died within six weeks. In 30 patients, the mobility status was unknown because these patients were not admitted or no further follow-up in the outpatient clinic was performed. Forty out of 112 patients (36%) had died at a median follow-up of 9 (IQR 6-10) years after the injury. No patients died during hospital admission as a direct result of the pelvic ring injury. One 100-year-old patient died in-hospital 6 days after the

Table 1
Baseline characteristics.

	FFP I (N=112)	FFP II (N=50)	FFP III (N=16)	FFP IV (N=9)	All patients (N=187)
Male	76 (68)	38 (76)	13 (81)	6 (67)	128 (68)
Age at time of injury median (IQR)	81 (74-86)	78 (69-84)	81 (77-87)	76 (71-89)	79 (73-86)
CCI* median (IQR)	5 (4-7)	5 (4-7)	5 (4-7)	5 (4-5)	-
Time to presentation in days median (IQR)	0 (0-0)	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)
ISS median (IQR)	5 (4-9)	9 (4-13)	4 (4-7)	9 (6-9)	5 (4-9)
DXA performed	32 (29)	13 (26)	4 (25)	1 (11)	50 (27)
Osteoporosis or osteopenia	32 (100)	11 (85)	4 (100)	1 (100)	48 (96)
Treatment					
Non-operative	112 (100)	46 (92)	16 (100)	9 (100)	183 (98)
Operative	-	4 (8)	-	-	4 (2)
Walking <6 weeks	77 (70)	40 (80)	8 (50)	5 (56)	130 (70)
FU in years median (IQR)	2 (1-3)	2 (1-4)	4 (1-4)	4 (1-4)	2 (1-4)
Deceased	40 (36)	13 (26)	11 (69)	3 (33)	70 (37)
< 30 days	3 (3)	2 (4)	2 (13)	-	7 (4)
Deceased <3 months	5 (5)	5 (10)	4 (25)	-	14 (8)
Deceased <1 year	18 (16)	8 (16)	7 (44)	1 (11)	34 (18)
Deceased <5 year	34 (30)	10 (20)	8 (50)	3 (33)	55 (30)

Numbers are expressed in N with the percentage in parentheses unless otherwise specified.
* CCI; Charlson Comorbidity Index Score, total scores ranging from 0-37 with higher scores indication a cumulative increased likelihood of one-year mortality.

injury as result of a thorax trauma. Two patients died after respectively six months and two years as a result of cardiac failure and three patients after respectively two, seven and ten months because of cancer. In the other cases, causes of death were unknown. Thirty-two patients with FFP type I filled in the PROMs (median follow-up of 2 (IQR 1-3) years). Scores on the SMFA and EQ-5D-5L are given in Table 2. Patients reported a mean decrease of 20% on the SMFA compared to normative data from the general population. Also, EQ-5D score was significantly decreased with an average of 27%. The distribution of the different types of FFPs are shown in Fig. 1 and baseline characteristics are presented in Table 1.

FFP type II

Four out of 50 (8%) patients with FFP type II were treated operatively. Three patients (FFP type IIc) underwent examination under anesthesia (EUA) to test instability of the pelvis. All three showed rotational instability. The first was treated with an external fixator and an SI screw. The second was treated with an SI screw and pubic symphysis plate. The third patient got two SI screws. The last patient (FFP type IIb) presented at the day of the injury and was initially treated non-operatively. She dealt with persisting pain sixteen months after the injury. Because imaging showed non-union of the pubic bones, the patient was eventually treated with a pubic symphysis plate. All operatively treated patients recovered uneventfully. A DXA scan was performed in 13 out of 50 patients (26%) showing osteoporosis in six patients (47%), osteopenia in five patients (38%) and normal bone in two patients (15%), respectively. Forty out of 50 patients (80%) were able to walk within six weeks, four between six weeks and three months after being restricted to only mobilize bed-chair in the first six weeks, one patient had died within six weeks and of five patients no information on mobility was available. Thirteen patients (26%) had died at a median follow-up of nine (IQR 6-10) years. No patients died during hospital admission as a direct result of the injury. One patient died after 12 days because of cancer and one after three months because of a septic shock possibly due to intestinal ischemia. In the other cases, causes of death were unknown. Nineteen patients with FFP type I responded to the PROMs (median follow-up of two (IQR 1-3) years). They reported a mean decrease of 20% on the SMFA and EQ-5D scores compared to normative data from the general population (Table 2).

FFP type III

All 16 patients with FFP type III were treated non-operatively. A DXA scan was performed in four of them (25%) all showing osteoporosis. Eight out of 16 patients (50%%) were able to walk within six weeks, one between six weeks and three months after being restricted to only mobilize bed-chair in the first six weeks, one patient was not able to walk at the last follow-up visit seven weeks after the injury, two patients had died within six weeks and of four patients no information on mobility was available. Eleven patients (69%) had died at a median follow-up of nine (IQR 6-10) years. No patients died during hospital admission as a direct result of the pelvic ring injury. Causes of death after years were unknown in all of the cases. Only five patients were available for follow-up analysis of which three responded. This number was considered too low for comparison with normative data in terms of physical functioning and quality of life.

FFP type IV

All nine patients with FFP type IV had been treated non-operatively. One DXA scan was performed showing osteopenia. Five out of nine patients (56%) were able to walk within six weeks, one within three months after being restricted to only mobilize bed-chair in the first six weeks and of three patients no information on mobility was available. Three out of nine patients had died at a median follow-up of nine (IQR 6-10) years. None of these patients died during hospital admission as a direct result of the pelvic ring injury. One patient died after five months because of cancer, in the other cases, causes of death were unknown. Six patients were available for follow-up of which four responded. Similar to FFP type III, the total number of FFP type IV was considered too low for comparison with normative data in terms of physical functioning and quality of life. More details of the patients with FFP type III and IV are presented in supplementary file 1 and 2.

Treatment algorithm

Based on our experiences in the treatment of FFPs during the last decade and the work presented by Rommens et al. among others [4,12], a treatment algorithm for the management of FFPs was constructed (Fig. 3).

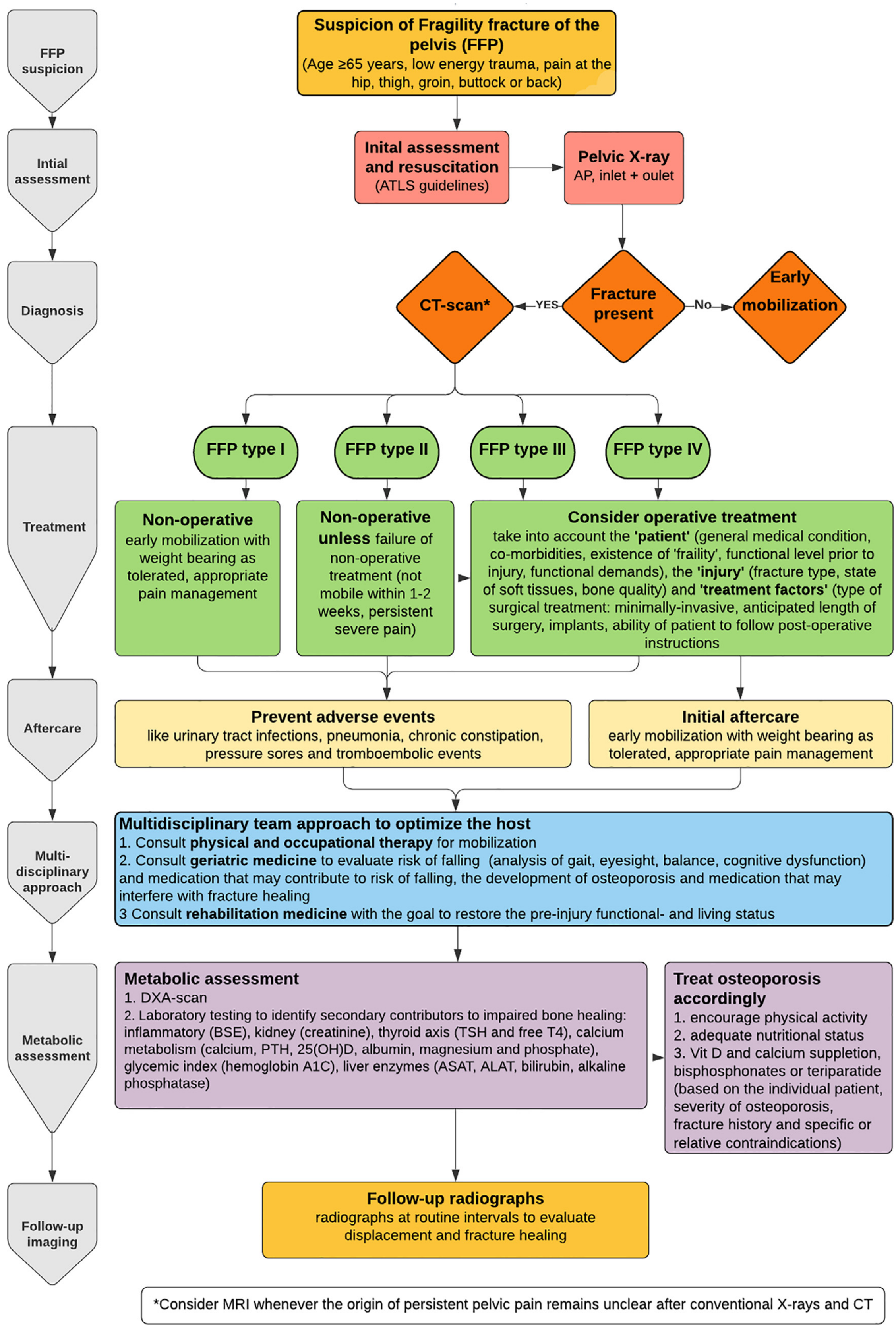

Fig. 3. Proposed treatment algorithm of FFP diagnosis and treatment.

Table 2
Scores on SMFA and EQ-5D per FFP type.

	Type I (N=32)	Type II (N=19)	Type III (N=3)	Type IV (N=4)	Total study population	General population	Type I vs. General population	Type II vs. General population
SMFA								
Function index	68 (21)	69 (21)	62 (11)	62 (21)	68 (20)	87 (14)	**<0.001**	**0.001**
Bother index	70 (22)	67 (22)	53 (6)	60 (22)	68 (21)	85 (19)	**0.001**	**0.003**
Lower extremity dysfunction	69 (22)	71 (22)	60 (18)	61 (23)	69 (22)	86 (15)	**<0.001**	**0.006**
Problems with daily activities	62 (24)	63 (24)	48 (11)	56 (26)	61 (23)	86 (17)	**<0.001**	**0.001**
Mental and emotional problems	74 (19)	70 (19)	66 (5)	62 (15)	71 (19)	80 (17)	0.09	**0.03**
EQ-5D-5L	0.60 (0.32)	0.65 (0.29)	0.26 (0.36)	0.69 (0.29)	0.61 (0.31)	0.87 (0.17)	**<0.001**	**0.004**

Data are given as mean (SD).

Discussion

This study evaluated the clinical outcomes in a large cohort of elderly patients who sustained an FFP in the last decade. Insights were gained on CT-based subtypes I-IV with regards to the choice of treatment, mobility, mortality, as well as long-term physical functioning and quality of life. In our cohort FFP type I was most common (60%), followed by type II (27%). Type III (8%) and IV (5%) were rare. Almost all FFPs in this cohort were treated non-operatively. After non-operative treatment, 70-80% of patients with FFP type I and II were able to walk within six weeks compared to only about 50% of patients with FFP type III of IV. Mortality rates were high with 18% at one year increasing up to 30% at five years after the injury. At a median follow-up of two years, patients with FFP type I and II dealt with a decrease of at least 20% in physical functioning and QoL when compared to the age-matched peers from the general population. A treatment algorithm is presented for the management of FFPs. It is based on our experiences and the recent literature.

A limitation of this study was that all patients without a CT scan were excluded from our study population. A CT scan is mandatory for an accurate (sub)classification of FFPs, especially regarding the detection of concomitant posterior ring fractures [4]. No valid classification of FFPs can be performed based on only conventional radiographs. Research has shown that in patients presenting with only a pubic fracture on the pelvic radiograph, 54-98% also had an additional fracture of the posterior pelvic ring after obtaining a CT scan of the pelvis [13–16]. Traditionally, standard CT evaluation for elderly with low-energy pelvic ring injuries was not common practice. Out of 1007 elderly patients treated for an FFP in our practice over the last decade, 14% of patients had a CT between 2007-2011, 18% between 2012-2016 and 33% between 2017 and 2020. This is in line with the new insights about FFP injury based on the extensive work of Rommens et al. in which CT analysis is recommended for elderly with low energy pelvic ring fractures [3,4,13,17]. However, it should be noted that the FFP classification has displayed moderate and substantial intra-rater and inter-rater reliabilities [18], which could have its influence on the distribution and subsequent interpretation of the different types of FFP in our study. Additionally, the absence of baseline measurements of physical functioning and quality of life might be another limitation inherent to the retrospective study design, which leaves us guessing to what extent the decreased physical functioning and quality of life was preexistent or should be attributed to the injury itself. To the best of our knowledge, this is the only study in which CT-based classification of FFPs subtypes has been related to clinical outcome. However, due to low incidence of FFP type III and IV, substantial mortality rates and low response rate, which is inherent to a fragile elderly population, no comparison to normative data could be made for these injuries, even though this study included FFPs of two level-1 trauma centers over a period of 13 years.

All patients with isolated anterior pelvic ring fractures (FFP type I) were treated non-operatively, which reflects current recommendations [4] and is in line with a recent study by Rommens et al. who evaluated 138 patients with FFP type I of which 98.6% was treated non-operatively [19]. Most patients (70%) in our study were able to walk within six weeks post injury, but some required a walking aid either temporarily or permanently. This is similar to the study by Rommens with 75% of patients being mobile at discharge [19], but in contrast to a study by Yoshida et al. who found that only 34% maintained gait ability at one year as measured by the Majeed score [20]. All patients from whom a DXA was available had osteoporosis or osteopenia. Therefore, accurate diagnosis and subsequent treatment for (secondary causes of) osteoporosis is important in the follow-up of these patients. The mortality rate at one year was 16%, which is in line with previous studies that reported 1-year rates between 13 and 19% [19,21,22]. Five-year mortality was as high as 30%, similar to the 30% found by Rommens [19], but lower than the 54% reported by Hill et al. [21]. For the patients that did survive, (long-term) effects on physical functioning and quality of life are expected as these injuries may lead to muscle atrophy due to immobility and loss of independence. However, it is relatively unknown to what extent [3,23,24]. Quality of life as measured by the EQ-5D was 0.60, comparable to the 0.62 found by Rommens et al. [19]. This translates into a 27% decrease compared to normative data. Besides, physical functioning was decreased with 20%.

Of the patients with FFP type II, four out of 50 (8%) were treated operatively. The indication for operative treatment included instability during EUA in three cases and persisting pain in one case. Since EUA was initially intended for assessment of stability in high-energy injuries, its role in assessment of stability of low-energy FFPs is still unknown [25]. Similar to our study, Studer et al. who evaluated a cohort of 132 elderly patients >65 years with low-energy pelvic fractures of which 53% received a CT-scan, found that only 4% of patients initially being treated non-operatively needed operative treatment due to persisting pain [22]. However, there is still an ongoing debate whether operative treatment might be indicated for pain relief and early mobilization in some FFP II cases. Similar to FFP type I, most patients (80%) were able to walk within six weeks after the injury. Yoshida et al. found that only 42% of patients maintained gait ability one year after FFP type II [20]. Mortality at one year was 16% in our study, similar to the 14-17% reported previously [26–28]. Physical functioning and QoL were decreased by an average of 20%. No other studies assessed physical functioning and quality of life after CT-diagnosed FFP type II. Studer et al. reported a 30% loss of independence, and only 56% of patients were living in their own home at one year after the injury [22]. Moreover, they did not distinguish between different subtypes of FFP.

The occurrence of FFP type III and IV was rare (respectively 16 and 9 out of 187 patients). All patients were treated non-operatively over the past decade (supplementary file 1 and 2). This is not completely in line with the recently proposed guideline of Rommens et al. which suggests to consider operative treatment of patients with FFP type III and IV [13]. Advocates of operative treatment pose pain relief, early mobilization [29,30] and better long-term survival as arguments to proceed to surgery [30]. However, there is a high risk of implant loosening due to osteoporosis, wound healing problems, as well as high rates of perioperative complications and morbidity [31] that should be considered before proceeding to operative treatment in a fragile elderly population. Wagner et al. described the lack of clinical evidence for operative treatment [32]. Hence, treatment should be individually adapted to fracture morphology, pain level, comorbidities, pre-traumatic level of functioning and, more importantly, the patient's preference. In our study, half of patients with FFP type III and IV were able to walk within six weeks. This rate is higher than the results found by Yoshida et al. with a mobility rate of 41% (type III) and 24% (type IV) one year after the injury [20]. Mortality rates <30 days of patients with FFP type III was 13%, and 25% of patients had died within three months. Rapp et al. suggested that, due to complications, pain and immobilization, the majority of deaths occur during hospitalization and within the first three months [33]. The mortality rate at one year was respectively 44% (FFP III) and 11% (FFP IV) in our cohort. Physical functioning and quality of life seemed decreased but results could not be compared to normative data due to the low numbers of these types of FFP. No other CT-based studies reported on mortality, physical functioning and quality of life after non-operatively treated FFP type III and IV.

Overall, our cross-sectional study showed that patient care of FFPs was partially lacking from regular CT evaluation, standardized clinical decision-making and a multidisciplinary approach over the past decade (supplementary file 1), even though literature on patients with hip fractures, a comparable injury, has conclusively shown that systematized care with medical co-management and an organized care pathway seems to improve outcome [4]. From that perspective, we proposed a treatment algorithm for the management of FFPs. This algorithm is based on our own experiences and the new insights provided by Rommens and Hofmann [4] and may guide clinicians to structure the care of these fragile patients.

Conclusion

Most patients with a fragility fracture present with FFP type I or II injuries. Management of FFPs over the last decade was mainly non-operative. After non-operative treatment, the mobility at six weeks was good in patients with FFP type I and II, but less so in patients with FFP type III and IV. Mortality rates at one and five years were high for all FFP subtypes. Physical functioning and quality of life was about 20-30% decreased in patients with FFP type I and II compared to the general population. By increasing the awareness of FFP subtypes and by highlighting the importance of a standardized multidisciplinary approach, as proposed in our treatment algorithm, we hope this condition will be diagnosed and treated optimally. In line with our study, future prospective studies with validated baseline as well as follow-up patient-reported outcome measurements are mandatory. Recently initiated prospective studies may elucidate which patients may benefit from early operative treatment in terms of clinical outcome and long-term survival and which patients are better off treated non-operatively.

Declaration of Competing Interest

Each author certifies that neither he or she, nor any member of his or her immediate family, has funding or commercial associations (consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2021.09.056.

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