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ORIGINAL ARTICLE

Fragility fractures of the pelvis: treatment and preliminary results

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Abstract

Background With increasing life expectancy, fragility fractures of the pelvic ring (FFP) are becoming frequent. In elderly, osteoporosis leads to a decrease of bone strength and resistance to the ligament's traction; this represents the most important difference between FFP and fractures in young patients. Usually, these fractures are underestimated and treatment is often conservative.

Aims To evaluate clinical and surgical outcomes of surgically treated patients with FFP.

Methods We retrospectively enrolled 14 patients, in our Trauma Center, underwent surgery procedures for FFP between 2012 and 2014. All patients attended clinical and radiological investigation at 1, 3, and 6 months postoperatively and every year after surgery with a mean follow-up of 22 months.

Results At 6-month follow-up, 11 patients resulted asymptomatic: able to maintain standing position and walk without crunches. Two patients were able to walk with one crunch. The patient with history of previous acetabular fracture walks with two crunches and is still waiting for total hip arthroplasty.

Discussion The compromised health status and the diminished bone-healing capacity, in elderly, decrease chances for a good clinical outcome. In literature, many authors suggest that mortality rate in patients with FFP is similar to those with hip fracture. Diagnosis of FFP is very important: these fractures are highly disabling in elderly and can lead to displacement and instability. For these reasons, correct diagnosis and well-conduct preoperative plan are necessary to improve stability of fractures and support bone healing. After diagnosis, an anti-osteoporotic treatment is indicated to improve bone quality and bone healing.

Conclusions Our study shows encouraging results and demonstrates that minimally or less invasive osteosynthesis technique could lead to good outcome in these patients.

Keywords Fragility pelvic fracture · Osteoporosis · Surgical treatment · Pelvic fracture outcome

Introduction

Pelvic fractures are usually caused by high energy trauma, as car accident or high highness falls. A mean energy between 2000 and 10,000 N is required to generate a pelvic disruption [1].

Tile's classification, which considers the fracture stability and the trauma direction, is largely used to characterize pelvic fractures. Treatment of these fractures is clear and usually requires surgical approach [2]. The pelvic osteo-ligament complex, which is the strongest of the entire human body, has to be considered in classification and treatment of pelvic fractures [3]. With increasing life expectancy, fragility fractures of the pelvic ring (FFP) are becoming frequent. FFP represent a large series of injuries. The incidence of these fractures is poorly defined, but it is estimated that this fracture occurs in 25–92 per 100,000 persons years [4].

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The average cumulative risk at the age of 65 years for an incident FFP until the age of 90 years was 6.9 % in women and 2.8 % in men [5].

In elderly, osteoporosis leads to decreased strength and resistance of bone tissue to the ligament traction; this represents the most important difference of FFP than fractures in young patients. The trauma mechanism of these kinds of fractures is challenging to comprehend; sometimes they are due to low energy trauma, in other cases, a recent story of trauma is not identifiable. It is necessary to remark how in osteoporotic elderly poor bone quality adversely affects tissue competence, leading to an impaired healing capacity [6].

Usually, traditional X-rays are able to highlight anterior arch lesions, but posterior injuries are difficult to visualize; therefore, those injuries are commonly underestimated [1].

Clinically, these types of fractures present an aspecific pattern and the diagnosis is often insidious and difficult [3–7].

In FFP, plain radiographs of the pelvis are often performed as the first screening test. The three conventional views (anteroposterior and Pennal inlet and outlet views) are the first step of the diagnostic workout. Plain radiographs have sensibility for anterior arch lesions (pubic fractures, symphysis pubis disruptions), but diagnosis of non-displaced or incomplete lesions of posterior pelvic lesions is often not possible [8]. X-ray computed tomography (CT) scan is helpful by showing fissures and displaced or non-displaced fractures of the sacral wing especially in coronal plain. Typically, fractures are located in the sacral wing, between the neuroforamina and the sacroiliac joint. In some cases, a destruction of the cancellous bone with widening of the fracture gap is visible [1].

Multiplanar reconstruction in the Pennal's plane should be useful to better characterize the fracture pattern.

Magnetic resonance imaging (MRI) is considered the gold standard for the imaging of FFP. It combines high sensitivity with high specificity. In T1-weighted sequences, these fractures appear as low signal intensity; in T2-weighted sequences appear as high signal intensity; short-tau inversion recovery (STIR) sequences are particularly sensitive. Often in axial plane, a fracture line can be visualized, but sometimes the appearance can be non-specific imaging. Coronal imaging is helpful by showing a horizontal component of the fracture. Bone scintigraphy is a sensitive technique for suspected FFP [9].

Pelvic fractures in elderly are different than in young patients due to the presence of osteoporosis which makes the bone less resistant to the ligaments traction. For that reason, fractures are usually more stable compared to the young patients. In 2013, Rommens published a new classification based on clinical and radiological criteria to characterize FFP and to evaluate the proper treatment [7].

This classification is based on the degree of instability derived from radiological and clinical findings.

Rommens et al. distinguished, as major categories: slight, moderate, high and highest instability. They selected 4 types of fractures: FFP type I includes anterior injuries; FFP type II non-displaced posterior injuries; FFP type III displaced unilateral posterior injuries and FFP type IV displaced bilateral posterior injuries.

Each type is divided into subtypes.

Within each type, Rommens distinguished different subcategories that are characterized by the localization of the injuries and the presence of fracture displacement identifiable on conventional X-rays, CT views and/or MRI images [7, 10].

Displaced lesions are characterized by deformation of the anatomical landmarks.

Type I is divided into two different entities: type Ia lesion is a unilateral anterior disruption; type Ib lesions are characterizes by bilateral anterior disruption. The prevalence of type Ia and Ib lesions is less common in the elderly than in younger patients.

In all FFP type I lesions, only the anterior pelvis is broken, with no evidence of crush or fissure fracture in the dorsal pelvis.

In FFP type II lesions, the instability is moderate; three subcategories are distinguished: type IIa non-displaced lesion and isolated unilateral sacral fracture which is best seen in CT imaging. Usually, the fractures run vertically through the sacral wing, laterally from the neuroforamina and medially from the sacroiliac joint. Other fractures, with an atypical fracture pattern, are more frequent in patients with implants or nearby the hip joint [11]. In type IIb, pubic and ischiatic rami fractures are combined with a crush zone of the sacral wing, without the presence of displacement.

In type IIc lesions, pubic and ischiatic rami fractures are combined with a non-displaced sacral wing fracture.

Type III lesions have a high degree of instability. These lesions are divided based on the localization of the dorsal injury: disruptions running through the iliac bone, through the sacroiliac joint and through the sacrum. In the anterior pelvic ring, there is a complete unilateral or bilateral disruption at the pubic and ischiatic rami or at the pubic symphysis.

In type IIIa, there is a complete unilateral iliac disruption combined with a complete anterior disruption. The dorsal disruption starts from the ilium's inner brim and runs laterally through the iliac wing to reach the iliac crest at different levels.

Type IIIb has an iliosacral disruption combined with a complete anterior disruption. In type IIIc lesion, there is a

complete unilateral sacral disruption combined with a complete anterior disruption [12].

Type IV lesions have the highest instability. These fractures are different from all other categories because of one specific characteristic: the complete dissociation between the spine and the pelvic ring (spinopelvic dissociation). These lesions require specific fixation, connecting the lumbosacral spine with the dorsal pelvic ring. Three different types of disruptions are observed: in type IVa lesion there is a bilateral iliac fracture, starting from the inner brim of the ilium and running to the iliac crest; the spine including the total sacrum and dorsal parts of the ilium are separated from the rest of the pelvic ring. In type IVb lesions, there is a bilateral and complete sacral wing fracture. The sacral bodies and the bony structures around the neuroforamina are separated from the sacral wing. A transverse fracture line may connect the two vertical sacral wing fractures: the transverse fracture line is typically situated at the level of S1 or S2 (H fracture).

In type IVc lesions, there is a combination of different instabilities in the dorsal pelvis: a transiliac instability combined with a trans-sacral instability on the other side, a trans-sacral instability combined with a transiliosacral on the other or a transiliac instability on one side with a transiliosacral instability on the other.

Rommens et al. described that a lesion can move from a category with a lower instability to a category with higher instability, when not adequately treated.

The treatment of FFP differs from those occurring in young patients too. The integrity of ligaments structures and the higher stability of these fractures allow a percutaneous or minimally invasive stabilization in most of the cases. Type I fractures are generally conservatively treated with bed rest and medical treatment to improve bone quality. Type II is treated with percutaneous stabilization after a period of medical treatment. Mostly, type III and IV are treated with minimally invasive or percutaneous stabilization, when reduction is not required. Different treatments are suggested for pelvic fractures, such as sacroplasty, iliosacral screw and lumbopelvic fixation [1].

The Rommens classification gives hints of which type of surgical therapy could be performed for every lesion category. Type I lesions could be treated conservatively with bed rest and analgesic medication, followed by mobilization out of bed and increasing weight bearing of the injured side [1].

The presence of osteoporosis and bone metabolism should be investigated, taking into account the possibility to start an adapted drug therapy [13]. More conventional pelvic overviews or additional CT examinations are recommended in case of persistent pain to exclude fractures or displacements that may not have been visible or present at admission [14].

In type II lesions, an isolated posterior or a combination of anterior and minor posterior instability is identifiable. With early mobilization, there is a risk of increasing instability or nonunion. Recovery with conservative treatment will be longer and more problematic than in type I lesions; therefore, surgical fixation should be considered [1].

Sacroplasty is increasingly used to treat incomplete and isolated sacral ala fractures [15].

In literature, there is still no evidence of long-term results of sacroplasty technique. Cement leakage represents the more common complication of this technique and could affect the fifth lumbar nerve root due to the special course of its ventral branch over the sacral promontory [16]. Nondisplaced sacral fractures can also be fixed with percutaneous iliosacral screws. Two screws are inserted in the S1 body or one screw in S1 and a second screw in S2. In the anterior ring, retrograde screws are inserted from the pubic tubercle through the pubic rami towards the iliac bone medially and cranially of the acetabulum.

In type III lesions, an open surgical procedure is sometimes needed. In the anterior pelvis, could be distinguish pubic rami fractures and symphysis pubis disruptions. For pubic rami fractures, the percutaneous retrograde screw insertion is an option. When the pubic fractures are situated laterally, a plate osteosynthesis is considered as an alternative to retrograde screw placement. Three posterior types of osteosynthesis are possible: iliosacral screw osteosynthesis, placement of a trans-sacral positioning bar and placement of a trans-sacral bar [1].

Aims

Our purpose was to evaluate clinical and surgical outcomes of surgically treated patients, with FFP.

Materials and methods

We retrospectively enrolled 14 patients who underwent surgery procedures for FFP between 2012 and 2014. Inclusion criterion was surgery due to chronic lower limbs pain or low back pain with no other diagnosis and not responding to FANS therapy. Every patient was studied with 5 plains radiographs and CT scan to diagnose FFP. Risk factors for fragility fractures were investigated and after surgery all patients were screened for bone turnover markers, and DEXA scan was performed. All the patients attended clinical, radiological and osteoporotic investigation at 1, 3, 6 months postoperatively and every year after surgery. The mean follow-up was 22 months.

Results

All the 14 patients were studied postoperatively and the mean follow-up was 22 months. Nine patients were female and five were male; mean age was 69.6 years (range 63–81). According to Rommens classifications for FFP, 3 fractures were distinguished as FFP type II, 9 fractures as FFP type III, and 2 as FFP type IV.

Six patients referred a low energy trauma and eight a spontaneous pain or suffered low back pain. Most patients referred a fall on their side or backwards at home. Pains worsen in standing position and walking. Four patients were unable to walk; among these, two patients were wheelchair forced. A patient underwent kyphoplasty and total hip arthroplasty (THA) for the same clinical findings within 3 months before the FFP. One patient had history of previous pelvic (bilateral sacral wing fracture and symphysis disruption) and acetabular fracture treated conservatively; the sacral wing fractures evolved in sacral wing bone reabsorption and in pelvic instability; the acetabular fracture leaded an acetabular malunion and avascular necrosis of the femoral head (Fig. 1a–c).

Four patients had undisplaced anterior ring pelvic fracture treated conservatively in the previous 2 years. No CT scan was performed at the time of admission in emergency department. All patients were taking non-steroidal anti-inflammatory drugs (NSAID) as pain medication, with no improvement of quality of life. Only five patients had diagnosis of osteoporosis at the moment of FFP. All of them were taking bisphosphonate but not well screened for osteoporosis.

All the patients were studied with the radiological three conventional views (anteroposterior, inlet view, outlet view), CT scan (Fig. 2a–d) and in five cases was performed an MRI. All of them were screened for osteoporosis and underwent to densitometry, vitamin D blood dosage and dorsal and lumbar spine X-ray for morphometry.

All patients had osteoporosis at dual X-ray absorptiometry (DEXA) scan with a mean T score value of -3.3 DS (range -2.4 and -4.6 DS). The mean vitamin D value was 11.3 ng/ml (range 5.2 and 19.6 ng/dl). X-ray morphometry showed almost a vertebral compression fracture (vertebral fixation complex) in 11 patients, 4 patients suffered multiple VFCs.

The patients with FFP type II fractures, after 6 months of conservative treatment, underwent surgical procedures of percutaneous iliosacral screws associated with symphysis plate fixation in one case (Fig. 1d–f) or retrograde pubic rami screw in two cases. The FFP type III fractures were treated in five cases with percutaneous iliosacral screws associated with symphysis plate fixation or retrograde pubic rami screw (Fig. 2e); in three patients a trans-

sacral bridge plate was associated to percutaneous iliosacral screws for posterior stabilization. The two patients affected by FFP type IV underwent to percutaneous lumbopelvic fixation and symphysis plate fixation. The patient with previous history of complex pelvic trauma was treated with trans-sacral bridge plate associated to the percutaneous lumbopelvic fixation and symphysis arthrodesis with autologous bone withdrawn from the iliac crest and plate fixation through Pfannenstiel approach (Fig. 1d–f).

Patients underwent radiological conventional three views in the postoperative period. In one case of the lumbopelvic fixation, we observed one intrapelvic iliac screw (Fig. 1e); the case was studied with CT scan, and no vascular, neurological or internal organs lesion was noticed. Due to the different surgical treatment performed, surgical timing resulted not homogeneous, varying between 70 and 220 min.

No neurological palsy or vascular lesions were observed; no patient needed intensive care unit after surgery. No major complications were observed. The mean hospitalization time was 5.8 days.

After surgery, the patients were bed-rested for 4–6 weeks.

After this period, the entire series were verticalized and walking with partial weight bearing for 6–8 weeks was permitted.

At 6-month follow-up, 11 patients were asymptomatic with restored ability to stand and walk without crunches; two patients were able to walk with one crunch. The patient with history of previous acetabular fracture walks with two crunches and is still waiting for THA.

CT scan and radiological conventional views showed fracture healing in all cases after 6 months (Figs. 1f, 2f) and showed no implant mobilization at the very last follow-up.

Densitometry at 1 year was performed in four patients and it showed an increase of T score values both in lumbar spine and in femoral neck ($+4$ %).

All the patients underwent pharmacological treatment for osteoporosis after diagnosis; we modified, after the fracture, the anti-osteoporotic therapy for the five patients under bisphosphonate treatment. In eight cases, we prescribed denosumab and in six cases, we prescribed 1–34 parathyroid hormone (PTH) therapy. To all patients, we also prescribed vitamin D supplement.

Conclusions

Fractures of the pelvic ring are different from high energy pelvic fractures in young patients due to the presence of osteoporosis which makes the bone less resistant to the ligaments traction. The incidence of FFP has recently showed a
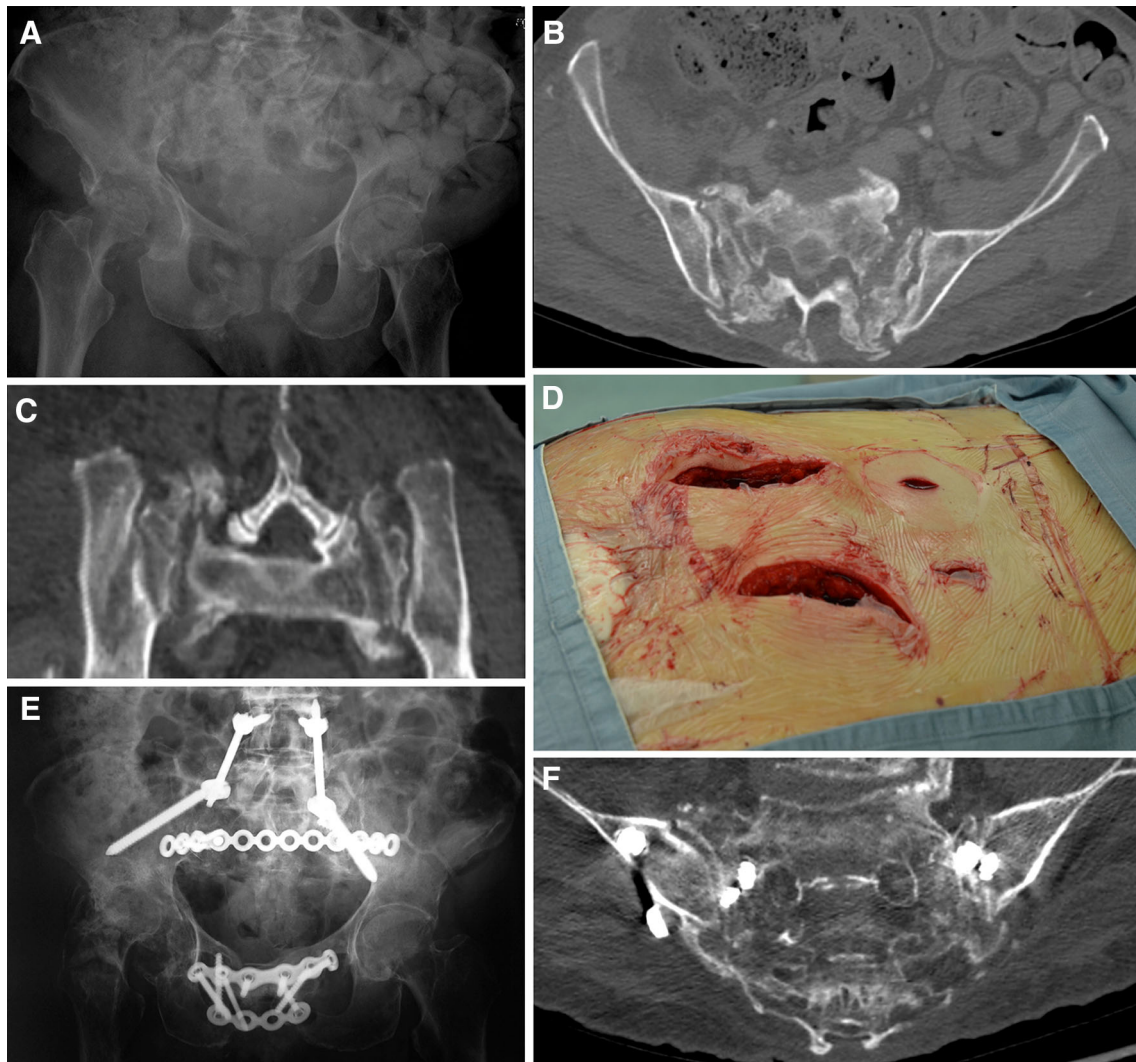
Fig. 1 a Female patient, 66 years old. History of previous pelvic (bilateral sacral wing fracture and symphysis disruption) and acetabular fracture treated conservatively; the sacral wing fractures evolved in sacral wing bone reabsorption and in pelvic instability; the acetabular fracture leaded an acetabular malunion and avascular necrosis of the femoral head. The patient was wheelchaired. **b, c** CT scan showed bilateral sacral wing fractures, with spinopelvic dissociation. The patient was classified as FFP type IVc according to Rommens's classification. **d** The patient underwent minimally invasive lumbopelvic fixation, and symphysis fusion with autologous bone from iliac crest and plate fixation (Pfannenstiel approach). **e, f** at 1-year follow-up AP X-ray and CT scan showed fracture healing in all patients after 6 months and did not show implant mobilization. One iliac screw was positioned intrapelvic; no vascular, neurological or internal organs lesion was noticed. The patient is still waiting for THA

marked increase due to the greater longevity of population. The compromised physiologic reserve and the diminished healing capacity typical of elderly people have an adverse effect on the potential for a favorable clinical outcome.

Low energy falls are responsible of majority of FFP, however, up to one-third have been noted to occur in absence of trauma [17].

Several paper suggest how mortality rates of patients with FFP is similar to those seen for hip fracture [4], reaching 20 % at 6 months. At 5-year follow-up, there was no difference in mortality between patients with pelvic fractures and hip fractures [9].

Immobility following non-operative treatment has been associated with serious complications: decreased muscles strength, deep venous thrombosis, pulmonary embolism, postural hypotension, decreased cardiac function, urinary retention, constipation, pressure ulcers, impaired pulmonary function, bone reabsorption and osteoporosis aggravation, psychological dysfunction with depression [9].

In our advice, in emergency department, isolated fractures of the anterior pelvic arch should be examined with CT scan for the exclusion of posterior sacral lesions. This behavior can lead to correct treatment of these patients. Primary risk factor for FFP is osteoporosis, in fact these
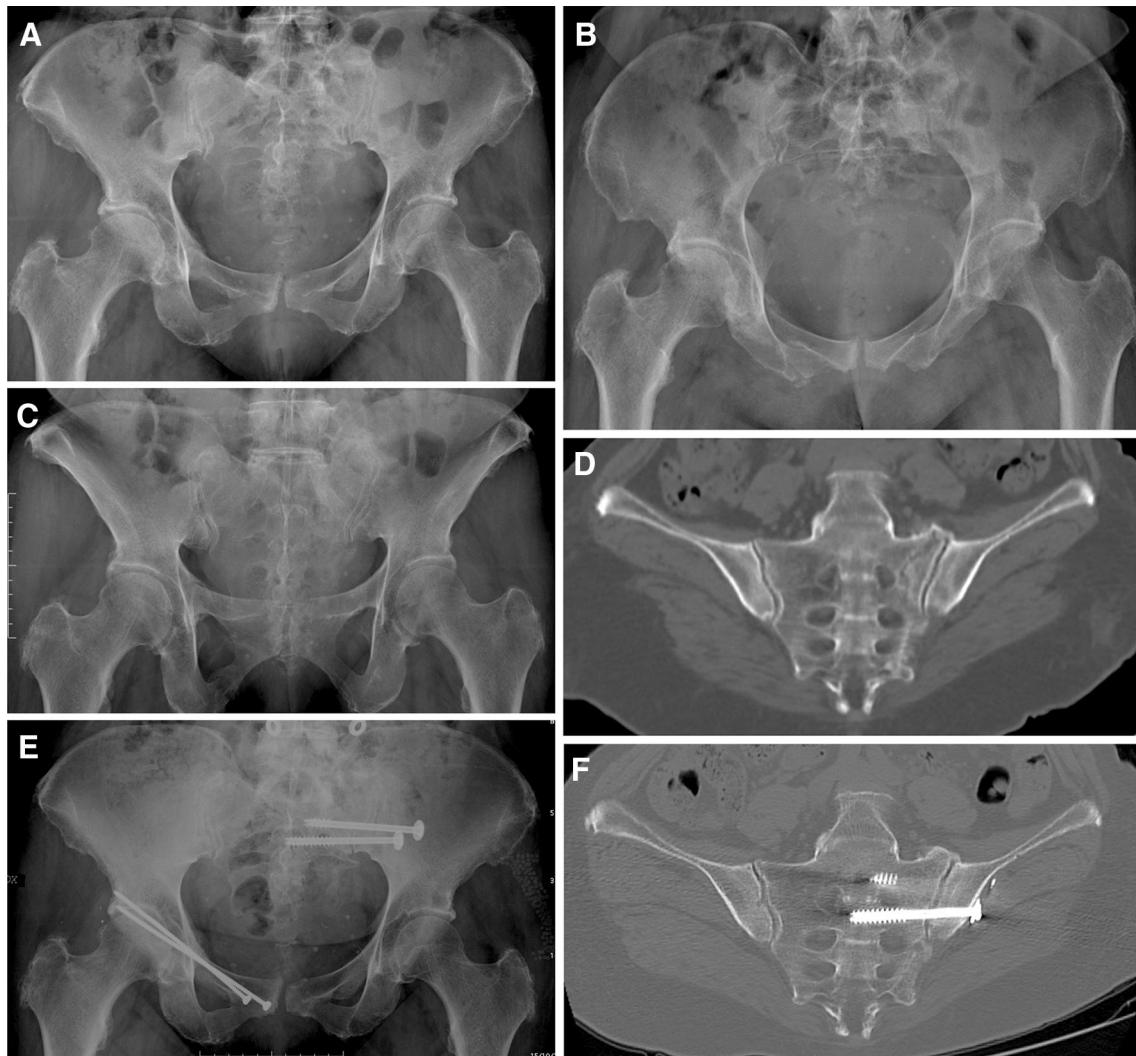
Fig. 2 a AP view of female patient, 73 years old with onset of spontaneous pain, she suffered low back pain; the patient was walking with 2 crunches. **b**, **c** Inlet and outlet views showed right iliopubic and ischiatic rami fractures, and bone reabsorption at fracture site. Posterior lesions were not visible on radiological views. **d** CT scan showed insufficiency fracture of the left sacral wing, with signs of bone reabsorption. The patient was classified as FFP type III according to Rommens's classification. **e** The patient underwent iliosacral screws fixation and percutaneous fixation of the pubic rami. At 2-year follow-up AP, inlet and outlet views showed bone consolidation. **f** CT scan showed that sacral wing fractures were healed; the fracture site was no more recognizable

kinds of fractures occur in post-menopausal women and in patients at risk for vertebral compression fractures [18].

These injuries result in significant morbidity, prolonged hospitalization, immobility and loss of autonomy in previously active patients. An opportunity exists to improve outcomes with surgical managements [8]. Diagnosis of FFP is of paramount importance; they are highly disabling in elderly patients and can lead to insidious progress of bone damage leading to complex displacement and instability. Rommens et al. described that a lesion can move from a category with a lower instability to a category with higher instability, when not adequately treated [1].

In elderly patients, bone microdamage and structural modifications arise from cellular and metabolic changes. Biomechanical studies have shown that a rise of 4 % of cortical porosity determines an increase of bone's microdamage. With a 20 % of cortical porosity, they found a decrease of bone resistance; especially in over 65-year-old patients, in which the average is about 46 % [19].

For these reasons as diagnosis of FFP type II or greater is taken, planning a adequate treatment for these patients is mandatory to improve stability of fractures and allow bone-healing process.

When diagnosis is taken, it is mandatory to set up an anti-osteoporotic pharmacological treatment to improve bone quality and bone healing.

All patients with FFP should be screened for bone metabolism and bone densitometry and properly treat for osteoporosis.

Rommens classification characterizes FFP allowing the evaluation of the right treatment. Most of FFP needs percutaneous treatment providing less invasive surgery granting good postoperative results and a quick rehabilitation of patients and strongly improving quality of life.

Our study brings encouraging results; minimally or less invasive osteosynthesis technique should lead an improved life quality in these patients. Surgical treatment should be always associated with a proper anti-osteoporotic therapy.

Limitations of the study are the follow-up length and the small number of cases.

Early results of minimal invasive procedures for FFP are promising but further researches are necessary to reveal the long-term outcomes and complications.

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