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Surgical issues in total hip replacement of post-traumatic outcomes around the hip

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Summary

The increase in life expectancy and aging of the population will lead to an increased number of patients who will need revision surgery to treat surgical failures or medium- and long-term complications of fractures involving the hip joint.
The purpose of this article is to identify the causes of the failure of primary surgery and to provide the elements to identify the main critical issues that the surgeon will face.
The effort of the orthopedic surgeon must be aimed at restoration of hip joint function through a well-planned surgical procedure conducted in the least invasive way possible in order to minimize the impact of surgery on the patient's physiology.
Restoration of the biomechanical parameters of the hip is essential to obtain a stable and functional implant for patients who are often at their last chance. In this scenario, it is fundamental that the surgeon dealing with these procedures has skills in both hip prosthesis and trauma surgery.

Key words: total hip replacement, revision surgery, proximal femur fractures, acetabular fractures, periprosthetic fractures

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Introduction

The global incidence of proximal femur fractures in Italy is estimated at more than 300 cases per 100,000 inhabitants in the female population and 150 cases per 100,000 inhabitants in the male population [1].
Although the age-standardized incidence shows a reduction in recent years, the increase in life expectancy and the aging of the population will lead to a larger number of proximal femur fractures, with a consequent rise in the rate of failures that need revision surgery [2]. Similarly, the incidence of acetabular fractures is also constantly increasing; alongside high-energy trauma in the younger population, nowadays one must also consider acetabular fractures for low-energy trauma in the elderly population. The annual incidence of acetabular fractures in England is estimated at around 2,000 cases per year, of which 72.5% occur in the elderly, a figure that is destined to rise with the increase in life expectancy [3].
The success rates of conservative treatment in older patients are rather poor, which has led to a greater need for surgical treatment with a consequent increase in the rate of complications or failures, especially considering that the results of this sur-

gery are less satisfactory than in younger patients, with 50% of patients requiring early prosthetic replacement [4].
For the same reasons, the incidence of periprosthetic fracture is growing with rates of post-operative periprosthetic fracture ranging between 0.1 and 18% after total hip arthroplasty [5]. An increase in patients who will need revision surgery to treat surgical failures or medium and long-term complications of hip fractures is therefore expected. These are patients who often present problems that complicate their management including osteopenia, osteoporosis, long periods of disability, the presence of previous implants that can impact on the bone stock of the proximal femur or acetabulum.
The purpose of this article is to identify the causes of the failure of primary surgery and to provide the elements to identify the main critical issues that the surgeon will face; the goal is to restore the correct biomechanics of the hip joint.

Femoral neck fracture failure

Failure of surgically treated femoral neck fractures (31 B according with AO-OTA classification) can occur in case of implant failure with early secondary displacement, non-union, infection, or femoral head avascular necrosis.
Slobogean et al. included 1558 femoral neck fractures occurred in patients 60 years of age or younger in their meta-analysis and reported an 18% pooled incidence of reoperation (the total pooled incidence was 14.3% for avascular necrosis, 9.3% for non-union, 7.1% for malunion, 9.7% for implant failure, and 5.1% for infection) [6].
If the femoral head is not damaged, revision internal fixation is usually recommended and is associated with good functional outcomes and low rates of complications. Arthroplasty is the best surgical choice if the joint is compromised and may also be the best option in case of older patients with preserved joint but poor bone quality [7].
In case of failure of femoral neck fractures previously treated with osteosynthesis, the implanted fixation devices have a low impact on local bone stock as these usually have a low footprint on the proximal femur (cannulated screws, short DHS with or without anti-rotational screw) (Fig. 1).
In fact, some studies have shown that patients with previous intertrochanteric fractures treated with cephalomedullary nails more often require the use of distally fixing stems instead of metaphyseal press-fit stems compared to those treated with screws and DHS constructs, thus suggesting that nails compromise more proximal metaphyseal bone stock than other kind of implants [8].
Previous implant identification is essential to make removal easier with the suitable equipment, but additional extraction equipment such as a standard broken screw removal set should always be available.

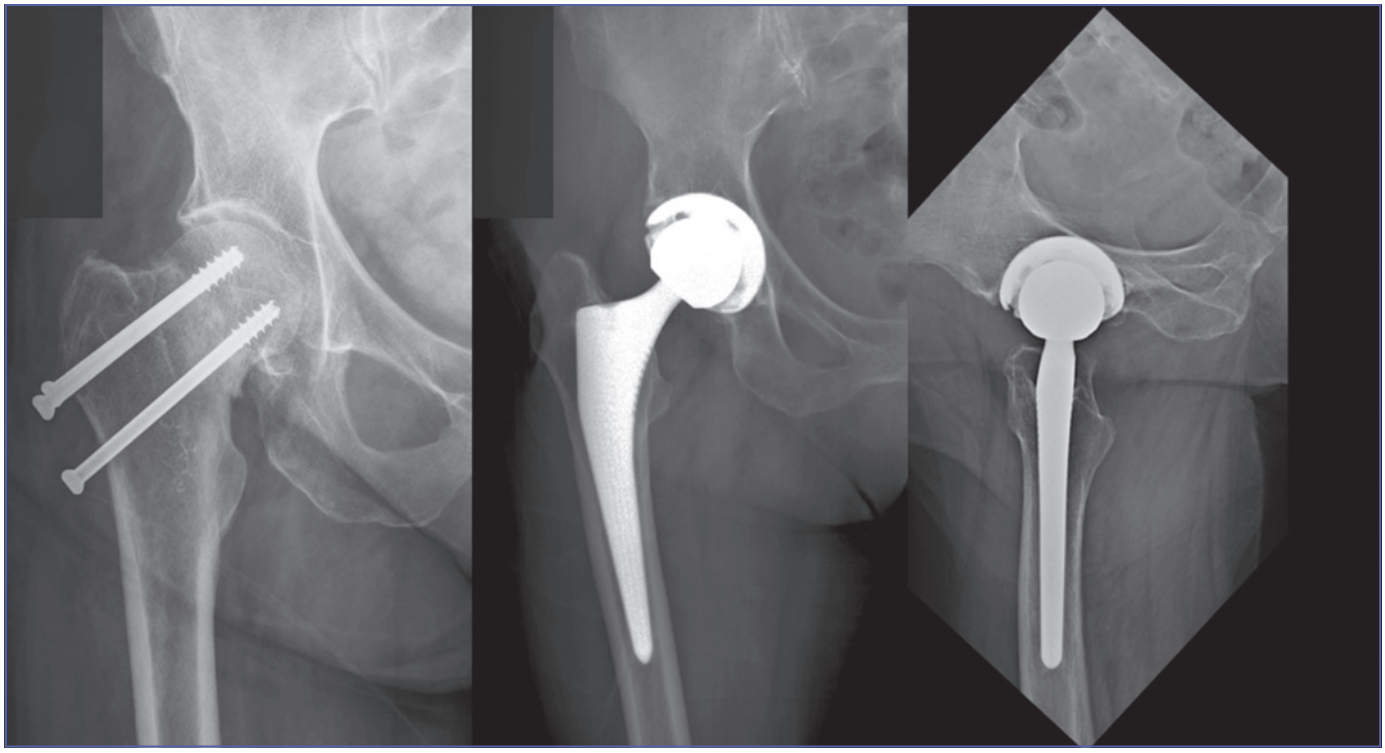

Figure 1. Failure of femoral neck fracture previously treated with three cannulated screws. This case can be managed with a conventional cementless stem due to the low footprint of fixation devices on the proximal femur.

It is well established that the incidence of dislocation after revision total hip arthroplasty is higher than that of primary total hip arthroplasty. For these reasons, it is probably preferable to use surgical approaches with a lower impact on joint stability such as the lateral or anterior ones. In fact, some studies show a higher rate of implant dislocation when a posterior approach is used compared to a lateral one [9].
Nevertheless, the literature agrees that there is no single surgical approach that should be recommended for all cases; the choice should be made on the basis of prior surgical approaches, the need to remove previous fixation devices and the surgeon's experience [7]. In our experience, the best surgical approach is the one that allows easier hardware removal.
Dual mobility cups may be useful to improve stability in patients with unmodifiable risk factors for implant dislocation, as in the case of primary total hip arthroplasty [10].
Among these risk factors, extensive bone loss, long periods of disability, and poor muscle tone are particularly frequent in patients with previous femur fractures who undergo revision surgery; for this reason, dual mobility cups may be useful, especially when these risk factors are associated with previous comorbidity such as neurological disability (motor, cognitive or psychiatric disorders).
As already anticipated, conventional stems can be used in the treatment of femoral neck fracture failures without need for revision stems because of the relative low footprint of screws and plates on the proximal femur [8].
In the literature, there is no clear preference between cemented and cementless stems [7]; the choice of the type of fixation of the femoral component should be based on the patient's age and bone quality (not quantifiable but to be evaluated on the basis of age, clinical history, comorbidities, and x-ray images) in analogy to how the surgeon choose the implants for primary arthroplasty in proximal femur fractures.
Obviously, when a cemented stem is needed, it is necessary to plug holes from prior fixation before introduction of the femoral component to avoid migration of cement into soft tissues [11].
If a cementless stem is used, it is recommended to bypass prior screw holes to avoid a stress riser in the metadiaphyseal region and if in doubt to use a preventive cable [12].

Trochanteric fracture failure

Failure of surgically-treated trochanteric fractures (31 A according with AO-OTA classification) can occur for the same reasons previously discussed (implants failure, non-union, malunion, infection or in case of femoral head avascular necrosis) [13].
Femoral head avascular necrosis is infrequent with an estimated incidence of 1.37% within two years from injury, but must be taken into account among the possible reasons of failure and is related to the severity of trauma, fracture pattern, and displacement [14]. Previous patient-related factors and a potential risk of circulatory damage to the femoral head blood supply during surgery must also be considered.
In anticipation of total hip arthroplasty, infection must be excluded as the cause or contributing cause of failure in this group of patients since they will undergo a more demanding surgery.
As previously mentioned, implanted fixation devices have a higher impact on femur bone stock with frequent extension to the diaphyseal region [8].
In this group of patients, great attention must also be paid to the trochanteric region as it plays a fundamental role in the restoration of joint biomechanics with its muscle insertions.
This aspect assumes great importance because of a higher incidence of dislocation after total hip arthroplasty performed for failure of surgically-treated trochanteric fractures. The reason for the higher incidence is related to a greater difference in femoral neck anteversion between the affected and healthy sides if the fracture reduction is not performed optimally in trochanteric fractures compared to femoral neck fractures [15].
In this case, previous implant identification is also essential to make removal easier with the suitable equipment.
In case of plate with diaphyseal extension, the surgical approach must be distally extensible for removal but there is no single surgical approach that can be recommended: between a posterolateral approach and an anterolateral approach, the choice should be made on the basis of the surgeon's preference [7].
The distal extension of the surgical approach should be made anatomically, separating the vastus lateralis muscle from the intermuscular septum and tying eventual perforating vessels to avoid significant bleedings.
The status of the great trochanter is definitely important: when trochanter malunion or deformity prevents adequate preparation of the femoral canal (overhang of the great trochanter), a simple trochanteric osteotomy can be useful, preserving the continuity of the abductors and the vastus lateralis which are important in hip stability [16].
In case of femoro-acetabular impingement and joint stiffness, a digastric osteotomy of the trochanter according with Ganz with proximal release of the gluteus muscles and distal release of the vastus lateralis in line with their fibers may be useful to gain easier access to the femoral canal, thus avoiding intraoperative fractures [17].
Acetabular component do not usually present critical issues: the choice between traditional cups and cemented cups and use of fixation screws should be made on the basis of local bone quality [18]. As in other cases, dual mobility cups may be useful to improve the stability of the implant [10]. In case of acetabular bone defects due to device migration (such as head screws of a cephalomedullary nail), morselized cancellous bone autografts taken from the femoral head may be useful [7]. In this group of patients, revision stems with diaphyseal fit should be preferred for many reasons: as previously noted, the implants used to treat trochanteric fractures have a higher impact on the proximal femur bone stock making the use of metaphyseal press fit stems more critical [8]. Furthermore, long revision stems allow to bypass eventual subtrochanteric extension of the fracture and any area

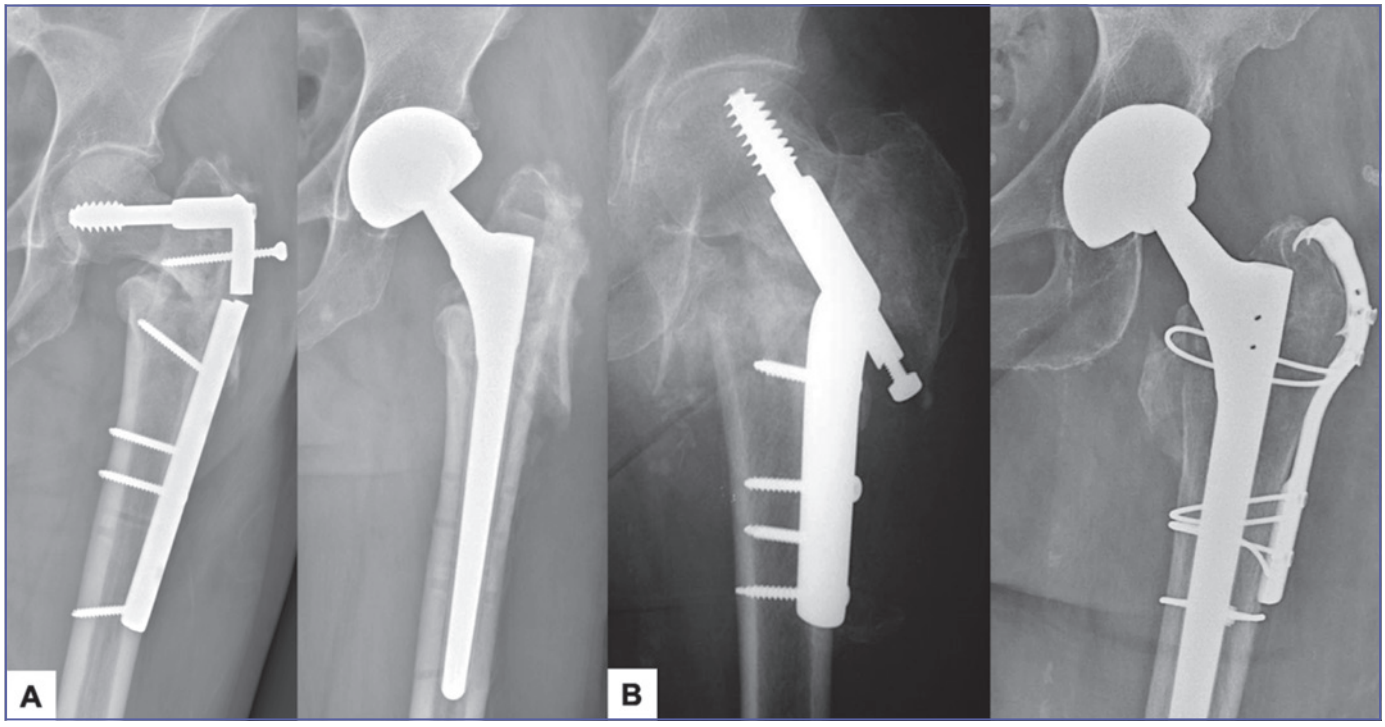

Figure 2. Failure of trochanteric fractures. In A, there was no need to stabilize the trochanteric region once its stability was assessed intraoperatively: in B, displacement and instability of the trochanteric region required stabilization with hook and cable plate to prevent the traction force effected by the gluteal muscles and secondary loss of reduction.

of less resistance due to previous screws holes [13]. For the same reasons, cemented stems find few indications; in fact, the use of a cemented prosthesis may be associated with cement leakage through previous screws holes and embolization [19].

Another critical issue in revision total hip arthroplasty performed in these failures is trochanteric reattachment that may be needed in case of trochanteric nonunion in order to restore local biomechanics (Fig. 2).

The current literature agrees that the use of cable plate results in improved clinical performance compared with early generation cable or traditional wire fixation. Compared with these kind of devices, trochanteric cable plates are associated with more effective restoration of abductor function with a lower complication rate [20]. In these situations, the restoration of local joint biomechanics achieving a stable prosthetic implant is the main challenge for the orthopedic surgeon, who must combine skills in prosthetic surgery and in reduction and fixation techniques, typical of trauma surgery.

Periprosthetic fracture failure

Several factors make the surgical management of periprosthetic femoral fractures technically challenging; among these, poor bone quality can be highlighted, along with altered local anatomy and necessity to manage both the prosthesis and fracture. The main aspect to be evaluated to choose the best therapeutic strategy is stem stability: in general terms, open reduction and internal fixation is the gold standard in case of well-fixed stems (B1 type according with Vancouver classification), whereas loose stems (B2 type) require revision arthroplasty, in some cases in association with osteosynthesis. Open reduction and internal fixation for a periprosthetic fracture in which the stem is loose is associated with an extremely high failure rate [21].

It is therefore evident that an important cause of failure can be incorrect evaluation of stem size and stability, which can cause secondary displacement of the fracture site and subsidence of the femoral component with consequent loss of implant stability (Fig. 3). In addition, other important causes of failure are nonunion and infection.

In general terms, nonunion of a periprosthetic femoral fracture is infrequent, but the treatment is particularly difficult with a high rate of complications and relatively poor functional outcomes [22]. In analogy to trochanteric fractures, great importance must be attributed to stabilization of the trochanteric area. In fact, if proper stabilization is not achieved the prosthetic stability can be negatively affected. Modern angular stable systems, trochanteric hook, and cable plates are associated with a more effective restoration of abductor func-

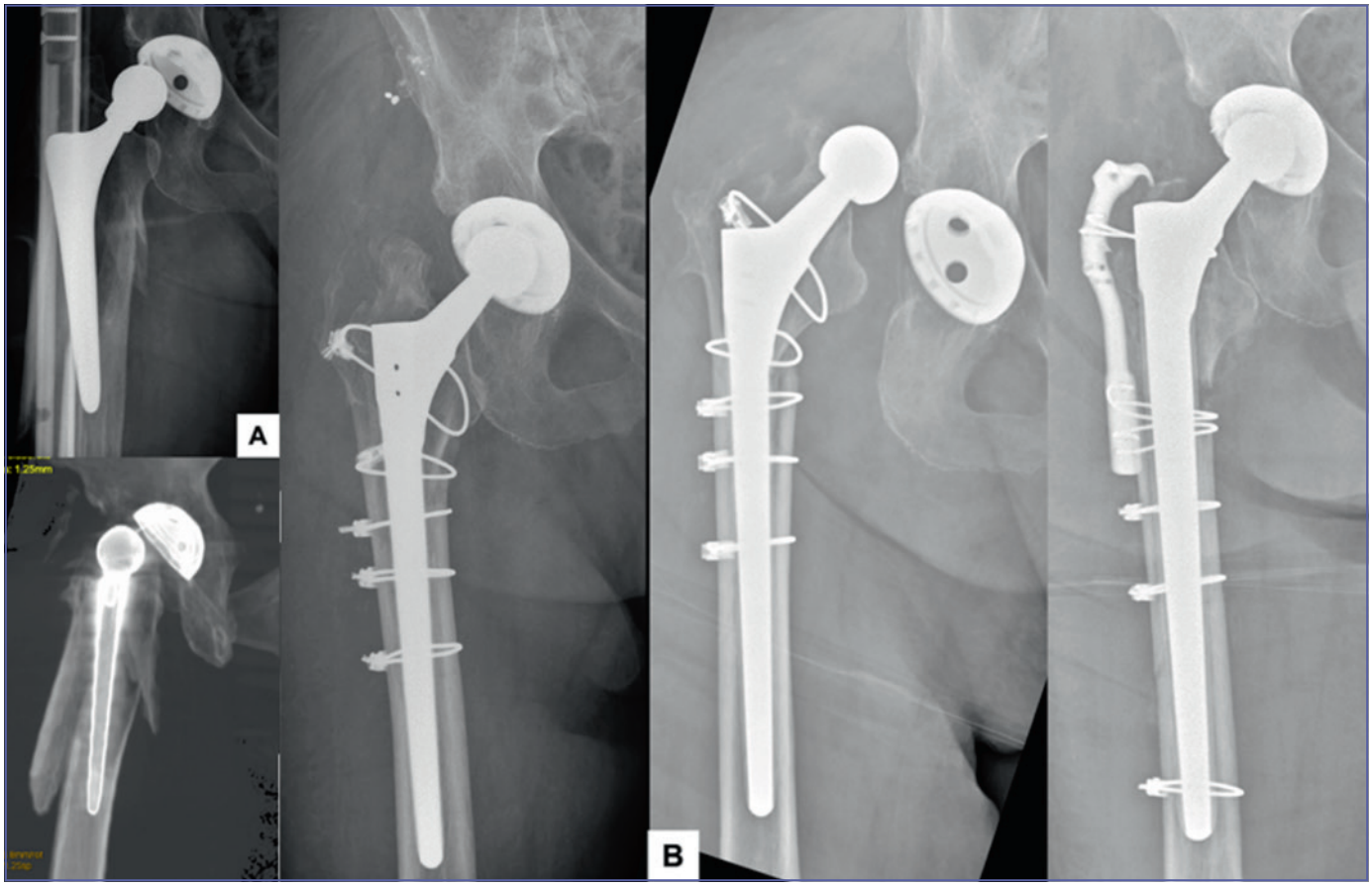

Figure 3. A) B2 type periprosthetic fracture treated with revision stem and cerclages to maintain reduction of the meta-diaphyseal fracture; B) early failure at seven days with subsidence of the femoral component and joint dislocation due to poor stability of the trochanteric area and undersized femoral stem. Revision surgery with longer and greater diameter stem and osteosynthesis of the trochanteric region with hook plate and cables.

tion and allow to efficiently contrast the traction effect exerted by the gluteal muscles on the trochanteric fragment [20]. Regarding the surgical approach, we prefer to perform the same approach used in the primary surgery to avoid excessive weakening of the hip joint.

Acetabular fracture failure

Complications following surgical fixation of acetabular fractures are common; some of these may require revision prosthetic surgery. Post-traumatic arthritis is one of these complications; Giannoudis et al. reported that 13-44% of patient successfully treated with open reduction and internal fixation developed post-traumatic arthritis [23].

Other causes of failure are early loss of reduction or nonunion with late femoral head avascular necrosis.

Fracture patterns that are more often related to poor outcomes are hip dislocation with posterior wall involvement, posterior wall comminution, marginal impaction, and superomedial roof impaction.

Tannast et al. [24] reported that age greater then 40 years, hip dislocation, posterior wall involvement, femoral head impaction fractures, marginal impaction, and initial articular displacement greater than 2 cm were associated with the future need for arthroplasty.

Poor bone quality together with a complex fracture pattern may be a contributing cause of fixation failure. Some authors suggest the association of fixation and acute total hip arthroplasty to minimize the risk of failure and guarantee the fastest functional recovery.

Major indications in older patients for acute total hip arthroplasty are severe comminution related to poor bone density, femoral head lesions, impaction fracture of more than 40% of the dome, femoral head and/or neck fractures, and preexisting severe degenerative arthritis [25].

In case of failure of a previously fixed acetabular fracture, pelvic and hip radiographs are required; oblique radiographs

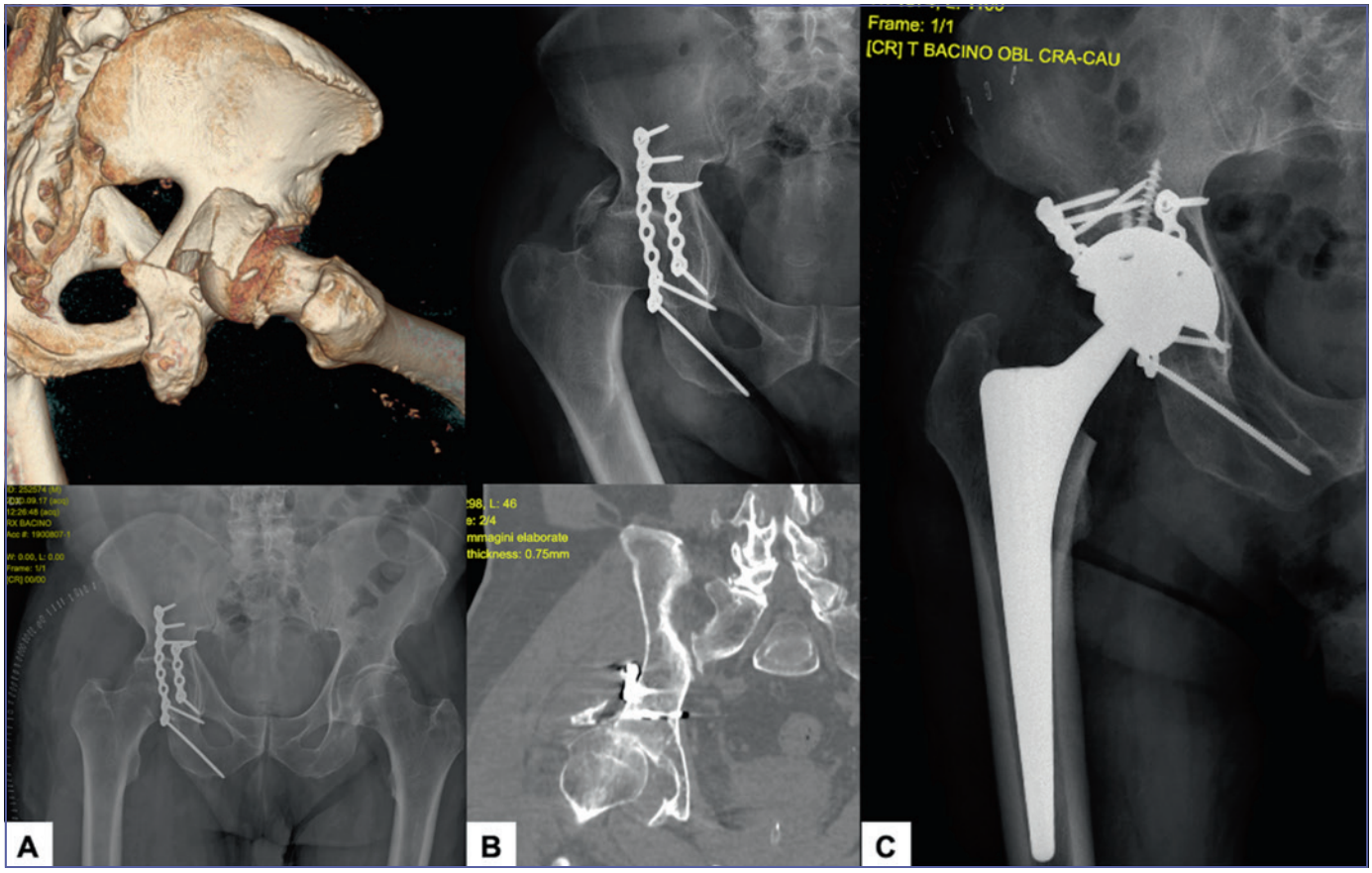

Figure 4. A) 84-year-old male with multifragmentary PW + PC fracture and hip dislocation treated with osteosynthesis through a Kocher-Langenbeck approach; B) early failure at 21 days due to poor fixation of the posterior wall fracture and recurrent posterior dislocation trough superior dome comminution and posterior wall fracture; C) revision surgery with total hip arthroplasty carried out with the same approach which allowed to change the position of the posterior plate increasing primary stability of the acetabular cup.

(Judet views) and computed tomography can be useful to identify areas of structural deficiency in the columns, pelvic discontinuity, or intraarticular screws which can make acetabular preparation difficult [7].

In our opinion, when a Kocher-Langenback approach is performed, it is preferable to proceed with a posterolateral approach to the hip joint to remove eventual intraarticular fixation devices, remove calcifications, and modify the positioning of a posterior plate in case of early displacement to increase primary stability of the cup (Fig. 4).

Patients with previous acetabular fracture frequently have acetabular bone deformity, acetabular bone loss, poor acetabular bone quality, and retained hardware from previous procedures. In this scenario, uncemented porous-coated revision cups, which also give the possibility to implant a large number of screws, are preferable, providing excellent primary stability and a very low rate of loosening. Segmental bone defects (more frequent at the level of the acetabular fundus and roof) are routinely filled with morselized autograft taken from the femoral head or with metal augments [7].

Conclusions

The constant increase in peri-articular hip fractures in fragile and osteoporotic patients necessarily leads to an increased rate of fixation failures. These patients need quick recovery to avoid serious complications that are sometimes fatal. In this scenario, the effort of the orthopedic surgeon must be aimed at restoration of hip joint function, through a well-planned surgical procedure conducted in the least invasive way possible in order to minimize the impact of surgery on the patient's physiology. Restoration of the biomechanical parameters of the hip is essential to obtain a stable and functional implant for patients who are often at their last chance.

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Authors' contributions
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Ethical consideration
This article does not contain any studies with human participants or animals performed by any of the Authors.

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