Surgical prosthetic treatment

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Summary

Fragility fractures typically occur in elderly patients related principally to osteoporosis. A significative percentage of these fractures have to be treated surgically but comorbilities are often present, and need to be grossly stabilized before surgery. However, there is for these fractures a high rate of morbidity and mortality at short-term.
Moreover, patients affected by a fragility fracture are at risk for another fragility fracture later in life.
The Authors present an overview of the main patterns of proximal femoral fractures, underlining the peculiar features and choices of surgical treatment, and relating to specific indications and results of each treatment.

KEY WORDS: Fragility fractures, open reduction and internal fixation, prosthetic treatment.

Introduction

Fragility fractures typically occur in elderly patients, with prevalence on women. Related principally to weakening of bone structure induced by osteoporosis, these fractures are the result of low-energy injuries. Comorbilities are often present and show quick worstening after a femoral fracture: patients' health status has to be grossly stabilized before surgery to limit peri-operative complications. However, there is for these fractures a high rate of morbidity and mortality at one year, approximatively 20%-30%, which represents the worst scenario at short follow-up among all fractures (1). Moreover, patients affected by a fragility fracture are at risk for another fragility fracture later in life.
Even if osteoporosis could virtually concern all bones, some district is more often involved: fracture of proximal femur is one of the most typical pattern of elderly patients. The incidence of hip fracture doubles for each decade of life after the fifth decade and the number of patients affected is expected to have an increase up to 190% in 2051 respect to present (2, 3).
Treatment of fragility fractures of legs is usually a surgical issue, because of the poor quality and weak biomechanical behaviour of the bone. Considered this particular background, surgery is intended to avoid additional damage, restore hip articularity, allow quick mobilization and functional recovery. Surgical technique and choice of the implant depend principally on the pattern of the fracture. Thus, an exact evaluation of the fracture is of paramount importance to achieve a good clinical result.
One of the main problem for the Orthopaedic Surgeon is to conciliate the need of a good reduction and stability with surgical efficacy to ensure a fast and longlasting recovery: in fact, a weak bone not only is at risk of fracture, but offers a structure that may be not strong enough to mantain a mechanical device as a nail, plate or implant, in particular after surgery, when mobility is of capital importance to ensure a safe recovery for the patients.
On the other side, the huge advancement of the biomedical technology still overcomes the complete knowledge of bone properties and behaviour of this tissue after a fracture, thus at now there is not a single best approach, choice of device or implant and surgical technique to obtain a better and longlasting result.
Some Authors postulated that osteoporotic bone has no impairment of its capacity for fracture healing: tendency to fall is the most important factor in fractures in the elderly, not osteoporosis and impaired function due to poor surgical technique in the elderly is unacceptable. The actual issue is to ensure an adequate fixation or implant stability in a poor bone structure even if technology has reached fine results in the manufacturing devices and prostheses with a favourable mechanical behaviour (4, 5).
We agree with the concept that the most of the efforts must be reserved to the acknowledgement of the biologic properties of the bone, while surgical technique and choice of implant have to follow and respect these improvements.
From an anatomic point of view, fractures of proximal femur may be intracapsular (femoral neck fractures) or extracapsular (trochanteric fractures): the incidence of the two patterns is equally distributed among fragility fractures.
The following is an overview of the specific pattern of upper femur fracture and the correlated treatment options.

Intracapsular hip fractures

Several classifications were proposed to correlate the aspect of femoral neck fractures with better treatment or prognosis.
Pauwels grouped these fractures according to the angle of the rim ($\leq 30°$, 30°-50°, $\geq 70°$), hypotesizing a relationship between obliquity of the fracture, stability of the reduction and rate of failure (6).
Garden classified femoral neck fractures in four types, according to displacement of fragments, relating it to a possible vascular damage and, ultimately, to healing of the fracture and survival of the femoral head (7).
Recently, AO classification divided femoral neck fractures in type B1, B2 and B3 depending on undisplaced subcapital, displaced transcervical and displaced cervical fractures (8).

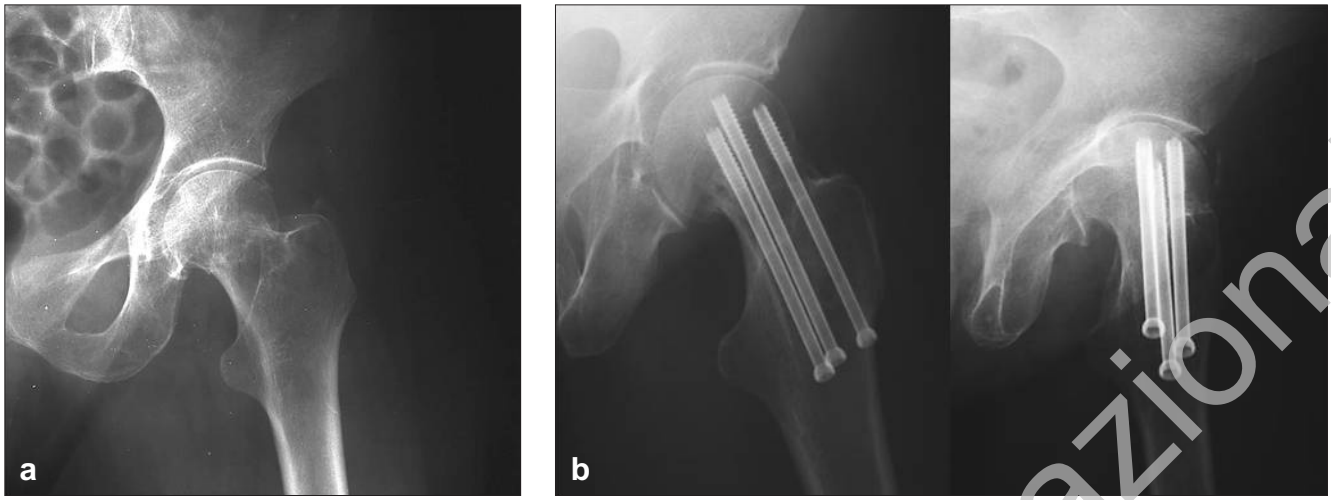

Figure 1 a, b - **a:** Garden 1 type femoral fracture in a 61 years old male patient. **b:** Fixation with three partially threaded screws.

Whatever the classification, operative treatment is the choice for the majority of the displaced femoral neck fractures.
Appropriate surgical treatment is usually open reduction with partially threaded, cannulated screws, for Garden and Pauwels type 1 and 2 type and AO B1 fractures, and hip joint replacement for Garden type 3 and 4, Pauwels type 3 and AO type B3 fractures (2, 3).
However, debate regarding whether the femoral head should be retained or replaced still continues. In their meta-analysis, Rogmark and Johnell showed that, regardless of the type of internal fixation, the failure rate was 21-57% and further surgery was required in 14-53% of all their cases. In contrast, reprise of surgery after arthroplasty was 7%, confirming analogous results of previous meta-analysis (9). Moreover, in a recent prospective randomised study Firhagen et al. reported that among people over 60 years old arthroplasty was associated with better functional outcome, higher health-related quality of life and more independence compared with internal fixation (10).
These fractures are rare among young people, generally correlated with high-energy accidents. There is consensus about appropriate treatment of these patients, that is early internal fixation and closed reduction in an attempt to preserve the femoral head (9). It has been shown that young adults achieve higher rates of fracture union and it is believed to be due to high healing potential and good bone quality of the upper femur in this age group (11) (Figure 1).
Prosthetic treatment provides different technical solutions to be evaluate on each specific case.
Hemiarthroplasty has been the workhorse for displaced femoral neck fractures for decades. Classically, a Hemiarthroplasty is intended as unipolar or bipolar implant. Unipolar is an anatomical solution characterized by a cemented femoral stem and a large metal ball with its diameter corresponding to the removed femoral head. It shows advantages on simplicity and rapidity of surgical technique, but presents a significative incidence on acetabular chondral wear and dislocation rate (1) (Figure 2).
Bipolar prosthesis are characterized by a large mobile cup articulating with a fixed smaller head joined to a cemented femoral stem: it has a theoretical advantage because of the design and biomechanic behaviour in order to reduce the acetabular wear, pain and dislocation rate while increasing range of motion (12). However, they are more expensive and it is still unclear whether or not the inner bearing looses mobility with time and become stiff. A recent meta-analysis reported no statistically significant differences between the two types of implants for outcome concerning dislocation, acetabular erosion, sepsis, revision, deep vein thrombosis and mortality (13,14) (Figure 3).
Additional studies are still needed to evaluate the better choice for active elderly people with life expectancy of more than ten years (4).
For healthy, active and mentally alert elderly people, primary total hip replacement has been proposed as a treatment option for displaced intracapsular fractures, providing better outcomes than internal fixation (15,16). Many randomised studies showed fewer complications, low rate of further surgery, better function and health related quality of life (4, 12, 16).
In this age group, hip replacement seems to be a reliable option when compared with hemiarthroplasty, according to many recent studies, without increasing the complication rate. However, total hip replacement after femoral neck fracture demonstrated an increased risk for early dislocation and periprosthetic fracture compared with prosthetic replacement performed for osteoarthritis. An attempt to reduce the complications rate may be achieved by use of a large or dual mobility femoral head an either a lateral surgical approach (4) (Figures 4, 5).
Cementing of femoral stem is still matter of debate. In a recent review of 7.774 patients at Mayo Clinic mortality was two folds when cementation was used, particularly in patients with cardiovascular disease (17). In the most recent meta-analysis, cemented implants, compared with cementless ones, were associated with less pain at short-term follow-up and a tendency to better initial mobility; however, no significant differences in surgical complications were found (14).

Extracapsular hip fractures

Almost more than 50% of hip fractures belongs to this type: they includes intertrochanteric (IT) and subtrochanteric (ST) fractures. The former group comprehends undisplaced, displaced and displaced unstable (with reverse obliquity or displacement of the lesser trochanter) pattern of fracture: these fractures present less risk of femoral head necrosis but more risk of blood loss and are complicated by higher mortality at one year. The latter group includes femoral fractures as up to 5 cm below the lesser trochanter, almost always displaced and to be early reduced and fixed with care and experience by the Surgeon. Several classifications were proposed for both extracapsular fractures, but, differently for intracapsular ones, none of these are actually useful from a prognostic point of view, representing only a descriptive outline.
Surgical treatment is almost the gold standard, except in rare cas-

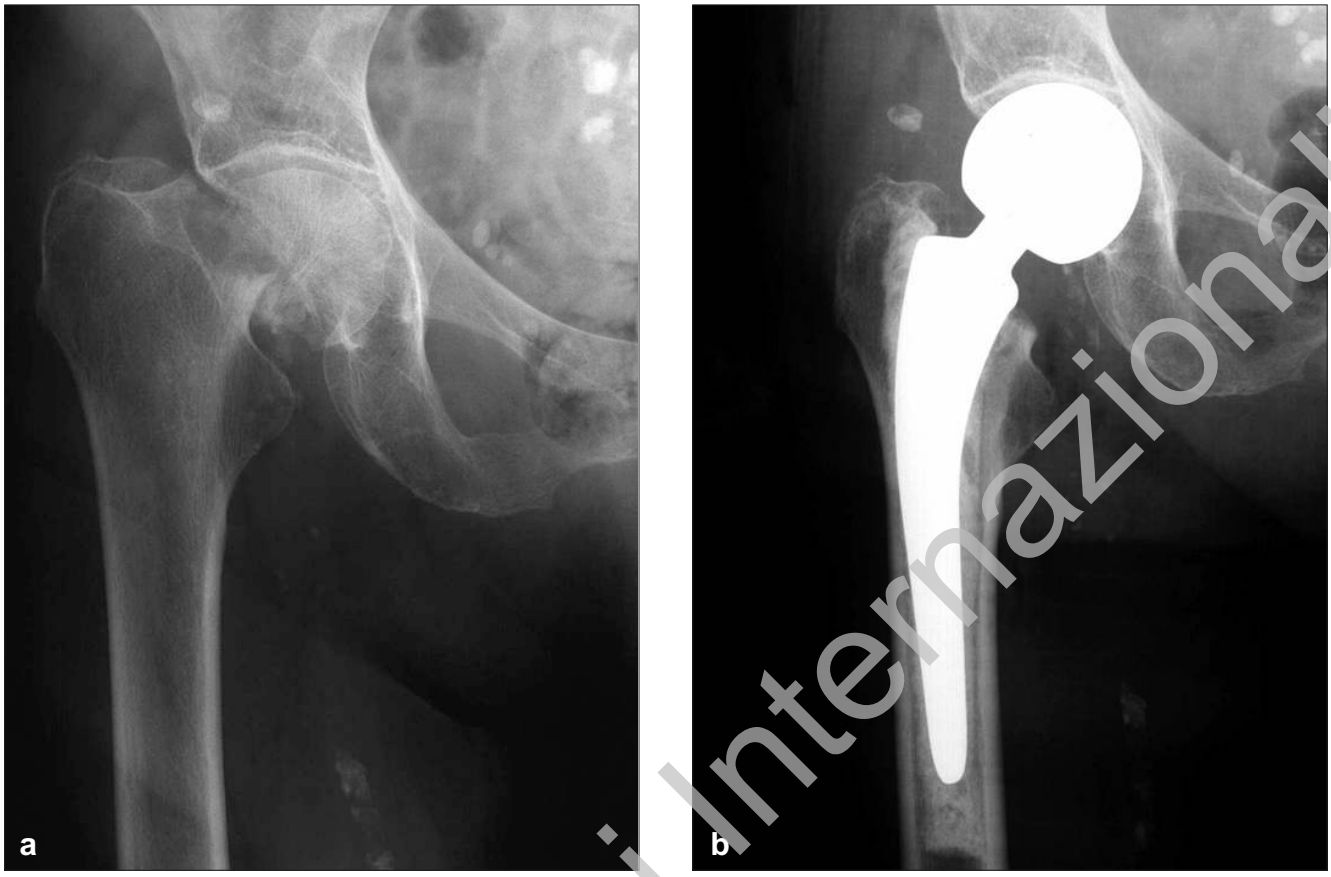

Figure 2 a, b - **a:** Garden 4 type femoral fracture in a 80 years old female patient. **b:** Unipolar cemented prosthesis.

es of high intraoperative risk of death due to patient's severe comorbidities. Successful internal fixation may be challenging because these fractures occur in osteopenic bone with reduced stock and decreased capacity to support adequately fixation devices.

The main matter of debate is how to obtain the stability and consequently an early mobilization of the patients, particularly in cases of unstable IT fracture. Still now, the main devices used to fix this kind of fractures are Sliding Hip Screw (SHS) and In-

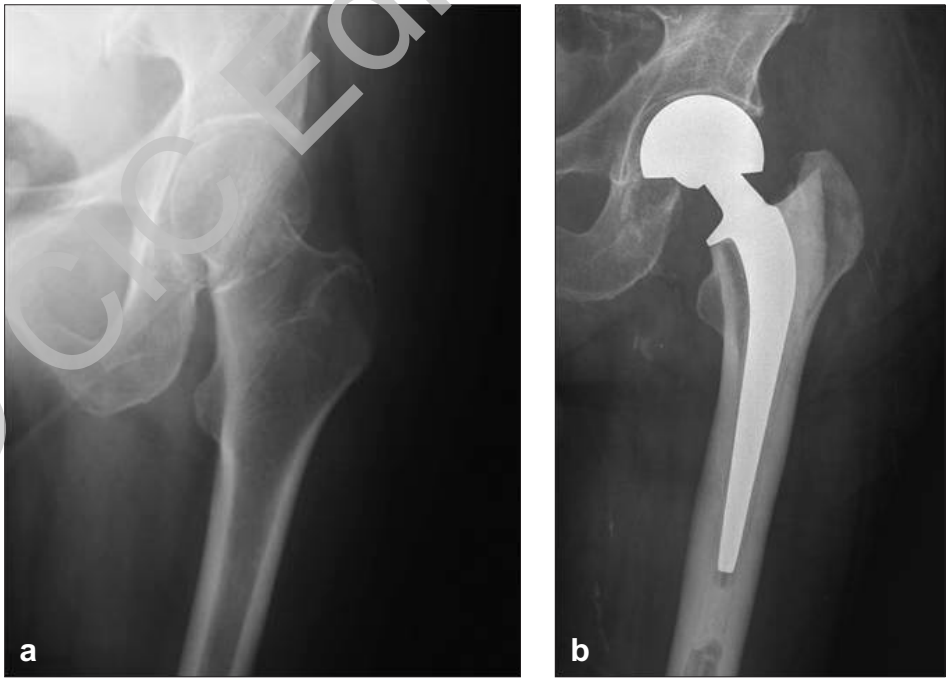

Figure 3 a, b - **a:** Garden 3 type femoral fracture in a 76 years old female patient. **b:** Bipolar cemented prosthesis.

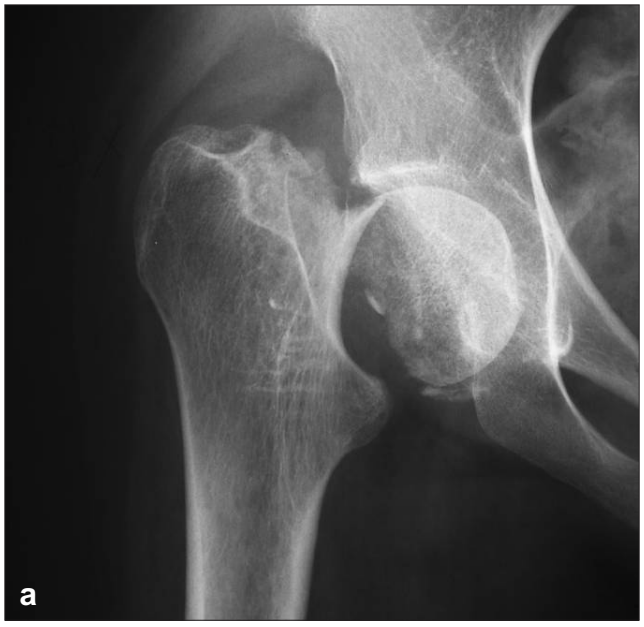

Figure 4 a, b - **a:** Garden 4 type femoral fracture in a 62 years old male patient. **b:** Total hip cemented arthroplasty.

tramedullary Locked Nail (ILN) (Figures 6, 7).
SHS and plate systems have provided satisfactory results in the treatment of IT fractures over the past decades (18). Nonetheless, they have been associated with clinical failure of up to 23%. Intramedullary devices were introduced in the late 1980s (19, 20). The main advantage was good stability with minimal surgical exposure. Historically, the first generation of intramedullary nails were developed in order to improve clinical results and minimize complications (19-21). At the same time a variety of trials have been published, comparing new and old designs of intramedullary implants with SHS.
Despite theoretical advantage of intramedullary implants, most studies failed to confirm any superiority over SHS and plate fixation. Initial reports concluded that for stable IT fractures both options had similar results, but for unstable and fragmented fractures the use of an intramedullary implant had theoretical advantages. However, results from recent prospective randomised and meta-analyses did not reveal the superiority of either implant in terms of intra-operative or post-operative complications, fracture healing problems or reoperations. The same conclusion applies for stable IT fractures and for the more unstable fracture patterns such as reverse oblique and transverse fractures. More interestingly recently published investigations support the superiority of the SHS over ILN in view of the lower complication rate. Thus, there is no significative evidence in the literature in favour of the use of one respect to the other as the treatment of choice for the stable and unstable intertrochanteric fractures. It seems that other parameters such as the Surgeon's experience, operative technique and implant positioning may play equally important roles in obtaining the optimal oucome (4).
In order to improve the fixation stability, helical blade has been proposed instead of the femoral neck screw. This new device has the property to compact the cancellous bone, to support the osteoporotic bone and, at the same time, provide an anti-rotational mechanism to avoid femoral head rotation (Figure 8).
Biomechanical tests in cadaveric femurs have shown that this new fixation with a helical blade is superior to fixation with a standard sliding screw (22). It seems that these devices are reliable and safe in the treatment of unstable IT fractures and are associated with fewer complications than conventional intramedullary devices. The problem seems to be the migration of the blade into the articulation. However, other authors noted that helical blade penetration into the acetabulum occurred in percentage similar to those reported with the use of conventional devices. Moreover, the long term results of this implant design are still to be investigated to prove the real value of this new device (4).
The rationale of treating the extracapsular fractures in the elderly patients with a prosthetic implant was proposed many years ago with good results between 75% and 95% (23, 24). Two options exist, either the deficient proximal medial femur can be augmented with a calcar replacement prosthesis (25), or the calcar can be reconstructed (26). Early weight bearing with pain free mobilization and low complication rate have been the main advantages of prosthetic replacement, which has also been used in the past following failed internal fixation of lateral femoral fractures (24) (Figure 9). More recent studies support the feasibility of this treatment option for unstable IT fractures. Rodop et al., using a calcar-replacing bipolar hemiprosthesis, reported excellent and good results in about 80% of cases using the Harris Hip-score (25). Furthermore, no dislocations or stem loosening were seen during a 3-year study period. In another investigation, Kayali et al. compared the functional outcomes of unstable IT fractures treated with internal fixation or cone hemiarthroplasty at a mean follow-up period of 24

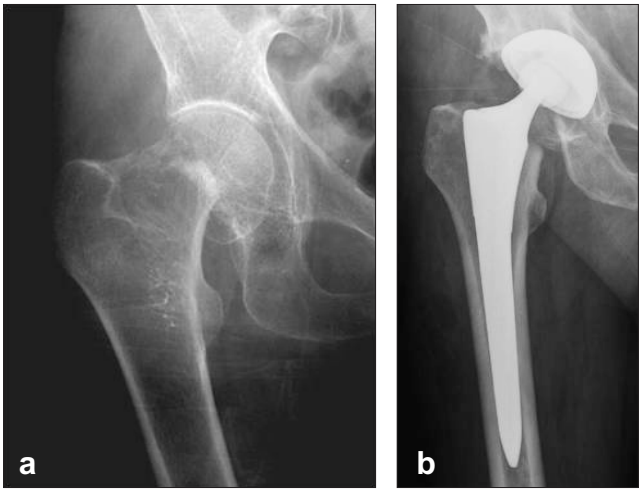

Figure 5 a, b - **a:** Garden 3 type femoral fracture in a 60 years old female patient. **b:** Total hip cementless arthroplasty.

Figure 6 a, b - **a:** Trochanteric fracture in a 77 years old female patient. **b:** Open reduction and internal fixation with sliding hip screw.

Figure 7 a, b - **a:** Trochanteric fracture in a 75 years old female patient. **b:** Open reduction and internal fixation with intramedullary nail.

months (27). Their results showed that, whereas clinical outcomes were similar for the two groups, hemiarthroplasty had a lower postoperative complication rate and earlier weight bearing. Grimsrud et al. used a standard cemented femoral component and reconstructed the fractured metaphyseal bone fragments and greater trochanter with a novel cabling technique (26). They showed that, at 1-year minimum follow-up, there was no loosening or subsidence of the femoral components, and functional results and complication rates were similar to those associated with internal fixation. Chan and Gill treated IT fractures with a standard cemented femoral stem and retained the lesser and greater trochanters with cerclage wires; of the 40 participants who survived to 6-month follow-up (28), two individuals required reoperation, one for exchange of an oversize femoral component and another for conversion to a total hip arthroplasty because of hip pain, and two more experienced complications related to non-union or fracture of the greater trochanter. The authors of this study supported the principle that standard cemented hemiarthroplasty is a reasonable alternative to a sliding screw device for the treatment of IT fractures. Nevertheless, in a recent prospective randomised series, Kim et al. evaluated the treatment of unstable IT fractures among elderly people and compared the results of long-stem cementless calcar-replacement hemiarthroplasty with those of treatment with a proximal femoral nail. The group treated with the nail had a shorter operative time, less blood loss, fewer units of blood transfused, a lower mortality rate, and lower hospital costs compared with those treated with the prosthesis (29).There is a paucity of well-conducted randomised studies to support the superiority of arthroplasty over internal fixation for unstable IT fractures, particularly in the long-term. Potential long-term problems associated with prosthetic replacement, such as loosening, acetabular erosion, stem failure, late infection and late dislocation, have yet to be investigated. Taking into account the higher cost of the implants used and the more demanding surgical technique, it has to be concluded that prosthetic replacement can be only be regarded as an alternative treatment, particularly after failed internal fixation (4).

Prosthetic solution is suitable only for IT fractures, since subtrochanteric fractures can not be treated with a replacement: the only exceptions are impending or conclamate pathological fractures, which may need an extensive replacement with megaprostheses.

Finally, it should be remembered that surgical treatment and clinical result are dramatically related to an adequate and equilibrated rehabilitative protocol: this rieducative program has to consider necessarily health status and comorbilities, quality of reduction, bone characteristics, and the features of the implant, to avoid complications and delays in the functional recovery of the single patient.

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Figure 8 a, b - **a:** Trochanteric fracture in a 70 years old female patient **b:** Open reduction and internal fixation with intramedullary locked nail and helical blade.

Figure 9 a, b - **a:** Complex trochanteric fracture in a 79 years old female patient. **b:** Total hip cemented arthroplasty with a calcar reconstruction implant.

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