Update on post-traumatic periprosthetic acetabular fractures

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Correspondence should be sent to M. A. Selmene
selmene.amine@gmail.com

M. A. Selmene,[1,2] P. E. Moreau,[1] M. Zaraa,[1] P. Upex,[1] P. Jouffroy,[1] G. Riouallon[1]

[1]Orthopaedic Department, Paris Saint-Joseph Hospital Group, Paris, France
[2]Faculty of medicine of Tunis, University of Tunis El Manar, Tunis, Tunisia

Aims
Post-traumatic periprosthetic acetabular fractures are rare but serious. Few studies carried out on small cohorts have reported them in the literature. The aim of this work is to describe the specific characteristics of post-traumatic periprosthetic acetabular fractures, and the outcome of their surgical treatment in terms of function and complications.

Methods
Patients with this type of fracture were identified retrospectively over a period of six years (January 2016 to December 2021). The following data were collected: demographic characteristics, date of insertion of the prosthesis, details of the intervention, date of the trauma, characteristics of the fracture, and type of treatment. Functional results were assessed with the Harris Hip Score (HHS). Data concerning complications of treatment were collected.

Results
Our series included 20 patients, with a mean age of 77 years (46 to 90). All the patients had at least one comorbid condition. Radiographs showed that 75% of the fractures were pure transverse fractures, and a transverse component was present in 90% of patients. All our patients underwent surgical treatment: open reduction and internal fixation, revision of the acetabular component, or both. Mean follow-up was 24 months, and HHS at last follow-up was 75.5 (42 to 95). The principal complications observed were dislocations of the prosthesis (30%) and infections (20%). A need for revision surgery was noted in 30% of patients. No dislocation occurred in patients undergoing osteosynthesis with acetabular reconstruction. We did not note either mechanical loosening of the acetabular component nor thromboembolic complications. In all, 30% of patients presented acute anemia requiring transfusion, and one death was reported.

Conclusion
Post-traumatic periprosthetic acetabular fractures frequently have a transverse component that can destabilize the acetabular implant. The frequency of complications, principally dislocations, led to a high rate of revision surgery. Improvements in preoperative planning should make it possible to codify management to reduce this high rate of complications. The best results were obtained when the surgical strategy combined osteosynthesis with acetabular reconstruction.

Take home message
- Periprosthetic acetabular fractures are rare but serious; most of them have a transverse component.
- Their surgical management requires a team experienced in periprosthetic and traumatological surgery. This type of surgery is associated with many complications, especially instability and infection, which leads to a high rate of revision surgery.
- The best results were obtained when the surgical strategy combined osteosynthesis with acetabular reconstruction.

Bone & Joint Open

Introduction

Periprosthetic fractures of the hip are a serious problem and are becoming increasingly common with the increase in the number of prostheses inserted each year.[1-4] Femoral fractures are the most frequent and have been widely studied.[2,3] By contrast, acetabular fractures are relatively rare and have been studied only in small cohorts. Few scientific studies have described the particular features of these fractures, and the postoperative results and specific characteristics of the fracture were not clearly reported in the conclusions.[1-3] These fractures may occur during or after surgery. Postoperative fractures occur following trauma, spontaneously following major acetabular bone lysis, or after both.[1,2] Paprosky established a classification for fractures of this type in 2003.[5]

We specifically focused on post-traumatic periprosthetic acetabular fractures (Paprosky type III) in patients with total hip arthroplasties (THAs) who were treated surgically. In this study, we aimed to describe the specific characteristics of these fractures and the functional results and complications of their treatment.

Methods

We performed a single-centre, retrospective descriptive study of patients with THAs suffering post-traumatic acetabular fracture. The files were compiled from a prospective database of acetabulum fractures between 2016 and 2021. This is a retrospective observational study, so ethical approval and informed consent are not required.

Data collection

We collected data concerning the demographic characteristics of the patients, date of prosthesis insertion, details of the intervention, date of the trauma, its type, and the time between initial prosthesis insertion and trauma. We described the type of fracture according to the Letournel classification.[6] We used the Paprosky classification as a basis for describing the type of the periprosthetic fracture and the condition of the acetabular implant.[5] We classified each implant as stable or unstable. Implants were considered unstable in the event of displacement from the pre-fracture position, as assessed by comparison to pre-injury radiographs. The preoperative health status of the patients was assessed and classified according to the American Society of Anesthesiologists (ASA) score. According to surgery, data were extracted from the patient's medical record for the date of the operation dedicated to the fracture, time since trauma, surgical approach, and type of surgery performed.

Evaluation

The results of postoperative treatment were recorded at the last follow-up visit, with a questionnaire based on the items of the Harris Hip Score (HHS).[7] We assessed intraoperative and postoperative bleeding from the number of packed red-blood cell units received by the patient during and after surgery. Hospital stay was quantified as the number of days spent in hospital since the trauma.

Postoperative complications were assessed and classified as surgical complications (dislocation of the prosthesis, infection, pseudarthrosis, loosening, and neurological injury), medical complications (deep vein thrombosis, pulmonary embolism), or death. Cases of revision surgery were also identified. We finally measured the prosthetic femoral offset and that of the contralateral hips on standard radiographs, as well as the acetabular component version, in an attempt to explain the occurrence of certain complications.

Table I. Types of acetabular fractures identified, according to Judet & Letournel classification[6] .

Variable	Patients, n (%)	Transverse component
Transverse fractures	15 (75)	Yes
Anterior column	1 (5)	No
Posterior wall	1 (5)	No
Transverse (posterior wall)	1 (5)	Yes
T-fractures	2 (10)	Yes
Total	20 (100)	18 (90)

Results

Description of cohort

We identified 20 patients with THA diagnosed with a post-traumatic periprosthetic acetabular fracture. Overall, 14 of these patients (70%) had fallen from standing height, and six (30%) were victims of a road accident. The mean age of the patients at the time of trauma was 77 years (46 to 90), and 16 (80%) were aged 70 years or over. All the patients had at least two medical comorbidities: heart disease, arterial hypertension, diabetes, or stroke. The acetabular implant was displaced in 80% of the cases (n = 16). Only one patient had a Kerboull cross-type support ring. A posterolateral approach had been used for the arthroplasty procedure in 80% of patients (n = 16), and 90% (n = 18) had simple mobility cups. The anterior approach was used in 15% of cases and the lateral approach (n = 3), with trochanteric osteotomy, in 5% of cases (n = 1). The indication for arthroplasty was hip osteoarthritis in 80% (n = 16), and a femoral neck fracture and aseptic osteonecrosis of the femoral head in two cases, respectively. The mean time between prosthesis insertion and trauma was ten years (six months to 22 years).

Radiological description

Transverse fractures predominated and were observed in 75% of cases (n = 15). T-fractures were observed in two patients, and posterior wall, anterior column, and transverse posterior wall were observed in one patient each. A transverse component of these fractures was present in 90% of patients (n = 18) (Table I). Acetabular fractures were displaced in 85% (n = 17).

Overall, 39% of the patients had prosthetic dislocation (n = 9): central dislocation in 30% (n = 7) and posterior dislocation in 10% of the cases (n = 2); 20% of patients had stable cups (Paprosky III-A; n = 4); and 80% had unstable cups (Paprosky III-B; n = 16).

Of the Paprosky III-B periprosthetic fractures, 56% (n = 9) were protrusive, 38% (n = 6) were tilted, and 6% (n = 1) was both tilted and protrusive. None of the patients exhibited any signs of osteolysis or loosening of the acetabular or femoral component pre-injury. In terms of the associated lesions, one patient had a contralateral obturator ring fracture and another

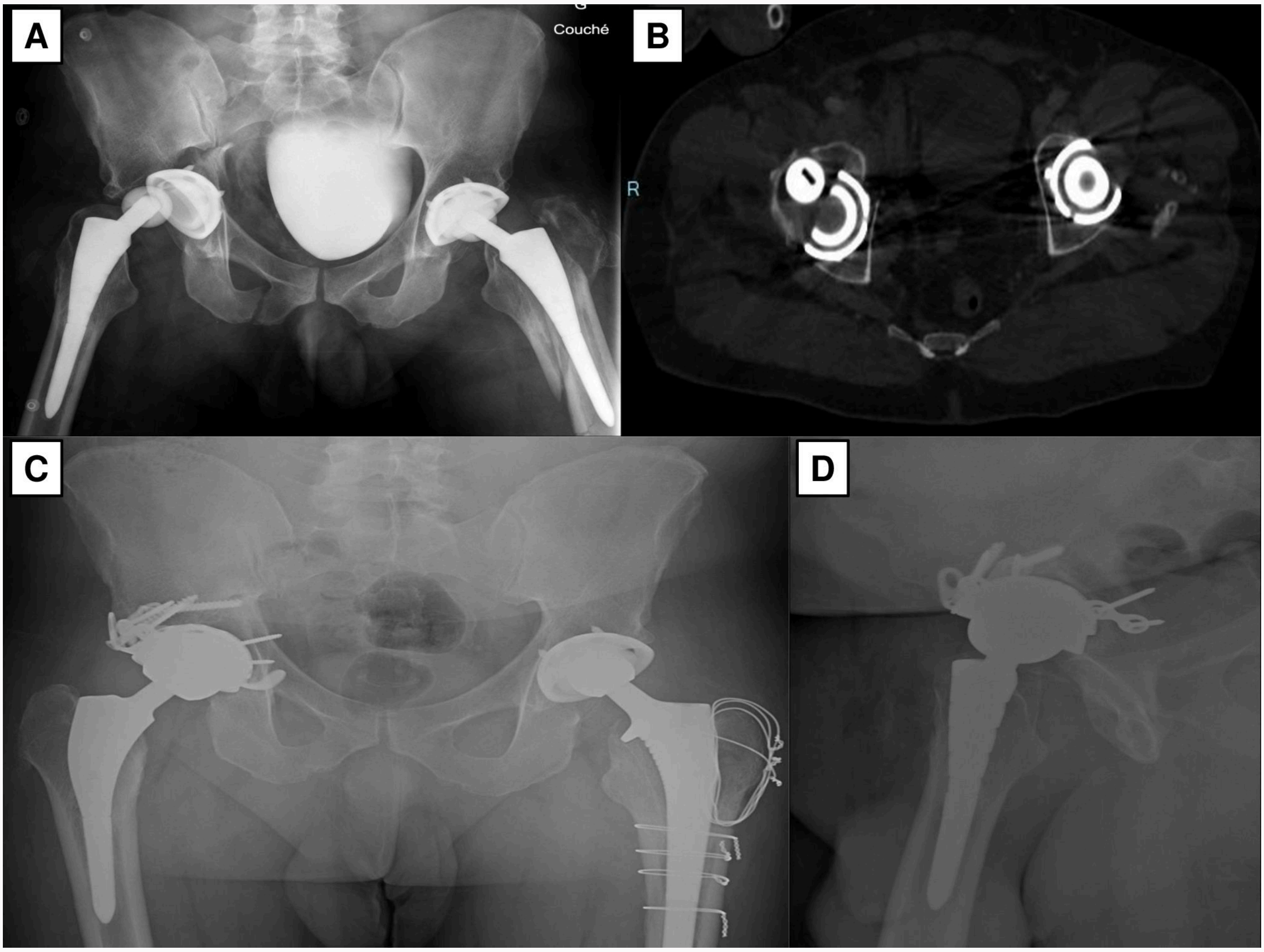

Fig. 1

Patient 1: Male aged 49 years with a transverse periprosthetic acetabular fracture, a posterior hip prosthesis dislocation and a probably stable acetabular implant who have had ORIF with a posterior plate, impacted fragmented bone graft and acetabular reinforcement with a δ Revision TT ring (Lima Corporate) (operative delay from the trauma = five days). a) Anteroposterior (AP) pelvis radiograph. b) Axial CT-scan view. c-d) Postoperative radiographs.

presented a periprosthetic femoral fracture on the contralateral hip prosthesis.

Treatment

Our patients were treated surgically at a mean of 14 days (4 to 20) after the trauma. The indication for surgery was a displaced fracture, an unstable acetabular component (Paprosky IIIB), or both. Surgical approaches used to address the fracture and prosthesis were posterolateral in 75% of patients (n = 15), Kocher-Langenbeck in 20% (n = 4), and lateral with trochanteric osteotomy in 5% (n = 1).

In 14 patients, a bone graft was performed, with a femoral head from a tissue bank, together with acetabular reinforcement (70%). Only one of these patients had a screw-fixed posterior structural graft. The remaining 13 patients had an impacted fragmented bone graft. Three patients underwent this type of surgery together with a reduction and osteosynthesis of the fracture with a posterior plate, via a Kocher-Langenbeck approach, during the same operation. For acetabular support, a δ Revision TT ring (Lima Corporate, Italy), which allows acetabular revision and osteosynthesis of fractures thanks to screwing in the proximal leg and intra-cupular, was used in 15 cases (Figures 1 and 2), and a Kerboull cross-plate was used in two cases. Another two patients underwent acetabular arthroplasty associated with an impacted fragmented graft without acetabular support. Only one patient underwent ORIF of the fracture with a posterior plate (Figures 3 and 4). Concerning the frictional torque, 85% of the patients had prostheses with a dual-mobility metal-polyethylene bearing head-socket combination. Only three patients had a ceramic-ceramic combination. These patients were the youngest in the series (46, 52, and 56 years) (Table II).

Results

Functional results

The mean final follow-up in our study was 24 months (12 to 60). Mean hospital stay was 19 days (11 to 30). At last follow-up, 47% of the patients were able to walk unaided and 43% walked with the aid of one or two canes/crutches or a walking frame.

Overall, 70% of these patients regained a level of autonomy similar to that before the fracture (n = 14). Most patients (84%) did not report pain in the operated hip. Mean HHS was 75.5 (42.o to 95.0).

Table II. Description of the cohort and treatment.

Patient no.	Age, yrs	Sex	Indication for THA	Mode of trauma	Associated lesions	Need for surgery	Appraoch	Type of surgery
1	65	F	Hip osteoarthritis	Road accident	Knee bruise	Displaced fracture tilted cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
2	56	F	Hip osteoarthritis	Road accident	N/A	Displaced fracture stable cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
3	71	F	Hip osteoarthritis	Fall from height	N/A	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
4	81	F	Hip osteoarthritis	Fall from height	Contralateral obturator ring fracture	Displaced fracture stable cup	Kocher-Langenbeck	Open reduction – internal fixation with a posterior plate
5	88	F	Hip osteoarthritis	Fall from height	Forearm bruise	Displaced fracture tilted cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
6	73	F	Hip osteoarthritis	Road accident	Fracture of lower limb of radius	Displaced fracture stable cup	Kocher-Langenbeck	Open reduction – internal fixation with a posterior plate + Acetabular reinforcement (δ Revision TT ring (Lima Corporate))
7	74	M	Hip osteoarthritis	Fall from height	N/A	Non-displaced fracture tilted cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
8	81	F	Hip osteoarthritis	Fall from height	Head trauma	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
9	80	F	Femoral neck fracture	Fall from height	N/A	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
10	46	M	Femoral head necrosis	Road accident	Periprosthetic femoral fracture on the contralateral hip prosthesis	Displaced fracture stable cup	Kocher-Langenbeck	Open reduction – internal fixation with a posterior plate + Acetabular reinforcement (δ Revision TT ring (Lima Corporate))
11	81	M	Hip osteoarthritis	Fall from height	Head and facial trauma	Non-displaced fracture tilted cup	Posterolateral	Bone graft + acetabular arthroplasty
12	78	F	Hip osteoarthritis	fall from height	N/A	Displaced fracture tilted cup	posterolateral	Bone graft + acetabular reinforcement with a Kerboull cross-plate
13	84	M	Hip osteoarthritis	Fall from height	N/A	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular arthroplasty (cemented cup)
14	82	F	Femoral neck fracture	Fall from height	N/A	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular reinforcement with a Kerboull cross-plate
15	77	F	Hip osteoarthritis	Fall from height	N/A	Displaced fracture protrusive cup	Greater trochanter osteotomy	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
16	84	F	Hip osteoarthritis	Road accident	Facial contusion	Displaced fracture tilted cup	Kocher-Langenbeck	Open reduction – internal fixation with a posterior plate + Acetabular reinforcement (δ Revision TT ring (Lima Corporate))
17	90	F	Femoral head necrosis	Fall from height	N/A	Displaced fracture tilted + protrusive cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
18	85	F	Hip osteoarthritis	Fall from height	N/A	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
19	59	M	Hip osteoarthritis	Road accident	Fracture of the nasal bones	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))
20	81	F	Hip osteoarthritis	Fall from height	Head trauma	Displaced fracture protrusive cup	Posterolateral	Bone graft + acetabular reinforcement (δ Revision TT ring (Lima Corporate))

N/A, not applicable; THA, total hip arthroplasty.

Postoperative complications

In terms of medical complications, 30% of the patients received at least one unit of packed red blood cells for acute anemia. No cases of deep vein thrombosis or pulmonary embolism were noted. Only one patient died, from a stroke that occurred 15 days after surgery, as mentioned above. In terms of surgical complications, dislocation of the prosthesis occurred in 30% of patients (n = 6), and 83% of these dislocations were associated with the use of dual-mobility cup during the revision procedure. 83% of these patients had δ Revision TT-type acetabular support (Lima Corporate) (n = 5), and 17% had a Kerboull cross-plate (n = 1) without ORIF.

Infection of the prosthesis was noted in 20% of cases (n = 4). Two patients presented clinical signs of sepsis of the prosthesis. One presented a surgical-site haematoma associated with two episodes of dislocation.

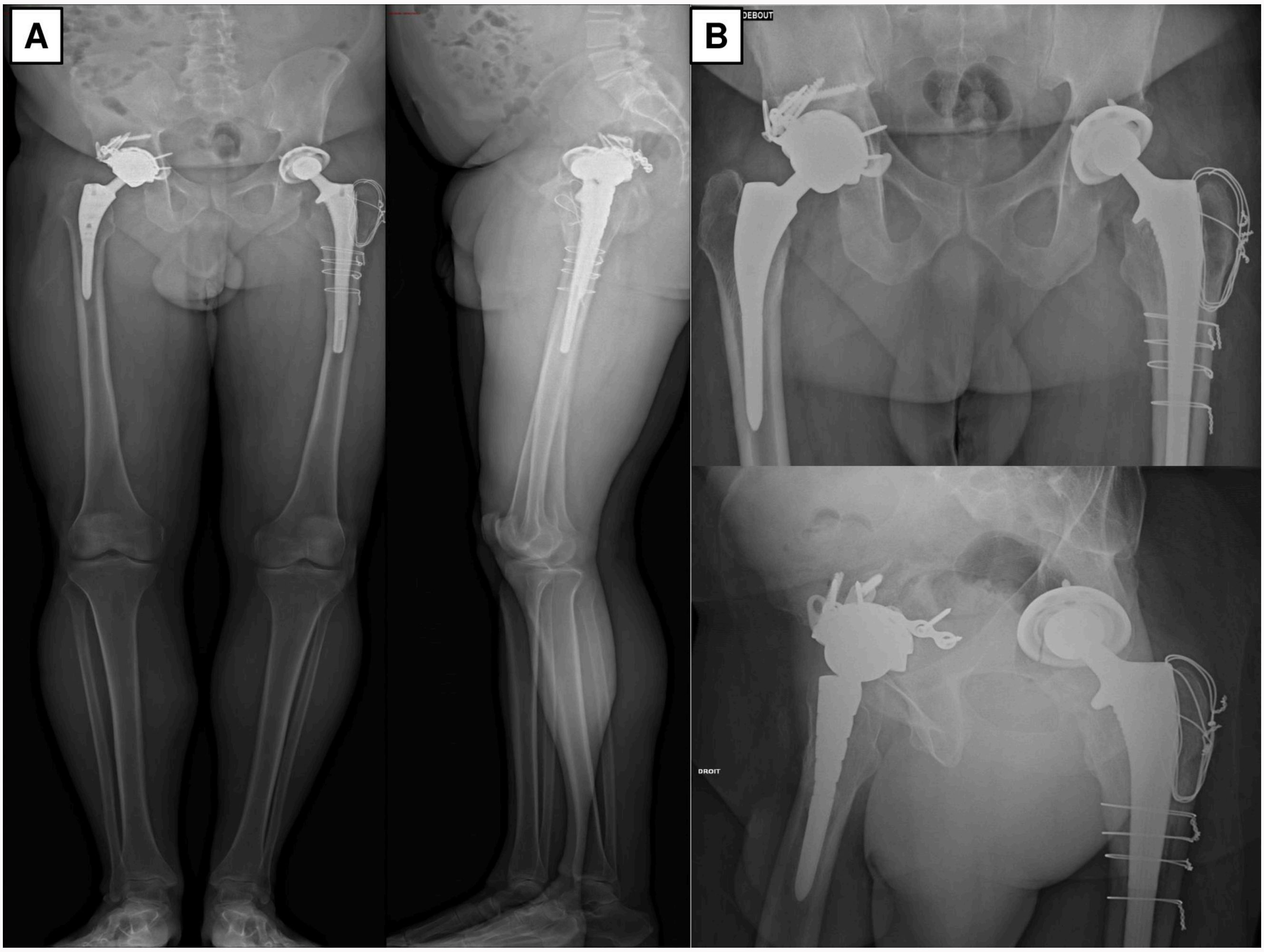

Fig. 2
Patient 1. Pangonogram and radiographs at last follow-up (28 months).

In the remaining two cases, the infection was revealed by routine bacteriological samples collected during revision surgery for repeated dislocations. Overall, almost one third of the patients (30%) underwent revision surgery (for prosthetic dislocations and/or infection) (n = 6) at a mean time of 22 days (5 to 86). We did not observe mechanical loosening of the acetabular component. No pseudoarthrosis or neurological damage (to the sciatic nerve in particular) was identified.

Radiological measurements

The mean femoral offset on the operated side was 46 mm, and that of the contralateral hips (native or prosthetic) was 42 mm ($p < 0.001$). 15% of our patients showed a significant difference in femoral offset between the 2 hips, but these were patients with no history of postoperative dislocation (n = 3). A quarter of our cohort had a postoperative CT scan (n = 4). The acetabular component was anteverted by 30° and 35° in two cases, neutral (0°) in one and retroverted by 25° in the fourth. The latter patient had a posterior dislocation related to this malposition.

Discussion

Post-traumatic periprosthetic acetabular fractures are rare lesions with an incidence estimated at 0.07% in a study by Peterson et al.[8]

Like all scientific studies, our study had several limitations, including the retrospective nature of the series and the absence of statistical studies. We did not perform statistical analyses due to the small size of the sample and the paucity of the literature in terms of articles similar to our study. Despite the small size of this cohort, our series is the largest in terms of number of patients evaluating fractures of this type treated surgically, with 20 cases identified over a period of six years. For comparison, Peterson et al[8] reported a series of 11 patients with posttraumatic fractures collected from the Mayo Clinic registry over an extended period, from 1971 to 1991. Pascarella et al[9] reported a series of 24 patients with periprosthetic acetabular fractures identified over a period of eight years. Only eight of these patients had posttraumatic fractures and bone lysis. Rommens et al[10] studied fractures of this type in six patients over a period of seven years. Hickerson et al[11] presented five cases from the register of operations performed by the same surgeon over 22 years (Table III).

The management of these fractures was principally surgical. Non-surgical treatment has been shown to be

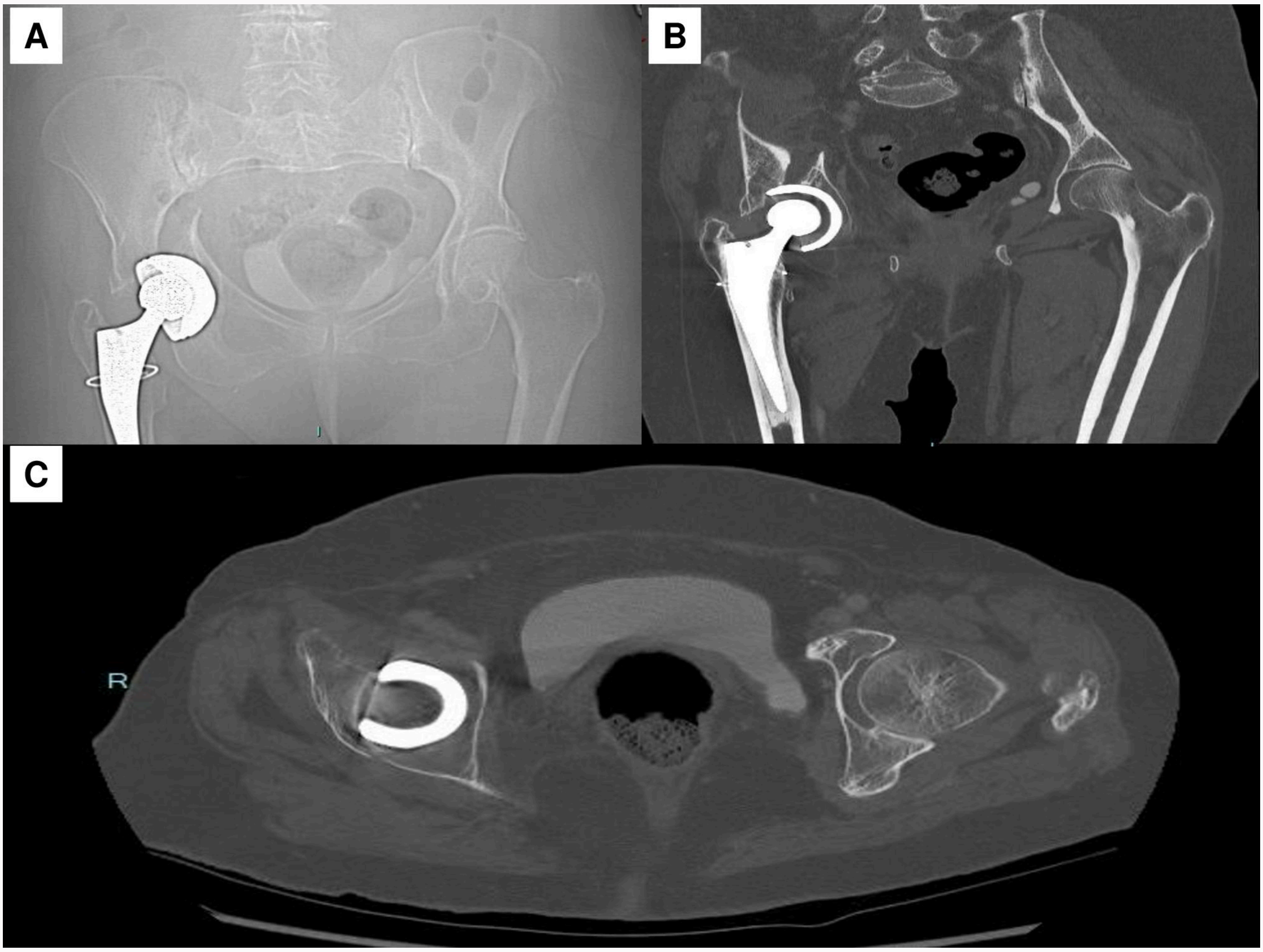

Fig. 3

Patient 2: Female aged 82 years with a transverse periprosthetic acetabular fracture and a stable acetabular implant who have had ORIF with a posterior plate (operative delay from the trauma: eight days). a-b) Pelvis scout CT-scan image and a frontal CT-scan view. c) Axial pelvis CT-scan view.

associated with a high failure rate. For example, eight of the 11 patients in the series of Peterson et al[8] had a type IIIA stable implant fracture and received functional treatment, with 75% subsequently requiring early revision surgery on the acetabular implant.[8,11,12] These fractures are difficult to treat, often requiring major surgery. Surgical treatment follows two principles: a rigid reconstruction of the columns to consolidate the fracture and a stable bone/implant interface.[12] Ideally, prevention is better than cure, and this requires knowledge of the risk factors. A review of the literature by Pierce et al[13] focusing on periprosthetic acetabular fractures identified various postoperative risk factors for such fractures. These factors can be either patient- or implant-related. Trauma is the major patient-related risk factor, whether at high or low velocity. Being female is another risk factor. Female predominance was also noted in studies by Hickerson et al[11] and Rommens et al[10] (80%). Related to this factor, osteopenia and osteoporosis are frequently associated with this type of fracture, especially for low-velocity trauma (falls from standing height). Finally, people aged over 70 years were more at risk of this type of injury. In terms of implant-related factors, the incidence of such fractures is higher with impacted one-piece elliptical acetabular cups,[3] especially when they are large.[13] Benazzo et al[1] added obesity, cotyloid dysplasia, and bone irradiation to the risk factors. In our series, we also found a clear predominance of females (78%), the elderly, and a large majority of impacted acetabular cups.

The type of fracture varies considerably between individuals. The description of acetabular fractures of hip prostheses follows Judet and Letournel's classification, as for native hip fractures.[6] Transverse fractures were the most frequent, being present in 75% of the patients in our series. Resch et al[14] reported a similar rate of this type of fracture in their series (71.4%). Beyond this result, we show that the presence of a transverse component of these fractures was even more prevalent, found in 90% of the patients (including the T and transverse fractures associated with a posterior wall). There are no equivalent results in previous studies, which lacked a description of the manifestations of type of fracture. This distribution is different from that of acetabular fractures of the native hip. A large published series found a predominance of both columns, transverse fractures associated with the posterior wall, whereas transverse fractures are generally considered to be the fifth most frequent type.[6,15-19] We think that the acetabular reaming performed when the hip prosthesis is implanted may weaken the bone at the level of the quadrilateral blade and between the two columns,

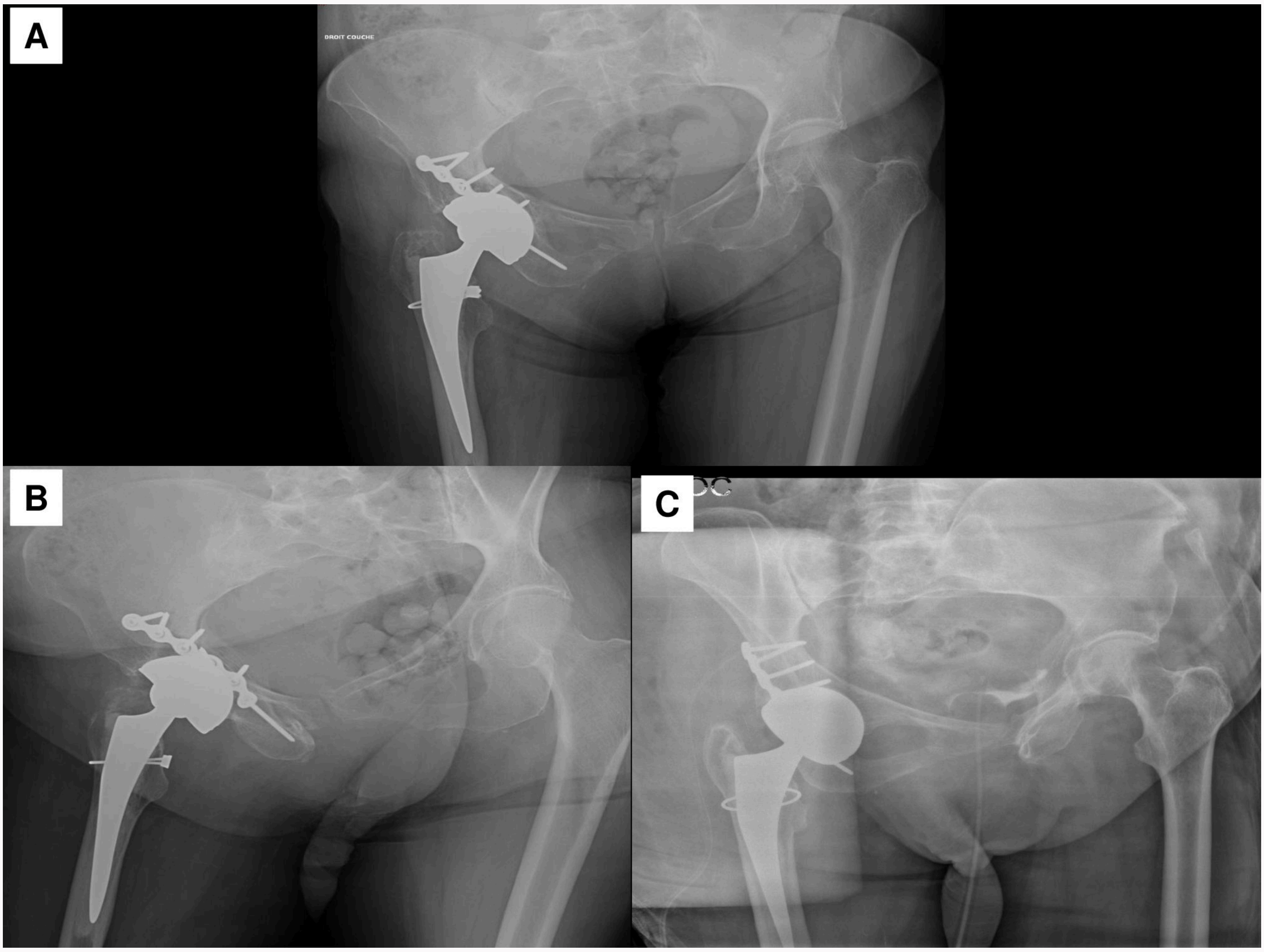

Fig. 4
Patient 2. a) Postoperative AP pelvis radiograph. b-c) Postoperative alar and obturator oblique views.

potentially accounting for the predominance of the transverse component.

In the absence of a published series similar to ours in terms of methodology, we have studied some series studying the results of THA revisions. Clinical HHS was higher in the series of Chang et al[20] (90.4 vs 75.5 in our series). In our series, postoperative dislocations occurred at a higher rate than reported in previous studies (30%). The rate of prosthesis infection was also higher (20%). Surgical revisions also exceeded the average revision rate (30%).[4,20] This comparison is not logical but could give an idea of the seriousness of this pathology given the poor literature on the subject.

Several hypotheses can be put forward to explain this poor result and the high frequency of complications. The high rate of postoperative infections could be related to the posttraumatic context. In a small series of six patients undergoing surgery for periprosthetic acetabular fractures, Rommens et al[10] reported a mean age similar to that for our series (79.5 years) in patients with at least one comorbid condition (heart disease, diabetes, dementia, osteoporosis). This small series was comparable to ours and supports the hypothesis that patients suffering from this type of trauma generally have a complicated background that may affect the outcome of management. In addition to the fragility of the patients, we believe that muscle weakness associated with posttraumatic and preoperative bed rest and a loss of autonomy may have affected the results, leading to a higher rate of dislocation. It should be noted that the mean time to surgery was 14 days, due to various factors, including possible transfers of patients from another centre or from a retirement home, and the time required for an anesthetic assessment appropriate for the seriousness of the programmed surgery. Operating earlier is probably one of the most advantageous solutions to compensate for these bad results. We also think that a modification of the normal anatomy of the acetabulum in this type of fracture in patients with prostheses may explain the difficulties encountered in the positioning of the acetabular implant and the frequency of dislocations potentially linked to its mispositioning. Indeed, a modification of the acetabular version is possible following this type of fracture. In our cohort, only four patients had postoperative CT scans, and the results showed wide variability in acetabular component version measurements (anteverted by 30° and 35°, 0° and retroverted by 25°). In addition, an increase in the size of the acetabular cavity due to inter-fragmentary diastasis of the fracture which leads very often to a change in the centre of rotation of the hip. All of these make the technique of the implants' positioning more delicate.

Moreover, in our series, despite the use of a metal/polyethylene dual-mobility bearing unit in 85% of the patients, the number of postoperative dislocations was considerable, and all occurred in patients requiring an acetabular support ring. On the one hand, this may explain why these patients presented significant acetabular damage following the fracture. On the other, it provides support for the hypothesis that the implants are difficult to implant, particularly in difficult situations, such as those considered here. We also noted the absence of dislocations among subjects who underwent fracture reduction and osteosynthesis before insertion of the support. This step would probably result in a better restoration of acetabular anatomy, thereby improving implant positioning. Five of the six cases of dislocation occurred in patients with δ Revision Lima supports. Technically, supports of this type make it possible to repair a transverse fracture without the need for a plate. We think that this characteristic may have made it possible to fix certain fractures, but at the expense of suboptimal implant positioning maybe because of its rigidity which does not offer many options for correcting the acetabular version. Having recourse to the Lima cup makes it possible to ensure both the osetosynthesis and the acetabular reconstruction, that is why plate didn't have added in some cases. But this implant did not limit the occurrence of complications as much as desired. However, a solid osteosynthesis associated with acetabular reconstruction limits the high risk of complication.

In the current state of knowledge, there is no management algorithm for these fractures. The least bad strategy would be a reduction and fixation of acetabular fractures before prosthetic arthroplasty, thus reducing the high rate of dislocation. This study has the inevitable limitations related to its retrospective nature and the size of the sample analyzed. However, this is the largest cohort published on this subject to date and it highlights very specific complications. The prevention of such complications will require improvements in surgical planning, including, in particular, analysis of the extremely frequent transverse component, and the anatomical modification of the acetabular cavity induced by the fracture and the possible correction defect will need to be considered during placement of the acetabular implant. 3D reconstruction and intraoperative navigation systems may be useful avenues to explore in this field.

In conclusion, post-traumatic periprosthetic acetabular fractures are rare but serious. They have a particularly frequent transverse component, which may render the acetabular implant unstable. Their management is difficult and requires an experienced team. The rate of dislocation is the main concern, leading to a high rate of revision surgery. Our results argue in favor of osteosynthesis associated with acetabular reconstruction to reconstruct the physiological anatomy as closely as possible.

Table III. Comparison of series studying post-traumatic periprosthetic acetabular fractures.

Series	Patients, n	Inclusion period, yrs	Follow-up, yrs
Peterson et al[8]	11	20	21
Pascarella et al[9]	8/24	8	8
Rommens et al[10]	6	7	7
Hickerson et al[11]	5	22	22
Our series	20	6	6

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Author information

M. A. Selmene, MD, Orthopaedic Surgeon,
Orthopaedic Department, Paris Saint-Joseph Hospital Group, Paris, France;
Faculty of medicine of Tunis, University of Tunis El Manar, Tunis, Tunisia.

P. E. Moreau, MD, Orthopaedic Surgeon
M. Zaraa, MD, Orthopaedic Surgeon
P. Upex, MD, Orthopaedic Surgeon
P. Jouffroy, MD, Orthopaedic Surgeon
G. Riouallon, MD, Orthopaedic Surgeon
Orthopaedic Department, Paris Saint-Joseph Hospital Group, Paris, France.

Author contributions

M. A. Selmene: Investigation, Validation, Writing – original draft.
P. E. Moreau: Supervision, Writing – original draft, Writing – review & editing.
M. Zaraa: Supervison, Writing – original draft, Writing – review & editing.
P. Upex: Supervision, Validation, Writing – review & editing.
P. Jouffroy: Supervision, Writing – review & editing.
G. Riouallon: Supervision, Writing – original draft, Writing – review & editing.

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