European Journal of Trauma and Emergency Surgery (2019) 45:1031–1038
https://doi.org/10.1007/s00068-018-0976-x

ORIGINAL PAPER

The value of a standardized and reproducible surgical technique in treatment of Vancouver B2 periprosthetic fractures: our experience

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Received: 6 October 2017 / Accepted: 12 June 2018 / Published online: 19 June 2018

Abstract

Purpose To retrospectively review results and complications of our standardized surgical technique addressed exclusively to Vancouver B2 fractures.

Methods From January 2006 to July 2016, we treated 235 consecutive patients, 47 males and 188 females, mean age at surgery of 71 ± 10 years, with periprosthetic B2 fractures. Exclusion criteria were other kind of periprosthetic fractures and other femoral fractures. The patients were assessed clinically and radiographically following our standard protocol at the last available follow-up. The mean follow-up time was 6.4 years. Radiographic evaluation was performed according to Beals and Tower's criteria and clinical evaluation was performed using the Harris Hip Score and clinical exam.

Results From the starter cohort of 235, 207 patients (88.1%) were fully evaluated, while 28 were lost to follow-up. According to Beal and Tower's criteria, we found excellent results in 72 patients (34.8%), good results in 133 patients (64.3%), and poor results in 2 patients (0.9%). Mean HHS was 75 ± 9 points, with a statistically significant correlation between good functional results and better radiographic assessment ($p = 0.001$). The use of support plate ($p = 0.008$) and the acetabular revision ($p = 0.002$) showed a statistically significant distribution with worse radiographic results. Late complications detected were ten dislocations.

Conclusion Our experience suggests that using a standardized and reproducible surgical technique, as our technique proposed, can surely reduce surgical time, the complication rate, and the mortality rate. During acetabular evaluation, the choice of performing a cup revision must be weighed on overall patient's assessment.

Keywords Periprosthetic fractures · Hip · Arthroplasty · Revision

Introduction

Periprosthetic femoral fractures (PPFF) are serious postoperative complications of increasing finding, affecting about 1% of primary Total Hip Arthroplasty (THA) and about 4.2% of revision THA [1]. The increasing population's mean age and the growing of surgical procedures will lead to this complication [2, 3].

World's major joint arthroplasty registers include PPFF among the first five causes of revision, mostly affecting elderly and octagenarians [4, 5].

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The 1 year mortality rate of PPFF ranges from 11 to 24%, comparable as hip fractures in elderly [6–9]; therefore, surgical goals are to obtain a stable implant and/or synthesis, to achieve fracture healing, to minimize residual pain, to reduce further postoperative complications, and to allow a faster rehabilitation [10, 11].

Vancouver classification (Fig. 1) is a safe and reliable algorithm for diagnosis and treatment. Type A and type C fractures have an easier management; conversely, type B fractures require more analysis. Usually, an intraoperative evaluation of stem stability is required, and this is the most important issue leading for the best treatment [12–14].

The aim of this paper is presenting our standardized surgical technique, result of the experience gained within 10 years (2005–2015), addressed exclusively to type B2 fractures, describing the outcomes and complications.

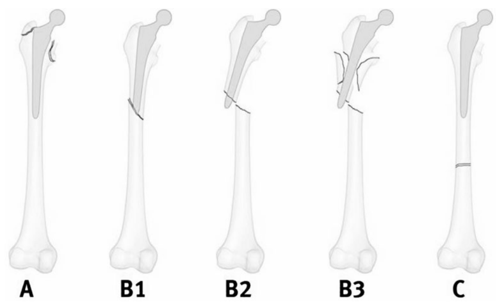

Fig. 1 Vancouver classification of periprosthetic hip fractures [12]

Methods

Materials and methods

Using the Institution register, a cohort of 235 consecutive Vancouver B2 PPFF was identified, among 11.075 joint arthroplasties procedures from 2005 to 2015.

We reviewed retrospectively between January 2006 and July 2016 the treated patients, 47 (20%) males and 188 (80%) females. Mean age at surgery was 71 ± 10 years (range 34–89). In the same period, the overall mean age at surgery of patients who underwent a total hip replacement was 58 ± 12 years (range 21–93).

Inclusion criteria were type B2 fracture according to Vancouver's classification following first implant THA; exclusion criteria were: any periprosthetic fractures following a revision procedure, intraoperative fractures, and type A, B1, B3, and C fractures. We included in our series the only B2 fractures after their identification during surgery: the first surgeon checked manually and subjectively the stem stability, as well as for the bone quality. The diagnostic confirmation of the fracture pattern was only intraoperative. Mean follow-up was 6.4 ± 3.2 years (range 1–9).

Preoperative imaging included a standard AP pelvis and affected hip X-rays; in 31 cases (9.3%), considered more complex at evaluation time, a CT scan of the pelvis and the affected hip was performed.

Preoperative planning and templating was always performed prior to surgery. The surgical technique is described afterwards.

Stem revision was always performed in the evaluated cohort, while the use of a support plate was reserved to 18 cases (5.9%), considered more instable (i.e., in cases of displaced and comminuted greater trochanter). Mean hospital stay time was 13 ± 4 days (range 7–22).

Non-weightbearing active and passive rehabilitation was started during recovery for all patients. Partial weightbearing was not allowed unanimously, suggested by the first surgeon depending to the fracture pattern, age, and patient's functional requirements and the obtained synthesis stability. The support plate cohort was not allowed partial weightbearing for 45 days after surgery, while, for the other patients, the physiotherapic care was "customized". In general, partial weightbearing was allowed within 10 days after surgery.

Our standard follow-up includes clinical and radiological evaluations at 45 days, 3–6–12 month postoperatively, and then annually. We performed the retrospective evaluation at the last available follow-up. Radiographic assessment was performed according to Beals and Tower's criteria (Table 1) [15], while, for clinical assessment, the Harris Hip Score (HHS) has been used [16]. Preoperative HHS was not collected.

Statistical analysis

Categorical data were summarized using counts and percentages, while continuous data were expressed as mean and standard deviation. Comparison between groups (i.e., Beals and Tower's criteria, the use of a support plate vs only cerclage wire, liner revision vs no liner revision, and cup revision vs no cup revision) was performed with Chi-squared test or Fisher's exact test, as appropriate. A p value of < 0.05 was considered as statistically significant. We used the mean value of HHS of the entire cohort as cutoff between good and bad functional results. We termed "better radiographic results" the whole excellent and good outcomes according to Beal and Tower's criteria.

Surgical technique

The patient is positioned in lateral decubitus with the affected hip superiorly. A distally extended posterolateral approach to the hip joint is performed [17]. After superficial and deep dissection, the fracture is exposed. A cerclage

Table 1 Beals and Tower's criteria for radiological evaluation—modified from Beals and Tower [15]

Outcome	Arthroplasty		Fracture
Excellent	Stable	and	Healed with minimal deformity without shortening
Good	Stable Subsidence	or	Healed with moderate deformity and shortening
Poor	loose	or	Nonunion, sepsis, or new fracture with severe deformity and shortening

metallic wire distally to the fracture is placed to control the distal fragment and neutralize any torsional forces. We always use in these cases a 2.0 mm cerclage wire. Then, the fracture is reduced and synthesized with further metallic cerclages. Thus, the hip is dislocated and the stem stability evaluated. If the stem is well fixed, we possibly proceed with the osteosynthesis; otherwise, we perform the stem revision.

We routinely use, in these cases, a monobloc conical long stem (i.e. Wagner SL Revision™, Zimmer INC, Warsaw, IN, USA), used both as an intramedullary nail and a revision stem, exceeding the fracture with the tip of the stem of a distance of about 5 cm. After the stem revision, we check again the synthesis, and possibly, we reinforce it. In general, we do not use more than three or four metallic wires to avoid ischemic lesions [18].

The use of femoral periprosthetic plate with trochanteric hooking is reserved to more instable pattern (i.e., comminution and displacing of the grater trochanter) (Fig. 2). The synthesis of the greater trochanter with cerclage wire is reserved in cases of displaced but not comminuted fragment (Fig. 3). Plate or trochanteric cerclage must be always positioned with the hip reducted to maintain a good gluteus tension.

Finally, we assess the acetabular component looking for osteolysis, wear debris, or loosening, even if a prior evaluation is performed during X-ray evaluation and preoperative templating. We believe that wear polyethylene osteolysis is a major contributing cause in PPFF genesis, as confirmed by the literature [19]. Therefore, following the above-mentioned procedures, we associate, if necessary, a liner or cup revision. Surgical technique is summarized in Table 2.

Results

At follow-up, 207 patients (88.1%) were available to clinical and radiographic follow-up, from the starter cohort of 235 patients, while 28 (11.9%) were dead. Specifically, 9 patients (3.8%) dead during the hospital stay time, and 19 (8.1%) during the first year after surgery for causes not related to the surgical procedure. Each evaluated patient has a minimum

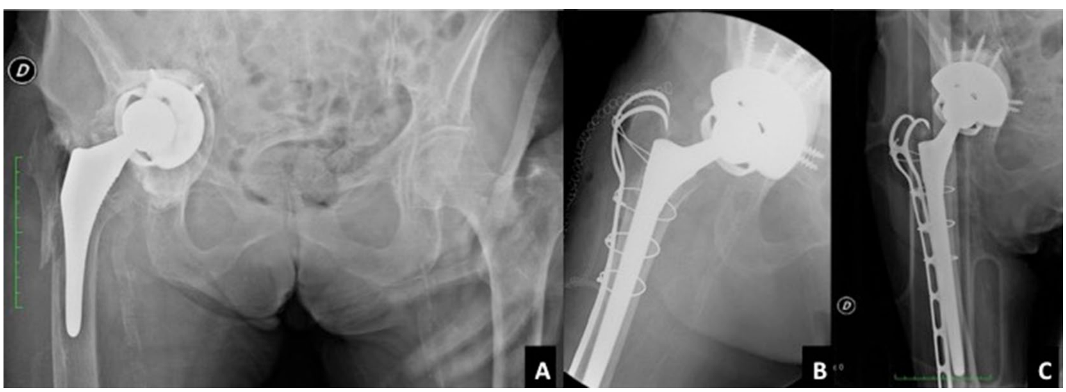

Fig. 2 Example of B2 PPFF with stem revision associated with support plate and cup revision. **a** Preoperative AP pelvis X-ray. **b** Postoperative X-ray showing acetabular revision with additional screws, stem revision, and synthesis with trochanteric hooking plate. **c** One year of follow-up shows good radiographic result according to Beal and Tower and good clinical functional outcome

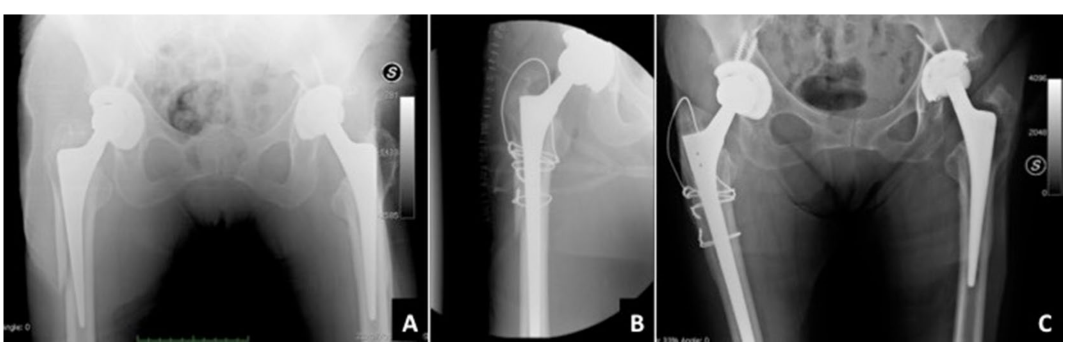

Fig. 3 Example of B2 PPFF. **a** Preoperative AP pelvis X-ray. **b** Postoperative X-ray showing stem revision and synthesis with cerclage wires. **c** Three-year follow-up showing excellent radiographic result according to Beal and Tower and very good clinical functional outcome

Table 2 Surgical technique according to the authors

Surgical technique
1. Distal cerclage beneath the fracture
2. Fracture reduction
3. Fracture osteosynthesis with metallic cerclages
4. Stem removal
5. Stem revision procedures
6. Second fracture evaluation and eventual support plate or addition of metallic wires
7. Acetabular evaluation and eventual liner or cup revision

of 1 year of follow-up. Five patients died within 3 years after surgery for causes not related to the surgical procedures.

According to Beal and Tower's criteria, we found excellent results in 72 patients (34.8%), good results in 133 patients (64.3%), and poor results in 2 patients (0.9%).

As regards clinical outcome, mean HHS was 75 ± 11 points (range 48–87). We found a statistically significant correlation between good functional results and better radiographic assessment ($p = 0.001$).

No statistically significant differences in distribution were found between excellent (HHS 79 ± 3.7, range 75–87) and good results (HHS 72 ± 9.2, range 63–84) ($p = 0.1$), while a statistically significant distribution was found between both excellent and poor results (HHS 52 ± 5.6, range 48–56) ($p = 0.001$) both good and poor results ($p < 0.0001$).

The cohort of poor results failed due to sepsis treated with later two-stage revision.

The support plate cohort (18/235 patients) reported excellent results in 3 cases; good results in 14 cases and only one case reported a poor result. We found a statistically significant correlation between the use of no support plate and better radiographic results ($p = 0.008$). No differences were detected between excellent and good results ($p = 2.65$), but a statistically significant distribution was found between both excellent and poor results ($p = 0.0003$), and both good and poor results ($p = 0.02$).

In our series, we performed 12 acetabular cup revisions (5.8%) and 48 liner revisions (23.2%). Patients undergoing cup revision reported, according to Beal and Tower's criteria, excellent results in three cases, and good results in eight cases and only one case reported poor results; while patients undergoing liner revision reported excellent results in 17 cases and good results in 31 cases. We found no statistically significant correlation between liner revision and radiographic criteria ($p = 0.8$), but a statistically significant distribution between acetabular cup revision and poor radiographic results ($p = 0.002$). No differences were found between excellent and good results ($p = 0.53$), against good vs poor results ($p = 0.001$) or excellent vs poor results ($p = 0.0003$). Results are resumed in Table 3.

Late implant complications (i.e., after 1-year follow-up), unrelated to the fracture, were 10 dislocation, 6 of them treated with constrained cup revision. No further implant complications were detected. All the implant dislocations belonged to the cohort of patients without liner/cup revision, with no statistically significant distribution ($p = 0.32$).

Discussion

Periprosthetic femoral fractures (PPFF) are serious issues of increasing trend, with consequent greater costs for hospitals and clinics. Any revision arthroplasty leads to a mean surgical time longer than 41%, a blood loss greater than 160%, a complication rate greater than 32%, and a longer hospital stay [20]. In particular, hip revision due to periprosthetic fracture leads to a longer hospital stay and a delayed surgical time compared with a lesser financial impact of materials and drugs, compared to other causes, with a global cost of about 18.185 £ (about 21.538 €) [21].

The evaluation of the femoral component in fractures at the level of the stem is the most important factor for intra- and postoperative management. Vancouver's algorithm is a safe and reliable method where the osteosynthesis is reserved for fractures with stable stem and the revision to the fractures with loose stem [12].

Nevertheless, this algorithm is radiograph-dependent. It has been widely shown by Fleischmann and Ken that about 20% of loose stems remain unnoticed. Moreover, the largest

Table 3 Results grouped according to Beals and Tower's criteria

	Excellent	Good	Poor	*p* value
N	72/207 (34.8%)	133/207 (64.3%)	2/207 (0.9%)	
HHS mean ± SD (range)	79 ± 3.9 (75–87)	72 ± 9.2 (63–84)	52 ± 5.6 (48–56)	0.001
Support plate	3/18 (16.6%)	14/18 (77.7%)	1/18 (5.7%)	0.008
Liner revision	17/48 (35.4%)	31/48 (64.6%)	0/48 (0%)	0.8
Cup revision	3/12 (25%)	8/12 (66.6%)	1/12 (8.4%)	0.002

number of failure of the osteosynthesis occurs in fractures with stable stem, compared to fractures with loose stem [22].

Lindhall et al. have emphasized about the intraoperative assessment of stem stability. They reported that, although carefully following the Vancouver algorithm, 47% of B2 fractures, confirmed intraoperatively, were initially classified as B1 on X-ray evaluation [14]. We support this thesis, so we routinely check the stem stability during surgery. This leads to a more accurate classification, even if the patient' surgical stress is greater.

As regards the surgical exposure, Levine et al. compared the use of the fracture as a Wagner's transfemoral approach [11]. Differently, according to our surgical technique, we prefer to first reduce the fracture, then to revise the stem, because of a better management of the femur, and lower blood loss.

Any risk factor that could reduce the bone density can predispose to the onset of PPFF. Osteolysis, as evidenced by several authors, is one of the most serious causes of prosthesis–bone or cement–bone interface weakening [19, 23–27].

Surgeons, therefore, should not be focused only on the fracture pattern, but also on the patient's global view, as suggested by Coventry classification [27]. For this reason, we evaluate the acetabular component, and in cases of polyethylene wear, we always proceeded to its revision until this paper (Figs. 4, 5).

Contrarily to our surgical procedure, no correlation between better results and liner revision was found; instead, we showed a statistically significant distribution between poor results and cup revision ($p = 0.8$ vs $p = 0.002$). Of course, cup revision leads to a longer surgery and a higher chance to onset intra- and postoperative complications. Maybe, during acetabular evaluation, the choice of performing a cup revision must be weighed on overall patient's assessment.

There is no consensus about the best osteosynthesis device [28, 29]. Angular stability plates and the "Plate Cable Systems" (PCS) give a better support in osteoporotic bone, have more torsional stability, and are burdened with lower complications of malunion or pull-out of the screws than the standard plates, even if the surgical time with these is longer and brings to more pitfalls [30, 31].

Metallic cerclages do not offer the same reliability of those plates and often lead to implant subsidence; nevertheless, biomechanical studies have shown to be well suitable for reduction of fracture fragments around the prosthesis [28, 32, 33].

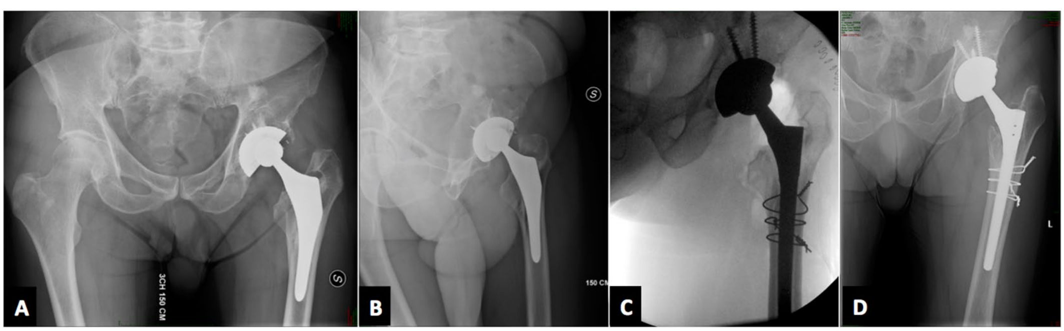

Fig. 4 Example of B2 PPFF with associated cup revision. **a, b** Preoperative AP pelvis and lateral view X-rays. Intraoperative check showed stem-loosening. **c** Postoperative X-ray showing acetabular revision with additional screws, stem revision and synthesis with cerclage wires. **d** One year of follow-up shows excellent radiographic result according to Beal and Tower and good clinical functional outcome

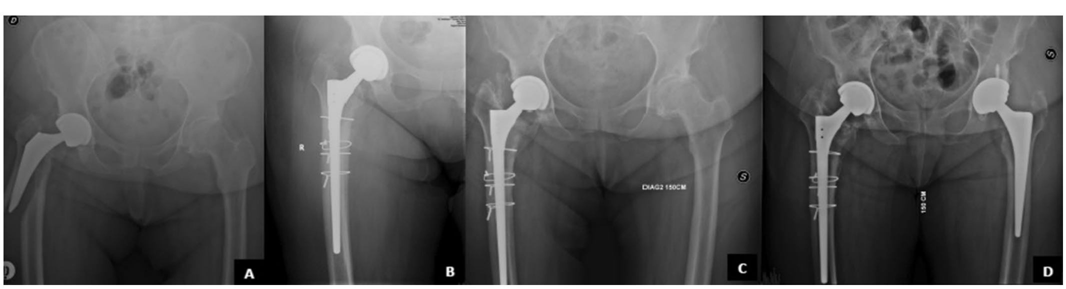

Fig. 5 Example of B2 PPFF. **a** Preoperative AP pelvis X-ray. **b** Postoperative X-ray showing stem revision and synthesis with cerclage wires. **c** One-year follow-up. **d** Two-year follow-up. Postoperative X-ray shows minimal subsidence, however, with very good clinical functional outcome

In general, it is better to avoid too much rigid synthesis. Indeed, we found a strong relationship between the use of no support plate and a better result according to Beal and Tower's criteria ($p = 0.008$). This can be explained both because of the longer surgical time and because the support plate cohort allowed partial weightbearing at 45 days after surgery.

The possibility to avoid a too rigid fixation can be achieved even with a long angular stable plate, using the concept of internal fixator. This technique has a large consensus and well-established results, even in periprosthetic fractures [34].

We believe that, as mentioned before, these plates lead to a longer operative time and higher risk of complications, affecting negatively the functional outcome. The rationale of the long monobloc long conical stem follows the concept of the intramedullary nail. Nailing technique can be associated with cerclage wires, even if a few reports are described. Kennedy et al. [35] described this technique in intertrochanteric fractures, and Winquist et al. [36] successfully associated the intramedullary nailing of diaphyseal femur fractures with metallic cerclage, reporting only 0.8% nonunions and 0.4% infections.

However, the benefit that the patient can achieve from these procedures is not proportional to the quality and the accuracy of the act surgery [27]. Several studies have compared the mortality rate, the reoperation rate, and the residual disabilities that can result after PPFF. Lindhall et al. reported a complication rate of 12% [6]. Bhattacharyya et al. reported a 1-year mortality rate of 11%, similar to intra-articular hip fractures (16.5%) [7], while Spina et al. reported different failure and mortality rates, of about 11–12% comparable to hip fracture mortality rate (16.5%) [8]. Füchtmeier and coworkers have reported a 1-year mortality rate of 13.2% and a reoperation rate of 16.5%, which remain relatively stable over 1 year after surgery [9]. Similarly, Drew et al. reported a 1-year mortality rate of 13.1% and a reoperation rate of 12%, while, at 18 months after surgery, the mortality rate was 15.8% and the reoperation rate was 13.8% [30].

These high rates of complications are often related to non-modifiable risk factors, such as older age, ASA score, BMI, and associated comorbidities [30, 31, 37]. All these factors, while negatively correlating with the surgical outcome, do not seem to correlate with the functional outcome, showing overall unsatisfactory results and progressive functional deterioration [27, 38, 39].

These reflexions acquire particular importance in geriatric patients. In the presence of different comorbidities, surgery is usually postponed, leading to the increased onset of potential complications (i.e., cardiovascular, musculoskeletal, neurological, or cognitive), and, consequently, a more difficult rehabilitation [40, 41]. It is, therefore, important to achieve maximal functional capacity and quality of life, through a faster rehabilitation, avoiding stasis-related complications (i.e., decubitus wound, pulmonary thromboembolism, deep vein thrombosis, pneumonia, etc.) [42, 43]. In recent years, geriatric-specific models have gained great interest and popularity, with dedicated multidisciplinary team, facing the geriatric patient from a more comprehensive point of view, covering all aspects of geriatric rehabilitation, and minimizing the complications [44].

Limit of this study is the retrospective feature, the lack of a control group, and the lack of complication analysis. Further studies are necessaries addressing PPFF. Furthermore, we believe that there are some biases on missing data, even concerning the complication rate or the survival rate, because of the analysis of our medical reports. In our series, in fact, we found a 1-year mortality rate of 11.2% and a 3-year mortality rate of 14%, while the reoperation rate was 0.9%, surprisingly low compared with recent literature. Nevertheless, the high-volume surgery and the standardized surgical technique give us encouraging results, even related to the low complication rate, the low disability rate, and the overall good outcome. We did not include B3 fractures type, even if the management and the treatment are similar, because the identification of the fracture pattern is subjective and surgeon-related, and also, despite having similar surgical treatment, B3 fractures require additional hardware or bone grafting to improve stability. The relative young ages of the treated patients in our institution register can be explained by the large use of uncemented stems.

Finally, according to our experience, the use of a long monobloc long conical stem and the osteosynthesis with metallic wire seems to be the best strategy.

Conclusion

Periprosthetic fractures are severe complications often burdened by unfavorable outcomes, with significant mortality rates, reoperation rates, and disability. In our opinion, it is necessarily a correct integrated assessment that takes into account of the fracture pattern, the global patient's condition, the prosthetic implant, and the reach of any predisposing factors. Surgical success requires adequate training, a long learning curve, and a wide knowledge of the instruments. A standardized and reproducible surgical technique, as our proposed, can surely reduce surgical time, the complication rate, and the mortality rate. This is confirmed by experience that shows good results and the low complication rates. However, further studies are necessary to understand the better management and to minimize pitfalls. Acetabular cup revision is a debated issue that, despite the theoretical advantages, does not show, in our series, a statistically significant improvement in the functional results.

Funding There is no funding source.

Compliance with ethical standards

Conflict of interest Stefano Biggi, Andrea Camera, Riccardo Tedino, Andrea Capuzzo, and Stefano Tornago declare that they have no conflict of interest.

Ethical approval For this type of study, formal consent is not required.

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