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MANAGEMENT AND OUTCOMES OF VANCOUVER TYPE B PERIPROSTHETIC FEMORAL FRACTURES: A RETROSPECTIVE STUDY AND REVIEW OF THE LITERATURE

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ABSTRACT

Periprosthetic femoral fractures are a serious complication after total hip arthroplasty. The Vancouver classification divides fractures on location, implant stability and residual bone stock. The treatment of Vancouver B fractures is surgical and the first decision point surrounds whether or not the stem is well-fixed: well-fixed stems require Open Reduction and Internal Fixation, whereas loose stems require revision arthroplasty. Vancouver B1 fractures are treated with ORIF and had a poorer outcome when compared with B2 and B3 fractures because some B1 fractures were, in reality, probably B2 fractures. In Vancouver B2 and B3 fractures, the stem is loose and the revision of implant is mandatory. Controversy remains around the indications to perform ORIF or revision for Vancouver B fracture. In the future, it could be useful to combine information from both the radiographs and the medical records in order to be able to more correctly evaluate the type of fracture and its treatment.

1. Introduction

Total hip arthroplasty is a successful surgical procedure that increases annually and leads to satisfactory quality of life (1). Periprosthetic femoral fractures are a rare, albeit serious, complication with substantial economic impact. These fractures are the third cause of revision surgery with an estimated incidence from 0.1 to 2.1% (2), but studies with incidence up to18% are described in the literature (3).
The incidence of this pathology can be attributed to older patients with poorer bone quality, as well as to younger patients with higher activity demands.
Many risk factors are involved in pathogenesis of periprosthetic fractures: age, gender, BMI, component fixation (cementless), stem design, osteolysis, loosening, surgical approach, primary diagnosis, bone fragility, anatomical factors (Dorr classification, osteoarthritis, hip dysplasia, neck-shaft angle, valgus morphology), and medical comorbidities (osteoporosis, autoimmune diseases, steroids therapy) (4,5).
Miller affirms that periprosthetic fracture is decreased if contralateral arthrosis is present and increased by major distance from the greater trochanter to the top of the femoral head, because neck-shaft anatomy could lead to fracture as the prosthesis concentrates more mechanical stress on the more inclined medial femoral neck(4). Carli affirms that cementless implants have the highest rates of periprosthetic fractures in the literature, recommending against their use in older patients with osteoporotic bone (6).
A recent study showed cementless implant to be associated with a higher rate of early revision for periprosthetic fractures compared with cemented prosthesis; therefore, orthopedics should take into consideration bone morphology for primary hip replacement and should use cementedcomponents in female and osteoporotic patients (7). These fracture scan occur after low energy trauma or even missed intraoperative fractures that propagate post-operatively following patient's mobilization.
Many factors affect outcomes of treatment: the location of the fracture with respect to the implant, the state of fixation of the stem and the quality of the surrounding bone.

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Patients with periprosthetic fracture have worse outcomes and higher mortality; Bhattacharyya reported a mortality rate of 11% one year after surgery, which is higher than total hip arthroplasty mortality rate (2.9%) (8).Therefore, it necessitates a treatment that promotes fracture healing and stable implant integration in order to allow a return to their pre-fracture level (3).

The aim of this study is to evaluate the clinical and radiographic result after Vancouver type B fractures and to compare postoperative outcome according to sub-type of treatment.

2. Material and methods

Classification

The Vancouver classification, developed in 1995 by Duncan and Masri, is currently the most commonly used classification, given its simplicity and ability to guide treatment, and uses radiographs to stratify the fractures on location, implant stability and residual bone stock (9).

This classification helps guide surgical management and divides periprosthetic femoral fractures into three types: type A occurring in the trochanteric region; type B around the stem or just below it (subdivided in B1 if the stem was stable, B2 in case of loose stem with adequate bone stock and B3 loose stem without fair bone stock); type C below the stem tip, and are usually associated with a well-fixed implant. Type A fractures may be treated either conservatively or surgically, depending on the stability of the fracture. Vancouver B fractures are classified based upon stem stability and remaining bone quality, and often require complex surgical management (Open Reduction and Internal Fixation or revision) and bone reconstruction.

Type C fractures are best treated using ORIF; in the presence of a prosthetic loosening, it is necessary to treat and consolidate the fracture and then revise the implant if the patient's general health condition allows it. Lee demonstrates that the diagnostic reliability and validity in cementless implants with Vancouver B fractures is lower than in cemented femoral stems, therefore radiographic assessment alone may thus be inadequate for determination of implant stability (10). An appropriate classification of periprosthetic fractures is critical to avoiding unnecessary further surgery and ensuring a cost effective and successful outcome.

Diagnosis

The identification of the fracture's type requires the surgeon to obtain radiographs of the hip and femur in both AP and lateral views. X-ray exam permits choosing the appropriate size and length of the implant by measuring the center of rotation and offset (contralateral side), in order to determine the best reconstructive option.

If pre-fracture radiographs are available, these can also be used in order to assess the state of health of the bone-stem interface. Accurate radiological evaluation in patients with pre-existing thigh pain and localization of the fracture near areas of lysis should lead to deciding on revision surgery instead of osteosynthesis treatment.

An assessment of the femoral bone stock should be done through a computed tomography (CT) exam with the purpose of providing axial and rotational support for the proposed femoral implant.

The compromise of the surrounding bone stock, that determines the differentiation of B2 and B3 fractures, is an important prognostic factor and may contribute to failure of treatment: the surgeon must know previous operations on the hip, previous infection or fracture, severe lysis or osteopenia (11).

Particular attention was paid to stem stability evaluation with computer tomography scans and intraoperative assessment after exposure of the fracture.

In a cemented implant, fracture of the cement mantle implies a loose stem; in a cementless implant, keys to distinguishing between B1 and B2 fractures include calcar widening, new bone-implant interface gaps and stem subsidence (12).The surgeon, by clinical inspection, imaging and intraoperative testing, may perceive if the component is securely fixed; if the quality of the fixation might be damaged a subsequent revision procedure may be required for loosening of the stem. Computed tomography is also often helpful in assessing the integrity of the cement mantle. Nevertheless, differentiation between B1 type and B2 type is often crucial and demanding also after CT scan studies. Lindhall observed that 47% of B2 fractures were classified initially as B1in relation with radiological findings (13). Fleischman reported a high number of failure in B1 fractures treated with ORIF when compared with B2 fractures treated with revision of the implant, very likely due to an incorrect diagnosis (14).

Study description

A retrospective study was performed of all Vancouver type B fractures treated surgically at our institution from January 2015 to December 2017 with a minimum follow-up of 2 years. Exclusion criteria were intraoperative fractures, concomitant infection, fractures after revision procedure, fractures related to tumoral lesions, and patients with Vancouver type A or C. A total of 73 consecutive Vancouver type B fractures (38 females and 35 males) were included with a mean age of 76 years (range 65-91). Patient demographic details, mobility prior to the fracture, local risk factors, fracture healing, functional score, radiological findings, treatment and complications were assessed. Indications for primary total hip replacement included 33 femoral neck fractures, 26 osteoarthritis and 14 avascular necrosis. The majority of fractures, 62 patients, were low-energy injuries after falling at home or while walking, while the rest did not present history of trauma. The type of fixation used, cemented or cementless, were assessed. The mean time from hip arthroplasty surgery and periprosthetic fracture was 12.8 years (range 2.4-21.7 years). The mobility prior to the fracture was assessed using the following categories: able to walk without help, able to walk with a walking stick, able to walk with a walking frame or two crutches, and unable to walk. We identified local risk factors such as osteoporosis, rheumatoid arthritis, osteolysis, loosening, and malposition of the stem. Osteoporosis was defined if there was low bone density by densitometry (T-score < 2.5) or previous osteoporotic fractures (radius, vertebral or hip), or cortical thickness index < 0.40 (measured on both anteroposterior and lateral radiographs of the hip).

Fracture healing was defined radiologically as callus formation on both anteroposterior and lateral radiographs, and clinically as weight bearing with no pain in the thigh; the time to union was recorded. The Harris Hip Score was used to evaluate the functional outcome.

Radiological findings were classified using the criteria proposed by Beals and Tower; according to this classification, outcome were classified as excellent (stable arthroplasty with minimal deformity), good (stable arthroplasty or with minimal subsidence and fracture healed with moderate deformity), or poor (loosening, nonunion, sepsis, severe deformity or new fracture). An implant was described as stable if there was an absence of radiolucent lines around the stem, implant migration, or subsidence.

The treatment was classified as open reduction and internal fixation (ORIF) and revision. Patients were divided into two groups according to the type of treatment. Fractures around well-fixed components, Vancouver type B1, were treated with ORIF: a total of 42 patients were treated using locking plates or cable-plate systems. Fractures with loosening of stem, Vancouver type B2 and B3, were treated with revision procedure and cortical allograft augmentation where necessary: a total of 31 patients (25 B2 and 6 B3)underwent revision arthroplasty with a cementless modular component (Wagner Stem). All stems bypassed the fracture site by at least two cortical diameters. Direct lateral approach (Bauer trans-gluteal) was performed in all cases. Complications were classified as dislocation, nonunion, refracture, aseptic loosening, subsidence, mechanical failure and neurovascular injury. Clinical and radiological assessment was performed at one, three, six, and twelve months, then annually after surgery. Clinical outcome, radiological findings and complications between internal fixation and revisions were compared.

3. Results

The mean follow-up was 43 months (range 29-57) in the ORIF group and 38 months (range 32-55) in the revision group. Of the 42 fractures classified as B1, 34 were treated with plates and cables, 8 fractures with cerclage wiring alone. All type B2 and B3 of fractures were treated with revision surgery in association with cerclage wiring (16 cases) or plates and cables (3 cases). All revision stems implanted were cementless. No acetabular component was substituted after the intraoperative evaluation. There is no difference in patient demographics details, local risk factors and mechanism of injury between the two groups. Most patients prior to the fracture were ambulators without help or able to walk with only a walking stick in both groups (> 90%).

In the ORIF group, Harris Hip Score at last clinical evaluation had a mean value of 58.2 (range 46-74); radiological findings were excellent in 10(23.8%) patients, good in 15(35.8%), poor in 17(40.4%); fracture union was obtained in 35 cases (83.3%) in a mean time of 5.2 months. Loosening of the stem with broken hardware was observed in 5 patients within one year of surgery; hardware removal and revision stem implantation with metallic cerclage wiring were performed. Two patients underwent a fracture at the same level a few months after surgery due to subsequent trauma; the patients were treated with plate removal, reduction and stabilization with another plate. Three cases of superficial infection were treated with antibiotic therapy and dressings.

In the revision group, Harris Hip Score at last clinical evaluation had a mean value of 70.5 (range 54-82); radiological findings were excellent in 12 patients (38.7%), good in 13 (41.9%), poor in 6 (19.4%); fracture union was obtained in 27 cases (87%) in a mean time of 5.6 months. Three cases of dislocation were observed within 6 months after surgery; the patients were treated with close reduction and one month with a hip brace. Two implants showed subsidence without progression beyond three months from surgery. One case of superficial infection was treated with antibiotic therapy and dressings.

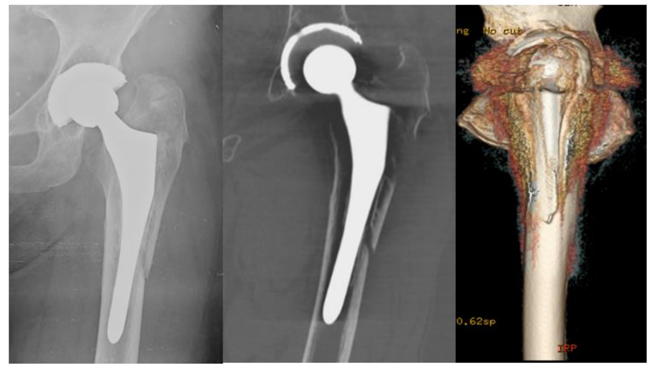

Figure 1a. Vancouver B1 fracture: preoperative radiographs and computed tomography exam of the femur

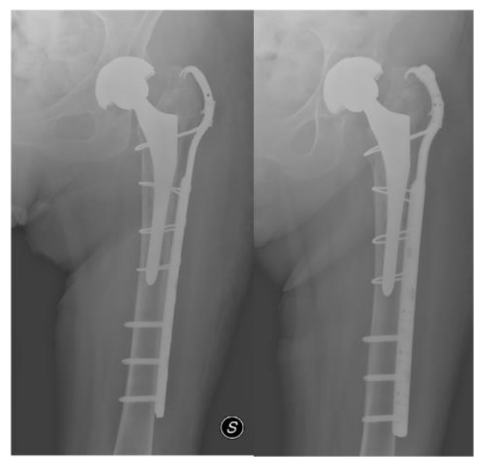

Figure 1b. Vancouver B1 fracture: postoperative radiographs showing treatment with ORIF.

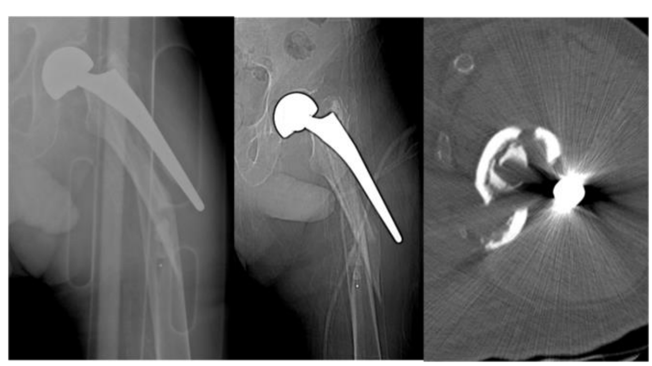

Figure 2a. Vancouver B2 fracture:preoperative radiographs and computed tomography exam of the femur

Figure 2b. Vancouver B2 fracture: postoperative radiographs showing treatment with revision surgery in association with cerclage wiring.

4. Discussion

The treatment of Vancouver B fractures is surgical. The surgical technique is generally an internal osteosynthesis or a prosthetic stem revision or a combination of both (15). Management of periprosthetic femoral fractures is technically demanding given the bone loss, altered anatomy, stability of stem and fracture, co-morbidities of patients, and extended periods of prolonged bed rest (16).In the treatment of periprosthetic femur fracture, the first decision point surrounds whether or not the stem is well-fixed: well-fixed stems require open reduction and internal fixation, whereas loose stems require erevision arthroplasty. The assessment of stem stability is based on clinical history (presence or absence of pre-fracture thigh pain) and on examination of the pre-operative radiographs. When doubt remains on the stability of the implant it should be assessed intraoperatively.

VancouverB1 fractures are one-third of all the periprosthetic femoral fractures and historically are treated non-operatively with bed rest (15,17). Conservative treatment was associated with high rates of early mortality and, in survivors, nonunion (18). Nowadays ,these fractures are treated with ORIF or the bicortical on lay allograft technique due to frequent complications, including nonunion, malunion, and the medical complications associated with prolonged bed rest (fig1 a-b) (15,19).Locking plates are frequently used for the treatment of periprosthetic femoral fractures because they provide advantages suchas: angular stability of the screw to the plate, the use of monocortical screws for fixation of the plate to the femoral component, and reduced soft tissue trauma. Several authors did not observe significantly higher reoperation rates of fractures treated with conventional plates compared with those fixed with locking plates (20, 21).

However,B1 fractures had a poorer outcome when compared with B2 and B3 fractures (13).Some B1 fractures were in reality probably B2 fractures as it is wrongly believed to have a well-fixed femoral stem; only a review of previous radiographs or a thorough history identifying pre-existing thigh pain will raise the suspicion of loosening of the implant. Another hypothesis to justify the clinical results of B1 fractures is that the bone-cement interface or the bone-femoral component interface in cementless prostheses may be partially damaged or interrupted. In cemented stems, a plate fixation may be inadequate because the fracture around the stem prosthesis violates the integrity of the cement mantle, which creates an unstable system even in the presence of an anatomic reduction of the fracture (22).

The ORIF treatment of a Vancouver B1 fracture in which the stem is loose is associated with a high failure rate (13,15). The choice between femoral revision and ORIF in B1 fracture did not influence the long-term outcome if the diagnosis is correct (16,20); yet, the treatment of a B1 fracture with intramedullary fixation (long femoral stem) allows a higher rate of immediate postoperative weight bearing compared to the use of plate fixation and, consequently, better conditions for fracture healing and a shorter time to union (20). In our study we observed a high number of failures in Vancouver B1 fractures due to stem loosening which resulted in removal of broken hardware and in revision of the stem in 5 patients. The cause of these failures is to be associated with a wrong diagnosis of the type of fracture (Vancouver B2 fracture instead of Vancouver B1 fractures). These data show that internal fixation had a higher rate of reoperation than revision arthroplasty. A biomechanical study by Moazen et al. affirms that long-stem revisions produce almost three times the construct than single plate fixation (19).

The distinction between a B2 and a B3 fracture is not always simple, especially when implant loosening is not obvious. Many different reconstructive options are available for surgeons to choose: long cemented stems, long cementless implant (fully or proximal porous coated stems), modular or monoblock implants, and proximal femoral replacement prostheses. In Vancouver B2 fractures the stem is loose and the bone stock is adequate; the revision of implant, with or without osteosynthesis, is mandatory to obtain long-term implant stability and fracture healing (fig 2 a-b).Lack of metaphyseal support requires a long stem that bypass the fracture.

Previous studies report no difference in the reoperation rate between cemented and cementless fixation of the femoral component (11,13), while other authors have affirmed that cemented implant had the highest revision rate (19%) compared with cementless implant (11%).The National Joint Registry of England and Wales reported a 1.6-fold increase in periprosthetic fractures around cemented hip prosthesis, respectively, between 2011 and 2016 alone, while it remained stable for uncemented implants (23).

Uncemented long stem have better outcomes in terms of intra-operative fracture rate, immediate axial and rotation stability, stress shielding and thigh pain (15,24,25). The long stem, even without the association of bone graft, enables adequate diaphyseal fixation, bypassing the fracture and the bone defect. The long stem does not need to fit and fill the femoral canal as it relies on a press fit concept and can reach a new stable position, sometimes with a secondary slight subsidence (22). The technique requires exposing the implant through the fracture or along a modified Wagner osteotomy (26); after this, the implant is removed, a cerclage is placed around the osteotomy or fracture, and finally a long stem is placed. Maintenance of the osseous vascularity is far more important than anatomic reconstruction of the proximal femur (15).

Vancouver B3 fractures are similar to Vancouver B2 fractures, but the difference is the poor bone quality. Management of Vancouver B3 fractures include long stem implants, impaction bone grafting, resection arthroplasty, allograft prosthetic composites, and proximal femoral replacements (15,27). Berry introduced the concept of reconstructing the bone as a scaffold loosely around the implant without anatomic reduction through the use of a distal fixating modular stem (26). Fixation choice has been evolving over the last 30 years. Initially, cemented femoral implant that allowed bypass of the fracture was the implant of choice; subsequently, due to mid-term loosening and high rates of non-union of fracture, cementless implants became the gold standard (3).

Where possible, it is useful to avoid the use of cement, which could interfere between the fragments of the fracture, prevent its reduction and consolidation, and make it difficult to re-operate if needed.

The Kaplan-Meier survival analysis showed a cementless long stem survival of 95.5% (3). Complications of long cementless implant are subsidence, intraoperative fracture, developed instability, postoperative periprosthetic femur fracture, loosening, stress shielding and stem fracture. Impaction bone grafting has been used in contained metaphyseal bone defects and require large diameters of implant. Subsidence of the stem with consequent loosening and implant instability are possible complications of this technique (15).

Therefore, synthetic bone with allograft have been recommended to give a structural support to the implant. Allograft prosthetic composites is technically demanding and is associated with high costs, limited availability of femoral allograft, and a high complication rate, including allograft nonunion, graft resorption, and disease transmission (15). Resection arthroplasty technique is considered where there is severe proximal bone loss and in low demand patients. The main advantage is a reduced surgical time, but the majority of literature on this technique is limited (15).

Controversy remains around the indications to perform ORIF or revision for Vancouver B fracture, due to the complexity of the fracture type, femoral bone loss, and anatomical variation in the setting of prior procedures (18).

Zheng showed a significantly longer time in fracture healing and lower postoperative mobility in cases of Vancouver type B2 and B3 fractures treated with internal fixation when compared to revision arthroplasty (18).In literature, a significant proportion of B3 and, particularly, of B2 fractures, were treated without revision of the stem and were associated with a higher rate of re-operation (11). Long-stem revisions permit an almost three times stiffer construct than plate fixation (11,19).Other authors affirm that, under certain conditions, B2 or B3 fractures could also be treated successfully with ORIF (28,29).

Internal fixation is an option in type B2 and B3 fractures when patients have severe comorbidities making surgery inappropriate, or in patients with low functional demands (18).This type of treatment provides that in the presence of good bone stock, the potential to reduce the fracture anatomically and the integrity of the cement mantle, rather than the instability of the implant, are the significant determinants for the treatment decision (13, 28, 30).

A fixation of periprosthetic fractures with ORIF could be advantageous to reduce surgical time, complexity, mortality, the need for blood transfusions and implant costs, and to preserve bone stock by avoiding a long-stemmed implant.

In our study, the revision group showed a higher incidence of dislocation (three cases);this complication is attributable to the difficulty of restoring the biomechanics of the hip in revision procedure compared to the first implants.

Analysing the Harris Hip Score, our study showed better results in revision group (70.5 instead of 58.2), probably due to an early mobilization and immediate weight bearing in these patients. Low score in the ORIF group and revision group with respect to primary implants are due to the invasiveness of the surgical procedure and the clinical characteristics of the patients (comorbidity and aging).

Radiological evaluation showed excellent and good results in the majority of the patients (59.6% in ORIF group and 80.6% in revision group); these results are in line with recent literature (2).

Between the ORIF group and revision group no statistical difference was found in terms of postoperative complications (23.8% in ORIF group and 19.3% in revision group).

5. Conclusions

Total hip arthroplasty is commonly performed to treat various hip pathologies. As the number of total hip replacements is increasing, the number of periprosthetic femur fractures is also expected to increase. Nowadays, these fractures are a challenge for orthopedic surgeons because they are characterized by long operative time and hospitalization. The main objective of periprosthetic hip fracture are to provide an adequate bone healing and return to previous functional status. Surgical management starts with assessing stem stability and bone quality: well-fixed stems require fracture fixation without stem revision, while loose stems require revision of implant. The treatment must be based on the stability of the implant as well as on the location and configuration of fracture, on the design of prosthesis, on bone characteristics, on the clinical features of patient, and the presence of infection. An adequate pre-operative study is very important in order to obtain a reconstruction of leg length and implant offset in revision surgery.

The Vancouver classification is not only helpful in classifying the fractures, but also in guiding the correct treatment through validated diagnostic algorithms. In the future, it could be useful to combine information from both the radiographs and the medical records in order to more correctly evaluate the type of the fracture and its treatment.

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