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Periprosthetic fracture management of the proximal femur

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Summary: The most common periprosthetic fractures occur around the hip. The most widely used classification is the Vancouver classification, and management requires careful planning and skill in both arthroplasty and fracture surgery. This article presents an overview of the diagnosis, classification, and management of periprosthetic fractures of the proximal femur. This work represents a summary review from Latin American Society Members of the International Orthopaedic Trauma Association.

Key Words: periprosthetic fracture, proximal femur fracture, fragility fracture, revision arthroplasty, fixation

1. Introduction

The number of arthroplasties performed worldwide is increasing as the population grows older while at the same time remaining more active than prior generations. Consequently, the number of periprosthetic fractures of the proximal femur (PPFsxPF) is also increasing.[1–3] PPFsxPF occur either intraoperatively or postoperatively. The rate of intraoperative femoral fractures is 0.23%–3.6% in primary total hip arthroplasty (THA) while it is significantly higher in revision surgery (6%–21%).[3,4] These fractures are more common in uncemented compared with cemented THA (5.4 vs. 0.3%).[4] The incidence of postoperative PPFsxPF has been reported to be approximately 0.4%–3.5% after primary THA and 2.1%–24% after revision arthroplasty. According to the Swedish National Hip Arthroplasty Register, PPFsxPF are the third most common reason for revision after THA and the second most common in patients beyond the fourth year after their primary THA.[5] In a systematic review and meta-analysis with 12,868 PPFsxPF reported across 18 eligible studies, 64% occurred after primary THA and 36% occurred after revision THA.[6] Sixty-six percent of all fractures occurred in women, and the Vancouver type B2 fracture was the most common type in 39% of cases. The time to fracture was 6.03 years after primary THA and 4.08 years after revision THA.[6] Ultimately, PPFsxPF represent a burden for the health system and governmental or private regulatory health agencies.

Most of the time, periprosthetic femoral fractures are usually the result of low-energy trauma, such as fall from standing height. Several risk factors have been implicated with PPFsxPF, including patient characteristics, the surgical technique, and stem stability. Patient characteristics include female sex, age older than 65 years, obesity, osteoporosis, Paget's disease, rheumatoid arthritis, and developmental dysplasia of the hip, although some of these are not entirely consistent throughout the current literature.[1,4,6] The surgical technique risk factors include the choice of approach, stem malposition (usually in varus, colliding with the anterolateral cortex), and cementless femoral implant.[1,4,7] The anterolateral approach in the supine position for obese patients undergoing THA increases the risk of intraoperative greater trochanteric fracture by 3-fold, although obesity is not considered a contraindication for this approach.[7] These usually occur during elevation and rasping of the femur. In addition, a large body mass index makes it difficult to identify bone landmarks through excess adipose tissue, increasing the risk of component malpositioning, especially the acetabular cup.[8] Iwata et al[7] recommended that when using the anterolateral approach in the supine position for obese patients, surgeons should be careful not to place an excessive load on the retractor when elevating the femur and perform an adequate capsular release in the remainder of the posterosuperior neck and piriformis fossa to avoid greater trochanteric fracture. The type of implant has also been associated with the incidence of PPFsxPF, with extreme proximal taper angle stems and cementless implants, specifically single-wedge and double-wedge implants presenting the highest rates of

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fracture, both intraoperatively and postoperatively.[1,9] A 14-fold higher incidence of intraoperative femoral fracture and 3-fold higher incidence of postoperative fracture with cementless stems have been reported.[10,11] Therefore, many surgeons recommend against cementless stems and press-fit techniques in older patients with osteoporotic bone. Finally, the stem stability has been proven as a critical risk factor of PPFsxPF. Over 75% of all postoperative fractures are related to aseptic loosening and preexisting osteolysis likely due to stress concentrations under normal loadings caused by nonuniformities in the bone, such as femoral stem migration, increased cement porosity, cortical microcracks, and bone erosions.[12]

The treatment of PPFsxPF requires individual therapeutic concepts taking patient-dependent and patient-independent factors into consideration. The Vancouver classification system and unified classification system have been widely accepted to guide management, dividing femur fractures into distinct anatomic sites for the implant and considering the stability of the implant and quality of the surrounding bone.[13,14] The conservative treatment of PPFsxPF is only justified in exceptional situations and is associated with poor outcomes.[2,4] Preoperative planning and adequate knowledge of the basic biomechanical principles of operative (osteosynthesis or revision arthroplasty) treatment of periprosthetic fractures is necessary.[2] A major component of treatment is the determination of stem stability because revision replacement is preferred for the aseptic loose stem. The overall goals of the procedure are to restore mechanical stability and anatomical alignment; enable fracture union; allow early patient mobilization; and provide a stable, pain-free, weight-bearing joint.[4,12]

This article presents an overview of the diagnosis, classification, and management of PPFsxPF. This work represents a summary review from Latin American Society Members of the International Orthopaedic Trauma Association.

2. Periprosthetic Fractures in the Vancouver Classification

2.1. Fracture Type A

Type A fractures affect the trochanteric region and are subdivided as A_G when they affect the greater trochanter or A_L when they affect the lesser trochanter. The incidence of these fractures is reported between 2.5% and 6%, being a more frequent intraoperative diagnosis.[4,11,15]

Treatment. The decision on the treatment of these fractures will depend on their extension, displacement, and, in the case of postoperative fractures, whether they occur in an area of osteolysis.[15,16] Generally, most of these fractures have no or minimal displacement and can be managed without blood loss.[4,15–19] Although in recent years, there is an increased tendency toward performing fixation, in this type of fracture (up to 40% of cases).[16,20]

2.1.1. Fracture Type AG. Stable fractures, with a displacement of <2.5 cm and that do not affect prosthetic stability, can be managed with nonoperative treatment. In these cases, weight-bearing protection and restriction of active hip abduction are indicated for 6–12 weeks.[11,15,16,19] In the case of displaced fractures, which generate pain, prosthetic instability, or weakness of the abductor apparatus, open reduction and internal fixation (ORIF) is indicated.[4,15,16,21] The fixation options described are represented by cerclages (wires or cables), plates, or plates with specific designs (hook plate-cable plates).[15,17,18] Although there is no agreement regarding the best fixation system, recent biomechanical studies have shown the superiority of cable plates and/or locked plates over the use of cerclages.[21]

2.1.2. Fracture Type AL. Typically, these fractures correspond to avulsions that can be managed nonoperatively. In those fractures that occur intraoperatively during the placement of the stem and compromise the medial cortex, management with cerclages or cables have shown good results.[11,16,22] For fractures that compromise a larger segment, affecting stability of the implant, fixation should be considered (either with cerclage systems or with cable plates) or revision to a distal fixation stem, depending on the case.[4,15,22]

2.2. Fracture Type B

2.2.1. Fracture Type B1. B1 fractures are located around or at the tip of the femoral stem and, by definition, present an implant with no signs of loosening or loss of bone stock. This subtype represents 30% of all type B fractures.[5] Differentiating a B1 fracture from a B2 fracture constitutes the greatest challenge when deciding on treatment.[4,19] The rates of reoperation or failure reported in their treatment have been related to a diagnostic error range between 20% and 47% (B2 fractures diagnosed as B1).[23–25] Therefore, determining the firmness of the stem requires a careful preoperative and intraoperative evaluation. Concepts such as the happy (firm stem) or unhappy (weak stem) hip reported by Ninan et al[26] or the remaining attaching index reported by Andriamananaivo et al[27] may be helpful.

These fractures are usually successfully treated with ORIF.[4,16] The morphology of the fracture can help when deciding on treatment. Although there is no universal agreement, a fracture that does not affect the medial cortex or calcar, especially those with long fracture lines (eg, spiral fractures), can be managed with wire loops, cables, and plates with screws, alone or in combination.[15,16,19] Those that affect the calcar area and have comminution and/or with a transverse configuration will require biplanar fixation (90-90 constructs), using either 2 plates or 1 plate and an allograft strut.[23,28,29]

Regardless of the type of system used, there are certain key points to keep in mind: The quality of reduction is directly related to the results[4,30]; obtaining adequate fixation in the proximal area around the stem is mandatory[4,15,19,31,32]; and devitalization of tissues should be avoided to maintain an optimal biological environment for healing.[30,31] New plate systems specifically designed for these lesions can be applied using a minimally invasive technique with indirect reduction.[4,33,34] In addition, the length of the plate is a factor to further consider. The current recommendation is to use plates if possible, avoiding areas of weakness. A plate's working length (central part of the plate without screws or cables, ie, above the fracture) should be at least 2 diaphyseal widths at the height of the fracture and no shorter than the fracture itself.[4,16,31] Recommended screw density, defined as the ratio of filled screw holes to total screw holes, is < 0.5 to avoid overly rigid systems.[31,35,36] Bicortical screw fixation is mechanically more stable; however, this is not always possible in the proximal area, so the use of cables or loops with unicortical screws in this region is another option.[31,37]

Although multiple studies have attempted to determine the best fixation system for these fractures, there is still no clear consensus. Currently, there is a trend toward the use of systems with specific designs for these lesions, which provide multiple fixation options (locking, polyaxial, and cable screws).[31,32,34,38,39] Roche-Alberto et al[31] recently reported excellent results with the use of locking screw plates and/or cables in a retrospective series of 39 patients. Similarly, Del Chairo et al[32] reported a 91% success rate in 32 patients using similar devices. On the other hand, Stoffel et al[34] in a systematic review analyzing 1571 fractures and Chatziagorou et al[39] in a cohort study of 1381 fractures reported lower rates of nonunion, refracture, and reoperation with the use of locking compression plates implanted minimally invasively versus conventional plates.

2.2.2. Fracture Type B2. Type B2 periprosthetic hip fractures are those that are located around the prosthesis and the stem is loose.[10] Treatment will depend on the location of the fracture, the state of implant fixation, and the patient's bone quality. A correct differentiation between B1 and B2 fractures is essential, and it is recommended to test the stability of the stem intraoperatively before attempting to fix the fracture, especially in uncemented femoral stems.[40,41] Standard AP and lateral x-rays should be obtained to assess fracture morphology, implant stability, component malposition, bone stock, location of any osteolytic lesions, and the presence of wear. In some cases, a CT scan may be used to assess the characteristics of the fracture.

Recent studies suggest that isolated osteosynthesis is indicated in a select group of patients with low demand and short life expectancy.[42] These patients have a lower rate of reoperation for type B2/B3 fractures with this approach.[43] In addition, the procedure has the advantages of less bleeding and anesthesia time, fewer intraoperative risks and complications, and ability to preserve bone stock.[44]

There is consensus that B2 fractures should be treated with or without osteosynthesis with a long stem plus a plate supplement or cortical allograft (struts).[13] The selection of the stem is important as it must provide distal fixation. It may be extensively porous or conical fluted, and must exceed the fracture by 2 to 3 diameters of the cortical bone (approximately 6 cm), thus achieving stable revision arthroplasty and fracture fixation.[45] Extensively porous stems are associated with problems with distal fixation, subsidence of the prosthesis, and thigh pain. Conical fluted stems are the stems of choice for B2 fractures, with their geometry allowing for axial fixation and the blades or grooves providing rotational stability. This type of stem requires only 2 cm of diaphyseal contact to achieve stability.[46] The modularity in this stem allows for greater flexibility to adjust to the patient's anatomy and fracture line, improves offset, and can adjust for limb length discrepancy and soft-tissue tension, allowing better stability.[47]

Studies have compared fully porous coated stems and modular tapered knurled stems. The group of fluted conical modular stems had superior Oxford Hip Scores and WOMAC scores. In addition, these stems had a greater restoration of the proximal bone stock.[48] These stems perform better than monolithic implants in subsidence and longitude discrepancy. The drawbacks of modular rods are their cost, corrosion, and fatigue fracture.

A variety of other implant-related issues are also considerations in the management of B2 fractures. The use of monoblock stems in the context of periprosthetic fractures is an emerging technique and has shown promising results in revision surgery. One study showed that monolithic stems have less stress shielding and better bone restoration.[49] Cemented stems allow for immediate support and do not have the risk of subsidence, but they present high rates of loosening and refracture, where only 60% of patients obtain a stable implant and union of the fracture.[50,51] They are indicated in fragile patients who require early mobilization. For proximal reconstruction of the femur, a minimal osteosynthesis with cable or wire should be performed around the implant without seeking an anatomical reduction but restoring the offset and good reduction of both trochanters to improve biomechanics.[52]

2.2.3. Fracture Type B3. This type represents perhaps the greatest challenge for management and reconstruction. Treatment requires meticulous evaluation and planning considering factors that include the patient's age, level of functionality, comorbidities, remaining bone stock, presence or absence of infection, and characteristics of the present prosthesis.[53] According to the authors of the classification, type B3 fractures more frequently require complex surgeries[42]; however, despite their complexity, various studies have shown that these fractures should be managed in a similar way to "native" fractures, specifically in the first 36–48 hours owing to increased mortality if treatment is delayed.[54]

Although the discussion about the ideal treatment of this type of fracture continues, the most frequently recommended option has been the revision of the femoral stem of the prosthesis. However, in some very selected cases, osteosynthesis has a place among the treatment options, although, in general, ORIF tends to be associated with higher revision and failure rates. Khan et al demonstrated in their systematic review that osteosynthesis management of B2 and B3 fractures was associated with a 28.6% reoperation rate, relative to a 14.4% rate in those managed with revision arthroplasty. Haider et al also found revision figures of 22.9% versus 13.5%, with ORIF versus revision arthroplasty, respectively, a difference that was only found in B3 and not in B2 fracture types.[43,55]

Recently, a systematic review and meta-analysis conducted by Haider et al compared the management of revision arthroplasty versus osteosynthesis in Vancouver B2 and B3 periprosthetic fractures. In 33 studies with 2509 patients, they found that, unlike B2 subtypes, the results of osteosynthesis in B3 subtypes were not comparable with those of revision arthroplasty. The latter group had lower rates of reoperation, lower rates of loosening of the femoral component, and better results in the Parker Mobility Score.[55]

Moreta et al[56] showed that revisions with uncemented femoral stems must exceed the fracture site by at least 2 to 3 times the length of the diameter of the femur. In addition, in cases with loss of bone tissue or severe osteoporosis, long cemented stems with impacted graft or with allograft flakes have been used to provide bone structure. This study also shows that there were no differences in the treatment of B2 and B3 fractures between modular and nonmodular stems.

According to the management algorithm published by Pavone et al, management with osteosynthesis without femoral revision is specifically suggested only for those patients with an ASA greater than 3 or very low functional demand.[55,57] Regarding the outcomes, several studies have shown consolidation rates of 98% at 4.5 years for B2 and B3 fractures, with an increase in bone stock in 89% of patients compared with treatment with modular conical stems.[50,58]

Despite these various treatments, the functional results are not encouraging. There are significant decreases in the functionality of patients, with up to 41.9% loss of previous function and with acceptable Harris hip scores in 50% and poor in 26.2%. The most frequent local complications are dislocation and infection, the latter being the most frequent cause of reoperation.[56]

2.3. Fracture Type C

This type of fracture constitutes around 10% of periprosthetic fractures,[10,59,60] with reports of up to 37% in some series, and a peak between the ages of 80 and 89 years.[61] In this situation, the stability of the femoral component is not considered a problem or concern at the time of treatment.[59] Therefore, the management of choice is osteosynthesis, and various techniques and implant solutions have been described, including locked plating, conventional plating, double plating, intramedullary nailing, cabling, and cerclage wiring.[59,62] The choice of treatment depends mainly on the type of fracture, patient's age, bone quality, level of functionality, and presence or absence of a knee prosthesis (TKR).

Chatziagorou et al reported 639 cases of Vancouver C fractures from the Swedish National Register of Arthroplasties. They found that those treated with locked plates had a lower rate of reoperation than those treated with conventional plates, intramedullary nails, or double plates and that they had better outcomes regarding dislocation, infection, stem loosening, pain, and nonunion. They also found that the presence of ipsilateral TKR had no effect on the results of any of the treatment subgroups.[62]

Management with retrograde nails has generally been avoided because it generates an increase in stress between the tips of 2 intramedullary elements; however, its use has been described in younger patients with ipsilateral TKR and good bone stock.[62] Regarding the use of double plates, it is a viable option in revision cases and interprosthetic fractures to enhance radiological consolidation and reduce the incidence of total femur replacements. This technique can be used with or without allograft struts.[62,63]

Some recommendations described to reduce the risk of failure by screw pullout or increased stress in type C fractures include the use of additional support with cables when the proximal screws are unicortical,[64,65] adequate contact and positioning of the plate with the bone, decreased rigidity of the construct by avoiding screws close to the fracture site, and adequate plate length exceeding the fracture by at least 1.5 to 2 times the transverse diameter at the level of the focus.[59,66] In addition, it is possible to extend the plate proximally until there is adequate overlap with the stem, as proximal as the greater trochanter in very proximal C-type fractures.[65]

3. Conclusion

The management of periprosthetic fracture around the hip, in addition to being the most common, is a therapeutic challenge because the patient's profile must be considered (age, comorbidities, bone stock). Because optimal fixation is required, whether internal fixation or arthroplasty, having the optimal surgical implant and a surgeon with skills for trauma and arthroplasty is crucial. The increase in hip arthroplasty procedures, coupled with a longer life expectancy, is reflected in an increase in the presentation of periprosthetic fractures in the proximal femur. In addition to the therapeutic considerations of the Vancouver classification, it is necessary to consider some other factors such as the fragility of the patient, type of stem, presence of infection, and bone stock. More clinical studies are necessary in relation to the results considering the duration of the implants after the revision because the current studies do not demonstrate solid evidence for periprosthetic fractures in the proximal femur.

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