PERIPROSTHETIC FRACTURES IN TOTAL KNEE ARTHROPLASTY

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ABSTRACT

The increasing number of total knee arthroplasties, in combination with the population's longer life expectancy, has led to a greater number of long-term complications. These add to the poor bone quality of elderly patients and often culminate in periprosthetic fractures. This complex orthopedic problem has a great diversity of clinical presentation. It may affect any of the bones in the knee and, because of the difficulty in finding solutions, may lead to disastrous outcomes. Its treatment requires that orthopedists should have broad knowledge both of arthroplasty techniques and of osteosynthesis, as well as an elaborate therapeutic arsenal including, for example, access to a bone bank.

Keywords – *Periprosthetic fractures; Arthroplasty, knee; Updating*

INTRODUCTION

There have been significant increases in the numbers of total knee arthroplasty (TKA) procedures performed over recent years, and this trend is expected to be maintained over the coming decades. Through this, the incidence of complications has undergone growth in absolute numbers. Better health conditions have brought increased life expectancy for patients and therefore the prostheses used have become more exposed to long-term problems such as aseptic loosening and osteolysis. The combination of reduction of the local consistency of bone material and patients of advance age has caused an increase in the number of periprosthetic fractures of the knee, which are a difficult problem for orthopedists to resolve. Orthopedists need to master not only complex knee arthroplasty techniques but also modern methods for osteosynthesis in osteopenic or osteoporotic bone tissue.

Fractures may affect all three of the bones treated through TKA, i.e. the patella, tibia and femur.

Patellar fractures

The most common postoperative complications from TKA involve the extensor apparatus, in various manners, and patellar fractures are a significant problem. According to data in the literature, the incidence ranges from 0.11% to 21.4%[1,2]. Several causes can be attributed: hyperpressure in the extensor apparatus caused by an excessively anteriorized femoral component or by insufficient resection of the patellar joint surface for a patellar prosthesis to be emplaced (overstuffing); vascular insufficiency caused by release of the lateral femoropatellar retinaculum, cementation effects, peripheral denervation of the patella or excessive bone resection on the joint surface; misalignment of the extensor apparatus, due mostly to incorrect rotation of the femoral and/or tibial component; use of a patellar prosthesis with a single-fixation, central, large-diameter plug; specific patient-related factors such as obesity, excessive physical activity or habit of knee hyperflexion; and, finally, consequent to trauma following the operation[1,3-12] (Figure 1).

The most frequent presentation is as absolutely asymptomatic radiographic findings at postoperative checkups. In such situations, if the extensor apparatus function is preserved, the usual procedure is just to continue to follow up the patient periodically[1,6,13-15].

The treatment should generally be selected while taking into account the findings from the physical examination. If the extensor apparatus is complete and adequately aligned, and the patellar component is seen to be fixed to the bone in the radiographic examination,

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Figure 1 – Patellar fracture

conservative treatment is advised, with immobilization to relieve the symptoms for six weeks[1,3,6,13,15]. In other situations, surgical treatment may be indicated: fixation of the patellar fracture using a tension-band system, or using bone anchors in cases of small fragments at the poles of the patella. These procedures are technically difficult in cases of patellar fracture in which a prosthesis is being used, and there may be additional problems if osteolysis or loosening of the patellar component occurs. In the literature, the reports on surgical treatment of patellar fractures describe high incidence of complications, which often in the end lead to salvage procedures such as arthrodesis or arthroplastic resection of the knee.

Modifications to the surgical technique, such as special attention to rotation of the components and reduction of the number of retinacular releases, have brought reductions in the incidence of patellar fractures. Some changes in component design have also contributed, such as a deeper patellar groove in the femoral component and modification of the system for fixation of the patellar component to the bone, with three small pegs instead of one central large-diameter peg[3,5,9,16,17].

It should be noted that experiences within several orthopedic services in which the joint surface of the patella was not replaced resulted in a marked reduction in patellar fractures following TKA, as in the case of present authors' service. Over the course of ten years of experience, with more than 2,000 TKA procedures performed in which patellar components were not used, we did not have any cases of patellar fracture up to the time of writing this article.

Tibial fractures

Periprosthetic fractures of the tibia are rare: as reported by Healy, only 32 cases were described between 1970 and 1992[16]. Over this same period, the largest series published consisted of 15 cases[17]. Subsequently, in 1997, Felix *et al*[18] presented 102 cases. Many of these cases occur during TKA revision procedures, generally without deviation. In other situations, tibial fracture may be associated with local osteolysis or aseptic loosening of the tibial component. Many patients who are not followed up regularly may present considerable bone losses and may return to their physicians because of occurrences of periprosthetic fractures.

If intraoperative fractures occur, radiographs should be produced to investigate the nature and extent of the problem. In cases of inadvertent perforation or bone loss, the use of homologous bone grafts may be indicated. These fractures are generally not deviated, and the intramedullary nail of the tibial component may, in itself, be sufficient to maintain the reduction and stability until consolidation has been achieved.

When bone losses consequent to mobilization of a loosened tibial component or to osteolysis occur several years after TKA, caused by particles that result from wear, these losses should be replaced. The defects can be filled in using methyl methacrylate cement, metal blocks and wedges or bone grafts from a tissue bank. The defect is filled in accordance with the nature of the defect: ground-up bone tissue if the defect is a cavity; and structural bone tissue if the defect is segmental (involving a significant proportion of tibial cortical bone material). In the latter case, the material is generally obtained from the proximal tibia of a donor cadaver. It is essential to use an intramedullary nail in the tibial component in these cases, with the aims of fixation of the implant to a stable bone segment and protection of the bone graft from mechanical forces[19,20] (Figures 2a, b and c).

Femoral fractures

Distal femoral fractures subsequent to TKA are the type most studied in the literature, because of their incidence rate (0.3 to 7.8%)[21,22] and clinical importance.

The risk factors are listed in Table 1. It is of interest to note that the possibility that bone defects in the femoral cortical bone material, caused while making cuts (notches) in order to implant the femoral component, might be the cause of the periprosthetic fractures has been raised. Of course, this depends on the extent of
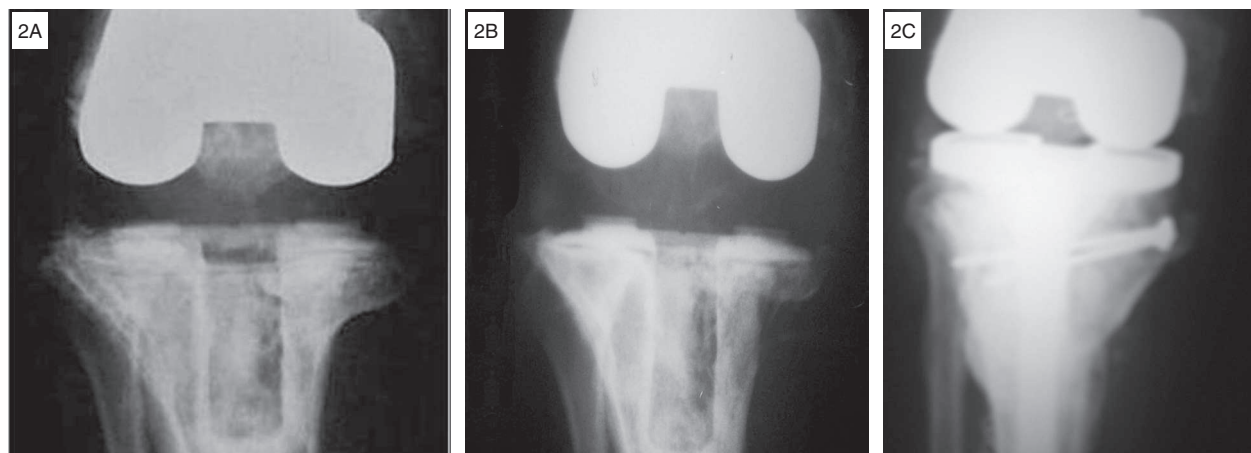
Figure 2 – A) Total knee prosthesis in the immediate postoperative period, with good-quality bone. B) Osteolysis of the proximal tibia with a periprosthetic fracture. C) Treatment with TKA revision and homologous grafting in the proximal tibia, fixed with screws

the iatrogenic defect, but in our personal experience and that of other authors[23], there have not been any cases of periprosthetic fractures in cases in which a femoral notch was cut subsequent to TKA.

Table 1 – Risk factors for femoral supracondylar fractures following total knee arthroplasty

Osteoporosis
Inflammatory diseases (RA, AS)
Chronic use of corticoids
Neurological diseases
Joint rigidity
Manipulation under anesthesia
Anterior cortical defect (notch)
Navigation
Osteolysis
Revision surgery

RA = rheumatoid arthritis, AS = ankylosing spondylitis.

An article describing a femoral periprosthetic fracture at the fixation site of a screw used in navigation surgery was recently published[24]. This has added a further argument to the controversy on the advantages and disadvantages of this technique for TKA.

There are several classifications for femoral periprosthetic fractures, including Neer et al[25], DiGioia and Rubash[26], Chen et al[27], Rorabeck and Taylor[28] and, finally, Backstein et al[29]. The Rorabeck classification, as is well known, is the one most used in recent papers on this topic. It divides periprosthetic fractures into three categories, according to the characteristics of the femoral component of the TKA: type I, if it is fixed; type II, if it is loose; and type III, if there has been significant bone loss from the distal femur.

The aim of the treatment is, of course, complete restitution, i.e. to return to the pre-fracture conditions or even better than this, in cases in which there have been complications in the TKA. However, in very many cases, this objective is not achieved. Some authors have established targets that are more modest. According to Cain et al[30], a good result would one without pain, with consolidation of the fracture, some capacity to walk and a range of knee mobility of 90 degrees of flexion/extension. Rorabeck et al[31] considered that the results from treating femoral periprosthetic fractures would be acceptable if there were not more than two centimeters of shortening and not more than five degrees of deviation of the varus-valgus axis or ten degrees in the sagittal plane.

TREATMENT

Most patients who suffer periprosthetic fractures are of advanced age or present multi-joint inflammatory diseases. Many of them present comorbidities that have the effect that prolonged immobilization may worsen their general state of health and compromise their return to an active life, at levels similar to what they had prior to the fracture. In our orthopedics service, the mean age at which primary TKA is performed on arthrosis patients (the principal indication for this procedure) is 71 years. On the other hand, periprosthetic fractures are often associated with aseptic loosening or osteolysis, which are complications with long-term incidence. It is easy to see that, since a large proportion of the patients with periprosthetic fractures are octogenarians, they need early rehabilitation after the fracture in order to avoid problems relating to loss of function of a lower limb.

At our service, because of the significant number of cases of periprosthetic fracture attended, we have created a modification of the classification of Rorabeck and Taylor[28]. Our aim in this was to include new types of fracture that have progressively greater incidence and, furthermore, to define the most appropriate types of treatment for each situation (Table 2).

Table 2 – Classification of femoral periprosthetic fractures following total knee arthroplasty, HC-Curitiba

Type 1	Fixed femoral prosthesis, good bone stock
	a) Stable fracture
	b) Unstable fracture
Type 2	Fracture + failure of prosthesis due to aseptic loosening or instability, with good bone stock
Type 3	Fracture + failure of prosthesis, poor bone stock
Type 4	Fracture at the level of the extremity of the intramedullary nail of the revision

For type 1a fractures, conservative treatment can be instituted. In general, this presents good evolution. A meta-analysis on 195 cases of undeviated stable femoral supracondylar periprosthetic fractures showed good results in 83% of the patients, compared with a 64% success rate from surgical treatment. The treatment objectives were to return to the pre-fracture conditions, with a pain-free knee that was stable and presented functional joint mobility.

Type 1b fractures account for most of the cases following primary TKA and have been the subject of a large number of published papers, with creative techniques for resolving this problem that is occurring increasing often. The recommended treatment consists of fracture reduction and stable osteosynthesis. The multiplicity of articles describing different surgical techniques and the relative bone fragility in most patients who suffer periprosthetic fractures led to large numbers of treatment failures in the past. There has been clear evolution in osteosynthesis methods since the time of Steinmann crossed wires, and passing through condylar plates and DCS implants, with reports of irregular results and frequent complications. Today, methods that are more stable and less invasive are the preferred options. For example, these include intramedullary locked nails, introduced via a retrograde route, or LISS plates, introduced via small incisions. These methods present lower surgical morbidity and enable faster recovery for patients. Intramedullary nails present two limitations in relation to plates: in fractures that follow a distal line, there may be

greater limitation because of the positions of the holes for the distal screws; and they cannot be used in cases in which the femoral prosthesis is of PS type (with a posterior stabilizer), in which the box for housing the tibial post is closed by metal. Newer models of PS femoral prostheses have an open box, thus preventing this technical problem, but periprosthetic fractures often occur in patients who had these prostheses implanted many years ago.

The degree of fracture comminution and advanced osteoporosis in some patients have led some authors to describe techniques for increasing the local stability through homologous bone grafts[32] or, furthermore, through acrylic cement in combination with a nail or plate[33].

Type 2 periprosthetic fractures are the least frequent form. In practice, when a prosthesis is loose or unstable, bone loss occurs concomitantly and intraoperative findings convert these to type 3. When these fractures occur, the proper treatment is to remove the prosthesis while preserving as much of the bone stock as possible, and then to perform revision using a new component with a long intramedullary nail. This fixation can be completed with thick metal wires or loop wire, a plate with screws or, possibly, a bone graft.

Type 3 fractures require replacement of the distal femur and the decision between using a massive bone allograft from the distal femur or a prosthesis for tumors depends on the patients' characteristics. If they are in a good clinical condition with the prospect of long and active survival, it is preferable to use grafts from the distal femur. The time taken to achieve consolidation is long, and the patient will have to be maintained with light partial loading on the operated leg for six months. The advantage of this treatment is that it is a biological option and, if consolidation is achieved, the prospects are for good results over the medium term[34]. In addition, there is the possibility of fixation of the capsule-ligament structures of the knee to the graft, thereby making it possible to use semi-constrained prostheses (Figure 3).

If patients are elderly, with comorbidities that require early mobility with loading on the operated leg, or with states of dementia or other situations that make it unlikely that they will follow the medical restrictions for restricted support, the use of distal femoral prostheses of the type used for tumor surgery is recommendable. This type of implant has a hinge system that does away with the function of the joint ligaments. It is fixed to the

Figure 3 – A) Type 3 periprosthetic fracture of the distal femur. B) TKA revision and use of a massive homologous graft in the distal femur, complemented with a cortical bone plate. C) Appearance three years after the operation, showing consolidation of the graft

medullary canals of the femur and tibia using cemented nails and therefore allows patients to fully support themselves on the operated leg on the day after the operation. The disadvantage of these prostheses is that they have a history of unsatisfactory results over the medium and long terms, with high incidence of complications such as aseptic loosening, breakage of the material or new fractures at the tip of the cemented intramedullary nail. It also has to be borne in mind that, if deep postoperative infections occur, there is a likelihood that the final solution will be amputation of the leg.

In fact, the operation to replace the distal femur is a fast procedure and can be applied to other types of fracture in which the patient is not in a clinical condition to withstand a long period of use of walking frames or crutches. This can be compared with cases of fractures of the femoral neck in which, in complex situations, prostheses are used instead of osteosynthesis, in order to avoid clinical complications in selected patients. However, because of the severity of the potential complications, their use should be greatly restricted (Figures 4 a, b, c, d).

Type 4 fractures represent a major technical challenge because of the presence of the intramedullary nail of the femoral revision component, thereby limiting the use of conventional osteosynthesis material. Some possible ways of resolving this are described in the pertinent literature, such as replacement of the intramedullary nail with another, longer one[35] or the use of cortical bone plates surrounding the focus of the fracture[36]. The use of plates seems to be more indicated in these situations, either of LISS type, with single threaded cortical screws in the plate, or of Dall-Miles type, in which a combination of steel wire loops is used at the extremity of the fracture where the intramedullary nail is present, with screws on the proximal side. In cases of osteoporosis, in which the fixation of the screws may be compromised, a bone plate that serves as a shield can be used in the medial cortex, thereby improving the screw fixation. In addition, the plate can be incorporated into the patient's bone, thereby reducing the possibility of refracturing (Figures 5 a, b, c).
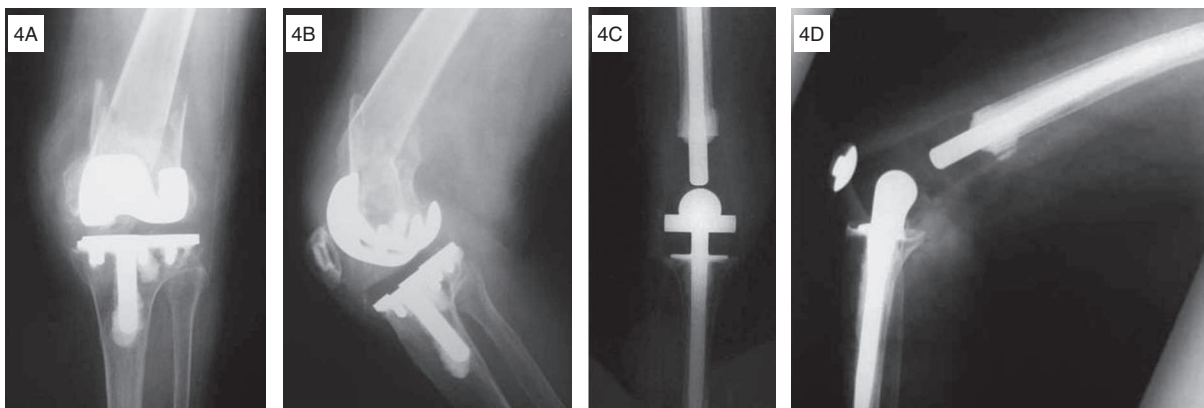

Figure 4 – A, B) Type 3 periprosthetic fracture of the distal femur in an 86-year-old patient (anterior and lateral views). C, D) Revision using unconventional endoprosthesis
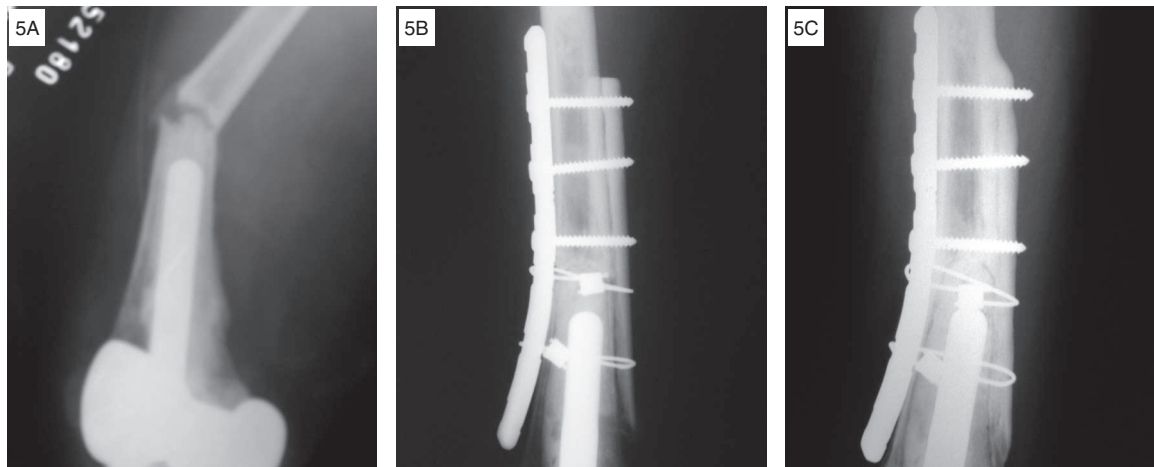
Figure 5 – A) Type 4 periprosthetic fracture. B) Fixation using Dall-Miles plate and medial bone plate, fixed using wires and screws. C) Checkup five years after the operation

CONCLUSION

Because of the increasing numbers of primary TKA procedures and patients' prospects of greater longevity, periprosthetic fractures in knees have become a problem of greater prevalence today. A systematic approach towards cases, with availability of modern means of osteosynthesis and prostheses of a variety of models and degrees of constraint, along with access to a bone bank, is a necessary resource for adequate treatment of these complex fractures, with the aim of maintaining patients' quality of life and functional capacity.

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