TECHNICAL NOTE

Periprosthetic femoral fractures: The minimally invasive fixation option

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Summary Increasingly frequent periprosthetic fractures are affecting the elderly; this patients group often suffers from significant co-morbidities that make it particularly difficult to manage these already complex injuries. The classic pitfalls of conservative treatment are many, including infections, pseudoarthrosis and the growing necessity of different postoperative supports. We present an internal fixation technique by minimally invasive surgery to manage periprosthetic fractures. The hardware used is a locking plate, with manufacturers’ recommendations usually allowing immediate weight bearing. This minimally invasive method provides optimal stability to the fixation, while avoiding the open approach shortcomings.

Level of evidence: IV: retrospective or historical series

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Introduction

Periprosthetic femoral fractures are relatively rare. Incidence rates of 0.1 to 2% around total hip arthroplasty (THA) and 0.3 to 2.5% around total knee arthroplasty (TKA) have been reported in the literature [1]. This pathology is, however, constantly increasing because of growth in the number of arthroplasties and aging of the population.

The modalities of osteosynthesis of these fractures are controversial in as much as various techniques are employed. It appears, however, that osteosynthesis by locking plate is recommended most frequently for fractures around THA (nearly 85%) with a lower proportion for fractures on TKA (40%). Conventional osteosynthesis techniques have several pitfalls: risk of infections, pseudoarthrosis and the necessity for delayed weight bearing.

We provide details of the osteosynthesis technique by mini-invasive surgery with locking plate that permits optimal care of elderly and fragile patients. The objective of this method is to combine stability of the assembly with the preservation of fracture hematoma, and it most often allows postoperative weight bearing.

Surgical technique

Materials

The osteosynthesis material is a titanium plate with 4.5-mm locking screws (LCP™, Synthes™). Two anatomical models

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are employed according to the fracture site: "diaphyseal plates" for proximal diaphyseal fractures, and "distal femoral plates" for distal diaphyseal fractures, condylar or supra-condylar. The ancillary Less Invasive Stabilization System (LISS), used consistently for distal femoral plates, allows easy plate introduction in the extraperiosteum and, above all, facilitates locking screws. The screws are either standard, permitting screwing of bone to the plate, or locked. Flat-end screws are also available in the ancillary, enabling mono-cortical periprosthetic locking in the presence of significant prosthetic cluttering. Furthermore, screwable bolts on the plate allow wire cerclage fixation. Installation of this locking screw system corresponds to the achievement of a one-piece assembly called the internal fixator.

**Installation**

The intervention is implemented by the dorsal decubitus approach, either on traction or a standard table. Installation on the traction table is identical to that done for centromedullary nailing. Traction may be acquired by boots for table fracture or by trans-osseous pin (trans-tibial or trans-condylar according to the level of the fracture). Installation on the standard table most often requires an operating assistant who puts the limb in traction in the axis and controls rotation of the fragments. The type of installation depends on the type of fracture but also on the surgeon’s habits. For distal fractures (distal third, supra- and inter-condylar), installation may be achieved on a standard or traction table. For middle third or proximal fractures, installation on a traction table is more effective.

**Approach**

The technique that we describe is mini-invasive. Thus, preoperative identification at different levels is essential (Fig. 1a). It will provide procedure guidance and reduce exposure time to irradiation. The different levels are marked by dermographic felt pen with an image intensifier control. The first mark concerns the fracture with delimitation of the distal and proximal levels (Fig. 1a). On anterior viewing, we mark: the extremity of the femoral stem (of the THA or TKA in case of long keels) (Fig. 1b), the level of the knee joint space and the upper part of the patella in case of fractures around TKA (Fig. 1c), and the level of the greater trochanter in case of high fractures around THA to center the incision. The axis of the femoral diaphysis is noted on lateral viewing (Fig. 1d) which permits orientation of the plate along the bone and the trajectory of the distal, lateral, para-condylar incision (Fig. 1e).

The approach is mini-invasive, i.e., without fracture exposure. It is true that in low femoral fractures around TKA, the fracture core is at the limit of the para-condylar incision and preservation of the fracture hematoma may be compromised. The incision is adapted to the fracture site and type of plate. Thus, a distal para-condylar approach is taken for "distal femoral" plates and distal fractures, with a para-trochanteric approach for high fractures and "anatomical diaphyseal" plates. The objective is to preserve the mini-invasive nature of this surgery. However, in

![Cutaneous marking. a: marking by dermographic felt marker: fracture core (A), distal para-condylar incision (B), diaphyseal axis (C), joint space (discontinuous arrow), top edge of the patella (full arrow), distal limit of the femoral implant (dotted arrow). b: peroperative X-ray tracking of the femoral implant extremity (example of a THA). c: peroperative X-ray location of joint space on a TKA. d: peroperative X-ray location on a sideview photograph of the femoral diaphyseal axis. e: peroperative X-ray location on a sideview photograph of the distal para-condylar incision trajectory.](image-url)
Figure 2  Indirect maneuver for fracture reduction by prosthesis. Example of femoral fracture around a TKA. a: standard anterior and lateral X-ray of a supra-condylar type B fracture on a TKA according to SOFCOT classification. b: temporary reduction by intra-focal pinning. c: control of positioning of the plate anterior view: joint parallelism of the pin. d: sequence of fracture reduction by a return screw fastening the bone on the plate, which serves as a reduction mold. The distal part of the plate is in bone contact and the proximal bone fragment is brought in contact. The screw is long enough to be able to grip the facing cortical. It will be removed at the end of the intervention. e: X-ray control at 2.5 months postoperatively. Note the significance of the bony callus and preservation of the axes despite allowed loading to the pain threshold.
Periprosthetic femoral fractures

Reduction and fixation

Reduction can be undertaken in two phases: preoperatively and peroperatively. It is always attempted indirectly by external maneuvers under fluoroscopic control.

The preoperative phase corresponds to fluoroscopic viewing of the installation. Traction in the limb axis, permitted by the traction table or with help during standard installation, constitutes the first maneuver and reduction step, as with centro-medullary nailing. The knee is slightly flexed by installing the folded drapes under the distal extremity of the femur, to eliminate the tendency towards recurvatum of the distal femoral fragment by traction of the gastrocnemius muscles.

The peroperative phase corresponds to supplementary reduction maneuvers (Fig. 2). As with intra-focal pinning, temporary pinning according to Kapandji (Fig. 2b) allows us to reduce overlapping in recurvatum, flessum or translation. Pinning is maintained until the stabilization of two fragments by at least two locking screws each. The anatomical nature of the distal femoral plate serves as a veritable reduction mold. In fact, the more distal screws are meant to be parallel to the knee joint space. Initial positioning of the plate is controlled under scopy with a 2-mm diameter pin introduced in a specific targeting sleeve that must be parallel to the space (Fig. 2c). The assembly is a one-piece system for internal fixation that does not need application to the bone. It must, however, be parallel both to the proximal and distal fragments. Indeed, there is a risk of inducing a vicious position if the plate is positioned asymmetrically. An indirect way of playing with the anatomical nature of the plate is by using a standard return screw to fasten the bone on the plate, with the latter serving as a reduction mold (Fig. 2d). This also prevents fragment translation. It is important that bone should come to the plate and not vice versa. In fact, the materials that we use are made of titanium, and are therefore elastic; if the plate goes to the bone it could be deformed and induce a vicious position in valgus because of its bending.

The objective is to achieve restitution of an anatomical bone axis (Fig. 2e). This is where the level of reduction is located. Marquetry of the fracture core is not required.

Six-point specifications for osteosynthesis

In our practice, immediate postoperative loading is attempted as much as possible, with the goal of recovering autonomy and reducing decubitus complications. However, the assembly must respect certain rules learned from our experience. Six points should be followed:

1. Avoid peaks of constraint between the two implants and a stress fracture. Thus, hardware already in place must be bridged (Fig. 3).
2. Install a long assembly with at least five holes beyond the fracture core. Locking screws should be placed in an alternative manner with one out of two screws. This spaced mounting enables better distribution and absorption of constraints (Fig. 4). Attempts should be made to install three screws per fragment. Screws placed opposite the implant (below a THA or proximal to a TKA should be bicortical). We have no confidence in monocortical screws, even if they are locked. If the length of the plate permits, a fourth mono-cortical screw will be put in place, unifying the constraints.
3. With regard to the femoral stem of a THA or the long keel of a TKA, bicortical screwing must be attempted. It is unfortunately tied to prosthetic clumping and the position of the stem. In fact, fortunately for traumatologists, orthopaedic surgeons will often place the femoral stem in flexion or extension, allowing bicortical screws on both sides of the stem. If this is not possible, a maximum of flat-end monocortical screws will be put in place (Fig. 4). The goal is to accomplish maximal periprosthetic hold. In cases of fractures around TKA,
Figure 4  a: type B fracture around a TKA with long keel. Significant prosthetic cluttering. b: X-ray at consolidation (union). The assembly is long with five holes beyond the implant and locked screws on two holes. Prosthetic cluttering is significant so that only monocortical screws can be placed. Bone quality is precarious and the grip of the monocortical screws, even if locked, is a concern, so that cerclage wires are placed by complementary mini-approaches.

a maximum of distal screws must be placed. In fact, cluttering of the femoral shield, notably in cases of postero-stabilized prosthesis, sometimes requires the positioning of “unicondylar” screws, which have, by definition, less hold. Optimally, we recommend placing four distal metaphyso-epiphyseal screws. Of course, this number depends on fracture location.

(4) In cases of significant prosthetic cluttering, and also in cases of type B fractures around THA, holding of the plate and stability of the assembly must be ensured with proximal trochanteric fixation. This proximal screwing will be particularly more effective since it will be anchored in cement (Fig. 5).

(5) If this proximal fixation is not possible or if prosthetic cluttering is too significant (THA or TKA), fixation of the plate and stability of the assembly must be ensured by one or more cerclages, fixed or not on a bolt screwed to the plate, to avoid pulling out the plate during loading (Fig. 4).

(6) Finally, screw locking will differ according to the type of fracture. It should be close to the core in cases of “complex” fracture and distant in cases of “simple” fractures [2]. The locking mode allows us to manipulate the elasticity of titanium material that is beneficial to bone consolidation (union), in adapting to the fracture: making complex fractures rigid, and leaving “dynamic” fractures simple. In fact, for “simple” fractures, leaving space avoids the concentration of constraints on the plate by excessive locking and the risk of stress fracture. In contrast, for complex fractures, bringing it close to the core allows it to rigidify.

Discussion

The fractures that we repair correspond to indications of conservative treatment found in the literature [1,3—5], with the majority being type C or type B1 according to the classification of Vancouver [6] for THA and of the Société Française de Chirurgie Orthopédique et Traumatologique (SOFCOT) [7] for TKA.

The choice of material is the LCP type (SynthesTM) “screw locking plate” system that theoretically allows better fixation in porotic bone [8–11]. This situation is frequently seen in the population affected by periprosthetic fractures. We, however, recommend the use of bicortical screws which, because of their characteristic locking to the plate,
present three fixation points (two corticals + the plate), limiting tearing phenomena. Furthermore, titanium, because of its superior biocompatibility, permits the most significant anchoring to bone. The locking nature of the screws to the plate confers the title of ‘‘internal fixator’’ to the LCP system [10,12]. The triple hold of screws and the one-piece character of the assembly provide better hold in fragile bone with better resistance to tearing [8,9,11]. The association of long assemblies, that permit the better distribution and absorption of constraints, with the fixation of fragments by a minimum of three to four screws with cerclage wires if necessary, provides significant and sufficient fixation a priori. Thus, these biomechanical considerations allow us to provide immediate loading.

The choice of plate depends on the type of fracture, but is especially dictated by the necessity of a stable mechanical assembly for immediate mobilization and, if possible, immediate postoperative loading. Thus, in a schematic way: type B or C fractures around TKA will be treated by a ‘‘LCP distal femur’’ plate, type C ‘‘distal’’ fractures around THA will also be treated by ‘‘LCP distal femur’’ plate, type C ‘‘proximal’’ fractures will be treated by one or the other LCP femoral plate (diaphyseal or distal femur) provided that the ‘‘mechanical specifications’’ described above are fulfilled, and type B fractures around THA will be treated by LCP diaphyseal plate.

The mini-invasive technique described enables biological synthesis with preservation of the hematoma (as with centro-medullary nailing) and respect of the periost and surrounding soft tissues because of a non-surgical approach [10,12,13]. The proposed technique combines the principle of a closed core with assembly stability. Thanks to its screw-locking nature, holding of the plate requires no bone contact for primary stability by the ‘‘friction effect’’ [10,12], which preserves peripheral vascularization and limits bone resorption phenomena under the plate.

The mini-invasive surgical technique is beneficial for patients, but requires rigor and technical skill with an indisputable but relatively short learning curve. This mini-invasive surgery should not be an end in itself. Obtaining quality reduction at the level of the bone segment must be the objective. We should not hesitate to convert and take a mini-approach to refine reduction temporarily with bone clamp, especially when there is an interposing muscle. As this surgery is by definition ‘‘closed’’, the problem of postoperative irradiation must be raised. The preparation and placement of cutaneous markers is essential to minimize this exposure to the maximum. On the other hand, dorsal decubitus installation (standard or orthopaedic table) also presents a significant advantage for this elderly population in which lateral decubitus positioning may not be suitable. The absence of a large, invasive approach diminishes blood loss (not evaluated at present in our practice) and immediate postoperative pains from an extensive approach. The technique, as described, has ideal indications in cases of fractures between implants (TKA-THA) which will be seen more frequently, but also in cases of fractures around TKA, of which cluttering of the shield does not permit retrograde nailing, while retaining the benefit of closed surgery. Finally, in type B2 fractures borderline for conservative treatment, this technique would allow surgery with less negative consequences, notably in relatively young patients.

Conflict of interest statement

M.E. Synthes™ occasional consultant.

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