ORIGINAL ARTICLE

Interprosthetic femoral fractures: Analysis of 14 cases. Proposal for an additional grade in the Vancouver and SoFCOT classifications

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Femoral fracture; Periprosthetic fracture; Interprosthetic fracture; Osteosynthesis; Internal fixation; Locking compression plate; Total femur replacement

Summary

Introduction: Interprosthetic fracture is a rare but serious entity, impairing consolidation and stability due to adverse mechanical conditions related to bone fragility and implant volume. Objective: The present study highlights the difficulties involved in managing such fractures, details treatment options and reports findings leading to a proposed additional grade in the comparable Vancouver (hip) and French Orthopedic and Traumatologic Surgery Society (Société française de chirurgie orthopédique et traumatologique: SoFCOT) (knee) classification systems. Patients and methods: A multicenter retrospective series included 14 interprosthetic femoral fractures: eight type double C (type C for both hip and knee), five type C for hip and B for knee, and one type double B (type B for both hip and knee) on the Vancouver and SoFCOT classifications. Fracture occurred on standard \( n = 15 \) or revision \( n = 13 \) implants. Six cases involved a femoral shaft encumbered by a total knee replacement (TKR) femoral extension stem and eight cases TKR without femoral long stem, assimilable to type C fracture. Results: None of the six fractures proximal to a constrained TKR with stem-achieved union by primary intention, whereas seven of the eight type-C fractures did so. Finally, 12 cases showed favorable evolution, with three secondary total femur replacements (TFR) and one death at 6 months without bony union or revision and one patient waiting for TFR. Discussion: To describe the status of the intermediate femur and its medullary canal encumbrance, we propose adding a category D to the SoFCOT and Vancouver classifications, corresponding to interprosthetic fracture on TKR with diaphyseal extension stem. Interprosthetic
Introduction

Periprosthetic femoral fracture is rare, with an incidence of 0.1 to 2% around total hip replacement (THR) implants, 0.3 to 2.5% around total knee replacement (TKR) implants [1] and about 1.25% for interprosthetic fracture [2]. The latter is a particular anatomic entity with specific therapeutic requirements due to unfavorable mechanical conditions between two rigid regions related to the presence of more or less extensive material in the femoral shaft. The Vancouver classification [3] is used to describe fractures around THR and the French Orthopedic and Traumatologic Surgery Society (Société française de chirurgie orthopédique et traumatologique: SoFCOT) classification [4] for fractures around TKR; neither, however, takes account of the status of the femoral shaft between the two prosthetic components [3,4]. Interprosthetic femoral fracture occurs more frequently in case of revision surgery [5,6] or of osteoporosis [2,7]. It is associated with elevated mortality and revision rates: greater than 50% revision according to Zuurmond et al. [8] and mortality in excess of the reference population according to Bhattacharyya et al. [9]. New osteosynthesis material using locking screws provides improved fixation in fragile bone [10–13] and may meet certain situations, especially if associated to minimally invasive techniques with hematoma and periosteum preservation [12,14–18]; it cannot, however, meet all situations, especially in case of limited bone support in case of arthroplasty with diaphyseal extension or implant loosening concomitant to the fracture [19,20].

The objectives of the present study were:

1) to highlight the difficulties of managing this kind of fracture, based on a 14-case series and;
2) to introduce an extension to the Vancouver hip classification [3] and SoFCOT knee classification [4], to differentiate prognosis according to form and to adapt treatment.

Patients and method

A retrospective study was conducted in three centers in France (Lille, Strasbourg and Dunkerque) from 2003 to 2009, including 14 interprosthetic femoral fractures (12 females, two males; mean age, 72 years (range, 49–89 years)). Mean fracture-THR interval was 136 months (range, 8–208 months) and mean fracture-TKR interval 84 months (range, 12–192 months). Etiologies were: osteoarthritis in seven cases, osteonecrosis in two, rheumatoid arthritis in four and fracture in one. There were eight primary and six revision arthroplasties. Table 1 shows the characteristics of the fractures, implants and treatment methods.

Postoperative complications comprised non-consolidation, early osteosynthesis material disassembly, non-union, superficial and deep infection, and any other event requiring revision surgery. Fracture consolidation was assessed as bony callus seen on two orthogonal X-ray incidences, without greater than 3° reduction loss, and allowing total weight-bearing without increase in pain above preoperative levels. Unfavorable evolution was assessed as non-consolidation at 3 months and/or failure to resume total weight bearing at 3 months, generally associated with increase in pain above preoperative levels.

Results

Seven patients had satisfactory clinical and radiological results (cases 3, 6, 7, 9, 10, 11 and 12; Table 1), without...
<table>
<thead>
<tr>
<th>Case</th>
<th>Center</th>
<th>Type of fracture</th>
<th>Primary treatment</th>
<th>Complications</th>
<th>Revision</th>
<th>Evolution (number of interventions)</th>
<th>Type D&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L</td>
<td>C on standard THR C on standard TKR</td>
<td>Closed retrograde nailing, area of weakness</td>
<td>Iterative fracture on area of weakness</td>
<td>Revision (2) by plate, inc; 1 with graft evolving to aseptic non-union revised by plate et rod allograft + BMP, complicated at 8 months by infection cured by 2 lavages</td>
<td>Favorable (n = 7)</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>L</td>
<td>C on standard THR B2 on revision TKR</td>
<td>Simple open cerclage</td>
<td>Delayed consolidation</td>
<td>Suggested TFR refused by patient</td>
<td>Death at 6 months (n = 1)</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>L</td>
<td>C on standard THR B1 on standard TKR</td>
<td>Closed retrograde nailing, area of weakness</td>
<td>Proximal locking route error (dynamic nail)</td>
<td>—</td>
<td>Favorable (n = 1)</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
<td>C on standard THR B2 on revision TKR</td>
<td>TKR replacement + plate + rod graft</td>
<td>Non-union and disassembly</td>
<td>TFR</td>
<td>Favorable (n = 3)</td>
<td>D</td>
</tr>
<tr>
<td>5</td>
<td>L</td>
<td>C on standard THR C onrevision TKR</td>
<td>Open plate osteosynthesis without graft</td>
<td>Non-union and material breakage</td>
<td>Open plate osteosynthesis + graft followed by material breakage and non-union Plate and graft</td>
<td>Unfavorable (n = 3)</td>
<td>D</td>
</tr>
<tr>
<td>6</td>
<td>L</td>
<td>C on revision THR C on standard TKR</td>
<td>Open plate osteosynthesis without graft</td>
<td>None</td>
<td>—</td>
<td>Favorable (n = 1)</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>L</td>
<td>C on revision THR C on standard TKR</td>
<td>Open plate osteosynthesis without graft</td>
<td>None</td>
<td>—</td>
<td>Favorable (n = 1)</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>L</td>
<td>C on standard THR C on revision TKR</td>
<td>Open plate osteosynthesis without graft</td>
<td>Non-union and early disassembly</td>
<td>TFR</td>
<td>Favorable (n = 2)</td>
<td>D</td>
</tr>
<tr>
<td>9</td>
<td>S</td>
<td>C on locked revision THR C on standard TKR</td>
<td>MI closed LCP osteosynthesis with implant bridging</td>
<td>None</td>
<td>—</td>
<td>Favorable (n = 1)</td>
<td>—</td>
</tr>
<tr>
<td>10</td>
<td>S</td>
<td>C on revision THR C on standard TKR</td>
<td>MI closed LCP osteosynthesis with implant bridging</td>
<td>None</td>
<td>—</td>
<td>Favorable (n = 1)</td>
<td>—</td>
</tr>
<tr>
<td>11</td>
<td>S</td>
<td>C on revision THR B1 on standard TKR</td>
<td>MI closed LCP osteosynthesis with implant bridging</td>
<td>None</td>
<td>—</td>
<td>Favorable (n = 1)</td>
<td>—</td>
</tr>
<tr>
<td>12</td>
<td>S</td>
<td>C on standard THR B1 on standard TKR</td>
<td>MI closed LCP osteosynthesis with implant bridging</td>
<td>None</td>
<td>—</td>
<td>Favorable (n = 1)</td>
<td>—</td>
</tr>
<tr>
<td>13</td>
<td>S</td>
<td>B1 on revision THR B1 on revision TKR</td>
<td>MI closed LCP osteosynthesis with implant bridging</td>
<td>Early disassembly (at-risk osteosynthesis)</td>
<td>Open LCP osteosynthesis</td>
<td>Favorable (n = 2)</td>
<td>D</td>
</tr>
<tr>
<td>14</td>
<td>D</td>
<td>C on revision THR C on revision TKR</td>
<td>Open plate osteosynthesis without graft</td>
<td>Non-union and early disassembly</td>
<td>TFR</td>
<td>Favorable (n = 2)</td>
<td>D</td>
</tr>
</tbody>
</table>

<sup>a</sup> Type D = interprosthetic fracture on TKR with femoral shaft extension stem.

Table 1: Case descriptions: fracture anatomy, treatment, evolution.

L: Lille; S: Strasbourg; D: Dunkerque; THR: total hip replacement; TKR: total knee replacement; TFR: total femoral replacement.
surgical revision. These implants (hip or knee) showed no loosening, and there was no osteolysis associated with the fracture. TKRs were all standard models, without femoral extension stem; five of the seven patients had revision THRs. Treatment in six cases was by plate osteosynthesis, performed using the closed Less Invasive Surgery System (LISS®) technique in four cases, with LC-DCP (Synthes®) locking compression plate, without associated graft (Fig. 2). In all cases, the plates bridged the femoral pivot by greater than two cortical diameters. Total weight bearing was resumed at 8 weeks postoperatively, with bone consolidation on X-ray.

Seven patients failed to show favorable evolution, due to mechanical treatment failure (cases 1, 2, 4, 5, 8, 13 and 14; Table 1); six of them had revision TKRs with femoral extension stems. In five cases, treatment used plate osteosynthesis, bridging the implants and extension stems by greater than two cortical diameters. There was one death, in an 88 year-old woman, at 6 months’ follow-up (case 2; Table 1) following multiple organ failure; she showed non-consolidation following insufficient cerclage osteosynthesis. Five patients showed favorable evolution after revision either for further open osteosynthesis (cases 1 and 13; Table 1), or for implant removal and TFR (Fig. 3) to bridge the fracture site (cases 4, 8 and 14; Table 1). Weight bearing was resumed at 1 week postoperatively. Two patients without dual mobility acetabular components (cases 8 and 14) showed postoperative instability of the hip, without requiring surgical revision.

Discussion

Results analysis and new classification

The present series highlighted the seriousness of this kind of fracture when the femoral shaft is invaded by an extension stem or revision implant and there is little remaining implant-free femoral shaft bone capital. The results point to failure of osteosynthesis of interprosthetic fracture when the TKR, whether primary or revision, includes diaphyseal extension. To better describe these fractures and the importance of residual femur free of medullary material, we believe it would be useful to add a grade to the Vancouver [3] and SoFCOT [4] classifications. This grade, ‘‘type D’’ (Fig. 1), corresponds to interprosthetic femoral fracture between a standard or revision THR and a revision TKR, wherever the fracture site. Extending the classification to identify an implant-free femoral length seems indispensable in order to remind surgeons of the need for a specific approach. It thus seems important to differentiate simple interprosthetic fracture, falling within Vancouver-SoFCOT type C, from this type D where there is little femoral shaft left free by the TKR extension stem. The shorter the free femoral shaft, the greater the stress exerted on the osteosynthesis.

Complications were observed in eight of the 14 cases (Table 1; cases 1, 2, 3, 4, 5, 8, 13 and 14), which is more than in Patel et al. series of periprosthetic fractures [21] with a 52% complications rate comprising infection, implant rupture, material breakage, dislocation and iterative fracture.

The issue of interprosthetic fracture

It is important to differentiate between type C and type D interprosthetic fracture. The technical difficulties are inversely proportional to the available bone capital or ‘‘implant-free femoral length’’.

Interprosthetic fracture may occur with well-fixed implants, which is the simplest case, with an extensive length of free femur; the choice of means of fixation, however, is crucial. Intramedullary retrograde nailing is theoretically possible, depending on the TKR design. But this
option requires planning, according to the available lengths of nail, to avoid having a peak stress area between the nail and the femoral pivot. This area of weakness concentrates load, with a risk of iterative fracture around the nail locking holes, as in case 1 (Table 1). We therefore prefer open plate osteosynthesis, with a plate long enough to bridge the fracture and adequate peri-prosthetic anchorage by cerclages and screws, away from the implant and combating avulsion [16]. A graft (cancellous autograft and/or allograft rod) improves consolidation [20,22], when associated to stable osteosynthesis, which is a prerequisite. The LISS technique respects the fracture site environment and consolidation factors [16–18], and may also be indicated in comminutive fracture if not extensive. Implant bridging eliminates areas of weakness and thus the risk of iterative fracture.

Interprosthetic fracture may also occur between loose implants or with osteolysis (cases 2, 4, 5 and 14; Table 1). The loosened implant should be replaced if the patient’s general health status allows. Replacement is generally associated to extension of femoral pivot length or to introduction of a TKR femoral extension stem. We recommend associating adjuvant complementary plate osteosynthesis to avoid an inter-implant peak stress area [23,24]. If both implants are loose, which is very rare, replacing both should be considered. Where bone capital is slight, leaving little chance of consolidation, TFR should be considered, despite the associated technical difficulties and risks [25]; it is a difficult indication to make in what are usually elderly patients with poor general health status, but is nevertheless the option with the best chance of succeeding [6,23]—on condition that the team is experienced, given the high rates of associated morbidity and mortality. Friesecke et al. [26] reported a complications rate of 32% and infection rate of 13% in a series comprising 40% of peri- or interprosthetic fractures managed by TFR. In such situations, osteosynthesis is a risky alternative, with complications rates up to 70% [27], and a primary failure rate of 100% in the present series (Table 1; cases 2, 4, 5, 8, 13 and 14). TFR was used in secondary salvage, with satisfactory results (Table 1; cases 4, 8 and 14).

Conclusion

Treating interprosthetic femoral fracture requires the femur to be considered as a whole, to avoid mechanical failure by iterative fracture or material failure. If osteosynthesis is indicated, it should bridge the two implants so as not to leave any area of weakness. Implant replacement should adequately bridge the fracture, and adjuvant complementary osteosynthesis should be associated so as not to induce any peak stress area. Finally, the present study highlights the difficulties involved in treating interprosthetic fractures with TKR with femoral shaft extension stem, for which we propose adding a type D to the Vancouver classification. In the present short series, evolution in these cases was satisfactory after TFR revision. Prevention of such fractures depends on conserving bone capital and the femoral medullary canal whenever possible, in both primary and revision implant surgery.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


