



Management of periprosthetic fractures in patients treated with a megaprosthesis for malignant bone tumours around the knee

Michael GEBHART, Félix SHUMELINSKY

From the Institut Jules Bordet, Brussels, Belgium

Early and late infection as well as loosening and mechanical failure are among the postoperative complications most often reported following reconstruction with a tumour prosthesis in patients with a sarcoma around the knee. Scarce instances of periprosthetic fractures have been reported. The literature includes the description of two patients with such a complication, however no treatment recommendation was detailed in those articles. We recorded in our experience two patients with a traumatic fracture following a massive prosthetic bone and joint replacement after major resection for a bone sarcoma. The surgical treatment was open reduction and internal fixation using a cable and plate system, allowing preservation of the prosthesis and providing stable fracture fixation and excellent fracture healing.

Keywords: knee ; tumour prosthesis ; periprosthetic fracture ; cable and plate fixation.

INTRODUCTION

Limb salvage surgery has become the standard for local control of aggressive bone and soft tissue tumours arising around the knee. Since the 1970's, major efforts have been made to improve effective adjuvant therapy, leading to an improved survival rate among bone sarcoma patients (10,23). Newer imaging techniques have widely contributed to a better preoperative assessment of tumour extension (20). Surgical techniques along with well-tolerated and durable biomaterials have made limb salvage

possible in the treatment of bone sarcomas. Limb-salvage surgery should not infringe oncological rules. It is obvious that functional, psychological and cosmetic outcome favours limb-sparing procedures over amputation or rotationplasty (8). Amputation has the advantage to be a definitive surgical procedure, allowing radical tumour removal followed by few complications. Limb sparing procedures on the other hand, are challenging and expose to a variety of immediate, early and late complications (17). Bone defect reconstruction became a major concern and several methods have been tried involving allografts, slightly modified classical knee and hip prostheses augmented by segmental allografts, and massive custom-made or modular metal prostheses. A trend toward the use of massive prosthetic devices instead of allografts is a very recent change in the treatment of lower extremity sarcomas (18). This is due to the risk of early infection, non-union, bone resorption and spontaneous fractures with allografts. Endoprosthetic reconstructions provide a consistently more

-
- Michael Gebhart, MD, Surgeon-in-Chief.
 - Félix Shumelinsky, MD, Orthopaedic Surgeon.
Department of Orthopaedic Surgery, ULB, Institut Jules Bordet, Brussels, Belgium.
Correspondence : Félix Shumelinsky, Department of Orthopaedic Surgery, Institut Jules Bordet, 1 Rue Héger-Bordet, B-1000 Brussels, Belgium.
E-mail : felix.shumelinsky@bordet.be
© 2012, Acta Orthopædica Belgica.

predictable outcome compared with allograft reconstruction. Even in patients with poor prognosis, they may have a role in optimizing quality of life, providing pain relief, and maintaining an intact body image (24).

Prosthetic loosening is a long lasting process with the formation of a fibrotic rim at the interface between bone and cement or prosthetic stem with substantial thinning of the cortical bone and subsequent bone resorption. Stress shielding and lesser use of the extremity will lead to general bone loss, resulting in a higher fracture risk, even with a minor trauma.

Patients who underwent bone resection for tumours, have most often had major soft tissue resection as well, resulting in relative weakness of the gait muscles, leading to more frequent falls (2,11).

A thorough search in the literature gives only scarce information about periprosthetic traumatic fractures and recommendations for their treatment in patients with large segmental bone and joint resection for bone tumours of the lower extremity. We found only three well documented cases among larger series reporting the outcome of massive endoprostheses used for the reconstruction of bone defects due to tumour resection (1,12,21). Referring to periprosthetic hip fractures, the Vancouver classification is used to establish the type of fracture as well as treatment options, whether fracture occurred proximally or more distally to the prosthesis or on a well anchored or loosened prosthesis (5). Rorabeck and Taylor proposed a very similar classification for fractures occurring in the distal femur after placement of a knee prosthesis (19).

No such classification was proposed until now for periprosthetic fractures around massive segmental joint prostheses for tumours around the knee. A similar classification could be imagined, based on fracture location and status of bone and prosthetic stem interface. Referring to conventional periprosthetic fractures, cast immobilization is a treatment option which can be considered in some selected situations. Most often however, surgical options must be considered because of significant displacement of the bone fragments. Fixation with conventional plates is almost impossible because of the

presence of the stem or cement in the medullary canal.

Different plates have been developed to fix fractures by extramedullary fixation (Dall-Miles plate, Mennen plate, a plate with lateral monocortical screws proposed by AO, different custom-made plates with lateral screw fixations). Cable plates have been developed recently. They have the advantage of treating fractures by cerclage when it is not possible to insert a screw (13).

CASE SERIES

Since 1986, 56 massive prostheses were implanted at our institution for reconstruction of major bone defects around the knee. Nine prostheses had to be revised for infection (three patients), mechanical failure (four patients) of the polyethylene component of the Delepine titanium custom-made prosthesis (3) and prosthetic dislocation (one patient) at the hinge of the OSS prosthesis (OSS®, Biomet Manufacturing Corp., Warsaw, IN, USA). Two patients were found to have traumatic periprosthetic fractures.

Case 1

The first patient is a female, born in 1993. Her medical history was uneventful until August 2005, when she started complaining of left knee pain. After a thorough work-up, the diagnosis of osteosarcoma of the left proximal tibia was confirmed by biopsy (Fig. 1). A PET-CT also showed intense uptake of a small area in the distal femur with a high suspicion of a skip metastasis in the femoral condyle. After preoperative chemotherapy with a good clinical response, large en bloc resection of the distal femur and the proximal tibia was performed with negative clinical and histological margins. Bone defect reconstruction was performed with a custom-made Phenix Growing Megaprosthesis (Phenix Medical, Paris, France) of both tibia and femur in January 2006. At the same time, reconstruction of the extensor mechanism was done by a gastrocnemius flap with a good clinical outcome. The lengthening mechanism of this prosthesis was activated by an external magnet and a 6 cm



Fig. 1. — Case 1. Preoperative radiograph showing osteosarcoma of the left proximal tibia and prosthesis template.

lengthening was ultimately obtained (Fig. discontinued Lengthening was discontinued once equal limb length was reached. In August 2009 after mechanical failure of the Phenix prosthesis occurred, it had to be revised with an OSS femorotibial prosthesis, with excellent clinical outcome (Fig. 3). In March 2010, the patient accidentally slipped on an icy road resulting in a proximal femur fracture (Fig. 4). According to the modified Vancouver or Rorabeck classification, this fracture could be classified as C1. The patient was treated by open reduction and internal fixation using a cable-plate device (Fig. 5). No weight bearing was allowed for 6 weeks. Rehabilitation of knee and hip was then conducted for three months. The fracture healed without any postoperative or late complication. The patient is currently 18 years old and has an almost normal gait and a 15 mm limb length discrepancy compensated for by a shoe lift. She has no pain, has recovered normal social activity and is a nursing student.

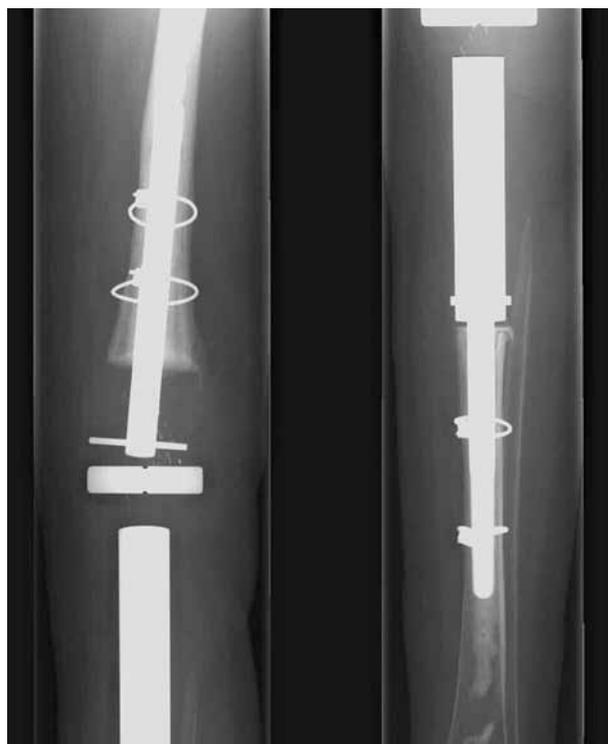


Fig. 2. — Case 1. Phenix growing prosthesis showing a limb lengthening of 6 cm. Resection of the proximal tibia caused weakening of the knee extensor mechanism treated by soft tissue reconstruction using a gastrocnemius flap to reattach the patellar tendon.

Case 2

The second patient is a male born in 1956. He was diagnosed with a distal femur osteosarcoma in 1977, when he was 21 years old. He was treated with a cemented carbon fiber megaprosthesis which provided a good clinical function during 19 years. No tumour recurrence occurred. In 1996 after breakage of the femoral prosthetic stem, the prosthesis was revised to a Delepine custom-made titanium megaprosthesis. No major postoperative complication occurred except difficult rehabilitation leading to a slight permanent limping, the use of one crutch, and a reduced range of motion of the prosthetic knee (from 0° to 110°). The patient was however walking without pain. In April 2009 an accidental fall caused a proximal tibia fracture (Fig. 6). Using the modified Vancouver or Rorabeck classification, this fracture could be clas-



Fig. 3. — Case 1. Conversion of the Phenix prosthesis into an Biomet® OSS megaprosthesis. Cerclage is consecutive to extraction of the femoral prosthesis using the sarcophagus technique.



Fig. 4. — Case 1. Periprosthetic fracture after an accidental fall.



Fig. 5. — Case 1. Open reduction and internal fixation with a cable-plate.

sified as B1. The patient was treated with open reduction and internal fixation using a cable-plate device (Fig. 7). No weight bearing was allowed for 6 weeks and currently this 55 y.o. patient has an excellent clinical outcome with radiographic consolidation and a gait function that is identical to the preoperative situation.

DISCUSSION

Multidisciplinary management of patients affected by malignant bone tumours has markedly improved survival rates, especially since the availability of more effective chemotherapies, new imaging techniques and limb sparing surgical techniques (10,23). Bone defect reconstruction after bone tumour resection around the knee is a major challenge for orthopaedic surgeons and engineers developing prosthetic devices. Given the complexity of this surgical procedure, it is one of the most



Fig. 6. — Case 2. Proximal tibia fracture after an accidental fall.

important responsibilities of the treating team to reduce associated morbidity and subsequent complications. Most of the complications are due to infection, prosthetic loosening and mechanical failure (12,21,23). Periprosthetic fractures are a well-documented late complication in the conventional knee replacements (14,19). Much less is known about periprosthetic fractures occurring around a megaprosthesis. Among the numerous causes for periprosthetic fractures are poor bone quality, bone devascularization due to reaming and cement heating, stress shielding and of course traumatic events (7). In certain tumours, chemotherapy and/or radiation therapy may also be responsible for bone weakening. Patients with massive endoprostheses for bone tumours of the distal femur or the proximal tibia also have large soft tissue resections, resulting in general weakness of the lower extremity. In the particular case of proximal tibia resection, the patellar tendon has to be detached from the tibial tuberosity and reconstruction of the extensor mech-



Fig. 7. — Case 2. Open reduction and internal fixation using a cable-plate.

anism is achieved using a gastrocnemius flap (6,9), resulting in an extension weakness that also may be a cause for more frequent falls. Treatment options for periprosthetic fractures around megaprotheses are an even more challenging situation than tumour resection and reconstruction itself. It is very difficult to perform osteosynthesis using conventional methods because of the presence of a stem. Stabilizing the fracture with a longer stem is a standard option that requires full revision of the implant (15). Unicortical screws were used to obtain fracture stability, but loosening of the plate easily followed this type of fixation (15). More recently a large variety of plates were designed to avoid the use of screws. The Dall-Miles plate with cables has however been considered insufficient when used alone for periprosthetic fractures (22). The Mennen plate with clips derived from the Judet struts does not offer sufficient stability either to achieve fracture consolidation (16). More recently the AO group proposed a plate using monocortical screws with a

transversal tunnel allowing the passage for a cerclage wire, and cable-plate devices became available on the marketplace. Cables are very resistant to stress and fixation becomes effective, while bicortical screws may be used in bone segments without a prosthetic stem (4).

REFERENCES

1. Ahlmann ER, Menendez LR, Kermani C, Gotha H. Survivorship and clinical outcome of modular endoprosthetic reconstruction for neoplastic disease of the lower limb. *J Bone Joint Surg* 2006 ; 88-B : 790-795.
2. Davis AM, Bell RS, Badley EM, Yoshida K, Williams JL. Evaluating functional outcome in patients with lower extremity sarcoma. *Clin Orthop Relat Res* 1999 ; 358 : 90-100.
3. Delepine G, Delepine N, Desbois JC, Goutallier D. Expanding prostheses in conservative surgery for lower limb sarcoma. *Int Orthop* 1998 ; 22 : 27-31.
4. Dennis MG, Simon JA, Kummer FJ, Koval KJ, DiCesare PE. Fixation of periprosthetic femoral shaft fractures occurring at the tip of the stem : a biomechanical study of 5 techniques. *J Arthroplasty* 2000 ; 15 : 523-528.
5. Duncan CP, Masri BA. Fractures of the femur after hip replacement. *Instr Course Lect* 1995 ; 44 : 293-304.
6. El-Sherbiny M. Pedicled gastrocnemius flap : clinical application in limb sparing surgical resection of sarcoma around the knee region and popliteal fossa. *J Egypt Natl Canc Inst* 2008 ; 20 : 196-207.
7. Gruner A, Hockertz T, Reilmann H. [Periprosthetic fractures : classification, management, therapy.] (in German). *Unfallchirurg* 2004 ; 107 : 35-49.
8. Hardes J, Exner GU, Rosenbaum D *et al.* Rotationplasty in the elderly. *Sarcoma* 2008 : 402378.
9. Horowitz SM, Lane JM, Healey JH. Soft-tissue management with prosthetic replacement for sarcomas around the knee. *Clin Orthop Relat Res* 1992 ; 275 : 226-231.
10. Ilyas I, Younge D, Pant R, Moreau P. Limb salvage for proximal tibial tumours using a modular prosthesis. *Int Orthop* 2000 ; 24 : 208-211.
11. Jones KB, Ferguson PC, Dehesi B *et al.* Complete femoral nerve resection with soft tissue sarcoma : functional outcomes. *Ann Surg Oncol* 2010 ; 17 : 401-406.
12. Kinkel S, Lehner B, Kleinhans JA *et al.* Medium to long-term results after reconstruction of bone defects at the knee with tumor endoprostheses. *J Surg Oncol* 2010 ; 101 : 166-169.
13. Laurer HL, Wutzler S, Possner S *et al.* Outcome after operative treatment of Vancouver type B1 and C periprosthetic femoral fractures : open reduction and internal fixation versus revision arthroplasty. *Arch Orthop Trauma Surg* 2011 ; 131 : 983-989.
14. Meek RM, Norwood T, Smith R, Brenkel IJ, Howie CR. The risk of peri-prosthetic fracture after primary and revision total hip and knee replacement. *J Bone Joint Surg* 2011 ; 93-B : 96-101.
15. Muller M, Kaab M, Tohtz S, Haas NP, Perka C. Periprosthetic femoral fractures : outcome after treatment with LISS internal fixation or stem replacement in 36 patients. *Acta Orthop Belg* 2009 ; 75 : 776-783.
16. Noorda RJ, Wuisman PI. Mennen plate fixation for the treatment of periprosthetic femoral fractures : a multicenter study of thirty-six fractures. *J Bone Joint Surg* 2002 ; 84-A : 2211-2215.
17. Ottaviani G, Robert RS, Huh WW, Jaffe N. Functional, psychosocial and professional outcomes in long-term survivors of lower-extremity osteosarcomas : amputation versus limb salvage. *Cancer Treat Res* 2009 ; 152 : 421-436.
18. Palumbo BT, Henderson ER, Groundland JS *et al.* Advances in segmental endoprosthetic reconstruction for extremity tumors : a review of contemporary designs and techniques. *Cancer Control* 2011 ; 18 : 160-170.
19. Rorabeck CH, Taylor JW. Classification of periprosthetic fractures complicating total knee arthroplasty. *Orthop Clin North Am* 1999 ; 30 : 209-214.
20. Seeger LL, Gold RH, Chandnani VP. Diagnostic imaging of osteosarcoma. *Clin Orthop Relat Res* 1991 ; 270 : 254-263.
21. Sim IW, Tse LF, Ek ET, Powell GJ, Choong PF. Salvaging the limb salvage : management of complications following endoprosthetic reconstruction for tumours around the knee. *Eur J Surg Oncol* 2007 ; 33 : 796-802.
22. Tsiridis E, Haddad FS, Gie GA. Dall-Miles plates for periprosthetic femoral fractures. A critical review of 16 cases. *Injury* 2003 ; 34 : 107-110.
23. Veth R, van Hoesel R, Pruszczynski M *et al.* Limb salvage in musculoskeletal oncology. *Lancet Oncol* 2003 ; 4 : 343-350.
24. Zahlten-Hinguranage A, Bernd L, Sabo D. [Amputation or limb salvage ? Assessing quality of life after tumor operations of the lower extremity.] (in German). *Orthopade* 2003 ; 32 : 1020-1027.