In Brief

Classifications in Brief

Vancouver Classification of Postoperative Periprosthetic Femur Fractures

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History

With a growing elderly population, the rates of primary and revision THAs also have increased. Paralleling the increased number of hip reconstructive procedures performed is the incidence of periprosthetic femur fractures [14]. Each periprosthetic fracture poses a unique challenge to the treating orthopaedic surgeon because of the many variables that must be considered with each fracture pattern. These variables include the relationship of the fracture to the implant, the specifics of the implant including wear, and the functional demands of the patient.

A couple studies outline the impact of periprosthetic femur fractures on mortality. Lindahl et al. investigated outcomes in patients from the Swedish national hip arthroplasty register and described higher mortality rates after surgery for patients with periprosthetic femoral fractures compared with patients who had total hip replacements [16]. Bhattacharyya et al. similarly found an increased mortality rate of 11% at 1 year (21% cumulative mortality rate) in patients treated operatively for periprosthetic femur fractures compared with a rate of 2.9% in patients who underwent primary joint arthroplasties [3]. They recorded mortality rates approaching those documented after hip fracture (16.5%), and also noted a nearly threefold increase in mortality in patients who sustained a fracture at the level of the prosthesis and were treated with open reduction and internal fixation versus patients treated with revision arthroplasty [3].

The Vancouver classification developed by Duncan and Masri [10] and Masri et al. [17] is the most widely accepted classification scheme to group fractures with similar characteristics from which a treatment algorithm is derived. Previous classification schemes and treatment algorithms for periprosthetic femur fractures focused primarily on location, fracture pattern, implant stability, and/or potential for loosening [2, 7, 13, 18, 21]. The Vancouver classification assimilates three key factors: location, stability of the implant, and the surrounding bone stock (Table 1). The classification has since been modified by Masri et al. to include intraoperative in addition to postoperative periprosthetic femur fractures [17]. The remainder of this discussion will focus on the Vancouver classification of postoperative periprosthetic femur fractures.

Purpose

An ideal classification system accurately groups similar diagnoses, allowing basic treatment principles to be applied to a group in a reproducible fashion. Revision surgery for periprosthetic femur fractures is associated with a high rate of complications including malunion, nonunion, implant failure, and infection. The Vancouver system was developed to distinguish between the varying types of periprosthetic femur fractures with respect to specific parameters including location, stability, and bone stock. Through accurate and reproducible classification criteria, the aim of the Vancouver system is to guide treatment based on the aforementioned variables [10, 17].

Three important factors guide treatment decisions when following the algorithm outlined in the Vancouver classification system. Anatomic location partitions fractures into one of three categories with Type A occurring around the

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Table 1. Vancouver classification of postoperative periprosthetic femur fractures

Type	Subtype	Description	Treatment
A	A L	Lesser trochanter	Conservative (consider ORIF if large segment of medial cortex involved)
	A G	Greater trochanter	Conservative with abduction precautions (consider ORIF if displaced > 2.5 cm)
B	B1	Well-fixed prosthesis	ORIF with or without cortical strut allograft
	B2	Prosthesis loose	Revision THA with long-stem prosthesis
	B3	Prosthesis loose with poor bone stock	Revision THA and augmentation of bone stock with allograft versus oncologic prosthesis
C		Fracture well below tip of the prosthesis	ORIF

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trochanteric region, Type B near or just distal to the femoral stem, and Type C well below the femoral stem. Type B fractures are subdivided based on stability and bone stock. B1 implies a well-fixed stem, B2 a loose stem with good bone stock, and B3 designates poor surrounding bone stock. Type A greater trochanteric fractures are typically stable and often treated nonoperatively with abduction precautions. Type A lesser trochanter fractures are rare and usually treated nonoperatively unless a large portion of the medial calcar is involved. The loss of the calcar implies instability in which case revision must be considered. Recommended treatment for Type B1 fractures is open reduction and internal fixation with or without cortical strut allograft; for Type B2 fractures revision to a longer femoral component with adjunctive fixation; and for Type B3 fractures revision with a structural allograft, tumor prosthesis, or allograft-prosthetic-composite. Type C fractures are treated with open reduction and internal fixation without regard for the prosthesis [10, 17] (Table 1).

Validation

Two separate studies have confirmed the reliability and validity of the Vancouver classification system, one by the Vancouver group [4], and another by Rayan et al. [19]. In the study by the Vancouver group [4], six observers (three expert attending surgeons and three nonexpert fellow and senior residents) examined 40 radiographs. Intraobserver reliability (observers interpreted the same radiographs 2 weeks apart) showed kappa values of 0.73 to 0.83, with a negligible difference between experts and nonexperts. Interobserver reliability revealed kappa values of 0.61 (first reading) to 0.64 (second reading), with a slightly greater agreement between experts. Validity was determined in the Type B subgroup by comparing observer analysis with intraoperative findings (via retrospective chart review).

The observed agreement was 80% among all observers with a kappa value of 0.69. From these results it can be inferred that the Vancouver classification system is reproducible and valid [4].

The European validation of the Vancouver classification system [19] consisted of 18 observers: six consultant orthopaedic surgeons specializing in joint replacement, six trainee surgeons, and six medical students. Similar to the Vancouver study, 28 radiographs were analyzed 2 weeks apart by each observer. Intraobserver reliability showed kappa values of 0.64 and 0.67 for consultants (first and second readings, respectively), 0.61 and 0.64 for trainee surgeons, and 0.59 and 0.60 for medical students (substantial agreement for all except the first reading by medical students). Interobserver reliability showed kappa values of 0.72 and 0.74 for consultants (first and second readings, respectively), 0.68 and 0.70 for trainee surgeons, and 0.61 for medical students. Validity among Type B fractures also was measured by comparing observer preoperative classification with actual intraoperative findings (via retrospective chart review). The observed agreement was 77% with a kappa value of 0.67. Rayan et al. concluded the Vancouver classification is reliable, reproducible, and valid. They also showed that substantial agreement can be attained among persons with no specialist training [19].

Limitations

Distinction between Types B1 and B2 (and less commonly B3) periprosthetic fractures is of utmost importance in preoperative planning and intraoperative decision making. Plain radiographs may not always provide enough information to distinguish between Type B1, Type B2, and Type B3 fractures. If there is any question pertaining to implant stability, it should be assessed intraoperatively.

Appropriate positioning (supine versus lateral), availability of proper instrumentation for fracture fixation, and revision femoral components are critical in allowing the surgeon flexibility should the implant be more or less stable than was interpreted preoperatively.

The inability to preoperatively determine the difference between a Type B1 and Type B2 fracture is not necessarily a limitation of the classification system, but rather an important concept for the treating surgeon to recognize. Open reduction and internal fixation alone for the treatment of fractures associated with loose implants (Type B2) has yielded unsatisfactory results [15].

It is difficult to predict the integrity of osteolytic bone preoperatively. Diagnosis of Type B3 fractures is often a subjective radiographic assessment. If there is uncertainty regarding the quality of bone stock preoperatively, the treating surgeon should have revision components readily available.

Conclusions

Although the Vancouver classification offers a framework for diagnosis and principles of management of periprosthetic femoral fractures, the optimal method of fixation for B1 fractures remains a source of controversy. An in-depth exploration and comparison of fracture management is beyond the scope of this classification summary, however, numerous studies evaluating various surgical interventions are worth mentioning [1, 5, 6, 8, 11, 12, 15, 20].

Numerous methods of revision and fixation have been proposed for Type B fractures [11]. Authors have reported good results after treatment of Type B1 fractures with lateral plates without bone grafting [1, 5, 20], whereas others advocate the routine use of cortical strut allografts with or without plates [6, 12], especially in the presence of medial cortex comminution [8]. Biomechanical analyses investigating optimal construct stiffness have led to varying recommendations of ideal constructs including: nonlocking cable plate and allograft [23], allograft-plate [22], and plate with proximal unicortical screws with or without cables and distal bicortical screws [9].

Future prospective studies directly comparing methods of fixation for Type B1 fractures will help elucidate the best treatment. The trend is toward indirect reduction methods with use of percutaneous plating for truly stable implants, but never at the expense of obtaining an anatomic fracture reduction. Augmentation with cortical strut allografts has a role in select cases to enhance healing from biologic and mechanical standpoints in periprosthetic fractures [6, 8, 12, 22, 23].

The Vancouver classification system is a useful tool in diagnosis and management of periprosthetic femur

fractures. It has been confirmed to be reliable and valid [4, 19]. One must not underscore the importance of verifying stability of the femoral component intraoperatively to properly guide treatment rationale.

References

1. Abhaykumar S, Elliot DS. Percutaneous plate fixation for periprosthetic femoral fractures: a preliminary report. *Injury*. 2000; 31:627–630.
2. Bethea JS 3rd, DeAndrade JR, Fleming LL, Lindenbaum SD, Welch RB. Proximal femoral fractures following total hip arthroplasty. *Clin Orthop Relat Res*. 1982;170:95–106.
3. Bhattacharyya T, Chang D, Meigs JB, Estok DM 2nd, Malchau H. Mortality after periprosthetic fracture of the femur. *J Bone Joint Surg Am*. 2007;89:2658–2662.
4. Brady OH, Garbuz DS, Masri BA, Duncan CP. The reliability and validity of the Vancouver classification of femoral fractures after hip replacement. *J Arthroplasty*. 2000;15:59–62.
5. Bryant GK, Morshed S, Agel J, Henley MB, Barei DP, Taitsman LA, Nork SE. Isolated locked compression plating for Vancouver B1 periprosthetic femoral fractures. *Injury*. 2009;40:1180–1186.
6. Buttaro MA, Farfalli G, Paredes Núñez M, Comba F, Piccaluga F. Locking compression plate fixation of Vancouver type-B1 periprosthetic femoral fractures. *J Bone Joint Surg Am*. 2007;89: 1964–1969.
7. Cooke PH, Newman JH. Fractures of the femur in relation to cemented hip prostheses. *J Bone Joint Surg Br*. 1988;70:386–389.
8. Corten K, Vanrykel F, Bellemans J, Frederix PR, Simon JP, Broos PL. An algorithm for the surgical treatment of periprosthetic fractures of the femur around a well-fixed femoral component. *J Bone Joint Surg Br*. 2009;91:1424–1430.
9. 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.
10. Duncan CP, Masri BA. Fractures of the femur after hip replacement. *Instr Course Lect*. 1995;44:293–304.
11. Giannoudis PV, Kanakaris NK, Tsiridis E. Principles of internal fixation and selection of implants for periprosthetic femoral fractures. *Injury*. 2007;38:669–687.
12. Haddad FS, Duncan CP, Berry DJ, Lewallen DG, Gross AE, Chandler HP. Periprosthetic femoral fractures around well-fixed implants: use of cortical onlay allografts with or without a plate. *J Bone Joint Surg Am*. 2002;84:945–950.
13. Johansson JE, McBroom R, Barrington TW, Hunter GA. Fracture of the ipsilateral femur in patients with total hip replacement. *J Bone Joint Surg Am*. 1981;63:1435–1442.
14. Lindahl H. Epidemiology of periprosthetic femur fracture around a total hip arthroplasty. *Injury*. 2007;38:651–654.
15. Lindahl H, Garellick G, Regnér H, Herberts P, Malchau H. Three hundred and twenty-one periprosthetic femoral fractures. *J Bone Joint Surg Am*. 2006;88:1215–1222.
16. Lindahl H, Oden A, Garellick G, Malchau H. The excess mortality due to periprosthetic femur fracture: a study from the Swedish national hip arthroplasty register. *Bone*. 2007;40: 1294–1298.
17. Masri BA, Meek RM, Duncan CP. Periprosthetic fractures evaluation and treatment. *Clin Orthop Relat Res*. 2004;420: 80–95.
18. Parrish TF, Jones JR. Fracture of the femur following prosthetic arthroplasty of the hip: report of nine cases. *J Bone Joint Surg Am*. 1964;46:241–248.

19. Rayan F, Dodd M, Haddad FS. European validation of the Vancouver classification of periprosthetic proximal femoral fractures. *J Bone Joint Surg Br.* 2008;90:1576–1579.
20. Ricci WM, Bolhofner BR, Loftus T, Cox C, Mitchell S, Borrelli J Jr. Indirect reduction and plate fixation, without grafting, for periprosthetic femoral shaft fractures about a stable intramedullary implant. *J Bone Joint Surg Am.* 2005;87:2240–2245.
21. Roffman M, Mendes DG. Fracture of the femur after total hip arthroplasty. *Orthopedics.* 1989;12:1067–1070.
22. Talbot M, Zdero R, Schemitsch EH. Cyclic loading of periprosthetic fracture fixation constructs. *J Trauma.* 2008;64:1308–1312.
23. Zdero R, Walker R, Waddell JP, Schemitsch EH. Biomechanical evaluation of periprosthetic femoral fracture fixation. *J Bone Joint Surg Am.* 2008;90:1068–1077.