Predicting Vancouver Types B1 and B2 Periprosthetic Fractures of the Femur

David M. Bennett, MD*; Logan R. Koehler, MD†; David J. Margolis, MD, PhD‡; Matthew J. Radelet, PA-C‡; Zhenqiang Lu, PhD§; Tony G. Pedri, MD*; Michael M. Decker, MD*; Michael D. Miller, MD§

*Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center

†Department of Orthopedic Surgery and Rehabilitation, William Beaumont Army Medical Center

‡Department of Orthopaedic Surgery, University of Arizona

§Statistics Consulting Laboratory, University of Arizona

Abstract

Background: Periprosthetic fractures of the femur after primary total hip arthroplasty (THA) can be complex and difficult injuries to treat. Because of the increased prevalence of THA, an overall increase is anticipated in the incidence of this complication. Vancouver types B1 and B2 periprosthetic femur fractures (defined as fractures around or just below the stem, with well-fixed and loose femoral stems, respectively) are particularly challenging to accurately classify and thereby treat owing to the difficulty in interpreting stability of stems on initial radiographs. To determine whether the method of stem fixation (ie, cement or press fit) may be a predictor of types B1 and B2 fractures, we performed a PubMed search and independently assessed data from 11 studies with 293 patients.

Methods: Studies were included that provided individual patient data (ie, fracture type, method of stem fixation, and stability of stem at the time of revision procedure). Only patients with Vancouver types B1 and B2 fractures were included. Statistical analysis was performed using a random-effects model, estimated with a restricted maximum likelihood method.

Results: A total of 59 and 92 cemented stems were found to be loose and well fixed, respectively (39% and 61%, respectively; n = 151). A total of 17 and 63 uncemented stems were loose and well fixed, respectively (22% and 78%, respectively; n = 80). The overall estimate of the odds ratio was 0.96 (95% confidence interval, 0.86–1.06).

Conclusions: Our findings suggest that fixation method of stems cannot significantly predict the likelihood of having Vancouver types B1 and B2 fracture patterns.

Introduction

Periprosthetic fractures of the femur are relatively uncommon complications, with occurrence rates between 0.1% and 3.5% after primary total hip arthroplasty (THA). Patient mobility and level of activity after THA have increased notably in the past decade.[1] This and the growing number of THA performed for treating the aging population of the United States[2] have resulted in an increasing incidence of periprosthetic fractures noted in recent studies.[2,3]

These fractures are typically classified using the Vancouver system, which is based on the radiographic characteristics of fractures and stability of the femoral stem.[4] In particular, Vancouver types B1 and B2 fractures are defined as fractures around or just below the stem, with a femoral stem that is well fixed (type B1) or loose with healthy proximal bone stock (type B2).[2] Differentiating between types B1 and B2 fractures is critical because each is treated using different methods. Type B1 fractures can typically be treated with open reduction and internal fixation (ORIF) while leaving the femoral stem in place. Type B2 fractures, on the contrary, require a revision of the femoral stem. These two procedures may necessitate different setup of the surgical suite, instrumentation, and operative techniques.[6]

Both Vancouver types B1 and B2 periprosthetic fractures involve complex fracture patterns, and thus the status of stem fixation can be difficult to predict before intraoperative treatment.[3] Risks of re-fracture and stem failure have been associated with treatment of type B1 fractures and attributed to initial misinterpretation of stem stability.[2] In identifying well-fixed or loose stems and thereby successfully categorizing type B1 or B2 fracture, respectively, multiple studies have explored the use of radiographic techniques,[1] other imaging methods, and revision THA instead of ORIF when the classification remains uncertain.[2]

Because of the challenges in confirming stem stability in Vancouver types B1 and B2 fractures, surgeons must increasingly plan ahead of the treatment to confirm availability of implants and operating room staff to treat either fracture pattern. As such, a reliable radiographic indicator for stem loosening may provide invaluable data to successfully prepare for and treat these fractures. We conducted a mta-analysis of studies on periprosthetic femur fractures after THA and included data on method used for stem fixation. We hypothesized that fixation method would significantly correlate with loosening of the stem in types B1 and B2 periprosthetic fractures of the femur.

Methods

In this meta-analysis, a total of 292 articles were initially identified by searches of PubMed with Boolean modifiers of "periprosthetic femur fracture," "Vancouver classification," "Vancouver B fractures," and "cemented versus uncemented stem." Clinical research with humans and supplemental references used in prominent studies were included. We excluded case reports, duplicate titles, and studies without individual patient data on whether the stem was cemented or uncemeted, Vancouver fracture type, and stability of the stem at the time of revision treatment. After further excluding patients with fractures classified as Vancouver types A, B3, and C, we found that data for 231 patients in 11 articles met the inclusion criteria. No study directly addressed our hypothesis and compared cementation status to stem loosening (Table 1).

A meta-analysis of the odds ratio was applied to use of cemented and uncemented stems, with regards to being well fixed or loose, in which patient sample size and heterogeneity were considered. The analysis was based on a random-effects model using restricted maximum likelihood. All 11 of the studies were included in the random-effects model for computing the odds ratio. Calculations were performed using R version 3.0.1 (The R Foundation, Vienna, Austria).

Results

Vancouver types B1 and B2 fractures were noted in 155 (67%) and 76 (33%), respectively, of the 231 included patients. A total of 59 (39%) and 92 (61%) of the cemented stems (n = 151) were loose and well fixed, respectively. A total of 17 (22%) and 63 (78%) of the uncemented stems (n = 80) were loose and well fixed, respectively. Results of statistical analysis using the random-effects model produced an overall estimate of odds ratio at 0.96 (95% confidence interval, 0.86–1.06; Figure 1).

Method of treatment used was available for 166 patients (72%). Of these, a total of 101 patients (60%) underwent ORIF without revision of the femoral stem, and well-fixed stems or type B1 fractures were noted in 90 (89%). Fifty-four patients (32%) underwent a revision procedure for stem fixation. Eleven (6.6%) of the patients were treated with nonoperative management or traction for 6 weeks.

Table 1. Data of 11 studies and 231 patients that met inclusion criteria on Vancouver types B1 and B2 periprosthetic fractures of the femur[a]

First author	Total (included) No. patients	Year published, journal	Country of research	Topic or conclusion
Grammatopoulos[1]	21 (20)	2011, *Injury*	UK	Collarless stems in VB2
Zuurmond[3]	71 (40)	2010, *Injury*	Netherlands	Complications in operative treatment
Bryant[5]	10 (10)	2009, *Injury*	USA	Fixation with ORIF for treating VB1
Holley[7]	99 (45)	2007, *HSS J*	USA	Vancouver-based treatment algorithm
van der Wal[8]	14 (8)	2005, *Int Orthop*	Netherlands	Vancouver-based treatment algorithm
Buttaro[9]	14 (14)	2007, *J Bone Joint Surg Am*	Argentina	Locking compression plates in treating VB1
Old[10]	20 (20)	2006, *J Bone Joint Surg Br*	USA	ORIF without using allograft struts for treating VB1
Tsiridis[11]	18 (9)	2005, *Acta Orthop*	UK	ORIF with dynamic compression plates for treating VB1
Cooper[12]	6 (5)	2009, *HSS J*	USA	Early VB2 fractures with non-cemented stems in preoperative morphology
Leonidou[13]	27 (19)	2013, *Injury*	Greece	Poor bone quality and high fracture angle in fracture patterns
Moloney[14]	58 (41)	2014, *Arch Orthop Trauma Surg*	USA	ORIF and stem lengths in predicting VB1 re-fracture rates

USA, United States of America; UK, United Kingdom; VB2, Vancouver type B2 fractures; ORIF, open reduction and internal fixation; VB1, Vancouver type B1 fractures.

[a] Preferred method of fixation of the stem (ie, coating or using collared prosthetics) was not available for most studies and thus was not used to determine the authors' classification of the stem as loose or well fixed.

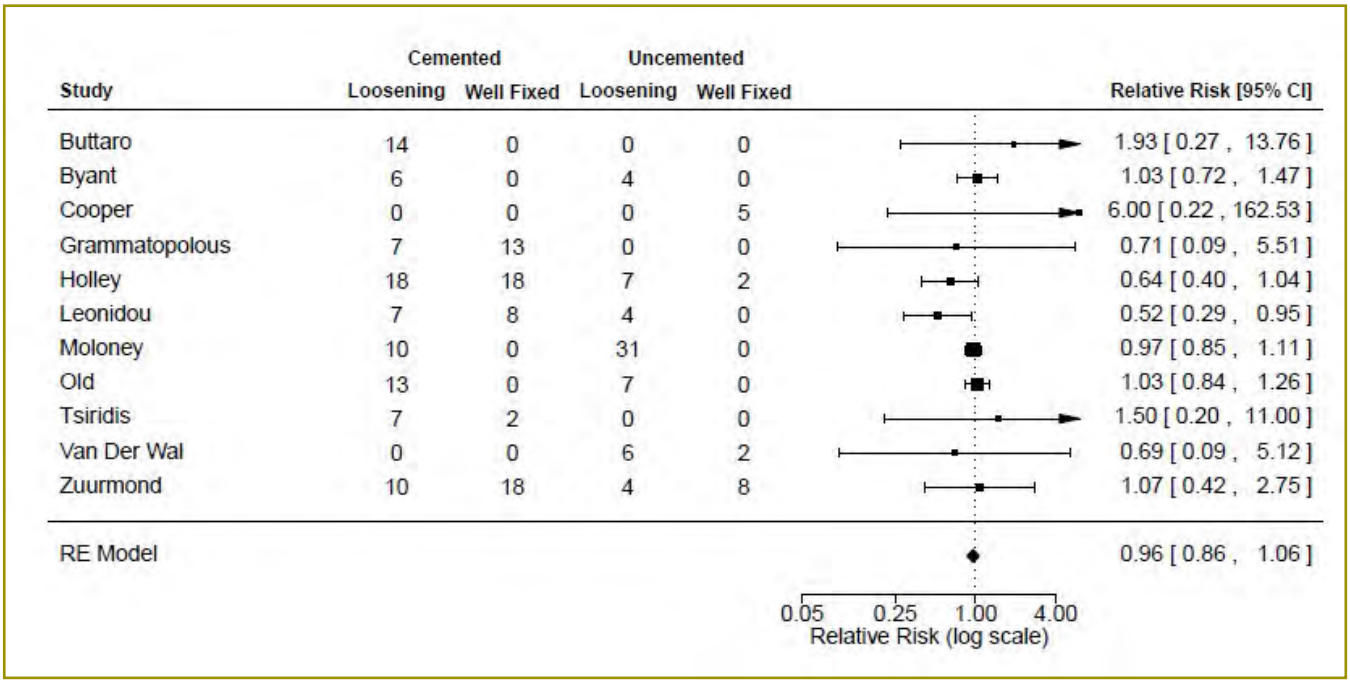

Figure 1. Results of statistical analysis using random-effects (RE) model to calculate the overall estimated odds ratio on each of the 11 studies[1,3,5,7-14] that met our inclusion criteria. Shows relative risk and indication of Vancouver types B1 and B2 periprosthetic femur fractures (classified by well-fixed and loose stems, respectively) based on the cemented or uncemented status of stems.

Discussion

The fixation method of femoral stems used during primary THA was not a statistically significant predicator for Vancouver types B1 and B2 periprosthetic femur fractures. We did note a slight trend toward a higher rate of stem stability in press-fit rather than cemented stem fixation at the time of operative treatment of types B1 and B2 fractures. These findings indicate that the femoral stem fixation method used for THA may not reliably predict the Vancouver classification of the fracture.

Reports of periprosthetic femur fractures with uncemented stems are limited, but van der Wal et al[8] found that use of larger-size uncemented stems was a possible risk factor for periprosthetic fractures owing to the greater implant stiffness. However, it was not clear how many of these fractures were iatrogenic complications of the primary THA procedure. Additionally, data on stem type and size were unavailable for our use from the studies included in this meta-analysis.

Our study has several limitations. The 11 articles used for data collection did not address the same clinical question as we did. Consequently, we could not apply consistent definitions of stem fixation descriptions such as "loose" and "well fixed." Additionally, the studies did not delineate between iatrogenic fractures at the time of initial THA and postoperative fractures related to another mechanism of injury. Furthermore, the Vancouver classification, which was originally described for fractures about cemented stems,[4] was applied to both cemented and uncemented stems in our study. Finally, we estimated our statistical confidence interval after the presence of empty data sets to compare the studies.

We did not find a statistically significant correlation between stem fixation method (ie, cemented or uncemented) and whether the stem was well fixed or loose in treating the periprosthetic fracture around or just distal to the femoral stem. Our findings support the use of intraoperative assessment of stem stability as the more reliable method to confirm a diagnosis of Vancouver types B1 or B2 periprosthetic femur fractures, and the results also reinforce the notion that a surgeon must be prepared to treat both fracture types if otherwise uncertain. Further research into risk factors and predictors for stem stability in periprosthetic femur factures is needed to help surgeons in effectively planning treatment of these complex fractures.

Funding

The authors received no financial support for the research, authorship, and publication of this article.

Conflict of Interest

The authors report no conflicts of interest.

References

1. Grammatopoulos G, Pandit H, Kambouroglou G, et al. A unique peri-prosthetic fracture pattern in well fixed femoral stems with polished, tapered, collarless design of total hip replacement. Injury 2011;42(11):1271-6.
2. Lindahl H, Malchau H, Odén A, Garellick G. Risk factors for failure after treatment of a periprosthetic fracture of the femur. J Bone Joint Surg Br 2006;88(1):26-30.
3. Zuurmond RG, van Wijhe W, van Raay JJ, Bulstra SK. High incidence of complications and poor clinical outcome in the operative treatment of periprosthetic femoral fractures: an analysis of 71 cases. Injury 2010;41(6):629-33.
4. Masri BA, Meek RM, Duncan CP. Periprosthetic fractures evaluation and treatment. Clin Orthop Relat Res 2004;(420):80-95.
5. Bryant GK, Morshed S, Agel J, et al. Isolated locked compression plating for Vancouver Type B1 periprosthetic femoral fractures. Injury 2009;40(11):1180-6.
6. Springer BD, Berry DJ, Lewallen DG. Treatment of periprosthetic femoral fractures following total hip arthroplasty with femoral component revision. J Bone Joint Surg Am 2003;85-A(11):2156-62.
7. Holley K, Zelken J, Padgett D, Chimento G, Yun A, Buly R. Periprosthetic fractures of the femur after hip arthroplasty: an analysis of 99 patients. HSS J 2007;3(2):190-7.
8. van der Wal BC, Vischjager M, Grimm B, Heyligers IC, Tonino AJ. Periprosthetic fractures around cementless hydroxyapatite-coated femoral stems. Int Orthop 2005;29(4):235-40.
9. 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(9):1964-9.
10. Old AB, McGrory BJ, White RR, Babikian GM. Fixation of Vancouver B1 peri-prosthetic fractures by broad metal plates without the application of strut allografts. J Bone Joint Surg Br 2006;88(11):1425-9.
11. Tsiridis E, Narvani AA, Timperley JA, Gie GA. Dynamic compression plates for Vancouver type B periprosthetic femoral fractures: a 3-year follow-up of 18 cases. Acta Orthop 2005;76(4):531-7.
12. Cooper HJ, Rodriguez JA. Early post-operative periprosthetic femur fracture in the presence of a non-cemented tapered wedge femoral stem. HSS J 2010;6(2):150-4.
13. Leonidou A, Moazen M, Skrzypiec DM, Graham SM, Pagkalos J, Tsiridis E. Evaluation of fracture topography and bone quality in periprosthetic femoral fractures: a preliminary radiographic study of consecutive clinical data. Injury 2013;44(12):1799-804.
14. Moloney GB, Westrick ER, Siska PA, Tarkin IS. Treatment of periprosthetic femur fractures around a well-fixed hip arthroplasty implant: span the whole bone. Arch Orthop Trauma Surg 2014;134(1):9-14.