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Original Research

Do All Postoperative Vancouver B2 Fractures Require Revision Arthroplasty With Cementless Stems?

Benjamin K. Wilke, MD[a, *], Aaron C. Spaulding, PhD[b], Matthew M. Crowe, MD[a], Cameron K. Ledford, MD[a], Courtney E. Sherman, MD[a], Luke Spencer-Gardner, MD[a], Kurt E. Blasser, MD[a]

[a] Department of Orthopedic Surgery, Mayo Clinic, Jacksonville, FL
[b] Department of Biostatistics, Mayo Clinic, Jacksonville, FL

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A B S T R A C T

Background: Management of periprosthetic fractures has been guided by the Vancouver classification, which recommends revision for fractures around a loose femoral implant (B2). New studies have challenged this approach, demonstrating acceptable outcomes with internal fixation. This study evaluates our experience with Vancouver B2 fractures, comparing internal fixation to femoral revision. We hypothesized that in select cases with cementless stems, internal fixation would provide acceptable results with reduced morbidity.
Methods: A retrospective review was performed of periprosthetic hip fractures treated at our institution between 1 January 2012 and 4 November 2022. We excluded patients who did not have prior radiographs and evidence of stem subsidence, suggestive of a Vancouver B2 fracture. Thirteen patients were included in the analysis.
Results: Four patients (31%) underwent revision of the femoral component, 4 patients (31%) underwent plating, and 5 patients (38%) underwent internal fixation with cerclage cabling. The average operative duration was 158 minutes, 203 minutes, and 62 minutes for the revision, plating, and cabling cohorts, respectively ($P = .009$). Blood loss was 463 cc, 510 cc, and 90 cc for the revision, plating, and cabling cohorts, respectively ($P = .036$). Three patients in both the revision and plating cohorts each received a transfusion (75%), whereas no patients in the cabling cohort required a transfusion ($P = .033$). All patients demonstrated fracture healing on the postoperative radiographs. No patients required additional surgery during the follow-up period.
Conclusions: We have demonstrated that Vancouver B2 periprosthetic fractures with intact lateral cortices may be treated with internal fixation with cerclage cabling with excellent results.

Introduction

Total hip arthroplasty (THA) is one of modern medicine's most successful surgical procedures, eliminating pain and improving quality of life for hundreds of thousands of patients yearly in the United States. Due to the procedure's success and the population's increasing age, procedural volume is expected to continue to rise rapidly over the next several years [1]. With this increase in THA procedures comes a concomitant increase in surgical complications, including periprosthetic fractures.

Postoperative periprosthetic fractures are rare, occurring in up to 3% of primary THA procedures [2-5]. This incidence is estimated to continue to increase over the next several decades, partially due to the higher prevalence of cementless fixation with femoral implants [6].

Current treatment strategies for postoperative periprosthetic fractures are variable. Historical treatment has been based on the Vancouver classification, which stratified fractures based on variables such as fracture location, stability of the femoral implant, and quality of the remaining bone [7]. For fractures around the femoral implant with a loose stem (Vancouver B2), the recommended treatment was revision of the component to a long cementless stem

* Corresponding author. Department of Orthopedic Surgery, 4500 San Pablo Road, Jacksonville, FL 32224, USA. Tel.: +1 904 953 2405.
E-mail address: wilke.benjamin@mayo.edu

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[8]. More recently, several studies have challenged this approach, advocating instead for open reduction and internal fixation of the fracture with acceptable results [9-11].

This study aimed to evaluate our institutional experience with Vancouver B2 periprosthetic fractures with cementless stems, comparing outcomes for patients who underwent component revision to those who underwent open reduction and internal fixation with implant retention. We hypothesized that in select cases with cementless stems, internal fixation and implant retention would provide acceptable patient outcomes with reduced surgical morbidity compared to revision of the femoral component.

Material and methods

Following institutional review board approval, we performed a retrospective review of Vancouver B2 periprosthetic fractures treated at our institution between 1 January 2012 and 4 November 2022. We identified patients using the CPT code 27507. Sixty-two patients were identified who were treated for a periprosthetic fracture around a THA during this period. We excluded all patients who did not have prior radiographs and evidence of stem subsidence following the fracture, suggestive of a Vancouver B2 injury. Fifteen patients fit this criterion. One patient passed away 1 month following surgery and was excluded. An additional patient did not follow up after 1 month postoperatively and was unable to be reached. Both the patients were in the femoral revision cohort. Thirteen patients were included in the final analysis.

Demographic data, operative characteristics, and postoperative outcomes were collected from chart review. Radiographic analysis was performed by one of the authors (BW), and fracture consolidation was determined when the fracture line disappeared on 2 orthogonal radiographs. Stem subsidence was determined by the criteria described by Al-Najjim et al. [12], by drawing a line from the greater trochanter to the shoulder of the implant, and from a line in the center of the femoral head to the lesser trochanter, using the femoral head size to correct for magnification (Fig. 1).

During the study period, fracture treatment and postoperative restrictions were based on surgeon preference rather than institutional criteria. Based on review of the records, surgeons performed internal fixation rather than revision if they felt that the stem would be stable following fixation. All fractures were treated by 6 high-volume arthroplasty surgeons. For procedures that involved revision of the femoral component, the patient was placed in the lateral decubitus position, and a posterior approach was utilized for component removal and revision (Fig. 2). An example of a stem removed during component revision is shown in Figure 3.

For patients that underwent open reduction and internal fixation with a plate or cerclage cables, the patient was placed supine on a Hana table, and intraoperative fluoroscopy was utilized to verify fracture reduction (Fig. 4). The Hana table allowed controlled distraction and rotation of the fracture during reduction. In general, the decision to proceed with cerclage cabling only (without a plate) was based on the stability of the lateral femoral cortex. If the cortex was intact, cables were used to reduce the medial calcar to the implant, which buttressed against the intact lateral cortex. If the lateral cortex was involved, a plate was added laterally to provide a point of stability to buttress against (Fig. 5). When cerclage cables were used, at least 2 cables were placed and alternately tightened to provide even compression across the fractured fragment (Figs. 6 and 7).

Statistical analysis

Means and ranges were used to describe continuous variables, while frequency and percentages were used to describe categorical variables. Further, continuous variables were compared using Kruskal-Wallis tests, and categorical variables were compared using Fisher's exact tests. All statistics were 2-sided, and P values $< .05$ were considered statistically significant. Statistics were performed using Stata/MP 18.0.

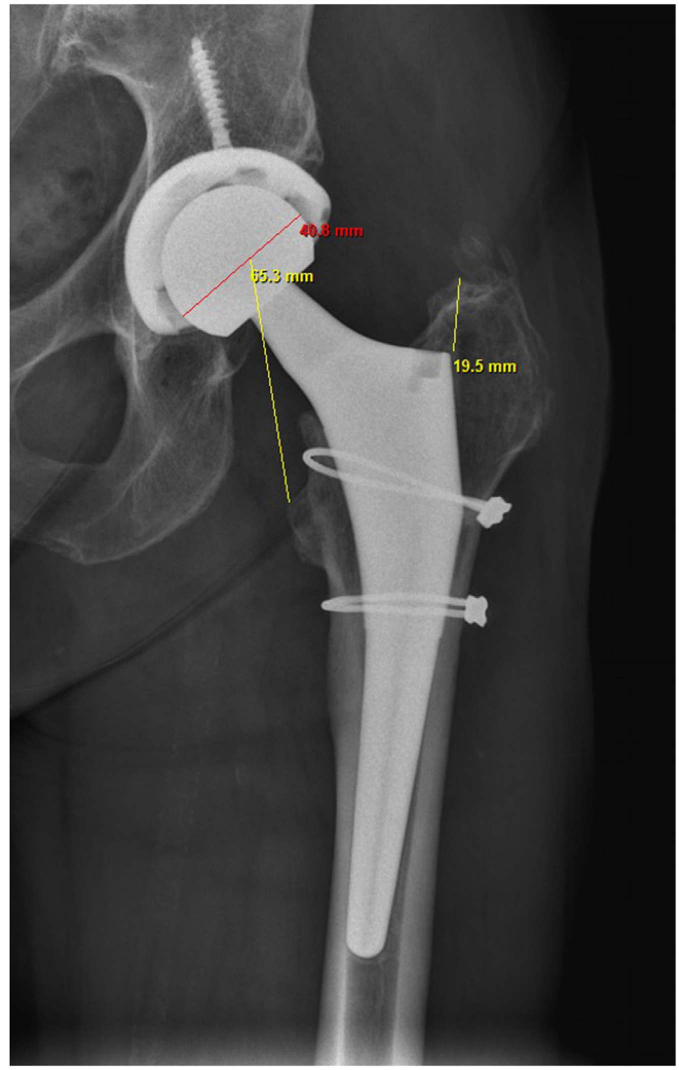

Figure 1. The technique for measuring stem subsidence includes correcting for magnification with the femoral head, followed by drawing lines from the tip of the greater trochanter to the shoulder of the implant, and from the center of the femoral head to the lesser trochanter.

Results

Thirteen patients were identified and included in the analysis. The average age at the time of surgery was 80 years (69-92 years). Eight women (62%) and 5 men (38%) were in the cohort. The average follow-up duration was 31 months (11-70 months). The average stem subsidence between the preinjury and injury radiographs was 10.7 mm (1.2-20.5 mm).

Four patients (31%) underwent revision of the femoral component to a long porous-coated stem. Nine patients (69%) underwent internal fixation with implant retention. Four patients (31%) had a lateral plate placed, whereas 5 patients (38%) only underwent internal fixation with cerclage cabling.

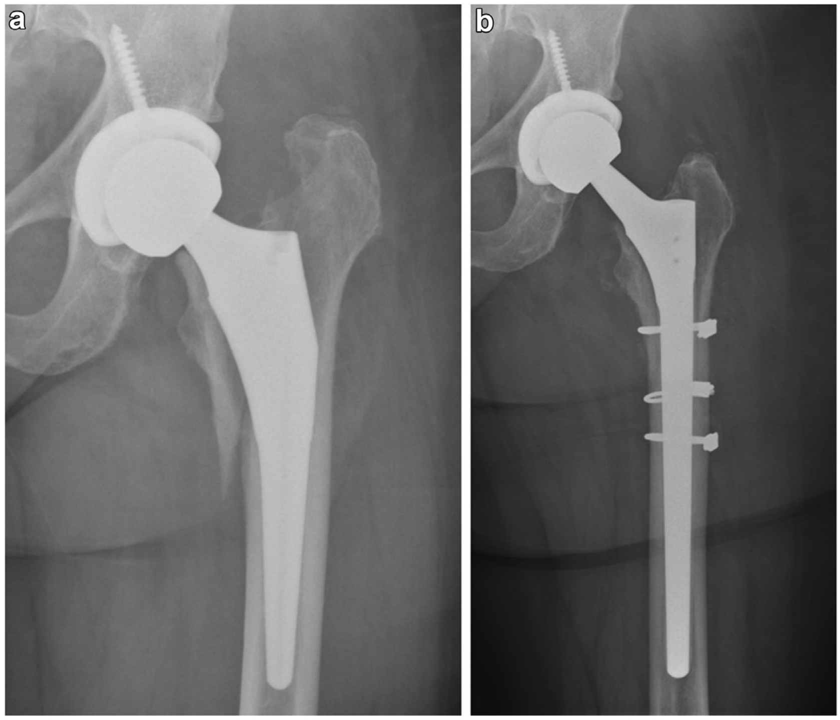

Figure 2. A Vancouver B2 periprosthetic fracture with subsidence of the stem (a), followed by revision to a long, fully porous implant. At 5 years, the patient was doing well (b).

The average operative duration was 158 minutes (129-211 minutes) for the revision cohort, 203 minutes (166-254) for the plate fixation cohort, and 62 minutes (46-77 minutes) for the cabling cohort ($P = .009$). The average blood loss was 463 cc (100-800 cc) for the revision cohort, 510 cc (200-900 cc) for the plate fixation group, and 90 cc (50-200 cc) for the cabling cohort ($P = .036$).

Three patients (75%) in the femoral revision cohort, 3 patients (75%) in the open reduction and plate fixation cohort, and no patients (0%) in the cabling cohort required a postoperative transfusion ($P = .033$).

The average length of hospital stay was 4 days (3-5 days) in the femoral revision cohort, 5 days (3-8 days) in the open reduction and plate fixation cohort, and 4 days (1-6 days) in the cerclage cabling cohort ($P = .441$). All patients were placed on partial weight-bearing restrictions postoperatively for 6 weeks. Eleven (85%) patients were discharged to a skilled nursing facility postoperatively. Two patients (15%), one in the open reduction and plate fixation cohort and the other in the cerclage cabling cohort, were discharged to home.

All patients demonstrated fracture healing on the postoperative radiographs. Time to radiographic union was on average 5.4 months (2.5-14.6 months). No patients required further surgery during the follow-up period. There were no postoperative dislocations in any of the cohorts. Average stem subsidence after fixation was 6.7 mm in the revision cohort (0-19 mm), 0.5 mm in the open reduction and plate fixation and plating cohorts (0-1.4 mm), and 0.4 mm in the cerclage cabling cohort (0-2.2 mm) ($P = .472$).

The Harris hip scores at the last follow-up were as follows: revision arthroplasty 82 (76-91), open reduction and plating 72 (63-84), and cerclage cabling 88 (73-100) ($P = .095$) (Table I).

Figure 3. A cementless stem removed during revision to a long fully porous femoral implant. Note the exposed on-growth surface and fragments of attached bone, for bone-to-implant and bone-to-bone healing.

Discussion

Complications following THA are rare but will become more prevalent with the increasing number of THA procedures performed yearly. Historically, the Vancouver classification for postoperative periprosthetic fractures has guided surgeons on treatment recommendations. This classification system was based on fracture location, femoral implant stability, and remaining bone quality [7]. For fractures with an unstable femoral implant and adequate bone stock (Vancouver B2), the treatment recommendation has been revision of the femoral component [8]. This is not without risk, however, as studies have demonstrated a high rate of reoperation (16.8%) and risk of dislocation (4.7%-15.6%) in patients that have undergone femoral component revision following a periprosthetic fracture [13,14].

More recently, reports have demonstrated acceptable patient outcomes after open reduction and internal fixation with femoral component retention. For example, a retrospective review by Gavanier et al. [9] reported on 45 patients with periprosthetic

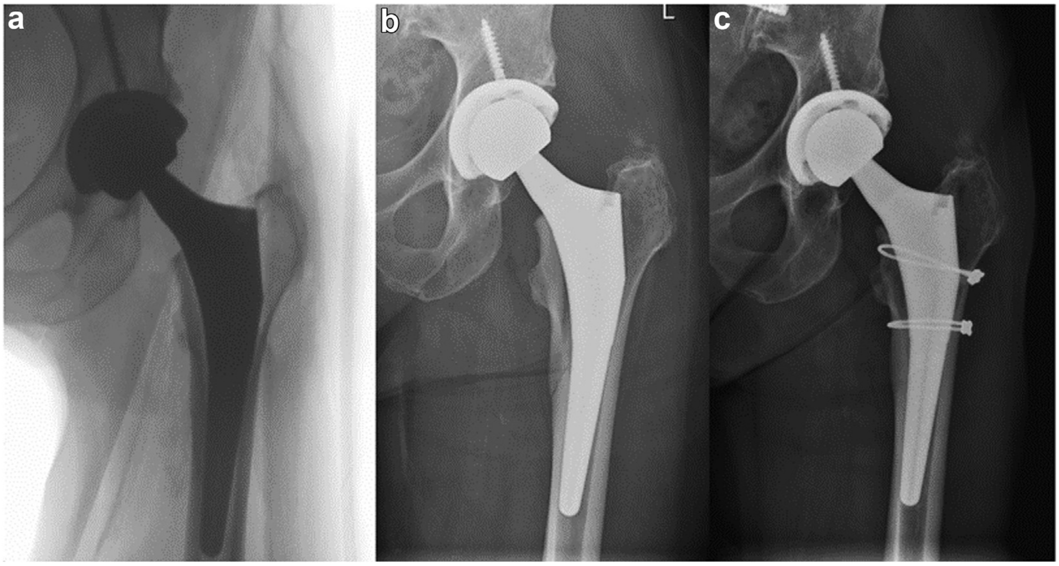

Figure 4. The intraoperative fluoroscopy during a direct anterior THA demonstrates initial placement of the stem (a). After a fall 23 days postoperatively, the implanted demonstrated subsidence of the stem (b), which was treated with cerclage cabling. The patient was doing well 1 year postoperatively with no complaints (c).

fractures, 5 of which were Vancouver B2. All fractures except one demonstrated union and had an average surgical time of 103 minutes. A larger study by Lunebourg et al. [10] reviewed 23 Vancouver B2 fractures treated with open reduction and internal fixation with plate osteosynthesis. All patients achieved union of their fracture, and the average operative time was 122 minutes. Finally, a study of 59 Vancouver B2 fractures treated with open reduction and internal fixation (24) or revision (35) demonstrated a lower complication rate in the open reduction cohort (12.5%) compared to the revision cohort (28.6%). The authors additionally reported a 0% dislocation rate following open reduction and internal fixation, compared to 14.2% after component revision [11].

Although recent evidence suggests osteosynthesis is an acceptable treatment for Vancouver B2 periprosthetic fractures, this strategy has not been universally accepted. A report by Fousek recommended revision of unstable femoral stems due to a 27.7% rate of nonunion and 16% rate of stem migration in their cohort of patients treated with open reduction and femoral component retention [15]. Similarly, a systematic review of osteosynthesis vs revision for Vancouver B2 fractures recommended osteosynthesis as appropriate for primarily low-demand patients and those with multiple comorbidities or high anesthetic risk despite demonstrating shorter operative times, less need for postoperative transfusions, shorter hospital stays, and fewer complications in the osteosynthesis group [16].

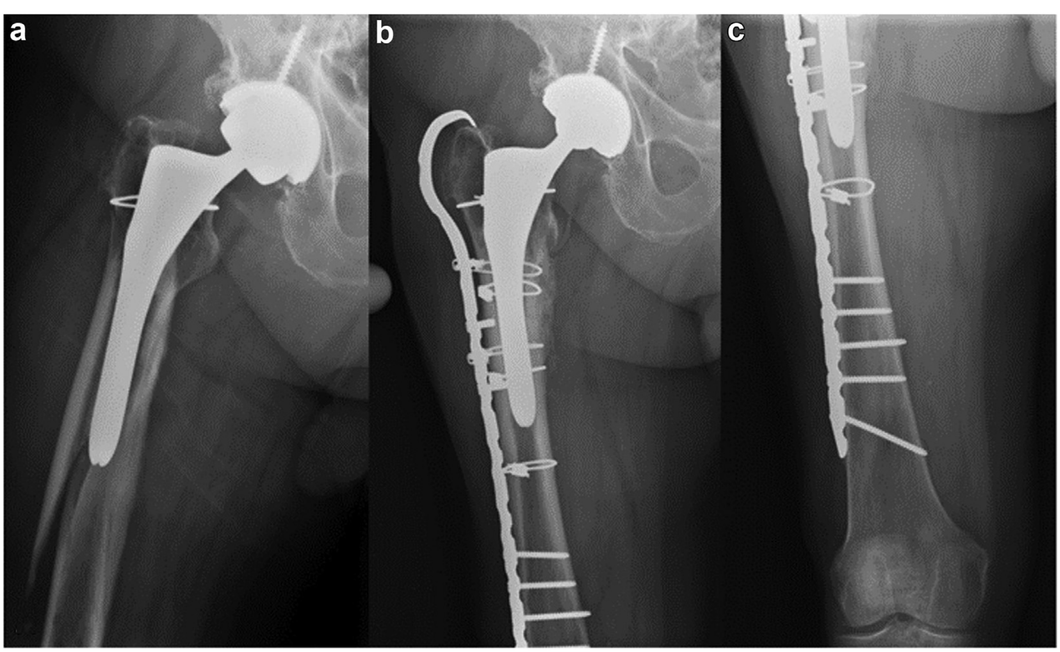

Figure 5. A Vancouver B2 periprosthetic with involvement of the lateral cortex (a). This was treated with a lateral plate and cerclage cables. At 2-years postoperative the patient was doing well (b and c).

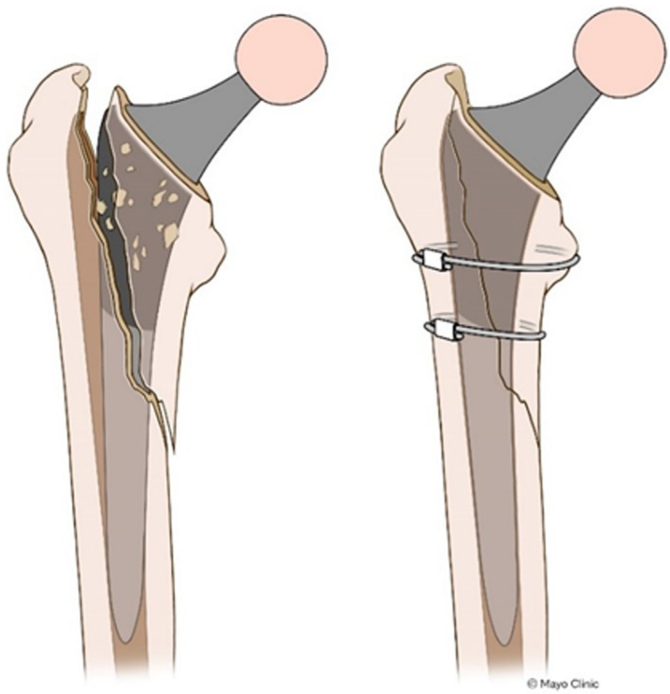

Figure 6. Cerclage cabling the Vancouver B2 fracture. At least 2 cables were placed and alternately tightened to provide even compression of the fractured fragment and stem against the lateral cortex, which acted as a buttress.

The purpose of our study was to evaluate our institutional experience with Vancouver B2 periprosthetic fractures around cementless stems, comparing outcomes for patients who underwent component revision to those who underwent open reduction and internal fixation with implant retention. We hypothesized that in select cases with cementless stems, internal fixation and implant retention would provide acceptable patient outcomes with reduced surgical morbidity compared to revision of the femoral component.

Our study is unique in that all fractures were treated by arthroplasty surgeons as we do not have a trauma division at our hospital. Despite the surgeon bias toward arthroplasty, most patients with Vancouver B2 fractures around cementless stems underwent open reduction and internal fixation with stem retention. These patients were subdivided into 2 groups; those that underwent open reduction with plate fixation and those who underwent cerclage cabling only. In prior studies, authors have recommended against cerclage cabling alone for B2 fractures as they felt this was inadequate fixation due to the lack of rotational stability [17,18].

In our cohort, we reported shorter operative times, less blood loss, lower risk for blood transfusion, and no treatment failures with cerclage cabling compared to both open reduction and internal fixation with a plate, or revision of the femoral component. Importantly there was no difference in postoperative restrictions as all patients were limited in their weightbearing following surgery, regardless of the procedure type.

Cerclage cabling alone was limited to patients with an intact lateral cortex with which to reduce the medial fragment and femoral implant against. This procedure allows bone-to-bone and bone-to-implant healing with minimal exposure, using the Hana table to control distraction and rotation of the leg. We believe surgical technique is important, and at least 2 cerclage cables are necessary for uniform compression of the medial fragment against the implant and lateral cortex. Care must be taken with sequential tightening of the cables under fluoroscopic guidance to appropriately key in the fracture fragment and provide sufficient compression to aid in healing and prevent subsidence of the stem.

If the lateral cortex was not intact, a plate was placed to reconstruct the lateral cortex prior to the reduction and compression of the medial fragment and femoral implant. This procedure required a much larger exposure and equivalent operative time, blood loss, and transfusion risk compared to femoral component revision. In these cases, depending on surgeon preference, we believe either option is a viable treatment approach. Open reduction and internal fixation may be a more appropriate option for surgeons not adept at revision arthroplasty to avoid complications such as an increased dislocation risk.

There are certain unavoidable limitations with this study. This was a retrospective review and is subject to the limitations inherent in that study design. Additionally, we excluded patients who did not have radiographs prior to the fracture, and those who did not have obvious stem subsidence on the injury films. This was intended to eliminate the possibility of including Vancouver B1 fractures in our patient cohort, but likely also inadvertently excluded some Vancouver B2 fractures.

Internal fixation relies on bone-to-bone healing of the fracture fragments and bone-to-implant healing to provide stability to the

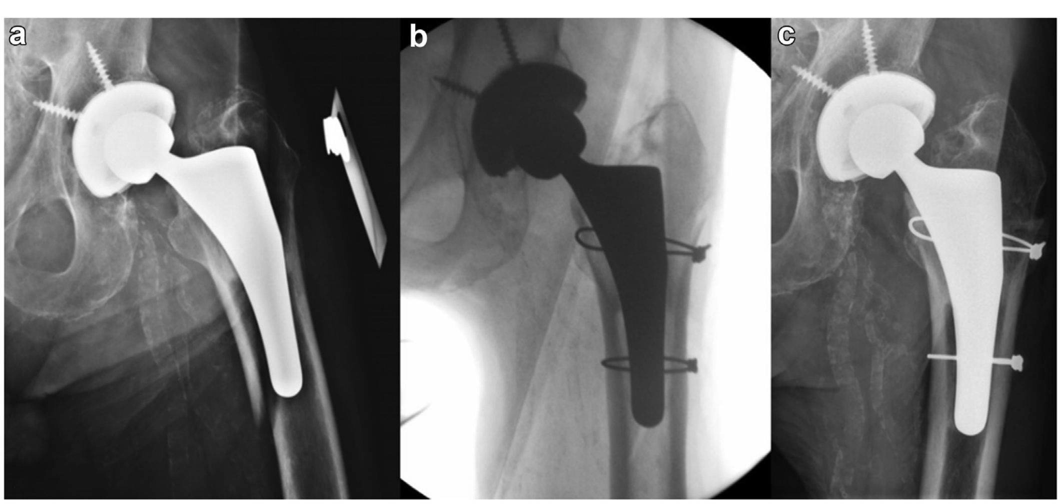

Figure 7. Radiographs of a periprosthetic femur fracture in an 85-year-old man after a fall demonstrate a Vancouver B2 periprosthetic fracture with subsidence of the stem (a). Intraoperative fluoroscopy was utilized to reduce the fracture with 2 cables (b). At 13 months postoperatively, the patient was doing well, with no complaints of pain in the hip (c).

Table 1
Patient demographics and outcomes.

Variables	Revision (n = 4)	ORIF + plate (n = 4)	Cerclage cabling (n = 5)	*P* value
Sex (male)	1 (25%)	2 (50%)	2 (40%)	.999
Age (y)	79 (73-92)	81 (76-87)	79 (69-91)	.823
Length of stay (d)	4 (3-5)	5 (3-8)	4 (1-6)	.441
Operative duration (min)	158 (129-211)	203 (166-254)	62 (46-77)	.009
Intraoperative blood loss (mL)	463 (100-800)	510 (200-900)	90 (50-200)	.036
Transfusion during hospitalization	3 (75%)	3 (75%)	0 (0%)	.033
Average follow-up (mo)	44 (19-70)	29 (21-37)	23 (11-60)	.172
Radiographic subsidence (mm)	6.7 (0-19)	0.5 (0-1.4)	0.4 (0-2.2)	.472
Harris hip score at last follow-up	82 (76-91)	72 (63-84)	88 (73-100)	.095

ORIF, open reduction and plate fixation.

femoral component. In all cases, patients had well-fixed cementless stems prior to their periprosthetic fracture. With this, we hypothesized either the on-growth surface is re-exposed, or bone fragments are attached to the surface, allowing bone-to-bone healing between the implant and femur. If the stem was loose prior to the fracture, we would anticipate the on-growth surface to be unavailable for healing secondary to fibrous interposition. This would necessitate a revision of the stem rather than internal fixation. In this retrospective review we were unable to perform an analysis of the surface of the implants to verify that this is indeed the case.

Conclusions

We have demonstrated that Vancouver B2 periprosthetic fractures with intact lateral cortices may be treated with internal fixation with cerclage cabling with excellent results.

Conflicts of interest

Cameron K. Ledford report being a board member for AAHKS, AAOS, and ABOS. Aaron Spaulding reports receiving royalties for a Predictive Analytics algorithm for Radiation Oncology Clinical Practice from Clearsense, LLC; however, this is not associated to topics, methods or any other topic associated with the work submitted. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101444.

CRediT authorship contribution statement

Benjamin K. Wilke: Writing – original draft, Methodology, Conceptualization. **Aaron C. Spaulding:** Formal analysis. **Matthew M. Crowe:** Writing – review & editing. **Cameron K. Ledford:** Writing – review & editing. **Courtney E. Sherman:** Writing – review & editing. **Luke Spencer-Gardner:** Writing – review & editing. **Kurt E. Blasser:** Writing – review & editing.

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