Outcomes After Operative Fixation of Vancouver B2 and B3 Type Periprosthetic Fractures

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Objectives: The incidence of periprosthetic femur fracture in the setting of total hip arthroplasty is steadily increasing. Although the traditional dogma is that loose femoral components must be revised, we propose that in a frail geriatric population, anatomic reduction and fixation of Vancouver B2 and B3 periprosthetic fracture variants can restore stem stability and provide similar outcomes as revision arthroplasty.

Design: Retrospective cohort study.

Setting: Level 1 trauma center, tertiary academic medical center.

Patients/Participants: We identified 94 patients over 65 years of age with Vancouver B2 and B3 fractures sustained between 2005 and 2019.

Intervention: Patients were treated by either open reduction and internal fixation (ORIF) or revision arthroplasty (RA) with or without fixation.

Main Outcome Measurements: Outcomes were mortality, time to full weight-bearing after surgery, intraoperative estimated blood loss, perioperative complications, reoperation, subsidence rate, and Patient-Reported Outcomes Measurement Information System pain and physical function scores.

Results: A total of 75 (79.8%) ORIF and 19 (20.2%) RA patients were reviewed. One-year mortality for our cohort was 26.3%, and there was no significant difference between groups. Mean time to weight bear and surgical complication rates were similar between groups. The ORIF group had a significantly shorter time to surgery than the RA group. The RA group had greater incidence and amount of subsidence as well as estimated blood loss than the ORIF group.

Conclusions: In geriatric patients with Vancouver B2 and B3 type periprosthetic fractures with known loose stems, ORIF may offer a similarly safe method of treatment than revision arthroplasty.

Keywords: periprosthetic femur fractures, vancouver classification, hip fractures, ORIF, revision arthroplasty

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

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BACKGROUND

The prevalence of periprosthetic femur fracture in the setting of total hip arthroplasty (THA) has been increasing.[1–3] This increase is attributed to a 70% increase in the rate of THA in the last 2 decades[4,5] and the growing indications for joint replacement.[6] Although the incidence of periprosthetic femur fracture (PPFF) after THA seems to range between 0.4% and 4%.[6] The most common classification system for these fractures is the Vancouver system,[7,8] a 3-category system based on fracture location, implant stability, and quality of surrounding bone stock.[9,10]

Distinguishing between the 3 Vancouver B-type subgroups is difficult, particularly between B1 and B2 fractures when evidence of loosening is often subtle. Type B2 fractures are the most common subtype of Vancouver fracture,[6] and distinguishing them from B1 fractures has historically been a critical juncture for surgical decision making between open reduction and internal fixation (ORIF) and revision arthroplasty (RA). Preoperative plain radiographs may not suffice and intraoperative assessment may be necessary. Although ORIF is associated with higher nonunion rates,[11] many PPFFs occur in geriatric patients with medical comorbidities that make RA of questionable advantage. When reviewing 203 patients, Gitajn et al found no survival benefit to treating these patients with either RA or ORIF and advocated that the optimal intervention may be based on surgeon proficiency. All ages were compared, and no subgroup analysis of geriatric patients was performed. More recently, Niikura et al[12] recommend altering the Vancouver treatment algorithm to meet an individual's pathology and activity status.

Although arthroplasty specialists often treat B2 and B3 with revision, changing practice patterns in the hands of trauma specialists may increase the use of ORIF as primary treatment. The primary purpose of this study was to evaluate the mortality and revision rates of patients with Vancouver B2 and B3 PPFFs with loose stems and treated with ORIF with implant retention compared with RA. To our knowledge, this is the largest study to date that evaluates surgical and functional outcome measures in geriatric patients with loose stems and Vancouver B2 and B3 type fractures treated with ORIF. We propose that in a geriatric population, anatomic reduction and fixation of these PPFFs can restore stem stability and provide similar outcomes to fixation with revision.

METHODS

With Institutional Review Board approval, we identified 263 PPFFs between 2005 and 2019 at our tertiary academic medical center. Of the 263 patients, 94 sustained Vancouver B2 and B3 fractures. Patients were identified through a query of billing records using Current Procedural Terminology codes. Inclusion criteria were PPFF around a hip implant classified as Vancouver type B2 or B3 and patient age greater than 65 years at the time of injury. Pathologic fractures, fractures around proximal femoral implants other than hip replacement prosthesis, Vancouver type A, B1, and C fractures, and fractures complicated by infection or nonunion at first presentation were excluded. The method of treatment was at the discretion of the surgeon. Patients were divided into 2 groups based on management—ORIF with retention of the femoral component or RA with or without fixation.

At our Level 1 trauma, PPFFs are primarily treated by our orthopaedic trauma team. Our traumatologists address all urgent fracture care with daily access to an orthopaedic trauma room, staffed by 3 trauma fellowship-trained subspecialists each with 17 years of experience. These traumatologists are also capable of performing arthroplasty revision procedures and have access to all fixation and revision instrumentation sets. Arthroplasty subspecialists only treat these fractures when covering a weekend call shift or during a direct referral.

The algorithm followed by the trauma surgeons involves an initial assessment of implant stability based on preoperative imaging. A loose prosthesis is confirmed intraoperatively by via an assessment of motion of the implant relative to the adjacent bone, using both direct vision and fluoroscopy.

Preoperative radiographs were retrospectively reviewed to determine implant stability and fracture classification. When implant instability was not confirmed radiographically with confidence, intraoperative findings via surgical reports were used to confirm stability. Postoperative radiographs and methodology described by Al-Najjim et al[13] were used to calculate the subsidence at 6 weeks, 3 months, 6 months, and 1 year of follow-up. The distance between the tip of greater trochanter and the shoulder of the stem (TG-SS) was measured at each time point and immediately postoperatively (baseline) and adjusted for magnification error. A difference of 3 mm or more between TG-SS distance at any time point and at baseline was considered clinically significant, whereas values below 3 mm were considered measurement errors.

Medical records were reviewed to collect patient baseline demographics, implant type, comorbidities, Charlson Comorbidity Index (CCI), and American Society of Anesthesiologists Classification. Our primary outcomes were 1-year mortality rate, time to full weight-bearing, rate of perioperative complications, and rate of revision after the primary treatment. Secondary outcomes were intraoperative blood loss, volume of transfused packed RBCs, length of stay, Patient-Reported Outcomes Measurement Information System (PROMIS) pain and physical function scores when available, and subsidence of the femoral implant. Due to the age group of our cohort and comorbidities, some patients expired before completing a full year of follow-up after surgery and were excluded. We collected PROMIS scores using either medical records or by contacting patients via phone.

Data are shown as mean ± SD for continuous variables and n (%) for categorical variables. We compared data between our primary exposure group of ORIF and RA with Student *t* test for continuous variables and χ^2 test for categorical variables. We used a *P*-value of 0.05 for statistical significance and used SAS 9.4 (Cary, NC) for all analyses.

RESULTS

Of the 94 patients enrolled, 75 (79.8%) underwent ORIF and 19 (20.2%) underwent RA. Although 68.1% were female, this was not statistically significantly different between groups. The ORIF patients were older with a mean age of 84.5 ± 7.7 years versus the 79.0 ± 7.0 years of the RA group ($P < 0.05$). There were 27 patients with hemiarthroplasty, 60 with primary THA, and 7 with revision hip implants at the time of injury. Among patients with revision hip implant, 2 had undergone 2 revisions and 5 had undergone 1 revision by the time of their injury. Cemented implants were found in 23 patients. The average time from implant insertion to fracture is 9 years (range 0–57 years). In 10 patients, the fracture occurred within 90 days of implant insertion. No implant characteristics were significantly different

TABLE 1. Patient Characteristics

	ORIF	Revision	*P*
Body mass index, kg/m^2	26.4 ± 6.0	29.1 ± 8.8	0.125
Gender			
F	53 (70%)	11 (58%)	0.266
M	22 (30%)	8 (52%)	
Anesthesiologists Classification			0.455
2	11 (14.6%)	3 (15.7%)	
3	56 (74.6%)	12 (63.1%)	
4	8 (10.6%)	4 (21.2%)	
CCI			0.968
Mean ± SD	5.6 ± 1.9	5.6 ± 1.6	
Median (IQR)	5.0 (4.0–7.0)	5.0 (4.0–7.0)	
Ambulatory			0.874
Yes	68 (91%)	17 (89.4%)	
No	7 (9%)	2 (10.5%)	

between the groups. Patient characteristics, including the preoperative ambulatory status, body mass index, the mean CCI, or Anesthesiologists Classification class, were found to be similar between groups (Table 1).

After consensus by 3 senior authors, 51 fractures were classified as Vancouver B2 and 43 as Vancouver B3. Seventy-eight percent (n = 40) of the Vancouver B2 fractures and 81% (n = 35) of the Vancouver B3 fractures were treated with ORIF (Table 2). Most patients were treated by the trauma team (n = 86). The arthroplasty surgeons were primary for 2.7% of patients in ORIF group (n = 2) and 31.6% in RA group (n = 6). Revision surgeries were primarily with long stem, variable version reconstructions systems. Some revisions were done with long cemented stems. Cerclage was primarily used in combination with revision prosthesis, and plating was used in 8 patients in the RA group.

One-year mortality for our cohort was 26.3%, and there was no statistically significant difference between the ORIF and the RA groups (28.6% vs. 17.6%, $P > 0.05$). There was over double the estimated blood loss in milliliters in the RA group versus the ORIF group (879.2 ± 432.7 mL vs. 425.3 ± 314.2 mL, $P < 0.001$). Although not reaching significance, the volume of packed red blood cells transfused perioperatively was almost 1.5 times as large in the RA group compared with the ORIF group (398.1 ± 467.6 vs. 279.8 ± 336.2, $P > 0.05$).

Mean time to full weight-bearing was 91.8 ± 115.9 days, with similar times between the ORIF and RA groups ($P > 0.05$). Although the ORIF group had a lower complication rate at 20% versus the RA group at 26.3%, this was not statistically significant. Similarly, there was no significant difference in length of stay between the groups (Table 3). The ORIF group had a shorter time to surgery than the RA group at 1.8 ± 2.6 days versus 2.3 ± 1.7 days, respectively, although this was not significant ($P > 0.05$). Our cohort's mean time to last follow-up was 6.6 months. However, RA patients on average had almost double the documented follow-up length than ORIF patients. The ORIF group did have 2 individual incidences of revisions and the RA group did not, although this was not a statistically significant difference.

Regarding functional scores, 17% of our population had available PROMIS scores. The RA group had similar means for PROMIS pain and physical function scores at 56.3 ± 5.1 and 42.5 ± 18.8 versus 55.0 ± 10.3 and 32.7 ± 11.8, respectively, for the ORIF group ($P > 0.05$).

Subsidence was found in only 6 patients (10.8%) in the ORIF group. In contrast, subsidence was noted in 6 patients (46.2%) in the RA group ($P < 0.001$). The RA group had 1.5 times higher value of measured subsidence in millimeters when compared with the ORIF group at 6 weeks (6.3 ± 1.8 vs. 4.0 ± 1.1, $P = 0.1$) and even more so at 3 months (8.1 ± 4.0 vs. 3.5 ± 0.3, $P < 0.5$). No patients had an incidence of subsidence after 3 months. However, the pattern of difference in the measured subsidence in the RA group continued to progress slightly at 6 months and at 1 year of follow-up (Table 4).

TABLE 2. Management of Periprosthetic Fractures

Type of Fx	N	ORIF, n (%)	RA, n (%)	P
				0.721
B2	51	40 (78%)	11 (22%)	
B3	43	35 (81%)	8 (19%)	

B2, Vancouver B2; B3, Vancouver B3; Fx, fracture.

DISCUSSION

There is debate concerning the optimal management of Vancouver type PPFFs with suspected loose femoral component, particularly in geriatric or otherwise debilitated patients.[14–16] This debate is exacerbated by the radiographic difficulty in delineating between well-fixed and loose femoral components.

We found no significant difference in one-year post treatment mortality between the ORIF or RA group. However, mortality did trend higher in the ORIF group. In a retrospective study of 203 Vancouver B PPFFs, Gitajn et al compared ORIF and RA and similarly found no difference in 1- or 5-year mortality between the treatment groups. In a subgroup analysis, they found that only CCI was independently associated as a risk factor for mortality. Other operative metrics, such as age, surgery type, or stability of the femoral stem, were not associated with any changes in mortality.[17] They did not focus on B2 and B3 but included all Vancouver variants regardless of stability.

In our analysis, patients who underwent RA for their PPFFs had greater estimated blood loss than ORIF patients. This finding is in accordance with other reports.[17] Volume of blood lost has been cited as an important marker of postoperative outcomes in frail/geriatric patients. Stenvers et al[18] categorized 63 patients using the complex fracture frailty index and found that more minimally invasive surgeries, such as ORIF, when compared with more invasive RA resulted in more major complications (30-day, 90-day, and 1-year mortality) and minor complications (implant infections, pneumonia, blood transfusions, and urine tract infections). These data are particularly applicable, as most Vancouver PPFF patients tend to be geriatric.

The importance of the ability to weight bear sooner rather than later in a geriatric population is a goal of treatment.[19] When analyzing 4918 patients using the National Surgical Quality Improvement Program (NSQIP) dataset, Ottesen et al[20] found that in patients >60 years of age, postoperative weight-bearing restrictions were associated with greater rates of developing major adverse events, delirium, infection, transfusion, and having a longer length of stay. Earlier weight-bearing with RA has a perceived advantage; however, as Baum et al[21] point out, the Vancouver system ignores nuances between fracture patterns—fractures with significant comminution are appropriately anatomically reduced with ORIF, meanwhile they may only be relatively approximated with RA. When comparing the average time to weight bear in our groups, we found no statistically significant difference between ORIF and RA. Postoperative weight-bearing restrictions were indicated by the surgeon but not standardized. For 1 of the senior surgeons, touchdown weight-bearing was indicated in post fixation patients for up

TABLE 3. Surgical Outcomes of Both Groups

Outcome Measured	Total	ORIF	RA	*P*
One-y mortality (%)	26.3%	28.6%	17.6%	0.363
EBL, mean ± SD (mL)	517.1 ± 385.2	425.3 ± 314.2	879.2 ± 432.7	**<0.001**
RBC transfused, mean ± SD (mL)	3050.0 ± 368.4	279.8 ± 336.2	398.1 ± 467.6	0.216
Perioperative complications (%)	21.3%	20.0%	26.3%	0.547
Length of stay (d)	6.7	6.5 ± 4.4	7.3 ± 2.7	0.456
Time to surgery (d, SD)	1.9 ± 2.4	1.8 ± 2.6	2.3 ± 1.7	0.426
Time to full weight-bearing (d, SD)	91.9 ± 115.9	93.1 ± 96.2	88.2 ± 162.0	0.879
Time since surgery to f/u (d, SD)	198.7 ± 369.9	161.1 ± 330.6	343.0 ± 476.4	**<0.05**
PROMIS pain score	55.4 ± 9.1	55.0 ± 10.3	56.3 ± 5.1	0.805
PROMIS function score	35.1 ± 13.9	32.7 ± 11.8	42.5 ± 18.8	0.232

Bold entries are values where $P < 0.05$.
EBL, estimated blood loss; f/u: follow-up; RBC, red blood cell.

to 6–8 weeks with the expectation that many geriatric patients would not be able to comply and may start weight-bearing early. Two other surgeons allowed patients to weight bear as tolerated. Weight-bearing recommendations were likely also not uniformly enforced at the various postdischarge rehabilitation facilities/nursing homes. Also, not all RAs were made full weight-bearing; those requiring plate fixation had initial limitations of weight-bearing. We recognize that this inconsistency may detract from some comparisons but is a limitation inherent to the retrospective nature of the study and our patient population.

Overall, we found that ORIF and RA patients have similar rates of complications during the hospital stay. Perisurgical complications reported were anemia requiring transfusion, urinary tract infection, pneumonia, delirium, atrial fibrillation, congestive heart failure exacerbation, and infection. There were 4 patients who expired during their hospitalization and were equally distributed between groups. In a retrospective review of 32 patients, Laurer et al reported that ORIF patients had more complications, specifically implant failure. However, Chakravarthy et al[22] found a 91% implant success rate when using locking plates on Vancouver B1 and C. Ricci et al[23] prospectively followed 41 patients and found that all Vancouver B1 patients after ORIF had satisfactory fracture healing. We found no statistically significant difference when comparing revision statistics between the treated groups. Our ORIF group exhibited 2 incidences of requiring revision surgery, whereas the RA group did not. This result, although not statistically significant, differs from the primary conclusion of a systematic review of 343 Vancouver B2 fractures and 167 Vancouver B3 fractures in a study by Khan et al.,[24] where they demonstrated that B2 and B3 fractures treated with ORIF without revision had higher reoperation rates. Nevertheless, there are also several reports in the literature of RA patients requiring revision surgeries.[21,25,26]

TABLE 4. Positive Subsidence Values

	ORIF, n (%)	RA, n (%)	*P*
No subsidence	50 (66.6)	7 (37)	**<0.001**
6 Weeks	3 (4)	6 (31.5)	
3 Months	3 (4)	0	
Missing	19 (25.4)	6 (31.5)	
Subsidence in mm			
6 Weeks			**<0.001**
Mean ± SD	4.0 ± 1.1	6.3 ± 1.8	
Median (IQR)	3.5 (3.3–5.3)	6.0 (4.7–7.2)	
3 Months			**0.001**
Mean ± SD	3.5 ± 037	8.1 ± 4.0	
Median (IQR)	3.5 (3.3–3.6)	8.3 (4.6–9.2)	

Bold entries are values where $P < 0.05$.

Although the median hospital length of stay time was lower for the ORIF group than the RA group in our cohort, this was not statistically significant. Other studies, however, have found that RA patients have significantly longer and costlier stays when compared with ORIF patients.[27,28]

Delays to surgery in proximal femur fractures are well-studied, some using large national datasets.[29–31] They report deleterious effects and increased mortality as time to surgery increases.[32] Studies investigating the relationship between time to surgery and outcomes are more limited in the periprosthetic fracture literature. We found that RA patients had a somewhat longer, but not significant, time to surgery than the ORIF group. In a review of 60 patients, Griffiths et al[33] found that 72 hours or more of delay to surgery was associated with adverse outcomes such as cardiac events, pulmonary embolism, dislocation, and implant failure. We found that mean time to surgery was 74.4 hours in RA patients, whereas it was only 38.4 hours in ORIF patients. The faster time to surgery in our system could be associated with the fact that these patients are often treated by orthopaedic trauma surgeons within a trauma care system designed for expedited care, as is needed for hip fractures and high-energy trauma.

The duration of documented follow-up was 2 times longer in our RA group when compared with the ORIF. The differences might be accounted by survival, although this was not supported by a significant difference in the mortality rate between groups. Completion of follow-up is determined by the treating surgeon once the fracture is deemed healed. Many of these patients and their families, particularly those with low functional status, were not encouraged to follow beyond the point of acceptable healing. Moreover, facility-dependent/logistical challenges also discouraged routine follow-up when no active issues were present.

Although a minority of our patients had PROMIS scores available, few other studies report on functional outcomes after ORIF and RA for PPFFs. In our cohort, there was no statistically significant difference in the PROMIS pain or PROMIS physical function score between the ORIF and RA group. RA is historically preferred by arthroplasty surgeons due to the intuitive expectations of a prompter returns to baseline ambulatory status when compared with fixation. However, Moreta at al.[25] found that in a series of 43 Vancouver B2 and B3 fractures treated with RA, 42% of the patients never returned to their original ambulatory status. In a retrospective study of 39 Vancouver B2 patients, Flury et al use the Harris Hip Score as their primary functional outcome. They found that ORIF patients had slightly higher scores, although this was not statistically significant.[16]

A common complication of tapered stems is subsidence. Many studies have used 5.0 mm or progression over time with persistent pain as a positive subsidence.[34,35] Although there have been reports of radiologic subsidence secondary to physiological fracture healing,[36] subsidence is a proxy for poor fixation and implant failure[37] and a particular concern in the setting of poor bone quality in geriatric patients. We determined a clinically meaningful measurement of subsidence to be a more-conservative measurement of >3.0 mm. In this study, 11% of our ORIF patients experienced subsidence, all of which were noted within 3 months. The RA group had a higher rate and amount of subsidence in millimeters. Our results challenge a recent consecutive series of 18 patients with Vancouver B2 and B3 fractures who underwent modular revision stem arthroplasty in a study by Schreiner et al. They found no implant-related failure or subsidence up to 18 months. Our study is in line with other studies, however, that found subsidence in revision arthroplasty patients that ranged from 9.1% to 77.3%.[38]

Our study was limited by several factors. Primarily, our retrospective design has no random allocation. Furthermore, several orthopaedic traumatologists and arthroplasty surgeons participated, thus nuanced differences in their approaches to complex periprosthetic fracture fixation may exist. Our groups also differed in size significantly, a reflection of our institutions' treatment protocol for periprosthetic fractures, but were statistically similar in baseline characteristics. The availability of functional scores was also limited given the age of our patient population and the retrospective nature of our study. Subsidence measurements were also contingent on radiologic landmarks and may be subjective between raters.

CONCLUSION

In select geriatric patients with Vancouver B2 and B3 type periprosthetic fractures, ORIF may be a similarly safe method of treatment with a trend toward reduced blood loss, faster time to surgery, and equivalent restoration of stability even when the implant stems are suspected loose.

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