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Vancouver B2 and B3 periprosthetic femoral fractures treated by ORIF. Mid to long-term follow-up study in 28 patients

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Abstract. – OBJECTIVE: Periprosthetic femoral fractures (PFF) are a serious complication in patients who have undergone hip arthroplasty. Some authors consider revision arthroplasty as the gold standard in the surgical treatment of Vancouver type B2 and B3 PFF. Others, however, prefer treating PFF by open reduction and internal fixation (ORIF), without revising loose stems, especially in elderly patients. In the present retrospective study, we report mid/long-term results in a series of patients affected by B2 or B3 PFF surgically treated by ORIF, using a locking compression plate (LCP), thus avoiding the need of revision arthroplasty.

MATERIALS AND METHODS: We reviewed 28 patients affected by B2 or B3 PFF surgically treated between 2010 and 2017 by ORIF using a LCP, after an average follow-up of 5.5 years. The average age of the patients at diagnosis was 78 years; in 17 patients, the femoral stem was uncemented while in 11, cemented. The mean interval time between hip arthroplasty and PFF was 6.7 years. Clinical results were assessed using Harris Hip Score (HHS), while radiographic results according to Beals and Tower criteria.

RESULTS: At follow-up, HHS ranged from 72 to 96 points; 8 patients had an excellent result, 12 got a good result and 8 a fair result. According to Beals and Tower criteria, all the radiographic results were excellent (9 patients) or good (19 patients). The majority of our patients returned to their previous ambulatory levels.

CONCLUSIONS: According to our results, in elderly patients affected by Vancouver type B2 or B3 PFF, surgical treatment by ORIF using a locking compression plate, without a stem revision, seems to be associated with satisfactory outcome.

Key Words:
Periprosthetic femoral fractures, Vancouver classification system, Open reduction and internal fixation, Locking compression plate.

Introduction

Periprosthetic femoral fractures (PFF) can occur intraoperatively and postoperatively. Postoperative femoral fractures following hip arthroplasty are becoming more frequent, especially in uncemented stems, and represent a serious complication whose treatment is a challenge for the orthopaedic surgeon, especially in elderly patients[1-4]. The Vancouver classification of PFF is the most common classification reported by several authors and suggest a specific treatment protocol[5]. This classification system considers the anatomical location of the fracture, the stability of the femoral component and the bone quality. The Vancouver classification system divides periprosthetic femoral fractures into three categories (A, B and C) based on fracture site. In PFF type A, the fracture is located in the proximal metaphysis of the femur and may involve the great trochanter (AG) or the lesser trochanter (AL). In PPF type B, the fracture is located around or just below the stem; this type of PFF are divided into B1 (stable implant), B2 (loose implant with adequate bone stock) and B3 (loose implant with poor bone stock). In PFF type C, the fracture is below the stem's tip.

The treatment algorithm of the Vancouver classification has widely been accepted and several studies[6-11] have reported its reliability and validity. According to the Vancouver classification system, well fixed stems (B1) require only ORIF whereas loose stems (B2 and B3) require revision arthroplasty in all cases. However, some recent studies[12-18] have suggested that ORIF for treatment of B2 and B3 PFF can be a

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satisfactory alternative option without revising loose stems, especially in low demand and elderly patients.

In the present study, we report the medium to long-term results in 28 patients surgically treated for a Vancouver B2 and B3 PFF, using a locking compression plate (LCP), without stem revision.

Patients and Methods

We selected 28 patients with a Vancouver B2 or B3 PFF treated between 2010 and 2017 by ORIF, without revision arthroplasty. Eleven were males and 17 females, with a mean age of 78 years (from 59 to 92 years). All these patients had an appropriate clinical and radiographic documentation and were analysed retrospectively after a mean follow-up period of 5.5 years (from 3 to 10 years). Twenty patients had a total hip arthroplasty, 4 a hemiarthroplasty and 4 a revision arthroplasty. In 20 patients, the fracture occurred with low-energy trauma, while in 8 patients with a high energy mechanism. Regarding the type of fixation, in 17 patients the femoral stem was uncemented, while in 11 it was cemented. Hip arthroplasty had been implanted for osteoarthritis in 16 patients, medial femoral neck fracture was registered in 7 patients, rheumatoid arthritis in 3 patients and avascular necrosis in 2 patients. The mean interval time between hip arthroplasty and fracture was 6.7 years (from one to 34 years). All patients were treated, through a lateral approach, by open reduction and internal fixation (ORIF) using a locking compression plate (LCP), fixed by screws and cerclage cables. In 3 patients, autologous bone grafting and in 4 patients synthetic bone grafting were applied around the fracture-site. In all cases, a drainage was applied and maintained for 24 hours. After surgery, postoperative radiographs were performed to assess the quality of the reduction. All patients started the physical rehabilitation the first day after surgery and they were placed in a sitting position; a partial weight bearing was permitted after two weeks, while the full weight bearing within six weeks. Radiographic control was performed after one, 2 and 6 months, then every year. During the last follow-up, clinical results were assessed using the Harris Hip Score (HHS). Out of a total of 100 points, 100 to 90 points were rated as excellent; 89 to 80 as good; 79 to 70 fair; less than 70 as poor. Radiographic results were assessed according to the Beals and Tower's criteria[19]. The result was considered excellent when the arthroplasty was stable and the fracture healed with minimal deformity without shortening; it was considered good when there was a stable subsidence of the prosthesis or where the fracture healed with moderate deformity or shortening; it was considered poor when a loose prosthesis, painful or not, or a non-union, sepsis, new fracture, severe deformity or severe shortening were present.

Statistical Analysis

Statistical analysis was performed to look for any correlations between the initial patient characteristics, which include sex, the energy mechanism (low versus high), cemented or uncemented stem and type of fracture (B2 or B3), with the final outcome (Harris Hip Score). The analysis was also performed to look for correlation between the HHS and the radiographic criteria (Beals and Tower's Criteria). The Student's *t*-test and Mann-Whitney U test were used to evaluate the significance of differences for continuous variables. All statistical analyses were performed using the SigmaStat Version 4.0 program (Systat Software, Inpixon, CA, USA); *p*-values lower than 0.05 were considered significant.

Results

Demographic, clinical and radiological results of our patients are reported in Table I. According to the Vancouver classification system, 16 fractures were classified as a B2 PFF, while 12 a B3. According to HHS, 8 patients showed an excellent result (Figure 1), 12 a good result (Figure 2), and 8 a fair result (Figure 3). No patient had a poor result. According to Beal and Tower criteria, radiographic results were excellent in 9 patients and good in 19. No patient showed a poor radiographic result. We observed no cases of dislocation of the implant. All patients were satisfied with the final result and the majority of them returned to their previous ambulatory levels.

Harris Hip Score was significantly higher in patients that had B2 fractures compared to those who had B3 fractures (86.1 ± 6.3 for B2 *vs.* 80.2 ± 7.0 for B3; $p = 0.027$). Additionally, patients with B2 fractures had 6 excellent, 8 good and 2 fair results, while patients with B3 fractures had 2 excellent, 4 good and 6 fair results.

Table I. Demographics, clinical and radiological results of 28 patients with Vancouver type B2-B3 periprosthetic femoral fracture (PFF), surgically treated by ORIF using a locking compression plate (LCP).

Case	Sex	Age	Side	Energy trauma	Type of prosthesis	Type of fixation	Implant indication	Type of fracture (vancouver classific.)	Interval between implant and PFF (years)	Follow-up (years)	Clinical results (HHS)	Radiographic results (beals and tower's criteria)
1	F	88	R	Low	Revision	Cemented	Fracture	B2	16	6	84	Good
2	F	76	L	Low	THA	Cemented	Osteoarthritis	B2	12	5	85	Excellent
3	M	79	R	High	THA	Cementless	Fracture	B2	5	7	81	Excellent
4	M	88	L	Low	THA	Cementless	Osteoarthritis	B3	7	6	78	Good
5	M	89	R	Low	THA	Cemented	Osteoarthritis	B2	15	4	83	Good
6	F	84	R	Low	THA	Cementless	Osteoarthritis	B3	5	5	72	Good
7	F	83	R	Low	Revision	Cementless	Osteoarthritis	B3	5	5	74	Good
8	F	70	R	Low	THA	Cementless	Osteoarthritis	B2	9	7	90	Good
9	M	72	L	Low	THA	Cemented	Rheum. Arth.	B2	34	7	75	Excellent
10	F	85	L	Low	Hemiarth.	Cementless	Fracture	B3	2	5	73	Good
11	F	83	L	High	THA	Cemented	Fracture	B3	6	3	82	Good
12	M	92	R	Low	THA	Cemented	Osteoarthritis	B3	8	5	83	Good
13	F	86	L	Low	THA	Cementless	Osteoarthritis	B3	5	4	92	Good
14	F	59	R	High	THA	Cemented	Avasc. Necr.	B2	4	6	86	Excellent
15	M	61	R	High	THA	Cementless	Rheum. Arth.	B2	5	4	77	Excellent
16	F	82	L	Low	Hemiarth.	Cemented	Fracture	B3	4	4	82	Good
17	M	72	R	High	THA	Cementless	Osteoarthritis	B2	3	5	92	Good
18	M	76	R	Low	THA	Cementless	Osteoarthritis	B2	4	8	95	Excellent
19	F	79	L	Low	THA	Cementless	Osteoarthritis	B2	7	7	82	Good
20	F	85	R	Low	Hemiarth.	Cemented	Fracture	B3	4	3	76	Good
21	F	71	R	High	THA	Cementless	Avasc. Necr.	B2	5	5	92	Excellent
22	M	74	L	Low	Revision	Cementless	Osteoarthritis	B2	4	6	92	Good
23	M	69	L	High	THA	Cementless	Osteoarthritis	B2	1	4	96	Excellent
24	F	85	R	Low	Hemiarth.	Cemented	Fracture	B3	2	5	80	Good
25	M	73	R	Low	THA	Cementless	Osteoarthritis	B2	3	10	86	Good
26	F	84	R	Low	Revision	Cemented	Osteoarthritis	B3	4	6	76	Good
27	F	79	R	Low	THA	Cementless	Osteoarthritis	B3	9	5	94	Excellent
28	F	64	L	High	THA	Cementless	Rheum. Arth.	B2	1	8	81	Good

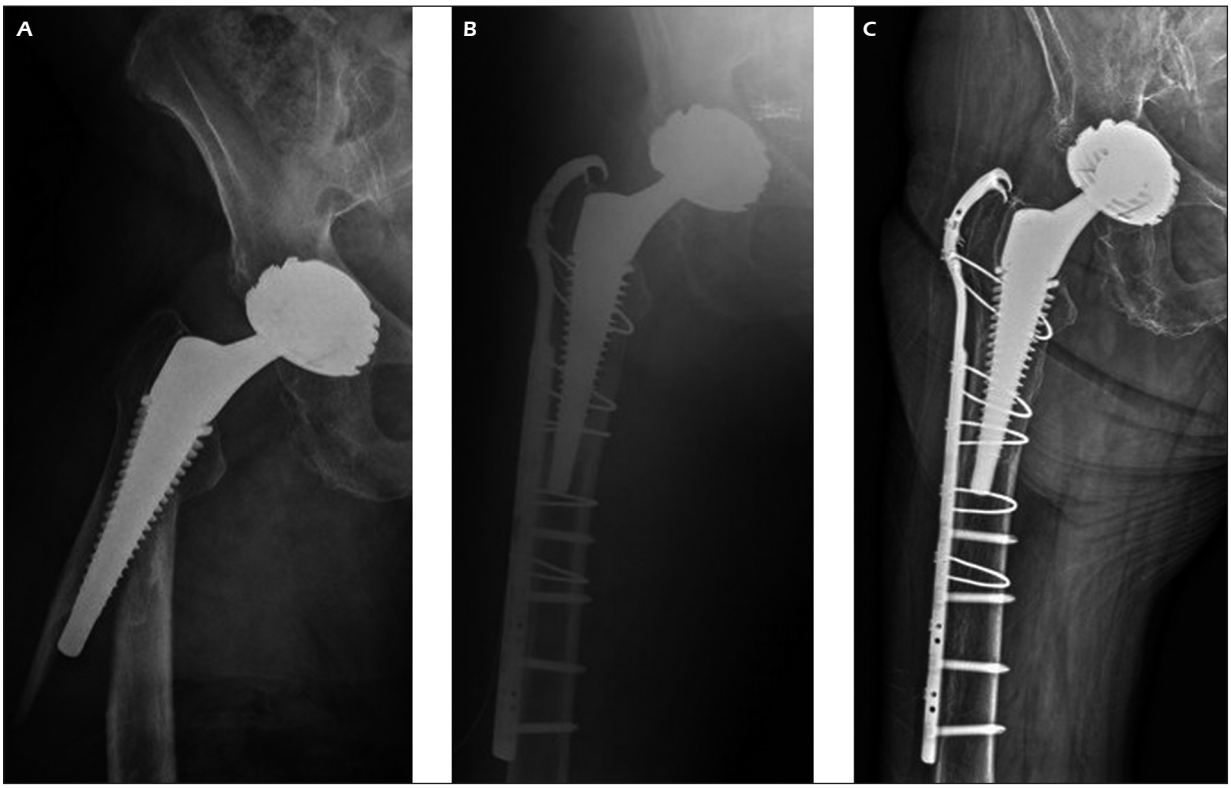

Figure 1. Radiographic examination of a Vancouver type B3 PPF of the right femur in a 79-year-old female (**A**) treated by ORIF with a compression plate fixed with screws and cerclages. The postoperative radiograph showed an anatomic reduction (**B**). The radiographic examination taken at follow-up, 5 years later, showed a fracture healing without deformity or shortening (excellent result, according to Beals and Tower's criteria) (**C**). At clinical evaluation, the HHS scored 94 points (Case No. 27 in Table I).

There were no statistically significant correlations between the HHS and sex, cemented or uncemented stems or energy mechanism ($p > 0.05$). Similarly, there was no correlation between HHS and radiographic results ($p > 0.05$).

Discussion

There are no universal accepted algorithms for the management of periprosthetic femoral fractures (PFF), however many authors consider revision arthroplasty the gold standard in the surgical treatment of Vancouver type B2 and B3 PFF. In fact, several studies[6-10] have reported the validity and reliability of the surgical treatment protocol based on the Vancouver classification of PFF which provides open reduction and internal fixation when the stem is stable (Vancouver B1) and revision arthroplasty when the stem is unstable (Vancouver B2 and B3).

Brady et al[6] reported the results obtained in a cohort of 40 patients affected by PFF in which a hip replacement was performed and concluded that the Vancouver classification was valid and reliable. The validity and reliability of the Vancouver classification was reaffirmed by the more recent study of Naqvi et al[7] that analyzed a cohort of 45 patients, emphasizing the intraoperative assessment of implant stability. Korbel et al[8] evaluated 47 PFF after a mean follow-up period of 27 months and concluded that the treatment of these fractures based on the Vancouver classification gives a positive result. Shah et al[9] stated that PFF with a loose femoral component can be a devastating event and femoral revision with a long-term prosthesis or modular stem is the best option of treatment. Analogous results were reported by Abdel et al[10] in another review article.

Khan et al[11] reported a systematic review of Vancouver B2 and B3 PFF. A total of 22 studies were analyzed, including 343 B2 fractures and

Figure 2. Radiographic examination of a Vancouver type B2 PFF of the right femur in a 59-year-old female (**A, B**) treated by ORIF with a compression plate fixed with screws and cerclages. The postoperative radiograph showed an anatomic reduction (**C**). The radiographic examination taken at follow-up, 6 years later, showed a fracture healing with a stable implant (excellent result, according to Beals and Tower's criteria) (**D**). At clinical evaluation, the HHS scored 86 points (Case No. 14 in Table I).

167 B3 fractures. Among the 343 B2 fractures, the treatment was a revision arthroplasty in 298 (86.8%) and ORIF alone in 45 (12.6%). Of the 167 B3 fractures, the treatment was a revision arthroplasty in 160 (95.8%) and ORIF alone in 8 (4.8%).

However, some recent studies[12-18] have showed that B2 and B3 PFF can be successfully treated with ORIF, without revision arthroplasty. Joestl et al[12], in a retrospective review of 36 B2 PFF, reported that all the 8 fractures stabilized with locking compression plate (LCP) without stem revision healed uneventfully and there were no signs of secondary stem migration, malalignment or plate breakage. They concluded that LCP fixation without revision arthroplasty may be an option of treatment for Vancouver B2 PFF in which a good bone stock is present, in elderly patients and in patients with multiple comorbidities. Spina and Scalvi[13]

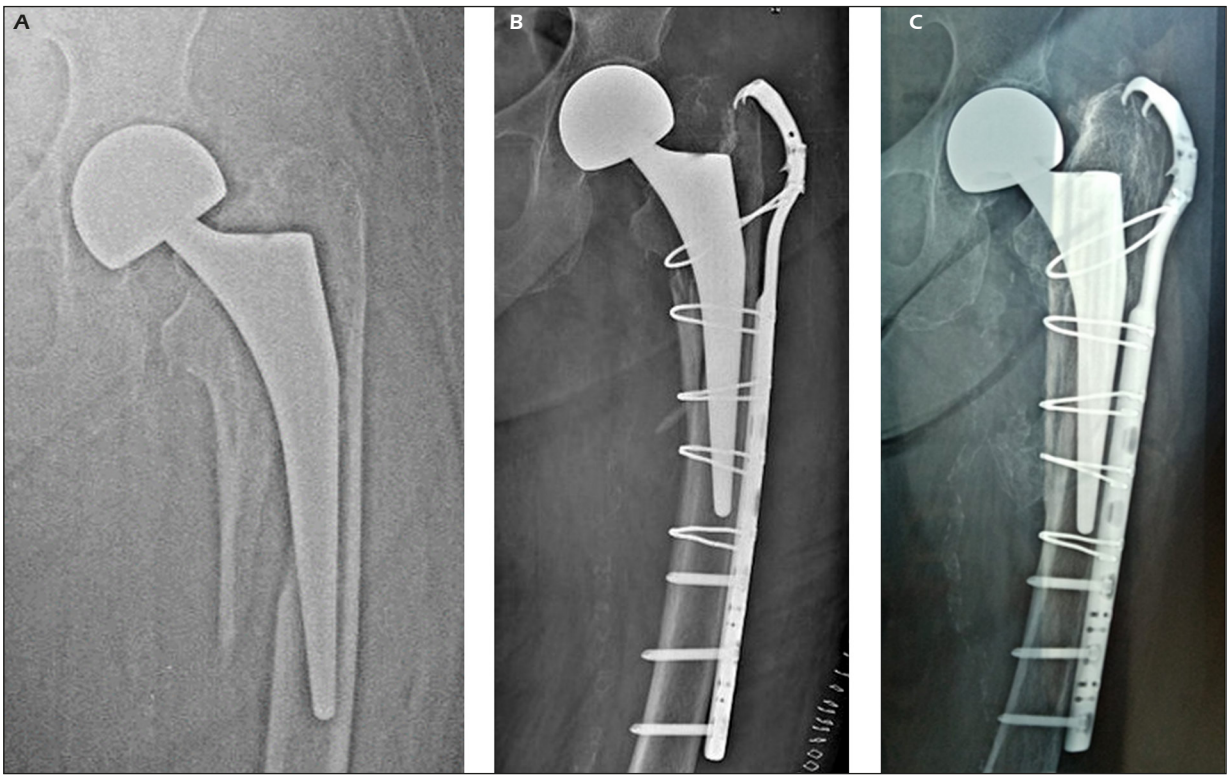

Figure 3. Radiographic examination of a Vancouver type B3 PPF of left femur in an 85-year-old female (**A**) treated by ORIF with a compression plate fixed with screws and cerclages. The postoperative radiograph showed a good reduction of the fracture (**B**). The radiographic examination taken at follow-up, 5 years later, showed the fracture healing with a mild subsidence of the femoral stem (good result, according to Beals and Tower's criteria) (**C**). At clinical evaluation, the HHS scored 73 points (Case No. 10 in Table I).

compared stem revision *vs.* ORIF in the treatment of 32 B2 PFF; 11 patients were treated with stem revision and 21 with ORIF. According to the authors conclusions, in selected cases, especially in geriatric patients, ORIF can be a viable alternative option for the treatment of B2 PFF. Stoffel et al[14], in a recent systematic review of 14 original research articles including both patients treated by stem revision or ORIF only for B2 or B3 PFF, reported that successful outcome can be achieved without revising loose stems. They concluded that "ORIF may be a viable option if bone stock is adequate around uncemented or cemented stems with an intact cement mantle and the fracture geometry allows stable anatomic reconstruction[14]".

Powell-Browns et al[15] reported a recent retrospective study of a large series of 152 PFF involving the Exeter cemented stem, the majority of which managed with ORIF (130 patients), without revision arthroplasty. According with their results, the authors concluded that when the bone cement interface was intact, fixation of B2 or B3 fractures was not associated with an increased risk of revision. In the same year, Slullitel et al[16] and Barghi et al[17] retrospectively reviewed two large series of 112 B1 and B2 PFF[16] and 75 B2 and B3 PFF[17] and concluded that elderly patients with B2 and B3 fractures can be safely treated with internal fixation, without revision arthroplasty. In agreement with this statement, a systematic review and meta-analysis recently published[18] concluded that while revision arthroplasty continues to be considered as the gold standard in the surgical treatment of B2 and B3 PFF, open reduction and internal fixation has been associated with satisfactory outcomes, especially in the treatment of Vancouver type B2 PFF.

Our results confirm the recent studies[12-18] that reported satisfactory clinical and radiographic results in B2 and B3 PFF treated with ORIF without revision arthroplasty, especially in elderly patients or patients affected by co morbidities. In our series, no case showed a functional worsening of the quality of life of the patients which returned to their previous ambulatory level; therefore, all patients had an excellent or good

radiological result at follow-up. However, Moreta et al[20] observed that in spite of a good radiological result, many patients did not return to their previous ambulatory levels.

Some studies[21-23] reported that total hip arthroplasty or hemiarthroplasty, implanted with uncemented femoral stems, are associated with an increased risk of PFF, especially in elderly females and that many PFF occurred within 1 year of the index surgery. In our series, the femoral stem was uncemented in the majority of the cases, and the mean interval time between previous surgery and PFF was 6.7 years (from one to 34 years). Moreover, in our cohort of patients, we never observed dislocation of the implant, while it seemed to be the most frequent complication (16.3% of the cases) in a recent study[24] of Vancouver B2 and B3 PFF in elderly patients treated by revision of the loose stems.

In our series, the average age at diagnosis was 78 years and only four patients aged less than 70 years; in according with previous studies[12-18], we observed the same satisfactory result also in this small group of patients, therefore we believe that ORIF without revision arthroplasty may be considered also in younger patients affected by B2 PFF.

While satisfactory results were obtained in all patients, the patients with B2 fractures had significantly better scores compared to those with B3 fractures after ORIF. Based on this result, ORIF can be considered an even better option when there is good bone stock.

More recently, some studies[25] have reported good results in a retrospective study on 12 patients surgically treated with a mega prosthetic implant for hip and distal femoral complex fractures, as well as PFF. They considered this surgical procedure as a safe and a viable option in elderly patients. We never adopted this treatment for PFF, nevertheless we believe that it may be an alternative option in selected cases.

Limitations

There are several limitations to our study, mainly that it is a retrospective study without a control group. Large multicenter prospective randomized studies are needed to make a definitive conclusion on how effective ORIF is in type B2 and B3 PFF compared to stem revision.

Conclusions

In conclusion, our results showed that satisfactory results can be achieved in geriatric patients with B2 and B3 PFF treated by ORIF only. However, revision arthroplasty continues to be the gold standard of surgical treatment of these lesions, although several recent studies[12-18] have reported similar satisfactory results using a surgical fixation with plates, screws and cerclage cables, that represent a less invasive procedure with lower risk of perioperative complications.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Informed Consent

Informed consent was obtained from all subjects involved in the study.

Ethical Approval

The study was approved by the Ethics Committee of University Hospital of Tor Vergata, Rome, Italy.

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