

General

Treatment of Periprosthetic Hip Fractures Vancouver B1 and C: The Significance of Bicortical Fixation. A Bicentric Study Comparing Two Osteosynthesis Systems

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INTRODUCTION

The incidence of periprosthetic fractures (PFFs) is estimated to range from 0.1% to 4.1%, due to the increasing prevalence of joint arthroplasties, coupled with an aging population.

Numerous risk factors, including advanced age (>80 years), female gender, implant type, prior diagnoses of osteonecrosis and rheumatoid arthritis, revision surgery, aseptic stem mobilization, and the use of non-cemented stems, have been identified.

Survivors of periprosthetic fractures often experience functional deterioration, facing a fourfold higher risk of hospitalization for postoperative complications compared to patients undergoing primary implantation, especially in the first postoperative year.

MATERIALS AND METHODS

Between 2018 and 2022, at the Maggiore Hospitals in Bologna and the San Matteo Policlinic in Pavia, we performed osteosynthesis on 84 patients with periprosthetic fractures of Vancouver type B1 or C. In 38 patients, we employed angular stable plates with the Zimmer Biomet NCB-PP® system. In 46 patients, we utilized INTRAUMA plates: DF distal femur and PFF proximal.

Relevant postoperative follow-up outcomes considered included reintervention, infectious complications, radiographic healing, and functional recovery, with reference to changes in the Glasgow Outcome Scale (GOS) and the Harris Hip Score (HHS). All patients underwent clinical and radiographic evaluations during the follow-up period, averaging 28 months (range: 12-48 months), with a minimum follow-up duration of 12 months.

RESULTS

At the 4-month postoperative assessment, 71% of patients maintained their preoperative functional level, 19% experienced a 1-point GOS scale drop, and 10% died (GOS 5). The average HHS at 4 months was 80.2 points (range: 65-90). At the 6-month follow-up, 98.2% of patients achieved complete healing on radiographic examination. Only 1 patient (1.2%) developed a pseudoarthrosis site with synthesis device rupture. Only 1 patient (1.2%) required additional surgical treatment 2 years later due to the development of an aseptic perisynthetic fluid collection, while the remaining 5 patients (6%) who developed complications benefited from conservative treatment:

4 patients (3.6%) with infectious complications were treated with intravenous antibiotics. In the 2 patients (2.3%) with mobilization or rupture of synthesis devices, clinical and

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radiographic monitoring was opted for. 8 patients (10.7%) died: one 48 hours after the surgery, and the other 7 more than one month after the surgery.

CONCLUSION

Our clinical findings align with to existing scientific literature on periprosthetic fractures (B1 and C according to Vancouver classification). Moreover, good stability has been guaranteed at the radiological follow up by Zimmer Biomet NCB-PP® and INTRAUMA DF distal femur and PFF proximal plates. The locking construct allows for improved stability especially in osteoporotic bone.

INTRODUCTION

Periprosthetic fractures (PFFs) represent a complex and challenging clinical entity within orthopedic surgery, posing significant hurdles in patient management and treatment strategies. The increasing prevalence of joint arthroplasties, coupled with an aging population, has elevated the incidence of PFFs, necessitating a nuanced understanding of their epidemiology and optimal therapeutic approaches.

The incidence of periprosthetic fractures is estimated to range from 0.1% to 4.1%.¹ Survivors of periprosthetic fractures often experience functional deterioration, facing a fourfold higher risk of hospitalization for postoperative complications compared to patients undergoing primary implantation, especially in the first postoperative year.² The majority of fractures occur, on average, 6 years after stem implantation.³

Numerous risk factors, including advanced age (>80 years), female gender, implant type, prior diagnoses of osteonecrosis and rheumatoid arthritis, revision surgery, aseptic stem mobilization, and the use of non-cemented stems, have been identified.⁴⁻⁶ Reports from the Swedish Hip Arthroplasty Register have shown that the survival of non-cemented total hip arthroplasty is lower than that of cemented implants, partly due to a higher incidence of early periprosthetic fractures.⁷

According to a meta-analysis by Jonathan N. Lamb et al. in 2022, encompassing 4841 patients over the last decade, the mortality of patients succumbing to periprosthetic fractures stands at 3% at 30 days (2.4% during hospitalization), 5% at 90 days, and 13% at one year post-fracture.^{8,9} The Vancouver classification is universally recognized as the most practical and reliable method for stratifying fractures with similar characteristics, leading to diverse therapeutic choices. This classification is based on the anatomical position of the fracture line in relation to the femoral stem, implant stability, and bone stock.

Vancouver type B1 and C are those around or distal to the stem with well-fixed implant. And osteosynthesis is the current treatment indication.

Angular stable plates facilitate optimal fixation of fracture fragments, particularly in severely osteoporotic bone. The operative challenge arises from the endocanal encumbrance of the stem, increasing the technical difficulty of screw placement when using monoaxial plates that allow only monocortical angular stable screw placement at the stem level, conventional screws or cerclage. As demonstrated by M. Lenz et al. in 2013¹⁰ all of these systems have sub-optimal mechanical characteristic compared to bicor-

tical screws. The aim of this study is to evaluate the outcome of treating well-fixed femoral stem fractures (B1 and C) with two different angular stable plate systems that allow bicortical fixation, even in the presence of a prosthetic stem, and to compare the effectiveness of the two systems.

We evaluated the outcome of Vancouver type B1 and C PFF in THR patients who were treated by these two osteosynthesis systems trying to offer insights that inform clinical decision-making and advance our comprehension to make recommendations for improvement of treatment algorithms.

MATERIALS AND METHODS

Between 2018 and 2022, at the Maggiore Hospitals in Bologna and the San Matteo Policlinic in Pavia, we performed osteosynthesis on 84 patients with periprosthetic fractures of Vancouver type B1 or C. In 38 patients, we employed angular stable plates with a polyaxial locking system, specifically the Zimmer Biomet NCB-PP® system, made by titanium. In 46 patients, we utilized INTRAUMA plates: DF distal femur and PFF proximal. The first 35 plates made by steel and the last 11 (starting from 2022) by titanium.

All periprosthetic femoral fractures were classified according to the Vancouver classification through anteroposterior (AP) and lateral x-rays, computed tomography (CT) and intraoperative assessment of stem stability. The study included only type B1 and C fractures, excluding Vancouver types A, B2, and B3.

Various patient parameters at the time of surgical intervention were collected, including the type of implant (endoprosthesis/arthroprosthesis), type of femoral stem fixation (cemented/uncemented), Vancouver Type, ASA score, duration of surgery, plate length, use of bone grafts, and the need for blood transfusion. Relevant postoperative follow-up outcomes considered included reintervention, infectious complications, radiographic healing, and functional recovery, with reference to changes in the Glasgow Outcome Scale (GOS) and the Harris Hip Score (HHS). Reasons for reintervention encompassed any cause, such as infection, hip dislocation, stem mobilization, synthesis device mobilization or rupture, and nonunion. Infections were categorized as deep or superficial, with deep infections requiring surgical treatment and superficial infections being treatable with antibiotic therapy and wound care. Additionally, immediate (within 48 hours) and delayed (beyond 1 month) mortality rates were calculated. The GOS was inversely calculated (1 = good recovery, 5 = death).

In all cases, the surgical technique involved open reduction and internal fixation (ORIF) through a direct lateral femoral approach, with no cases opting for a minimally invasive percutaneous osteosynthesis (MIPO) technique. All patients received perioperative antibiotic therapy according to the hospital protocol and thromboembolic prophylaxis. A preoperative fluoroscopic check ensured proper projections, and intraoperatively, the correct plate length was determined using the fluoroscopic guide to achieve at least ten cortices proximal and distal to the fracture.

All patients underwent clinical and radiographic evaluations during the follow-up period, averaging 28 months (range: 12-48 months), with a minimum follow-up duration of 12 months. The rehabilitation program was tailored based on bone quality and patient characteristics. Immediate recovery of hip and knee range of motion (ROM) was allowed in all cases, while weight-bearing restrictions were calibrated with a variability of 30 to 60 days (average 39.5 days).

The institutional review board of the involved hospitals decided that no ethical approval was necessary as it was thought that for this retrospective study named "Treatment of Periprosthetic Hip Fractures Vancouver B1 and C: The Significance of Bicortical Fixation. A Bicentric Study Comparing Two Osteosynthesis Systems" the informed consent of the patients was sufficient. Written informed consent was obtained from all subjects before the study.

RESULTS

The average age of the patients was 79 years (range: 55-98), with a preoperative ASA score averaging 2.2 (79% ASA 2, 21% ASA 3). There were 17 males (20%) and 67 females (80%). Fracture involved a cemented stem in 26% of cases (21 patients), uncemented stem in 74% (63 patients). Partial hip arthroplasty was involved in 15% of cases, and THA in 85%. One case involved a stage-one spacer, which was retained due to unsuitable conditions for definitive reimplantation, treating it as a primary implant.

Analyzing the data from our entire cohort (84 patients), the average time from trauma to surgery was 48 hours. Average surgical time: 160 minutes (range: 100-245). The most frequently used plate length was 9 holes (53%), followed by 12-hole plates in 30% of patients, 15-hole plates in 8.5%, and 18-hole plates in 8.5%. Permanent metal cerclages were placed in 78.9% of patients. In 3% of cases (2 patients), bone grafts were used due to poor bone stock quality.

Blood transfusions were required perioperatively and/or immediately postoperatively in 57.8% of patients, with an average transfusion of 2 units of packed red blood cells per patient (range: 0-4).

Regarding the rehabilitation program, the average complete weight-bearing restriction was 39.5 days (range: 30-60). The average latency for complete weight-bearing resumption was 72 days (range: 45-90).

12% of the patients in our cohort (10) were lost to follow-up after the initial check. 8 patients (10.7%) died: one

48 hours after the surgery, and the other 7 more than one month after the surgery.

Regarding the follow-up group that reached a 6-month period, 98.2% of patients had achieved complete healing. 67% of patients regained full range of motion in the hip and knee within the first 4 months of follow-up. Preoperative functional ability was mostly excellent, with a preoperative GOS of 1 in 77.8% of cases, and GOS 2 in 22.2% of patients. At the 4-month postoperative assessment, 71% of patients maintained their preoperative functional level, 19% experienced a 1-point GOS scale drop, and 10% died (GOS 5).

The average HHS at 4 months was 80.2 points (range: 65-90).

At the 6-month follow-up, 98.2% of patients achieved complete healing on radiographic examination. No fractures evolved with malalignment in terms of axial or rotational defects during healing. Only 1 patient (1.2%) developed a pseudoarthrosis site with synthesis device rupture.

Only 1 patient (1.2%) required additional surgical treatment 2 years later due to the development of an aseptic perisynthetic fluid collection, while the remaining 5 patients (6%) who developed complications benefited from conservative treatment:

4 patients (3.6%) with infectious complications were treated with intravenous antibiotics.

In the 2 patients (2.3%) with mobilization or rupture of synthesis devices, clinical and radiographic monitoring was opted for.

No significant differences were found between patients treated with plates alone and those requiring cerclages in terms of complication development.

No patient developed a refracture.

Only 1 case (1.2%), required reintervention.

DISCUSSION

The outcomes of our study on Vancouver B1 and C periprosthetic fractures treated with angular stable plates equipped with systems that facilitate bicortical fixation in every segment, reveal promising results. The cohort, consisting of 84 patients, demonstrated a successful rate of fracture healing, with 98.2% achieving complete radiographic healing at the 6-month follow-up. Reintervention rate, as indicated by the literature, was up to 52% with traditional systems in Vancouver type C fractures.¹¹ With monoaxial angular stable plates it dropped to around 21%¹² remaining high due to the difficulty in screw placement around the stem.

The use of plates enabling bicortical fixation, around femoral stem in PFF significantly contributes to reducing the reintervention rate provided that they have an anatomical design (pre-contoured plates), which match

the anatomy of the femur and a variable interlocking options facilitating screw fixation around the stem; extensions capturing the greater trochanteric region. Multidirectional screw placement which avoid obstacles as well as incorporation of wires/cables through the plate are others essential requirements to obtain good stability. Independently of the characteristic of the plates is also obvious that the surgeon has to overcome several challenges. Specif-

ically, obtaining adequate fixation proximally around the stem is a major concern. Bicortical fixation is biomechanically more stable, but if not possible, a combination of cerclage wires/cables (which offer mostly resistance to bending forces) with unicortical locking screws (that supplement with resistance to torsion and axial compression) should be used.¹³ It is recommended that an overlap between the stem and the plate should be superior to 4 cm and at least 6 cm in osteoporotic bone.¹⁴ Finally it is important to calculate the effective working length of a plate, which measure measure two to three times the width of the femur at the level of the fracture, to protect the plate from stress concentration and early fatigue failure and to promote callus formation.¹⁵

In our study sample (N + I), a complication rate of 7.1% was observed, of which only 1.2% required reintervention. The relatively low mortality rate of 9.5% is noteworthy in comparison to comparable cohorts showing 1-year mortality of 13%.

Regarding surgical technique, we employed an open approach with direct fracture reduction in all cases. Comparison with the literature did not reveal differences in complication rate compared to mini-invasive or mixed techniques.¹⁶ The use of cerclages did not increase the complication rate, consistent with recent literature. Some literature recommends using allograft to reduce nonunion rates.¹⁷ However, reported infection rates of up to 8.3% with additional allografts are 2.5 times the infection rate in our current study (3%). Therefore, the use of a single lateral polyaxial plate combining low infection rates (3%) with reasonable nonunion rates (1.7%) seems reasonable.¹⁸

Our study, like others, did not reveal a difference in outcomes after treating periprosthetic fractures on cemented or uncemented stems.¹⁹

The rehabilitation program, tailored to bone quality and patient characteristics, facilitated early weight-bearing resumption and a high percentage (67%) regained a level of ability similar to that before the fracture, contrary to values found in the literature for non-polyaxial systems, with an average of 52% of patients not recovering their previous functional level.²⁰

The average Harris Hip Score (HHS) at 4 months post-surgery was 80.2 points (range 65-90), 12 points higher than the literature for traditional or monoaxial systems.

The present study has several methodological strengths. Firstly, only Vancouver types B1 and C fractures were included. B1 classification was confirmed intraoperatively as suggested by Corten et al.²¹ and Pike et al.¹² Secondly the ratio between males and females, cemented and uncemented stems, and the median age of the population is comparable to that reported in other studies on PFFs. The weak points of this study are retrospective study design, high dropout rate and limited sample number.

CONCLUSION

Our clinical findings align with to existing scientific literature on periprosthetic fractures (B1 and C according to Vancouver classification). Moreover, good stability has been guaranteed at the radiological follow up by Zimmer Biomet

NCB-PP® and INTRAUMA DF distal femur and PFF proximal plates. The locking construct allows for improved stability especially in osteoporotic bone.

Table 1. Complications observed in our study

1 case of early infection with exposed plate, treated conservatively due to the patient's deteriorating clinical conditions, posing a high anesthetic risk;

1 case of aseptic loosening involving two screws in a fully asymptomatic patient after complete fracture healing not necessitating surgery;

1 case of synthesis device rupture at a pseudoarthrosis site, not subjected to surgical revision due to the patient's low functional demands;

1 case of fluid collection development 2 years post-surgery, found to be aseptic and surgically evacuated, resolving completely without further issues;

1 case of deep infection with fistulization, occurring in the only patient undergoing osteosynthesis for a Stage-One spacer stem, treated conservatively with antibiotic therapy

1 case of superficial infection with delayed wound healing, treated with antibiotic therapy, resulting in complete resolution.

DISCLOSURES

Enrico Ferranti Calderoni, Alex Pizzo, Giuseppe Melucci, Margherita Ghilotti, Alberto Castelli and Gianluigi Pasta worked on acquisition, analysis, or interpretation of data while Domenico Tigani and Eugenio Jannelli approved the final version to be published, after drafting the work or reviewing it critically for important intellectual content. The institutional review board of the involved hospitals decided that no ethical approval was necessary as it was thought that for this retrospective study named "Treatment of Periprosthetic Hip Fractures Vancouver B1 and C: The Significance of Bicortical Fixation. A Bicentric Study Comparing Two Osteosynthesis Systems" the informed consent of the patients was sufficient. Written informed consent was obtained from all subjects before the study.

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Table 2. Comparison between Zimmer Biomet NCB-PP® system (N) and INTRAUMA DF distal femur and PFF proximal plates system (I). No statistically significant differences have been found.

	HHS AT 4 MONTHS	1 POINT GOS REDUCTION	FRACTURE HEALING	COMPLICAZION	ONE YEAR MORTALITY
N	80,1	17%	4 MONTHS	2 INFECTIVE 1 NON INFECTIVE 1 REINTERVENTION	10,7%
I	80,3	21%	4 MONTHS	1 INFECTIVE 2 MECHANIQUE 0 REINTERVENTION	8,7%

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