Injury

Osteosynthesis in Vancouver type B1 periprosthetic fractures

--Manuscript Draft--

Manuscript Number:	JINJ-D-20-03063R1
Article Type:	SECOT Supplement 2021
Keywords:	periprosthetic hip fracture; osteosynthesis; bridge plate; locking compression plate
Corresponding Author:	Adrián Roche Albero, Ph.D., M.D. Hospital Universitario Miguel Servet Zaragoza, SPAIN
First Author:	Adrián Roche-Albero, Ph.D., M.D.
Order of Authors:	Adrián Roche-Albero, Ph.D., M.D.
	Jesús Mateo-Agudo
	Carlos Martín-Hernández
	María Arnaudas-Casanueva
	Jorge Gil-Albarova
Abstract:	Introduction The incidence of hip periprosthetic fractures has been increasing in recent years. In Vancouver type B1 there are several osteosynthesis options: short locking-compression plates, locking compression plates, long plates with variable angle locking-screws, and autograft contribution. The aim of this paper is to assess both the treatment and results of Vancouver type B1 periprosthetic fractures in patients operated at our centre. Material and Method An observational retrospective study of patients operated at Hospital Universitario Miguel Servet for type B1 periprosthetic fracture via osteosynthesis with plate between January 2014 and March 2017. Finally, 37 patients with a minimum 2 year follow-up were included. The following were used for fracture synthesis: the Cable-Ready ® plate(Zimmer–Biomet), Dall-Miles ® plate (Stryker) and femur NCB ® plate (Zimmer-Biomet). Functional outcome was assessed in terms of the Harris Hip Score. Results The average age of the sample was 80.7 (54-99), and included 21 women and 16 men. 8 of these patients died, with an average age of 85.6 (83-95). Out of these 8 dead patients, 4 died in the first year, with an average age of 87 (83-95). According to prosthesis type, 8 cases had a cemented partial arthroplasty, with an average period of 2.5 years (0.2-5.6) until periprosthetic fracture. 11 cases had a cemented total hip arthroplasty with an average period of 7 years (0.09-18.1) until fracture onset; non-cemented in 18 cases, with an average period of 8.1 years (2.6-12.7) until periprosthetic fracture. The mean Harris Hip Score postoperatively was 65 (44–95). Discussion Treatment via open reduction and internal fixation with locked lateral plate covering most of the femur in elderly patients or those with poor bone quality, or a plate with proximal cerclages and distal screws in patients with better bone quality are appropriate treatment methods. To achieve good results using these techniques, we consider minimisation of soft tissue dissection highly important likewise using a meticulous osteosynthesis technique with special attention to biology and biomechanics.
Suggested Reviewers:	

Dear Editor,

I would like to present the original article 'Osteosynthesis of Vancouver type B1 periprosthetic fractures' co-authored with Mateo-Agudo J, Martín-Hernández C, Aranudas-Casanueva M, Gil-Albarova J, for publication in *Injury, International Journal of the Care of the Injured*.

Today, periprosthetic hip fractures are scarce; yet their incidence has been on the increase in recent years, moreover it is expected to continue increasing in the short-term. In Vancouver type B1 there are several osteosynthesis options: short locking plates, locking compression plates, long plates with variable angle locking screws, autograft contribution and even a spare prosthetic rod.

There are few articles in literature showing clinical results regarding the treatment of these fractures; moreover, the series contain few cases. It is important for reference centres specialised in treating complex fractures to present the treatment options used likewise our results to enable meta-analysis and facilitate the generation of scientific evidence.

The purpose of this study is to analyse our experience in treating Vancouver type B1 periprosthetic fractures.

We are presenting an observational retrospective study of patients operated on at Hospital Universitario Miguel Servet for type B1 periprosthetic fracture via osteosynthesis with plate between January 2014 and March 2017. Finally, 37 patients with a minimum 2 year follow-up were included.

We demonstrate treatment via open reduction and internal fixation with locked lateral plate covering most of the femur in elderly patients or those with poor bone quality, or a plate with proximal cerclages and distal screws in patients with better bone quality are appropriate treatment methods. To achieve good results using these techniques, we consider minimisation of soft tissue dissection highly important likewise using a meticulous osteosynthesis technique with special attention to biology and biomechanics.

The authors state this manuscript has never been published either partially or wholly, nor is it being considered by any other journal. In addition, the authors have taken into account the ethical responsibilities in the *Injury, International Journal of the Care of the Injured* regulations. The procedures undertaken in this research are pursuant to the ethics principles of the regional animal and human experimentation committee likewise those of the World Medical Association and Declaration of Helsinki, which guarantee patients' rights to confidentiality and privacy pursuant to that set forth in the section corresponding to said principles. Furthermore, the article has avoided any kind of identification data in both texts and images.

The authors hereby state they have not received funds from any institution, moreover, they confirm they meet authorship requisites, and state there is no conflict of interest.

We have read and understood your journal policies, and consider neither our manuscript nor study infringe any of them.

Thanking you for your consideration.

Yours faithfully,

Adrián Roche-Albero

Hospital Universitario Miguel Servet. Aragon Institute for Health Research (IIS Aragon)

Paseo Isabel la Católica 1‑3, 50009 Zaragoza, Spain

Phone number +34 654071870

adrianroche@hotmail.com

MANUSCRIPT TITLE PAGE

Title: Osteosynthesis in Vancouver type B1 periprosthetic fractures

Authors:
Adrián Roche-Albero [a, b, c].
Jesús Mateo-Agudo [a, b]
Carlos Martín-Hernández [a, b, c]
María Arnaudas Casanueva [a]
Jorge Gil-Albarova [a, b]

a: Servicio de Cirugía Ortopédica y Traumatología, Hospital Universitario Miguel Servet, Zaragoza, Spain
b: Departamento de Cirugía de la Facultad de Medicina de la Universidad de Zaragoza, Spain
c: Institute for Health Research Aragón, Zaragoza, Spain

Corresponding author:
Roche-Albero, Adrián
Email: adrianroche@hotmail.com
Address:
Servicio de Cirugía Ortopédica y Traumatología
Paseo Isabel la Católica, 1-3
50.009 Zaragoza (Spain)

Co-autohors:

- Mateo Agudo, Jesús
  Email: jjmateo@comz.org
  Address:
  Hospital Universitario Miguel Servet. Servicio de Cirugía Ortopédica y Traumatología
  Paseo Isabel la Católica, 1-3
  50.009 Zaragoza (Spain)
- Martín Hernández, Carlos
  Email: cmartinh@me.com
  Address:
  Hospital Universitario Miguel Servet. Servicio de Cirugía Ortopédica y Traumatología
  Paseo Isabel la Católica, 1-3
  50.009 Zaragoza (Spain)
- Arnaudas Casanueva, María
  Email: maria.arnaudas@gmail.com
  Address:
  Hospital Universitario Miguel Servet. Servicio de Cirugía Ortopédica y Traumatología
  Paseo Isabel la Católica, 1-3
  50.009 Zaragoza (Spain)

- Gil Albarova, Jorge
  Email: jgilalba@unizar.es
  Address:
  Hospital Universitario Miguel Servet. Servicio de Cirugía Ortopédica y Traumatología
  Paseo Isabel la Católica, 1-3
  50.009 Zaragoza (Spain)

ORCID:
Roche Albero, Adrián: 0000-0001-7441-8731
Jesús Mateo Agudo: 0000-0002-8289-791X
Martín Hernández, Carlos: 0000-0002-0858-0340
María Arnaudas Casanueva: 0000-0002-5882-8316
Jorge Gil-Albarova: 0000-0002-1563-9136

CONFLICT OF INTERESTS

On behalf of all authors, the corresponding author states that there is no conflict of interest.

HIGHLIGHTS

- Treatment via open reduction and internal fixation with locked lateral plate covering most of the femur in elderly patients or those with poor bone quality, or a plate with proximal cerclages and distal screws in patients with better bone quality are appropriate treatment methods in Vancouver type B1 periprosthetic fractures.

- To achieve good results using these techniques, we consider minimisation of soft tissue dissection highly important likewise using a meticulous osteosynthesis technique with special attention to biology and biomechanics.

SUPPLEMENT STATEMENT

This paper is part of a supplement supported by The Orthopaedic Surgery and Traumatology Spanish Society (SECOT)

Table 1. Demographic data of patients operated on for B1 type fractures and reasons for prosthesis implantation.

N	Gender	Age	TKP [a]	Type	Cemented Rod	Nº of previous Surgeries[b]	Time [c]	Prosthesis Aetiology
1	F	82	NO	PHA	YES	2	1.1	CUT OUT CMN
2	F	85	NO	PHA	YES	1	5.6	FRACTURE
3	F	95	NO	PHA	YES	1	2.1	FRACTURE
4	F	78	NO	PHA	YES	1	0.2	FRACTURE
5	F	79	YES	PHA	YES	1	2.7	FRACTURE
6	F	99	NO	PHA	YES	1	2.5	FRACTURE
7	F	80	NO	THA	YES	2	18.1	COXARTHROSIS
8	F	83	NO	THA	YES	1	7.8	COXARTHROSIS
9	M	87	NO	THA	YES	1	9.6	FRACTURE
10	F	85	NO	THA	YES	1	4.0	FRACTURE
11	M	85	NO	THA	YES	1	0.8	COXARTHROSIS
12	F	66	NO	THA	YES	1	0.09	FRACTURE
13	F	83	NO	THA	YES	2	5.5	COXARTHROSIS
14	F	83	NO	THA	NO	1	11.7	COXARTHROSIS
15	F	77	NO	THA	NO	2	4.3	COXARTHROSIS
16	F	84	NO	THA	NO	1	8.1	FRACTURE
17	M	60	NO	THA	NO	1	5.5	COXARTHROSIS
18	M	81	NO	THA	NO	1	12.7	COXARTHROSIS
19	M	89	NO	THA	NO	1	2.6	FRACTURE
20	M	79	NO	THA	NO	1	8.7	FRACTURE
21	F	77	NO	THA	NO	1	5.0	COXARTHROSIS
22	F	87	NO	THA	NO	1	9.3	COXARTHROSIS
23	M	82	NO	THA	NO	1	4.6	COXARTHROSIS
24	M	57	YES	THA	NO	1	11.2	COXARTHROSIS
25	M	54	NO	THA	NO	1	6.1	AVNFH
26	M	86	NO	THA	NO	1	7.5	COXARTHROSIS
27	M	81	NO	THA	NO	1	7.6	COXARTHROSIS
28	F	85	NO	PHA	YES	1	5.2	FRACTURE
29	F	78	NO	PHA	YES	1	0.6	FRACTURE
30	M	87	NO	THA	YES	1	9.9	FRACTURE
31	F	80	NO	THA	YES	1	16.2	COXARTHROSIS
32	M	85	NO	THA	YES	1	1.2	COXARTHROSIS
33	M	79	NO	THA	NO	1	8.9	FRACTURE
34	F	85	NO	THA	YES	1	3.9	FRACTURE
35	F	83	NO	THA	NO	1	12.5	COXARTHROSIS

36	M	80	NO	THA	NO	1	9.1	FRACTURE
37	M	81	NO	THA	NO	1	9.7	COXARTHROSIS

M: Male. F: Female. PHA: Partial Hip Arthroplasty. TPA: Total Hip Arthroplasty. CMN: Central Medullary Nailing. AVNFH: Avascular necrosis of femoral head.

[a]Total ipsilateral knee arthroplasts.

[b]Number of femoral surgeries prior to periprosthetic fracture.

[C]Nº of years from prosthesis to periprosthetic fracture

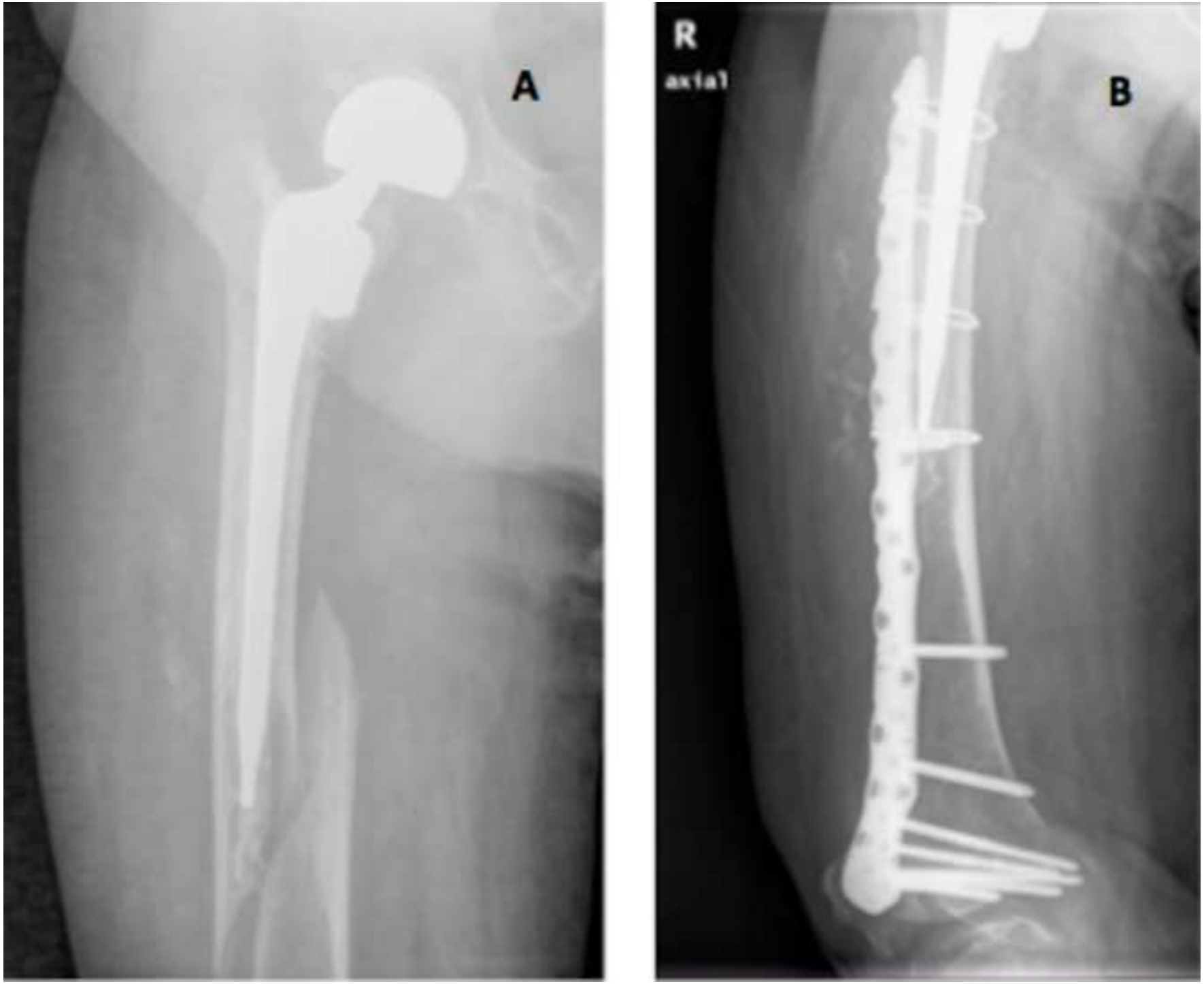
Figure 2. A: Vancouver B1 periprosthetic fracture. B. X-ray at 8 weeks. Long plate covering the entire femur was used. Fracture was compressed with 2 cerclages placed in the rod area and screws locked to the rest of the femur.

Figure 1. *Male patient aged 86 with total left hip prosthesis. (A-B) Antero-posterior-axial images of periprosthetic fracture around prosthesis rod without osteolysis or signs of loosening. (C-D) Images taken day after surgery, where you can objectify osteosynthesis via the Cable Ready hook plate type with cerclages at height of trochanters with rod and bi-cortical screws distal to implant. (E-F) Projections obtained at 12 months of intervention, where you can appreciate signs of consolidation and fracture, likewise a maintained reduction. This patient was prescribed bone formation drugs on hospital discharge.*

Figure 1

Click here to access/download;Figure;11 Figure 1.jpg

Figure 2



Osteosynthesis in Vancouver type B1 periprosthetic fractures

ABSTRACT

Introduction

The incidence of hip periprosthetic fractures has been increasing in recent years. In Vancouver type B1 there are several osteosynthesis options: short locking-compression plates, locking compression plates, long plates with variable angle locking-screws, and autograft contribution. The aim of this paper is to assess both the treatment and results of Vancouver type B1 periprosthetic fractures in patients operated at our centre.

Material and Method

An observational retrospective study of patients operated at Hospital Universitario Miguel Servet for type B1 periprosthetic fracture via osteosynthesis with plate between January 2014 and March 2017. Finally, 37 patients with a minimum 2 year follow-up were included. The following were used for fracture synthesis: the Cable-Ready® plate (Zimmer–Biomet), Dall-Miles® plate (Stryker) and femur NCB® plate (Zimmer-Biomet). Functional outcome was assessed in terms of the Harris Hip Score.

Results

The average age of the sample was 80.7 (54-99), and included 21 women and 16 men. 8 of these patients died, with an average age of 85.6 (83-95). Out of these 8 dead patients, 4 died in the first year, with an average age of 87 (83-95). According to prosthesis type, 8 cases had a cemented partial arthroplasty, with an average period of 2.5 years (0.2-5.6) until periprosthetic fracture. 11 cases had a cemented total hip arthroplasty with an average period of 7 years (0.09-18.1) until fracture onset; non-cemented in 18 cases, with an average period of 8.1 years (2.6-12.7) until periprosthetic fracture. The mean Harris Hip Score postoperatively was 65 (44–95).

Discussion

Treatment via open reduction and internal fixation with locked lateral plate covering most of the femur in elderly patients or those with poor bone quality, or a plate with proximal cerclages and distal screws in patients with better bone quality are appropriate treatment methods. To achieve good results using these techniques, we consider minimisation of soft tissue dissection highly important likewise using a meticulous osteosynthesis technique with special attention to biology and biomechanics.

Keywords

Periprosthetic hip fracture, osteosynthesis, bridge plate, locking compression plate

1. INTRODUCTION

Periprosthetic hip fracture is a rare pathology, estimated at having an accrued 5% incidence between 15 and 20 years after the primary prosthesis [1]. Its incidence has been increasing in recent years due to the increase in life expectancy and prosthetic treatment indications leading to a significative increase in the number of primary hip joint replacements [2-4].

Among the risk factors some are intrinsic due to diminishment in bone quality; and standing out among these are: advanced age (2.9 times more common in those over 70) [5], female, low weight (means lower biomechanical demand on bone), toxic habits, certain drugs, previous osteoporotic fracture, rheumatism and unstable gait. There is also a series of surgery derived factors which debilitate the femur, such as incorrect prosthesis implant technique, prosthesis type, non-cemented, incorrect cementing and revision surgery [6].

The Vancouver classification developed by Duncan and Masri [7] in 1995 is used to describe these fractures. This classification system uses X-rays to stratify fractures as per fracture location, implant stability and bone reserve quality. The fractures are classified type A, B or C depending on fracture location on the femur. B type fractures which occur around the rod or distally to the same are subdivided into B1 fractures involving a stable rod, B2 fractures where implant has loosened although bone reserve is correct and B3 fractures where the implant has loosened with little bone remaining. The key difference between Vancouver classification subtypes B1 and B2 lies in the implant stability conditioning treatment via osteosynthesis or revision of the femoral component.

Periprosthetic fractures in themselves are a complication of a previous procedure, thus fracture treatment is subject to the problems inherent in a re-intervention. This type of fracture has traditionally suffered torpid evolution complicated by: haemorrhaging, premature dislocation, pseudoarthrosis, infection of surgical site or septicaemia, deep vein thrombosis, cardiorespiratory disease and even death; therefore, as recommended by several authors, use of the correct technique is necessary coupled with special attention to soft tissue care likewise respecting patient’s biology [8, 9].

Today, the delay in consolidation or pseudoarthrosis is the most frequent cause of treatment failure. The predisposing factors for assessment are: prior bone quality, associated comorbidity, taking corticoids and also fracture type. Cementation does not appear to influence this aspect. Generally speaking, pseudoarthrosis percentage is higher for fractures treated with osteosynthesis than in those with revision of components and those where an allograft was used as opposed to those which were not [8, 10, 11].

There are several options in osteosynthesis selection, i.e. locking compression plates [12, 13], or long plates with variable angle locking screws avoiding use of cerclages in subjects with poor bone quality [9, 14-16].

In patients with periprosthetic fracture and associated bone fragility are advised to take fall preventing measures, control concomitant diseases and toxic habits, besides correcting nutritional deficiencies particularly vitamin D levels. None of the drugs used to treat osteoporosis include stability improvement of implants in their indications; nevertheless, several papers have underlined the use of these drugs might reduce osteolysis, by improving bone consistency around the prosthesis [17,18].

The purpose of this study is to assess the treatment and results of Vancouver type B1 periprosthetic fractures in patients operated at our centre.

2. MATERIAL AND METHOD

An observational retrospective study of patients operated at Hospital Universitario Miguel Servet for type B1 periprosthetic fracture via osteosynthesis with plate between January 2014 and March 2017.

All patients with periprosthetic hip fractures operated on at our unit during the study period were included resulting in 53 subjects altogether. Out of this group of patients we excluded fractures affecting the trochanteric mass (type A), fractures distal to rod (type C), those where the implant was unstable (types B2 and B3), those initially classified as B1 where the rod was found loose during surgery and intra-operational periprosthetic fractures. We also excluded B1 fractures requiring replacement of a prosthetic component (cotyloid cup, head, or polyethylene) for reasons unrelated to the fracture, like wear and tear of the friction torque or loosening of the acetabulum. Thus, the final study sample included a total of 37 patients with minimum 2 year follow-up.

All patients were attended during their hospital stay by the same multidiscipline team comprising members from the: Orthopaedic Surgery & Traumatology, Anaesthesiology, Internal Medicine and Geriatrics departments, as well as social workers and occupational therapists.

Femoral implant stability was determined by absence of X-ray signs of loosening and in some cases via computerised axial tomography.

Surgery was scheduled during usual working hours (Monday to Friday). We used the same surgical technique in all cases, i.e. patient lying on his/her side, a posterolateral approach to the femur was made, accessing via the fasciae latae and vastus lateralis. Special attention was made to limit the vastus lateralis approach as much as possible to maintain blood supply and facilitate consolidation. The stability of the hip implant and the cemented mantle integrity was evaluated intra-operatively by performing a mobilization test of the involved femoral stem by using a farabeuf or a lambotte clamp. For fracture synthesis we used the Cable-Ready® (Zimmer Inc., Warsaw, IN, USA) plate, the Dall-Miles® (Stryker Corporation, Kalamazoo, MI, USA) plate or the femur NCB® (Zimmer Inc., Warsaw, IN, USA) plate. We release the insertions at the trochanter tip to correctly adjust the plate hook over it ensuring an assistant maintains pressure on the axis to adjust the plate to this level until the fracture is fixed. The two proximal cerclages of the hooking plates require an oblique direction and pass distally to the lesser trochanter. From these we only routinely place the distal one, reserving the proximal one for cases where there is a fracture in the greater trochanter requiring fixation since the direction of the force exerted on the bone favours distraction from the fracture point instead of the compression sought. The order in which the cerclages are tensed and locked is important. Firstly, we lock the oblique proximal cerclage keeping the plate joined to the greater trochanter and exerting axial force. If this tensile strength is performed with the plate fixed to the distal fracture fragment, the direction of this oblique cerclage may cause undesired distraction on the fracture point. After inserting a screw in the distal fragment prior compression of the spot using reduction clamps and remembering to maintain axial

pressure on the plate at trochanter tip level. In the femoral areas unoccupied by the femoral rod or cements, we prefer to insert screws. Intra-operational radioscopic control performed to confirm correct fracture reduction and correct positioning of osteosynthesis material. When closing, we meticulously reinsert the insertions released on the trochanter tip passing the sutures through the plate. Infection prophylaxis was administered to all patients intravenously with Cefazolin 2 g or Teicoplanin 600 mg in the event of allergy 30 minutes prior to surgery. Post-operation all patients were administered thromboembolic disorder prophylaxis with low-molecular weight heparin in a single weight-adjusted dose (Enoxaparina, Clexane®, Sanofi-Aventis, Barcelona, Spain). The physiotherapist taught patients immediately post-operation: muscle-strengthening exercises, improving mobility range, and partial weight load with the aid of crutches or walking frame. During 4 weeks only partial load was allowed with subsequent progressive weight load. Total load and autonomous movement were allowed once consolidation had been radiographically observed as dictated by the orthopaedic surgeon who performed the medical check-up in the medical record.

For each patient we recorded: demographic variables (age and gender), prosthesis implant date and time lapse until fracture, prosthesis type (partial or total and whether cemented or not), aetiology (coxarthrosis, fracture, avascular necrosis of the femoral head or osteosynthetic failure of a previous nailing), association or not of ipsilateral knee prosthesis, treatment received until radiographic consolidation, surgical complications and mortality. To determine the time until radiographic consolidation, X-rays taken during follow-up were assessed, considering it present when bone bridges were objectified between the cortexes on the 2 orthogonal radiographic projections. Harris Hip Score (HHS) was used to evaluate the functional outcome [19]. Where patients were unable to attend the hospital for follow-up due to frailty, then HHS was assessed via a telephone interview.

3. RESULTS

53 periprosthetic hip fractures were intervened at Hospital Miguel Servet. According to Vancouver classification, 3 cases were classified type A, 40 as type B1 and 5 as type C. Three fractures initially classified as B1 were excluded from the study due to instability during the surgery. In the end, the study included a total of 37 subjects who met the inclusion criteria.

The average age of patients at time of fracture onset was 80.7 (54-99), moreover 21 women and 16 men were included. Out of these, 8 had died, with an average age of 85.6 (83-95). Out of these 8 dead patients, 4 died in the first year, with an average age of 87 (83-95).

Most of the patients had had only one hip operation prior to the periprosthetic fracture, for the hip prosthesis implant. Out of those requiring intervention between prosthesis implant and fracture, in the former (N 7) cotyloid replacement was required and in the latter (N 13) a dislocation requiring reduction, associated with femoral component replacement and in the third (N 15) there was an osteosynthesised periprosthetic fracture with subsequent plate breakage. One patient (N 1) had undergone surgery prior to hip prosthesis implantation, consisting of nailing cervical diaphysis due to intertrochanteric fracture requiring conversion to prosthesis due to cephalic screw extrusion.

Regarding the primary prosthesis type implanted, 8 cases had a cemented partial arthroplasty with a mean time to periprosthetic fracture of 2.5 years (0.2-5.6). 11 cases had a cemented total arthroplasty with mean time to fracture onset of 7 years (0.09-18.1), and non-cemented in 18 cases, with a mean time to periprosthetic fracture of 8.1 years (2.6-12.7). In 2 patients we observed the existence of an inter-prosthetic fracture, i.e. with the presence of an ipsilateral knee prosthesis, with fracture occurring 2.7 and 11.2 years after the primary hip arthroplasty (table 1).

On studying the pathologies which led to replacement of the primary joint, we observed 18 cases of coxarthrosis (48.6%), 17 intracapsular femoral fractures (45.9%), 1 case of centromedullary nailing failure (2.7%) and 1 case of avascular necrosis of femoral head (2.7%).

With regard to complications (table 2), we observed 5 cases of acute superficial infection of surgical wound, which were resolved with debridement, lavage and antibiotic treatment without implant removal. There was a case of chronic infection treated with antibiotic suppression (N8). 7 patients required intra-operational blood transfusion due to blood loss. 5 cases of pressure ulcers (4 sacral, 1 heel) were detected. No pseudoarthrosis or loss of reduction cases requiring osteosynthesis surgery observed. Moreover there were no cases of: prosthesis dislocation, loss of fracture reduction or breakage of osteosynthesis plate.

On analysing simple X-rays taken during follow-up and medical record notes, a mean time to fracture consolidation was calculated at 10.35 weeks. Only 19 patients were able to complete the HHS at the time of follow-up due to poor health status. In this group, the mean HHS postoperatively at the most recent follow-up visit was 65 (range 44–95), with a poor outcome (HHS < 70) in 68.4% of the patients.

Regarding post-surgery treatment, we only observed prescription of anti-osteoporosis drugs in 6 cases. Denosumab was prescribed in 4 cases and Teriparatide in 2 cases. In this sub-group of patients treated with anti-osteoporosis drugs, the mean time to consolidation was 9.3 weeks.

DISCUSSION

We show the results of Vancouver type B1 periprosthetic fracture treatment via osteosynthesis. A limited posterolateral approach was used paying attention to the meticulous handling of the soft tissues to cause the least possible injury at muscle and periosteal level. We used cerclages taking maximum care with the soft tissues in the area of the prosthetic rod and screws using percutaneous technique in those areas with free medullary canal. Thanks to current techniques, a surgeon experienced in fractures is capable of inserting cerclages with limited approaches. We perform anatomical reduction directly and interfragmentary compression where possible. Fracture consolidation was achieved with few complications in all cases. Neither allografts nor extensive approaches altering biology and without improving results were used.

High rates of loosening, re-fracture and lack of union requiring re-intervention have been described in fractures B1 [3]. Given these findings, it has been suggested some B1 fractures are in fact B2 with loosened rod, which was not recognised and the prosthesis should be considered mobilised until proven otherwise [20]. Lee & Cols [21] studied the reliability of the Vancouver classification, concluding it was low in the case of non-cemented rods. They pointed out radiographic assessment alone may be inappropriate to determine non-cemented rod stability in femoral periprosthetic fractures. However, Quah & Cols [22] considered classic algorithms based on Vancouver classification of periprosthetic fractures should take into account the specific characteristics of conical rods. We did not find any loosening or complications derived from incorrect treatment of a B2 fracture via osteosynthesis without replacement in our study. Fractures classified as B1, but during the intervention revealed a loose rod, were treated with osteosynthesis and revision of components; and were not included in this study, which centred on the study of B1 fractures confirmed after surgical treatment. We believe you cannot be absolutely certain of rod stability with just an X-ray, which is why we always have the material necessary to replace components should we find the rod loose during surgery. We do not dislocate the prosthesis routinely to check stability of prosthetic rod. We study the fracture X-rays, comparing them with previous ones, researching the loosening symptoms prior to the trauma causing the fracture; and during surgery we assess rod stability via the fracture line; moreover, we use a dynamic imaging intensifier where necessary. We consider routine dislocation of a prosthesis to assess rod stability causes serious aggression to the soft tissues, besides increasing the risk of post-surgery prosthetic instability. There were no prosthetic dislocations in our series during follow-up, which we believe is thanks to the fact we did not approach the joint to treat these fractures. Moreta et al in similarly elderly populations have found a mean HHS of 67.9 [17]. We have confirmed this low score with a mean value of 65 , but only 51.3% of patients were able to complete this questionnaire at the most recent follow-up.

Different risk factors associated with periprosthetic fractures have been described including: non-cemented primary rods, the presence of inflammatory arthropathy and revision surgery [3]. It is worth highlighting the fact that in 4 cases hip re-interventions were performed prior to the fracture for other reasons. The alteration of vascularisation due to repeated surgeries may favour femur weakening thereby increasing the risk of periprosthetic fracture. Periprosthetic fractures on non-cemented total arthroplasties predominate in comparison to the cemented. In the case of partial prostheses, the mean

time of periprosthetic fracture onset is considerably shorter than the rest, this is because they are implanted in elderly patients with greater risk of falls and little functional demand who are more inclined to suffer from osteoporosis. Thus, periprosthetic fracture in a shorter space of time may arise due to poor bone stock, biomechanical alteration and areas of stress generated by the implant. While the efficacy of anti-osteoporosis drugs has not been proven to prevent periprosthetic fractures, like Yamaguchi et al. [18], we believe the prescription of bone antiresorptive or formation drugs in patients with primary hip arthroplasty and low bone mineral density, should be considered if associated with other osteoporotic fractures [3,18]. Some studies have established the presence of osteopenia in 38% of patients with periprosthetic hip fracture [17].

Frequently, patients who suffer a periprosthetic hip fracture never recover the health or functional capacity they had prior due to the fracture itself, surgical aggression and complications arising during the process (pressure ulcers, infections, pseudoarthrosis, implant loosening, etc.). This quality of life deterioration also depends on the patient's basal characteristics and fracture complexity; therefore, we believe it necessary to pay special attention to and care for these patients throughout the process, starting by respecting soft tissue during the intervention likewise correct multidiscipline management during hospital stay and with a view to discharge. Our patients are systematically included in a critical assistance programme on admission for patients with hip fractures, consisting of orthopaedic surgeons, a specific team of internists and anaesthetists, likewise a team of nurses, auxiliaries and specific physiotherapists. Specific multidiscipline units have been proven efficient in delaying surgical intervention and preventing onset of some medical complications [23].

Generally speaking, the death rate of patients with hip or knee periprosthetic fracture in the first year is between 13 and 17% [2], very similar to that of patients with osteoporotic hip fracture yet significatively greater than reported for an elective primary hip arthroplasty, which is around 2.9%. Using these percentages, the mortality rate in year one found in our sample would be slightly lower than average (3 cases). It should be highlighted all the deaths during this period presented a local post-operation complication derived from bed-rest or surgery itself.

Osteosynthesis was performed using a posterolateral approach. In all cases, non-traumatic soft tissue management was used to minimise muscle and periosteal aggression, likewise performing direct anatomical reduction and interfragmentary compression where possible. We consider the surgical technique essential to achieve satisfactory results, looking after tissue biology, where possible avoiding large dissections traditionally used for allograft application [9]. Haddad et al. [10] achieved consolidation in 39 out of 40 fractures treated with cortical allografts with or without plate; however, they found 4 defective consolidations and a deep infection. Extensive femoral exposure negatively affects blood perfusion in the fracture area, moreover, the structural allograft although initially providing stability becomes weakened 4-6 after the incorporation process. Should fracture fusion be delayed longer in time, the structural allograft integrity may be compromised prior to fracture fusion [8]. We are against using allografts in this type of fracture.

We used locking compression plates most frequently for osteosynthesis. None of the patients had to be re-intervened due to pseudoarthrosis, refracture or other more serious complications, which corresponds to the results observed by Dehghan et al. [3], suggesting that apart from the fixation type used, B1 type fractures have a higher fusion rate (95%) and 15% complications.

Fixation with locking compression plates is a common surgical technique. Venu et al [12] and Tsiridis et al [13] show a re-intervention rate of 23% and 33% respectively in patients with this kind of fracture treated with Dall-Miles cable plates with or without allograft. However, Ricci et al [11] reported successful healing and no pseudoarthrosis cases in 50 Vancouver Type B1 periprosthetic fractures treated via reduction and indirect fixation using a locking compression plate without allograft. Our results are closer to those of this latter author, probably due to the soft tissue care employed.

The current trend for treating fractures in elderly patients is the use of a long lateral compression plate covering most of the femur. This plate provides additional strength along the femur reducing the risk of future fractures around the implant, often occurring in these patients secondary to osteopenia [9. 15]. Our series had no cases of femur fractures distal to the osteosynthesis plate. Some authors [14] recommend using fixed angle plates with locking screws covering most of the femur for Vancouver types B1 and C fractures with poor bone quality. Plates with locking screws provide sufficient resistance to maintain plate position in the femoral rod area, eliminating the need for additional stability via cables or cerclage wires. This system used as the sole stabilisation method appears to neutralise flex-extension, varus-valgus and torsional forces [16]. We have had no cases with fracture distal to the osteosynthesis plate inserted due to periprosthetic fracture. The use of long plates covering most of the femur is becoming generalised, and in our current clinical practice we often adopt this principle. However, in the sample studied, with good results using more limited plate lengths, we had no osteosynthesis material failures or fractures around the implant. We used long plates although we did not always cover the distal femur. In this population, with low functional demand and advanced age, we believe it is important to use long plates; although it is not necessary to reach the femoral distal metaphysis. Some authors [20] mention complications in treating type B1 fractures with plate alone and recommend using allografts. Our results contradict their conclusions, and in our opinion, current osteosynthesis concepts coupled with materials and techniques which minimise tissue damage, admit the use of osteosynthesis with good results.

Osteosynthesis with plate in these fractures is technically demanding and should be performed by an experienced surgeon. Long spiral fractures or complex fracture patterns present low stress at fracture level and can be successfully treated with a bridging plate technique. Simple fractures with two fragments with little contact surface in the fracture (oblique, short and transversal), which frequently occur near the tip of the femoral rod produce high stress at the spot requiring fixation with absolute stability. In these cases, some authors [22] replacing with longer revision exceeding the fracture spot by two femoral diameters minimum and at least a 5 cm diaphysis adjustment, which in practice acts biomechanically like an intramedullary nail. We prefer to achieve absolute stability via anatomical reduction of fragments and fixation with a traction screw or cerclage and an added neutralisation plate or using a plate in compression mode with correct eccentric screw placement to apply correct compression force. Locking screws are used to strengthen the assembly once absolute stability has been reached. Cerclages can be used in those areas with the medullary canal occupied by the prosthetic rod or cement; however, in these cases it is important to use a meticulous surgical technique employ minimally invasive manoeuvrability techniques to reduce soft tissue aggression. Correct usage of the dynamometer system is important when applying the cerclage tension to prevent exerting excessive pressure which may damage the femoral cortex. We had no cases of cortical damage in our series due to excessive cerclage tension (figure 1).

Bridging plates without absolute stability of the fracture sport enable micro-movements on the plate, frequently on a short segment with high stress and possibility of early material failure due to fatigue [22, 24]. This technique is correct for Vancouver type C fractures with plates covering the entire femur length; however, this is not routinely used in B1 type. Buttaro et al. [25] showed a series of 14 patients with Vancouver type B1 fractures, treated with locking plates, finding three pseudoarthrosis with plate breakage and 3 cases of reduction loss with fixation failure. In 5 out of these 6 failures, the patients had initially been treated without cortical allograft, leading the authors to conclude that such increase was necessary for success. Whereas our results and those of other authors [9] contradict these findings. There may be several reasons for these differences; nevertheless, the samples analysed in these series are highly heterogeneous and difficult to compare. We believe the technical details of osteosynthesis together with careful conservative dissection of the periosteum and muscle, anatomical reduction, compression of the fracture sport and a sufficiently long plate are beneficial from both a biological and biomechanical perspective (figure 2).

The difficulty in achieving these objectives in the osteosynthesis of transversal fractures has led some authors [22] to recommend treating them by replacing a long revision rod. In our series this kind of fractures was uncommon; nevertheless, we have had no osteosynthesis failures due to stress at fracture spot level.

Our results coincide with the evidence that careful limited dissection of soft tissue fosters fracture fusion [8, 15]. Although some patients may require a larger lateral incision at proximal level, elevation of the underlying muscle and periosteum as minimised as much as possible, and distal screws inserted percutaneously. Regardless of whether fracture reduction is obtained directly or indirectly, via a neutralisation or bridging plate, surgical dissection should be limited to the strictly necessary for fracture reduction and plate insertion along the lateral femoral cortex.

Our study has several limitations, in that it is a retrospective descriptive study on a small sample of 37 patients with limited evidence. Furthermore, the retrospective nature of the study exposes it to selection biases, which we have tried to avoid meticulous application of exclusion criteria, likewise information biases which reduce accuracy. The time until consolidation is inexact, and probably overestimated due to the length of time between medical check-ups. Patients are from a single centre with uniform peri-operational management and surgical technique, which may hinder extrapolation of our findings.

In conclusion, Vancouver type B1 periprosthetic hip fractures are a challenge for the orthopaedic surgeon. Treatment via open reduction and internal fixation with a lateral locking plate covering most of the femur in elderly patients or with bad bone quality or a locking compression plate with distal screws in patients with better bone quality are the appropriate treatment methods. To achieve good results with these techniques, we consider it important to minimise soft tissue dissection and use a meticulous osteosynthesis technique paying special attention to biology and biomechanics.

REFERENCES

1. Maradit Kremers H, Larson DR, Crowson CS, Kremers WK, Washington RE, Steiner CA et al. Prevalence of total hip and knee replacement in the United States. J Bone Joint Surg Am 2015;97:1386-97 DOI: 10.2106/JBJS.N.01141
2. Finlayson G, Tucker A, Black ND, McDonald S, Molloy M, Wilson D. Outcomes and Predictors of mortality following periprosthethic proximal femoral fractures. Injury 2019;50(2):438-43 doi: 10.1016/j.injury.2018.10.032. Epub 2018 Nov 2.
3. Dehghan N, McKee MD, Nauth A, Ristevski B, Schemitsch EH. Surgical fixation of vancouver type B1 periprosthetic femur fractures: a systematic review. J Orthop Trauma 2014;28:721-7 doi: 10.1097/BOT.0000000000000126.
4. Abdel MP, Watts CD, Houdek MT, Lewallen DG, Berry DJ. Epidemiology of periprosthetic fracture of the femur in 32 644 primary total hip arthroplasties: a 40-year experience. Bone Joint J 2016;98-B:461-7 doi: 10.1302/0301-620X.98B4.37201.
5. Toogood PA, Vail TP. Periprosthetic Fractures: A Common Problem with a Disproportionately High Impact on Healthcare Resources. J Arthroplasty 2015;30(10):1688-91. doi: 10.1016/j.arth.2015.04.038. Epub 2015 May 5.
6. Franklin J, Malchau H. Risk factors for periprosthetic femoral fracture. Injury 2007;38(6):655-60. doi: 10.1016/j.injury.2007.02.049. Epub 2007 Apr 30.
7. Duncan CP, Masri BA. Fractures of the femur after hip replacement. Instr Course Lect 1995;44:293-304
8. Holden, C.E. The role of blood supply to soft tissue in the healing of diaphyseal fractures. An experimental study. J Bone Joint Surg Am 1972 Jul;54(5):993-1000.
9. Bryant GK, Morshed S, Agel J, Henley MB, Barei DP, Taitsman LA et al. Isolated locked compression plating for Vancouver Type B1 periprosthetic femoral fractures. Injury, 40(11), 1180–6. doi: 10.1016/j.injury.2009.02.017.
10. Haddad FS, Duncan CP, Berry DJ, Lewallen DG, Gross AE, Chandler HP. Periprosthetic femoral fractures around well-fixed implants: use of cortical onlay allografts with or without a plate. J Bone Joint Surg Am 2002;84(6):945–50.
11. Ricci WM, Bolhofner BR, Loftus T, Cox C, Mitchell S, Borrelli JJ. Indirect reduction and plate fixation, without grafting, for periprosthetic femoral shaft fractures about a stable intramedullary implant. J Bone Joint Surg Am 2005;87(10), 2240–5. doi: 10.2106/JBJS.D.01911.
12. Venu KM, Koka R, Garikipati R, Shenava Y, Madhu TS. Dall-Miles cable and plate fixation for the treatment of peri-prosthetic femoral fractures-analysis of results in 13 cases. Injury 2001;32(5):395-400. doi: 10.1016/s0020-1383(01)00009-2.
13. Tsiridis E, Haddad FS, Gie GA. Dall-Miles plates for periprosthetic femoral fractures. A critical review of 16 cases. Injury 2003;34(2):107-10 doi: 10.1016/s0020-1383(02)00161-4.
14. Fulkerson E, Koval K, Preston CF, Lesaka K, Kummer FJ, Egol KA. Fixation of periprosthetic femoral shaft fractures associated with cemented femoral stems: a biomechanical comparison of locked plating and conventional cable plates. J Orthopaedic Trauma 2006; 20(2):89–93. doi: 10.1097/01.bot.0000199119.38359.96.
15. Perren SM. Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg Br 2002 84(8):1093-110. doi: 10.1302/0301-620x.84b8.13752.

16. Kregor PJ, Stannard JA, Zlowodzki M, Cole PA. Treatment of distal femur fractures using the less invasive stabilisation system: surgical experience and early clinical results in 103 fractures. J Orthop Trauma 2004;18(8):509-20. doi: 10.1097/00005131-200409000-00006.

17. Moreta J, Aguirre U, Ugarte OS, Jáuregui I, Mozos JL. Functional and radiological outcome of periprosthetic femoral fractures after hip arthroplasty. Injury 2015;46(2):292–8 doi: 10.1016/j.injury.2014.07.013. Epub 2014 Jul 19.

18. Yamaguchi K, Masuhara K, Yamasaki S, Nakai T, Fuji T. Cyclic therapy with etidronate has a therapeutic effect against local osteoporosis after cementless total hip arthroplasty. Bone 2003;33(1):144-9.

19. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am 1969;51:737–55.

20. Lindahl H, Malchau H, Oden 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. DOI: 10.1302/0301-620X.88B1.17029

21. Lee S, Kagan R, Wang L, Doung YC. Reliability and Validity of the Vancouver Classification in Periprosthetic Fractures Around Cementless Femoral Stems. J Arthroplasty 2019 Jul;34(7S):277-81. DOI: 10.1016/j.arth.2019.02.062

22. Quah C, Porteous M, Stephen A. Principles of managing Vancouver type B periprosthetic fractures around cemented polished tapered femoral stems. Eur J Orthop Surg Traumatol 2017 May;27(4):477-82. DOI: 10.1007/s00590-016-1883-7

23. Sanz-Reig J, Salvador Marín J, Ferrández Martínez J, Orozco Beltrán D, Martínez López JF. Risk-factors for surgical delay following hip fracture. Rev Esp Cir Ortop Traumatol. . 2017;61(3):162-9. doi: 10.1016/j.recot.2017.02.001. Epub 2017 Mar 31

24. Corten K, Vanrykel F, Bellemans J, Frederix PR, Simon JP, Broos PL. An algorithm for the surgical treatment of periprosthetic fractures of the femur around a well-fixed femoral component. J Bone Joint Surg Br 2009;91(11):1424–30. DOI: 10.1302/0301-620X.91B11.22292

25. Buttaro MA, Farfalli G, Paredes Nunez 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. DOI: 10.2106/JBJS.F.01224

Table 2. Surgical results and derived complications.

N	GENDER	AGE	TREATMENT	COMPLICATIONS	DEATH 1st YEAR	OP TREATMENT ON DISCHARGE[a]	Prior OP osteoporotic fracture[b]	TIME CONS.[c]	HHS
1	F	82	NCB PLATE	WOUND INFECTION	NO	NO	NO	10	61
2	F	85	READY CERCLAGE	NO	NO	NO	YES	6	60
3	F	95	CABLE READY PLATE	HAEMORRHAGE	YES	NO	NO	**	
4	F	78	CABLE READY PLATE	NO	NO	NO	YES	12	66
5	F	79	CABLE READY PLATE	WOUND INFECTION	NO	NO	YES	13	
6	F	99	CABLE READY PLATE	HAEMORRHAGE	NO	NO	YES	13	44
7	F	80	CABLE READY PLATE	NO	NO	Denosumab	YES	7	
8	F	83	CABLE READY PLATE	WOUND INFECTION	YES	NO	NO	**	
9	M	87	CABLE READY PLATE	SACRAL PRESSURE ULCER	NO	NO	NO	11	49
10	F	85	CABLE READY PLATE	NO	NO (*2018)	NO	YES	12	
11	M	85	CABLE READY PLATE	NO	NO (*2019)	NO	NO	13	
12	F	66	DALL MILES PLATE	NO	NO	NO	YES	9	
13	F	83	CABLE READY PLATE	NO	NO (*2018)	NO	NO	12	
14	F	83	CABLE READY PLATE	HAEMORRHAGE	YES	Denosumab	YES	9	
15	F	77	NCB PLATE	SACRAL PRESSURE ULCER	NO	Denosumab	YES	9	50
16	F	84	NCB PLATE	SACRAL PRESSURE ULCER	NO (*2018)	NO	NO	6	
17	M	60	CABLE READY PLATE	NO	NO	NO	NO	8	69
18	M	81	DALL MILES PLATE	WOUND INFECTION	NO	NO	NO	8	64
19	M	89	CABLE READY PLATE	NO	NO	NO	NO	11	
20	M	79	CABLE READY PLATE	NO	NO	NO	NO	12	60
21	F	77	DALL MILES PLATE	HAEMORRHAGE	NO	NO	NO	8	
22	F	87	CABLE READY PLATE	NO	NO	NO	NO	12	80
23	M	82	CABLE READY PLATE	WOUND INFECTION	NO	NO	YES	11	79
24	M	57	DALL MILES	NO	NO	NO	NO	8	79

			PLATE						
25	M	54	CABLE READY PLATE	NO	NO	NO	NO	11	95
26	M	86	CABLE READY PLATE	HAEMORRHAGE	NO	Teriparatide	YES	11	51
27	M	81	CABLE READY PLATE	NO	NO	NO	NO	12	
28	F	85	CABLE READY PLATE	WOUND INFECTION	NO	NO	YES	13	50
29	F	78	CABLE READY PLATE	NO	NO	NO	YES	12	
30	M	87	NCB PLATE	HAEMORRHAGE	YES	NO	NO	**	
31	F	80	CABLE READY PLATE	NO	NO	Teriparatide	NO	11	
32	M	85	CABLE READY PLATE	SACRAL PRESSURE ULCER	NO	NO	NO	11	58
33	M	79	CABLE READY PLATE	NO	NO	NO	YES	12	81
34	F	85	CABLE READY PLATE	HEEL PRESSURE ULCER HAEMORRHAGE	NO	NO	NO	10	59
35	F	83	NCB PLATE	NO	NO	Denosumab	YES	9	
36	M	80	DALL MILES PLATE	NO	NO	NO	NO	8	
37	M	81	CABLE READY PLATE	NO	NO	NO	YES	12	81

[a]Osteoporosis treatment on discharge.

[b] Prior osteoporotic fracture.

[c] Time to consolidation in weeks.

**Date of death of those surviving the first year. **Death prior to fracture consolidation.*

Revision note

Reviewer #1:
Retrospective study evaluating the results obtained in Vancouver B1 periprosthetic fractures between January 2014 to March 2017. The work is well planned, although the follow-up period is not clear to me, since in the material and method it indicates two years at the beginning, and one year later. ("..... surgical complications and mortality, both global during first year post-intervention .....).

Author:
I agree. Thank you. The final study sample included a total of 37 patients with minimum 2 year follow-up. I change the text: "..... surgical complications and mortality, ~~both global during first year post-intervention~~ ...."

Reviewer:
It is complex to differentiate stable Vancouver B1 or unstable B2 periprosthetic fractures; it would be interesting if they indicated what numbers of CT scans were performed for the preoperative diagnosis, as well as what intraoperative criteria they followed to assess implant stability, especially in the case of cemented arthroplasties and how many fractures initially classified as B1 were excluded from the study due to instability during the surgery.

Author:
The purpose of this study is to assess the treatment and results of Vancouver type B1 periprosthetic fractures. The diagnosis is not studied in depth. There is no evidence-based algorithm for periprosthetic fractures diagnosis.
I add in material and method: "The stability of the hip implant and the cemented mantle integrity was evaluated intra-operatively by performing a mobilization test of the involved femoral stem by using a farabeuf or a lambotte clamp".
In material and methods: "…. we excluded… fractures … initially classified as B1 where the rod was found loose during surgery and intra-operational periprosthetic fractures".
Results: "Three fractures initially classified as B1 were excluded from the study due to instability during the surgery"
I add in results: "Altogether 58.4% of the patients underwent a CT scan: 5 of the 8 cemeted partial arthroplasties, 9 of the 11 cemented total arthroplasties and 8 of the 18 non-cemented"

Reviewer:
Functional status of elderly patients with periprosthetic fracture Vancouver B1 is normally low, it would be interesting to assess functional outcome after surgery, that could explain the number of complications of pressure ulcers is almost 13%, it could indicate the area (trochanter, sacral ..)

Author:
I add:

- Material and method: “Harris Hip Score (HHS) was used to evaluate the functional outcome”
- Results: “Only 19 patients were able to complete the HHS at the time of follow-up due to poor health status. In this group, the mean HHS postoperatively at the most recent follow-up visit was 65 (range 44–95), with a poor outcome (HHS < 70) in 68.4% of the patients”.
- Table 2: I add a column with HHS values. I indicate the pressure ulcers área.
- Discussion: “Moreta et al. in similarly elderly populations have found a mean HHS of 67.9 [17]. We have confirmed this low score with a mean value of 65 , but only 51.3% of patients were able to complete this questionnaire at the most recent follow-up.”

Reviewer:
The paper indicates the importance of preserving vascularization and the correct management of soft tissues, but in material and method it does not describe what technique they use for this.

Author:
- In material and method: “Special attention was made to limit the vastus lateralis approach as much as possible to maintain blood supply and facilitate consolidation”.
- In discussion: “We used cerclages taking maximum care with the soft tissues in the area of the prosthetic rod and screws using percutaneous technique in those areas with free medullary canal. Thanks to current techniques, a surgeon experienced in fractures is capable of inserting cerclages with limited approaches”.

Reviewer:
It would be interesting to include in the statistical study not only the means, but also the ranges.

Author:
I have included the ranges in the results.

Reviewer:
I do not believe that osteoporosis in elderly patients with partial hip arthroplasty is really a cause that shortens the time to suffer a periprosthetic fracture, but rather their greater risk of falls. "In the case of partial prostheses, the mean time of periprosthetic fracture onset is considerably shorter than the rest, this is because they are implanted in elderly patients with little functional demand who are more inclined to suffer from osteoporosis ".

Author:
I agree. I correct the text: “…this is because they are implanted in elderly patients with greater risk of falls and little functional demand who are more inclined to suffer from osteoporosis”

Reviewer:

It is under discussion and I think it should go to material and method:

"We release the insertions at the trochanter tip to correctly adjust the plate hook over it ensuring an assistant maintains pressure on the axis to adjust the plate to this level until the fracture is fixed. The two proximal cerclages of the hooking plates require an oblique direction and pass distally to the lesser trochanter. From these we only routinely place the distal one, reserving the proximal one for cases where there is a fracture in the greater trochanter requiring fixation since the direction of the force exerted on the bone favors distraction from the fracture point instead of the compression sought. The order in which the cerclages are tensed and locked is important. Firstly, we lock the proximal oblique cerclage keeping the plate joined to the greater trochanter and exerting axial force. If this tensile strength is performed with the plate fixed to the distal fracture fragment, the direction of this oblique cerclage maycause undesired distraction on the fracture point. After inserting a screw in the distal fragment prior compression of the spot using reduction clamps and remembering to maintain axial pressure on the plate at trochanter tip level. In the femoral areas unoccupied by the femoral rod or cements, we prefer to insert screws. Correct usage of the dynamometer system is important when applying the cerclage tension to prevent exerting excessive pressure which may damage the femoral cortex. We had no cases of cortical damage in our
series due to excessive cerclage tension. When closing, we meticulously reinsert the insertions released on the trochanter tip passing the sutures through the plate ".

Author:
I have moved this part to material and method.

Thanking you for your consideration.

Yours faithfully,

Adrián Roche-Albero
Hospital Universitario Miguel Servet. Aragon Institute for Health Research (IIS Aragon)

Osteosynthesis in Vancouver type B1 periprosthetic fractures

ABSTRACT

Introduction

The incidence of hip periprosthetic fractures has been increasing in recent years. In Vancouver type B1 there are several osteosynthesis options: short locking-compression plates, locking compression plates, long plates with variable angle locking-screws, and autograft contribution. The aim of this paper is to assess both the treatment and results of Vancouver type B1 periprosthetic fractures in patients operated at our centre.

Material and Method

An observational retrospective study of patients operated at Hospital Universitario Miguel Servet for type B1 periprosthetic fracture via osteosynthesis with plate between January 2014 and March 2017. Finally, 37 patients with a minimum 2 year follow-up were included. The following were used for fracture synthesis: the Cable-Ready® plate (Zimmer–Biomet), Dall-Miles® plate (Stryker) and femur NCB® plate (Zimmer-Biomet). Functional outcome was assessed in terms of the Harris Hip Score.

Results

The average age of the sample was 80.7 (54-99), and included 21 women and 16 men. 8 of these patients died, with an average age of 85.6 (83-95). Out of these 8 dead patients, 4 died in the first year, with an average age of 87 (83-95). According to prosthesis type, 8 cases had a cemented partial arthroplasty, with an average period of 2.5 years (0.2-5.6) until periprosthetic fracture. 11 cases had a cemented total hip arthroplasty with an average period of 7 years (0.09-18.1) until fracture onset; non-cemented in 18 cases, with an average period of 8.1 years (2.6-12.7) until periprosthetic fracture. The mean Harris Hip Score postoperatively was 65 (44–95).

Discussion

Treatment via open reduction and internal fixation with locked lateral plate covering most of the femur in elderly patients or those with poor bone quality, or a plate with proximal cerclages and distal screws in patients with better bone quality are appropriate treatment methods. To achieve good results using these techniques, we consider minimisation of soft tissue dissection highly important likewise using a meticulous osteosynthesis technique with special attention to biology and biomechanics.

Keywords

Periprosthetic hip fracture, osteosynthesis, bridge plate, locking compression plate

1. INTRODUCTION

Periprosthetic hip fracture is a rare pathology, estimated at having an accrued 5% incidence between 15 and 20 years after the primary prosthesis [1]. Its incidence has been increasing in recent years due to the increase in life expectancy and prosthetic treatment indications leading to a significative increase in the number of primary hip joint replacements [2-4].

Among the risk factors some are intrinsic due to diminishment in bone quality; and standing out among these are: advanced age (2.9 times more common in those over 70) [5], female, low weight (means lower biomechanical demand on bone), toxic habits, certain drugs, previous osteoporotic fracture, rheumatism and unstable gait. There is also a series of surgery derived factors which debilitate the femur, such as incorrect prosthesis implant technique, prosthesis type, non-cemented, incorrect cementing and revision surgery [6].

The Vancouver classification developed by Duncan and Masri [7] in 1995 is used to describe these fractures. This classification system uses X-rays to stratify fractures as per fracture location, implant stability and bone reserve quality. The fractures are classified type A, B or C depending on fracture location on the femur. B type fractures which occur around the rod or distally to the same are subdivided into B1 fractures involving a stable rod, B2 fractures where implant has loosened although bone reserve is correct and B3 fractures where the implant has loosened with little bone remaining. The key difference between Vancouver classification subtypes B1 and B2 lies in the implant stability conditioning treatment via osteosynthesis or revision of the femoral component.

Periprosthetic fractures in themselves are a complication of a previous procedure, thus fracture treatment is subject to the problems inherent in a re-intervention. This type of fracture has traditionally suffered torpid evolution complicated by: haemorrhaging, premature dislocation, pseudoarthrosis, infection of surgical site or septicaemia, deep vein thrombosis, cardiorespiratory disease and even death; therefore, as recommended by several authors, use of the correct technique is necessary coupled with special attention to soft tissue care likewise respecting patient’s biology [8, 9].

Today, the delay in consolidation or pseudoarthrosis is the most frequent cause of treatment failure. The predisposing factors for assessment are: prior bone quality, associated comorbidity, taking corticoids and also fracture type. Cementation does not appear to influence this aspect. Generally speaking, pseudoarthrosis percentage is higher for fractures treated with osteosynthesis than in those with revision of components and those where an allograft was used as opposed to those which were not [8, 10, 11].

There are several options in osteosynthesis selection, i.e. locking compression plates [12, 13], or long plates with variable angle locking screws avoiding use of cerclages in subjects with poor bone quality [9, 14-16].

In patients with periprosthetic fracture and associated bone fragility are advised to take fall preventing measures, control concomitant diseases and toxic habits, besides correcting nutritional deficiencies particularly vitamin D levels. None of the drugs used to treat osteoporosis include stability improvement of implants in their indications; nevertheless, several papers have underlined the use of these drugs might reduce osteolysis, by improving bone consistency around the prosthesis [17,18].

The purpose of this study is to assess the treatment and results of Vancouver type B1 periprosthetic fractures in patients operated at our centre.

2. MATERIAL AND METHOD

An observational retrospective study of patients operated at Hospital Universitario Miguel Servet for type B1 periprosthetic fracture via osteosynthesis with plate between January 2014 and March 2017.

All patients with periprosthetic hip fractures operated on at our unit during the study period were included resulting in 53 subjects altogether. Out of this group of patients we excluded fractures affecting the trochanteric mass (type A), fractures distal to rod (type C), those where the implant was unstable (types B2 and B3), those initially classified as B1 where the rod was found loose during surgery and intra-operational periprosthetic fractures. We also excluded B1 fractures requiring replacement of a prosthetic component (cotyloid cup, head, or polyethylene) for reasons unrelated to the fracture, like wear and tear of the friction torque or loosening of the acetabulum. Thus, the final study sample included a total of 37 patients with minimum 2 year follow-up.

All patients were attended during their hospital stay by the same multidiscipline team comprising members from the: Orthopaedic Surgery & Traumatology, Anaesthesiology, Internal Medicine and Geriatrics departments, as well as social workers and occupational therapists.

Femoral implant stability was determined by absence of X-ray signs of loosening and in some cases via computerised tomography (CT) scan.

Surgery was scheduled during usual working hours (Monday to Friday). We used the same surgical technique in all cases, i.e. patient lying on his/her side, a posterolateral approach to the femur was made, accessing via the fasciae latae and vastus lateralis. Special attention was made to limit the vastus lateralis approach as much as possible to maintain blood supply and facilitate consolidation. The stability of the hip implant and the cemented mantle integrity was evaluated intra-operatively by performing a mobilization test of the involved femoral stem by using a farabeuf or a lambotte clamp. For fracture synthesis we used the Cable-Ready® (Zimmer Inc., Warsaw, IN, USA) plate, the Dall-Miles® (Stryker Corporation, Kalamazoo, MI, USA) plate or the femur NCB® (Zimmer Inc., Warsaw, IN, USA) plate. We release the insertions at the trochanter tip to correctly adjust the plate hook over it ensuring an assistant maintains pressure on the axis to adjust the plate to this level until the fracture is fixed. The two proximal cerclages of the hooking plates require an oblique direction and pass distally to the lesser trochanter. From these we only routinely place the distal one, reserving the proximal one for cases where there is a fracture in the greater trochanter requiring fixation since the direction of the force exerted on the bone favours distraction from the fracture point instead of the compression sought. The order in which the cerclages are tensed and locked is important. Firstly, we lock the oblique proximal cerclage keeping the plate joined to the greater trochanter and exerting axial force. If this tensile strength is performed with the plate fixed to the distal fracture fragment, the direction of this oblique cerclage may cause undesired distraction on the fracture point. After inserting a screw in the distal fragment prior compression of the spot using reduction clamps and remembering to maintain axial

pressure on the plate at trochanter tip level. In the femoral areas unoccupied by the femoral rod or cements, we prefer to insert screws. Intra-operational radioscopic control performed to confirm correct fracture reduction and correct positioning of osteosynthesis material. When closing, we meticulously reinsert the insertions released on the trochanter tip passing the sutures through the plate. Infection prophylaxis was administered to all patients intravenously with Cefazolin 2 g or Teicoplanin 600 mg in the event of allergy 30 minutes prior to surgery. Post-operation all patients were administered thromboembolic disorder prophylaxis with low-molecular weight heparin in a single weight-adjusted dose (Enoxaparina, Clexane®, Sanofi-Aventis, Barcelona, Spain). The physiotherapist taught patients immediately post-operation: muscle-strengthening exercises, improving mobility range, and partial weight load with the aid of crutches or walking frame. During 4 weeks only partial load was allowed with subsequent progressive weight load. Total load and autonomous movement were allowed once consolidation had been radiographically observed as dictated by the orthopaedic surgeon who performed the medical check-up in the medical record.

For each patient we recorded: demographic variables (age and gender), prosthesis implant date and time lapse until fracture, prosthesis type (partial or total and whether cemented or not), aetiology (coxarthrosis, fracture, avascular necrosis of the femoral head or osteosynthetic failure of a previous nailing), association or not of ipsilateral knee prosthesis, treatment received until radiographic consolidation, surgical complications and mortality. To determine the time until radiographic consolidation, X-rays taken during follow-up were assessed, considering it present when bone bridges were objectified between the cortexes on the 2 orthogonal radiographic projections. Harris Hip Score (HHS) was used to evaluate the functional outcome [19]. Where patients were unable to attend the hospital for follow-up due to frailty, then HHS was assessed via a telephone interview.

3. RESULTS

53 periprosthetic hip fractures were intervened at Hospital Miguel Servet. According to Vancouver classification, 3 cases were classified type A, 40 as type B1 and 5 as type C. Three fractures initially classified as B1 were excluded from the study due to instability during the surgery. In the end, the study included a total of 37 subjects who met the inclusion criteria.

The average age of patients at time of fracture onset was 80.7 (54-99), moreover 21 women and 16 men were included. Out of these, 8 had died, with an average age of 85.6 (83-95). Out of these 8 dead patients, 4 died in the first year, with an average age of 87 (83-95).

Most of the patients had had only one hip operation prior to the periprosthetic fracture, for the hip prosthesis implant. Out of those requiring intervention between prosthesis implant and fracture, in the former (N 7) cotyloid replacement was required and in the latter (N 13) a dislocation requiring reduction, associated with femoral component replacement and in the third (N 15) there was an osteosynthesised periprosthetic fracture with subsequent plate breakage. One patient (N 1) had undergone surgery prior to hip prosthesis implantation, consisting of nailing cervical diaphysis due to intertrochanteric fracture requiring conversion to prosthesis due to cephalic screw extrusion.

Regarding the primary prosthesis type implanted, 8 cases had a cemented partial arthroplasty with a mean time to periprosthetic fracture of 2.5 years (0.2-5.6). 11 cases had a cemented total arthroplasty with mean time to fracture onset of 7 years (0.09-18.1), and non-cemented in 18 cases, with a mean time to periprosthetic fracture of 8.1 years (2.6-12.7). In 2 patients we observed the existence of an inter-prosthetic fracture, i.e. with the presence of an ipsilateral knee prosthesis, with fracture occurring 2.7 and 11.2 years after the primary hip arthroplasty (table 1). Altogether 58.4% of the patients underwent a CT scan: 5 of the 8 cemeted partial arthroplasties, 9 of the 11 cemented total arthroplasties and 8 of the 18 non-cemented.

On studying the pathologies which led to replacement of the primary joint, we observed 18 cases of coxarthrosis (48.6%), 17 intracapsular femoral fractures (45.9%), 1 case of centromedullary nailing failure (2.7%) and 1 case of avascular necrosis of femoral head (2.7%).

With regard to complications (table 2), we observed 5 cases of acute superficial infection of surgical wound, which were resolved with debridement, lavage and antibiotic treatment without implant removal. There was a case of chronic infection treated with antibiotic suppression (N8). 7 patients required intra-operational blood transfusion due to blood loss. 5 cases of pressure ulcers (4 sacral, 1 heel) were detected. No pseudoarthrosis or loss of reduction cases requiring osteosynthesis surgery observed. Moreover there were no cases of: prosthesis dislocation, loss of fracture reduction or breakage of osteosynthesis plate.

On analysing simple X-rays taken during follow-up and medical record notes, a mean time to fracture consolidation was calculated at 10.35 weeks. Only 19 patients were able to complete the HHS at the time of follow-up due to poor health status. In this group, the mean HHS postoperatively at the most recent follow-up visit was 65 (range 44–95), with a poor outcome (HHS < 70) in 68.4% of the patients.

Regarding post-surgery treatment, we only observed prescription of anti-osteoporosis drugs in 6 cases. Denosumab was prescribed in 4 cases and Teriparatide in 2 cases. In this sub-group of patients treated with anti-osteoporosis drugs, the mean time to consolidation was 9.3 weeks.

DISCUSSION

We show the results of Vancouver type B1 periprosthetic fracture treatment via osteosynthesis. A limited posterolateral approach was used paying attention to the meticulous handling of the soft tissues to cause the least possible injury at muscle and periosteal level. We used cerclages taking maximum care with the soft tissues in the area of the prosthetic rod and screws using percutaneous technique in those areas with free medullary canal. Thanks to current techniques, a surgeon experienced in fractures is capable of inserting cerclages with limited approaches. We perform anatomical reduction directly and interfragmentary compression where possible. Fracture consolidation was achieved with few complications in all cases. Neither allografts nor extensive approaches altering biology and without improving results were used.

High rates of loosening, re-fracture and lack of union requiring re-intervention have been described in fractures B1 [3]. Given these findings, it has been suggested some B1 fractures are in fact B2 with loosened rod, which was not recognised and the prosthesis should be considered mobilised until proven otherwise [20]. Lee & Cols [21] studied the reliability of the Vancouver classification, concluding it was low in the case of non-cemented rods. They pointed out radiographic assessment alone may be inappropriate to determine non-cemented rod stability in femoral periprosthetic fractures. However, Quah & Cols [22] considered classic algorithms based on Vancouver classification of periprosthetic fractures should take into account the specific characteristics of conical rods. We did not find any loosening or complications derived from incorrect treatment of a B2 fracture via osteosynthesis without replacement in our study. Fractures classified as B1, but during the intervention revealed a loose rod, were treated with osteosynthesis and revision of components; and were not included in this study, which centred on the study of B1 fractures confirmed after surgical treatment. We believe you cannot be absolutely certain of rod stability with just an X-ray, which is why we always have the material necessary to replace components should we find the rod loose during surgery. We do not dislocate the prosthesis routinely to check stability of prosthetic rod. We study the fracture X-rays, comparing them with previous ones, researching the loosening symptoms prior to the trauma causing the fracture; and during surgery we assess rod stability via the fracture line; moreover, we use a dynamic imaging intensifier where necessary. We consider routine dislocation of a prosthesis to assess rod stability causes serious aggression to the soft tissues, besides increasing the risk of post-surgery prosthetic instability. There were no prosthetic dislocations in our series during follow-up, which we believe is thanks to the fact we did not approach the joint to treat these fractures. Moreta et al. in similarly elderly populations have found a mean HHS of 67.9 [17]. We have confirmed this low score with a mean value of 65 , but only 51.3% of patients were able to complete this questionnaire at the most recent follow-up.

Different risk factors associated with periprosthetic fractures have been described including: non-cemented primary rods, the presence of inflammatory arthropathy and revision surgery [3]. It is worth highlighting the fact that in 4 cases hip re-interventions were performed prior to the fracture for other reasons. The alteration of vascularisation due to repeated surgeries may favour femur weakening thereby increasing the risk of periprosthetic fracture. Periprosthetic fractures on non-cemented total arthroplasties predominate in comparison to the cemented. In the case of partial prostheses, the mean

time of periprosthetic fracture onset is considerably shorter than the rest, this is because they are implanted in elderly patients with greater risk of falls and little functional demand who are more inclined to suffer from osteoporosis. Thus, periprosthetic fracture in a shorter space of time may arise due to poor bone stock, biomechanical alteration and areas of stress generated by the implant. While the efficacy of anti-osteoporosis drugs has not been proven to prevent periprosthetic fractures, like Yamaguchi et al. [18], we believe the prescription of bone antiresorptive or formation drugs in patients with primary hip arthroplasty and low bone mineral density, should be considered if associated with other osteoporotic fractures [3,18]. Some studies have established the presence of osteopenia in 38% of patients with periprosthetic hip fracture [17].

Frequently, patients who suffer a periprosthetic hip fracture never recover the health or functional capacity they had prior due to the fracture itself, surgical aggression and complications arising during the process (pressure ulcers, infections, pseudoarthrosis, implant loosening, etc.). This quality of life deterioration also depends on the patient's basal characteristics and fracture complexity; therefore, we believe it necessary to pay special attention to and care for these patients throughout the process, starting by respecting soft tissue during the intervention likewise correct multidiscipline management during hospital stay and with a view to discharge. Our patients are systematically included in a critical assistance programme on admission for patients with hip fractures, consisting of orthopaedic surgeons, a specific team of internists and anaesthetists, likewise a team of nurses, auxiliaries and specific physiotherapists. Specific multidiscipline units have been proven efficient in delaying surgical intervention and preventing onset of some medical complications [23].

Generally speaking, the death rate of patients with hip or knee periprosthetic fracture in the first year is between 13 and 17% [2], very similar to that of patients with osteoporotic hip fracture yet significatively greater than reported for an elective primary hip arthroplasty, which is around 2.9%. Using these percentages, the mortality rate in year one found in our sample would be slightly lower than average (3 cases). It should be highlighted all the deaths during this period presented a local post-operation complication derived from bed-rest or surgery itself.

Osteosynthesis was performed using a posterolateral approach. In all cases, non-traumatic soft tissue management was used to minimise muscle and periosteal aggression, likewise performing direct anatomical reduction and interfragmentary compression where possible. We consider the surgical technique essential to achieve satisfactory results, looking after tissue biology, where possible avoiding large dissections traditionally used for allograft application [9]. Haddad et al. [10] achieved consolidation in 39 out of 40 fractures treated with cortical allografts with or without plate; however, they found 4 defective consolidations and a deep infection. Extensive femoral exposure negatively affects blood perfusion in the fracture area, moreover, the structural allograft although initially providing stability becomes weakened 4-6 after the incorporation process. Should fracture fusion be delayed longer in time, the structural allograft integrity may be compromised prior to fracture fusion [8]. We are against using allografts in this type of fracture.

We used locking compression plates most frequently for osteosynthesis. None of the patients had to be re-intervened due to pseudoarthrosis, refracture or other more serious complications, which corresponds to the results observed by Dehghan et al. [3], suggesting that apart from the fixation type used, B1 type fractures have a higher fusion rate (95%) and 15% complications.

Fixation with locking compression plates is a common surgical technique. Venu et al [12] and Tsiridis et al [13] show a re-intervention rate of 23% and 33% respectively in patients with this kind of fracture treated with Dall-Miles cable plates with or without allograft. However, Ricci et al [11] reported successful healing and no pseudoarthrosis cases in 50 Vancouver Type B1 periprosthetic fractures treated via reduction and indirect fixation using a locking compression plate without allograft. Our results are closer to those of this latter author, probably due to the soft tissue care employed.

The current trend for treating fractures in elderly patients is the use of a long lateral compression plate covering most of the femur. This plate provides additional strength along the femur reducing the risk of future fractures around the implant, often occurring in these patients secondary to osteopenia [9. 15]. Our series had no cases of femur fractures distal to the osteosynthesis plate. Some authors [14] recommend using fixed angle plates with locking screws covering most of the femur for Vancouver types B1 and C fractures with poor bone quality. Plates with locking screws provide sufficient resistance to maintain plate position in the femoral rod area, eliminating the need for additional stability via cables or cerclage wires. This system used as the sole stabilisation method appears to neutralise flex-extension, varus-valgus and torsional forces [16]. We have had no cases with fracture distal to the osteosynthesis plate inserted due to periprosthetic fracture. The use of long plates covering most of the femur is becoming generalised, and in our current clinical practice we often adopt this principle. However, in the sample studied, with good results using more limited plate lengths, we had no osteosynthesis material failures or fractures around the implant. We used long plates although we did not always cover the distal femur. In this population, with low functional demand and advanced age, we believe it is important to use long plates; although it is not necessary to reach the femoral distal metaphysis. Some authors [20] mention complications in treating type B1 fractures with plate alone and recommend using allografts. Our results contradict their conclusions, and in our opinion, current osteosynthesis concepts coupled with materials and techniques which minimise tissue damage, admit the use of osteosynthesis with good results.

Osteosynthesis with plate in these fractures is technically demanding and should be performed by an experienced surgeon. Long spiral fractures or complex fracture patterns present low stress at fracture level and can be successfully treated with a bridging plate technique. Simple fractures with two fragments with little contact surface in the fracture (oblique, short and transversal), which frequently occur near the tip of the femoral rod produce high stress at the spot requiring fixation with absolute stability. In these cases, some authors [22] replacing with longer revision exceeding the fracture spot by two femoral diameters minimum and at least a 5 cm diaphysis adjustment, which in practice acts biomechanically like an intramedullary nail. We prefer to achieve absolute stability via anatomical reduction of fragments and fixation with a traction screw or cerclage and an added neutralisation plate or using a plate in compression mode with correct eccentric screw placement to apply correct compression force. Locking screws are used to strengthen the assembly once absolute stability has been reached. Cerclages can be used in those areas with the medullary canal occupied by the prosthetic rod or cement; however, in these cases it is important to use a meticulous surgical technique employ minimally invasive manoeuvrability techniques to reduce soft tissue aggression. Correct usage of the dynamometer system is important when applying the cerclage tension to prevent exerting excessive pressure which may damage the femoral cortex. We had no cases of cortical damage in our series due to excessive cerclage tension (figure 1).

Bridging plates without absolute stability of the fracture sport enable micro-movements on the plate, frequently on a short segment with high stress and possibility of early material failure due to fatigue [22, 24]. This technique is correct for Vancouver type C fractures with plates covering the entire femur length; however, this is not routinely used in B1 type. Buttaro et al. [25] showed a series of 14 patients with Vancouver type B1 fractures, treated with locking plates, finding three pseudoarthrosis with plate breakage and 3 cases of reduction loss with fixation failure. In 5 out of these 6 failures, the patients had initially been treated without cortical allograft, leading the authors to conclude that such increase was necessary for success. Whereas our results and those of other authors [9] contradict these findings. There may be several reasons for these differences; nevertheless, the samples analysed in these series are highly heterogeneous and difficult to compare. We believe the technical details of osteosynthesis together with careful conservative dissection of the periosteum and muscle, anatomical reduction, compression of the fracture sport and a sufficiently long plate are beneficial from both a biological and biomechanical perspective (figure 2).

The difficulty in achieving these objectives in the osteosynthesis of transversal fractures has led some authors [22] to recommend treating them by replacing a long revision rod. In our series this kind of fractures was uncommon; nevertheless, we have had no osteosynthesis failures due to stress at fracture spot level.

Our results coincide with the evidence that careful limited dissection of soft tissue fosters fracture fusion [8, 15]. Although some patients may require a larger lateral incision at proximal level, elevation of the underlying muscle and periosteum as minimised as much as possible, and distal screws inserted percutaneously. Regardless of whether fracture reduction is obtained directly or indirectly, via a neutralisation or bridging plate, surgical dissection should be limited to the strictly necessary for fracture reduction and plate insertion along the lateral femoral cortex.

Our study has several limitations, in that it is a retrospective descriptive study on a small sample of 37 patients with limited evidence. Furthermore, the retrospective nature of the study exposes it to selection biases, which we have tried to avoid meticulous application of exclusion criteria, likewise information biases which reduce accuracy. The time until consolidation is inexact, and probably overestimated due to the length of time between medical check-ups. Patients are from a single centre with uniform peri-operational management and surgical technique, which may hinder extrapolation of our findings.

In conclusion, Vancouver type B1 periprosthetic hip fractures are a challenge for the orthopaedic surgeon. Treatment via open reduction and internal fixation with a lateral locking plate covering most of the femur in elderly patients or with bad bone quality or a locking compression plate with distal screws in patients with better bone quality are the appropriate treatment methods. To achieve good results with these techniques, we consider it important to minimise soft tissue dissection and use a meticulous osteosynthesis technique paying special attention to biology and biomechanics.

REFERENCES

1. Maradit Kremers H, Larson DR, Crowson CS, Kremers WK, Washington RE, Steiner CA et al. Prevalence of total hip and knee replacement in the United States. J Bone Joint Surg Am 2015;97:1386-97 DOI: 10.2106/JBJS.N.01141
2. Finlayson G, Tucker A, Black ND, McDonald S, Molloy M, Wilson D. Outcomes and Predictors of mortality following periprosthethic proximal femoral fractures. Injury 2019;50(2):438-43 doi: 10.1016/j.injury.2018.10.032. Epub 2018 Nov 2.
3. Dehghan N, McKee MD, Nauth A, Ristevski B, Schemitsch EH. Surgical fixation of vancouver type B1 periprosthetic femur fractures: a systematic review. J Orthop Trauma 2014;28:721-7 doi: 10.1097/BOT.0000000000000126.
4. Abdel MP, Watts CD, Houdek MT, Lewallen DG, Berry DJ. Epidemiology of periprosthetic fracture of the femur in 32 644 primary total hip arthroplasties: a 40-year experience. Bone Joint J 2016;98-B:461-7 doi: 10.1302/0301-620X.98B4.37201.
5. Toogood PA, Vail TP. Periprosthetic Fractures: A Common Problem with a Disproportionately High Impact on Healthcare Resources. J Arthroplasty 2015;30(10):1688-91. doi: 10.1016/j.arth.2015.04.038. Epub 2015 May 5.
6. Franklin J, Malchau H. Risk factors for periprosthetic femoral fracture. Injury 2007;38(6):655-60. doi: 10.1016/j.injury.2007.02.049. Epub 2007 Apr 30.
7. Duncan CP, Masri BA. Fractures of the femur after hip replacement. Instr Course Lect 1995;44:293-304
8. Holden, C.E. The role of blood supply to soft tissue in the healing of diaphyseal fractures. An experimental study. J Bone Joint Surg Am 1972 Jul;54(5):993-1000.
9. Bryant GK, Morshed S, Agel J, Henley MB, Barei DP, Taitsman LA et al. Isolated locked compression plating for Vancouver Type B1 periprosthetic femoral fractures. Injury, 40(11), 1180–6. doi: 10.1016/j.injury.2009.02.017.
10. Haddad FS, Duncan CP, Berry DJ, Lewallen DG, Gross AE, Chandler HP. Periprosthetic femoral fractures around well-fixed implants: use of cortical onlay allografts with or without a plate. J Bone Joint Surg Am 2002;84(6):945–50.
11. Ricci WM, Bolhofner BR, Loftus T, Cox C, Mitchell S, Borrelli JJ. Indirect reduction and plate fixation, without grafting, for periprosthetic femoral shaft fractures about a stable intramedullary implant. J Bone Joint Surg Am 2005;87(10), 2240–5. doi: 10.2106/JBJS.D.01911.
12. Venu KM, Koka R, Garikipati R, Shenava Y, Madhu TS. Dall-Miles cable and plate fixation for the treatment of peri-prosthetic femoral fractures-analysis of results in 13 cases. Injury 2001;32(5):395-400. doi: 10.1016/s0020-1383(01)00009-2.
13. Tsiridis E, Haddad FS, Gie GA. Dall-Miles plates for periprosthetic femoral fractures. A critical review of 16 cases. Injury 2003;34(2):107-10 doi: 10.1016/s0020-1383(02)00161-4.
14. Fulkerson E, Koval K, Preston CF, Lesaka K, Kummer FJ, Egol KA. Fixation of periprosthetic femoral shaft fractures associated with cemented femoral stems: a biomechanical comparison of locked plating and conventional cable plates. J Orthopaedic Trauma 2006; 20(2):89–93. doi: 10.1097/01.bot.0000199119.38359.96.
15. Perren SM. Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg Br 2002 84(8):1093-110. doi: 10.1302/0301-620x.84b8.13752.

16. Kregor PJ, Stannard JA, Zlowodzki M, Cole PA. Treatment of distal femur fractures using the less invasive stabilisation system: surgical experience and early clinical results in 103 fractures. J Orthop Trauma 2004;18(8):509-20. doi: 10.1097/00005131-200409000-00006.

17. Moreta J, Aguirre U, Ugarte OS, Jáuregui I, Mozos JL. Functional and radiological outcome of periprosthetic femoral fractures after hip arthroplasty. Injury 2015;46(2):292–8 doi: 10.1016/j.injury.2014.07.013. Epub 2014 Jul 19.

18. Yamaguchi K, Masuhara K, Yamasaki S, Nakai T, Fuji T. Cyclic therapy with etidronate has a therapeutic effect against local osteoporosis after cementless total hip arthroplasty. Bone 2003;33(1):144-9.

19. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am 1969;51:737–55.

20. Lindahl H, Malchau H, Oden 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. DOI: 10.1302/0301-620X.88B1.17029

21. Lee S, Kagan R, Wang L, Doung YC. Reliability and Validity of the Vancouver Classification in Periprosthetic Fractures Around Cementless Femoral Stems. J Arthroplasty 2019 Jul;34(7S):277-81. DOI: 10.1016/j.arth.2019.02.062

22. Quah C, Porteous M, Stephen A. Principles of managing Vancouver type B periprosthetic fractures around cemented polished tapered femoral stems. Eur J Orthop Surg Traumatol 2017 May;27(4):477-82. DOI: 10.1007/s00590-016-1883-7

23. Sanz-Reig J, Salvador Marín J, Ferrández Martínez J, Orozco Beltrán D, Martínez López JF. Risk-factors for surgical delay following hip fracture. Rev Esp Cir Ortop Traumatol. . 2017;61(3):162-9. doi: 10.1016/j.recot.2017.02.001. Epub 2017 Mar 31

24. Corten K, Vanrykel F, Bellemans J, Frederix PR, Simon JP, Broos PL. An algorithm for the surgical treatment of periprosthetic fractures of the femur around a well-fixed femoral component. J Bone Joint Surg Br 2009;91(11):1424–30. DOI: 10.1302/0301-620X.91B11.22292

25. Buttaro MA, Farfalli G, Paredes Nunez 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. DOI: 10.2106/JBJS.F.01224