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ORIGINAL ARTICLE

Pertrochanteric hip fracture osteosynthesis with percutaneous compression plate

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KEYWORDS
Intertrochanteric fracture;
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Blood loss;
Transfusions;
Minimally invasive surgery

Abstract
Objective: To evaluate the results obtained in the treatment of intertrochanteric hip fractures with a percutaneous compression plate (PCCP).
Material and method: We analysed 611 patients, operated on using PCCP, with a mean age of 79 years (65 to 99 years). The minimum follow up was 10 months (10 to 24). Data associated with blood loss and the post-operative recovery of the patients were analysed.
Results: The mean duration of surgery was 32 minutes (15 to 75 min). The mean drop in the haemoglobin value was 1.9 g/dl (0.3 to 8.4). A blood transfusion was required by 14.7%of patients, with a mean of 0.25 transfusion units (0 to 3). The mean hospital stay was 8 days. There were 12.6%medical complications and 5%radiological complications. The overall mortality in the first year was 3.8% (23 patients).
Conclusions: An early functional recovery of the patient associated with a low morbidity was achieved with PCCP, making it an alternative for the treatment of intertrochanteric hip fractures.

PALABRAS CLAVE
Cadera;
Fractura intertrocantérea;
Placa de compresión percutánea;
Pérdida sanguínea;
Transfusiones;
Cirugía mínimamente invasiva

Osteosíntesis de fracturas pertrocantéreas de cadera con placa de compresión percutánea

Resumen
Objetivo: Evaluar los resultados obtenidos en el tratamiento de fracturas intertrocantéreas de cadera con placa de compresión percutánea (PCCP).
Material y método: Analizamos 611 pacientes, intervenidos mediante PCCP, con una edad media de 79 años (65 a 99 años). El seguimiento mínimo fue de 10 meses (10 a 24). Se midieron datos relativos a la pérdida sanguínea, relacionándolos con la recuperación postoperatoria del paciente.
Resultados: La duración media de la cirugía fue de 32 min (15 a 75 min). La caída media en el valor de la Hb fue de 1,9 g/dl (0,3 a 8,4). El 14,7%de los pacientes precisó una

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transfusión sanguínea, con una media de 0,25 unidades transfundidas (0 a 3). La estancia hospitalaria media fue de 8 días. Ocurrió un 12,6%de complicaciones médicas y un 5%de complicaciones radiológicas. La mortalidad total en el primer año fue del 3,8%(23 pacientes).

Conclusiones: Con la PCCP se consigue una recuperación funcional precoz del paciente asociada a una escasa morbilidad, siendo una alternativa para el tratamiento de las fracturas intertrocantéreas de cadera.

Introduction

Fractures in the proximal region of the femur represent one of the most frequent types of fracture in the elderly and their incidence grows progressively higher due to the ageing of the population.[1] In addition, they represent 30% of hospital admissions for fractures, with approximately 50% of these fractures corresponding to the intertrochanteric region.[2] The treatment goal is to restore the prior function without associated morbidity, so it will be necessary to effect an anatomical reduction with stable fixation and the least possible surgical trauma to ensure the prompt mobilization of the patient.

Over the years, various treatment methods have been applied, including trochanteric osteotomies, cementing and different types of osteosynthesis designs.[3-5] These implants are widely used and not completely free of complications. The so-called "cut-out" for the cephalic screw is the most frequent and causes a varication of the fracture and the medial displacement of the femoral diaphysis. It has also been suggested that the extensive orifice drilled for the screw's insertion may cause a secondary fracture of the lateral cortex and collapse of the fracture.[6,7] In addition, a single screw may be insufficient to guarantee rotational stability, as the proximal fragment may rotate around it in certain kinds of fracture.

On the other hand, the surgical technique requires a long incision and an extensive dissection of the soft tissues, dividing the vastus lateralis muscle for at least 10 cm, so it may be associated with significant blood loss and tissue damage[8] that may worsen patients' status. These complications do not necessarily prevent fracture repair, but the pain caused by weight-bearing may delay the patient's short-term mobilization and recovery.

Minimally invasive surgery has gained in popularity in modern traumatology, as it is associated with lower blood loss and less post-operative pain and, potentially, a lower risk of post-surgical morbidity with faster functional recovery. In this context, intramedullary implants have arisen but they cannot really be considered minimally invasive as there is considerable tissue trauma, damage to the gluteus medius muscle during reaming and invasion of the femoral medullary canal, and the high bleeding they cause requires patients to have a large number of transfusions.[9] They are indicated in the fixation of unstable fractures,[5] but a considerable percentage of secondary diaphyseal fractures have been observed, particularly with the early designs.[10]

Percutaneous compression plates or PCCP have been designed to stabilize both stable and unstable intertrochanteric fractures by means of a minimally invasive technique,[6] representing a new surgical approach to the problems associated with these fractures. He implant consists in a single-length plate with a fixed cervical-diaphyseal angle (135°), finishing in a bevelled edge for its percutaneous insertion and sliding under the vastus muscle, two telescopic screws for the neck of the femur and three screws for diaphyseal fixation. The basic principles for PCCP treatment are to allow a closed reduction of the fracture; implantation through minimally invasive surgery without exposure of the focus of the fracture, thus avoiding the devascularization of the fragments and the loss of the fracture haematoma and, by reducing the surgery-related trauma, diminishing bleeding and pain. In addition, it is a bone-preserving technique, as the drilling of the lateral wall is of a lower diameter than with a single drill, preventing breakage of the lateral cortex of the femur and thus the displacement and collapse of the fracture.[4] It also provides rotational stability thanks to the two screws in the neck of the femur, with the ability to slide, providing a double-axis fixation and theoretically facilitate the controlled impacting of the fracture, i.e. allowing immediate weight-bearing.[7]

The goals of the present paper are to analyze the outcomes obtained with this technique in an large number of patients and to compare our results with the data published by other authors. It attempts to assess the potential benefits and, more specifically, to evaluate blood loss and its influence on the patient's recovery.

Patients and methodology

We have conducted a retrospective study of the 670 patients diagnosed as having intertrochanteric hip fracture and admitted through the Emergency Department between the months of October, 2003, and July, 2007, for surgery with PCCP osteosynthesis (Efratgo Ltd, Kiryat Bialik, Israel). The first 50 cases were considered to fall within the learning curve and were not included in the review.

The inclusion criteria for this study were: patients over 65 years of age with an acute fracture of the intertrochanteric region, types 31-A1 and 31-A2 according to the classification

Table 1 Demographic data of the sample

	Total	Percentage
Total number of patients	611	100
Age (mean and range)	79 (6-99)	
Gender		
Females	550	90
Male	61	10
Co-morbidities		
0 to 2	250	40.9
3 or more	361	59.1
Prior residence		
Own home	377	61.7
With relatives	128	20.95
Institution	106	17.35
Prior ambulation		
Independent	337	55.15
Assisted	195	31.91
No prior ambulation/ dementia	79	12.92
Type of fracture (AO)		
A1	389	63.66
A2.1	151	24.71
A2.2	71	11.63
Type of fracture (Evans)		
Stable	389	63.66
Unstable	222	36.34
Laterality		
Right	325	53.13
Left	286	46.87
ASA		
Grade II	186	30.47
Grade III	407	67.51
Grade IV	18	2.2

of the Orthopaedic Trauma Association (AO/OTA), or stable or unstable according to Evans's classification.

Patients were excluded if they presented an oblique inverse fracture or a fracture in the sub-trochanteric area (type 31-A3 of the AO/OTA), bilateral hip fracture, pathological and/or metastatic fractures, multiple associated lesions, where it was not possible to perform closed reduction and in those cases where surgery was contraindicated.

A total of 611 patients were considered for the final analysis. The mean age of the group was 79 years (range from 65 to 99 years), with 90.1% females and 9.9% males. Follow-up continued until the second year or the consolidation of the fracture and the patients' return to their activities prior to the lesion, during an average of 18 months (10 to 24). Patients were assessed after 3 months (83%) and at the end of the follow-up period (69%).

Information was collected retrospectively regarding aspects of the patients prior to the fracture and data about their surgery and subsequent course, by studying their case history and by interviewing patients or their relatives during subsequent follow-up sessions (table 1). The pre-operative data collected were: age, gender, functional level and place of residence, pathological history and surgical risk, according to the classification of the American Society of Anesthesiologists (ASA).

The functional level was assessed in terms of the ability to walk unassisted or otherwise and the degree of dependence for daily living activities. The patients' pathological history was grouped into neurological, cardiovascular, or pulmonary problems, diabetes, dialysis or cirrhosis (table 1).

X-rays were taken prior to surgery and on the first day after the procedure, and these were used to group the fractures according to the AO/OTA and Evans classifications.

Protocol for surgery

Patients were handled in accordance with the protocol for hip fractures applied at our centre. A complete pre-operative work-up was obtained and patients were stabilized with respect to their medical conditions as and when necessary. All the patients included in the study underwent the surgical procedure under general or spinal anaesthesia, using the technique described below, after giving their informed consent. Antibiotic prophylaxis was administered prior to surgery (2 g of cefazolin IV in a single dose) and anti-thrombotic prophylaxis was started after the procedure with low molecular weight heparin (enoxaparin 40 mg subcutaneously) until complete mobilization of the patient, generally for 4 to 6 weeks.

The rehabilitation protocol followed was similar in all previously ambulatory patients, except in those whose general deterioration made this unadvisable; it consisted in sitting them on the second day and early ambulation with weight-bearing depending on tolerance.

Surgical technique

The implant comprises a standard plate with a bevelled end allowing its insertion through soft tissue, two telescopic cervical-cephalic compression screws and three screws for diaphyseal fixation. The patient was placed in supine decubitus position on the orthopaedic table and the fracture was reduced using external traction and rotation manoeuvres and a posterior reduction device (Pord®), under monitoring with an image intensifier.

A first incision of 2 cm was made on the lateral face of the thigh at the level of the upper edge of the trochanter major, through which the plate connected to its targeting device was inserted. The targeting device is fitted with an external guide parallel to the plate, with a series of orifices through which the drills and screws will be inserted. The plate, with its bevelled end is slid in deep to the vastus lateralis muscle, remaining in contact with the periosteum of the lateral cortex of the proximal femur. Through a second incision measuring 2-3 cm, distal to the previous one, the diaphyseal hook fixing the plate temporarily to the bone is inserted and attached to the external guide. The

Figure 1 Radiographic control of a stable intertrochanteric fracture operated on using PCCP, with an excellent position of the distal cervical screw.

correct position of the plate is confirmed using lateral guidance; its upper part has to be aligned with the femoral neck and the lower part will be along the axis of the femur. The position of the plate is adjusted so that the guide needle of the first femoral neck screw, inserted through the most distal oblique orifice on the external guide (and on the plate), is 2-3 mm proximal to the calcar in the anteroposterior view and in the centre of the neck and head of the femur in the lateral view. The orifice is drilled gradually (7 mm and 9.3 mm) and the telescopic screw of an appropriate length is placed 5 mm from the sub-chondral bone. Next, three 4.5 mm cortical screws were used to fix the plate to the femoral diaphysis, and the diaphyseal hook was removed to place the second cephalic screw, above and parallel to the first. The targeting device was disconnected and removed, and the wounds were irrigated and closed (fig. 1).

The following parameters were collected from patients during their hospital stay: time elapsed until surgery, type of anaesthesia, duration of the procedure, duration of their hospital stay and the onset of complications in the post-operative period (cardiovascular or pulmonary, vein thrombosis or pulmonary thromboembolism, urinary infections, disorientation, gastrointestinal alterations).

Prior to surgery, the haemoglobin level (Hb) was measured in patients' blood. With regard to blood loss, the post-operative Hb was analyzed after 48 hours and the fall in the Hb value was determined with respect to the pre-operative value, the amount of blood collected in drainage, where this was put in place, and the patient's need for transfusion, thus determining the number of patients receiving transfusion and the number of units transfused.

Table 2 Estimated peri-operative blood loss and transfusions necessary

	Mean	Range
Hb pre-operative (g/dL)	13.28	7.7-16.9
Hb post-operative (g/dL)	11.35	6.2-14.9
Fall in the Hb value (g/dL)	1.9	0.3-8.4
Blood in drain (mL)	49.8	0-300
Transfusions (units)	0.25	0-3

Following discharge from hospital, the patients' status was re-assessed after 6 weeks and at 3, 6 and 12 months in terms of mortality, wound complications, medical complications (deep vein thrombosis, pulmonary thromboembolism, cardiovascular, renal or pulmonary problems), and the recovery or not of their ability to walk. After the first year, only complications related to their hip surgery were noted.

Statistical analysis

Continuous quantitative variables were compared using Student's t test or Anova when appropriate. The analysis of categorical variables was conducted with the chi-square test. In the comparison of our results with those of other series using different implants, the t test was used. All the statistical calculations were effected using the STATA computer programme.

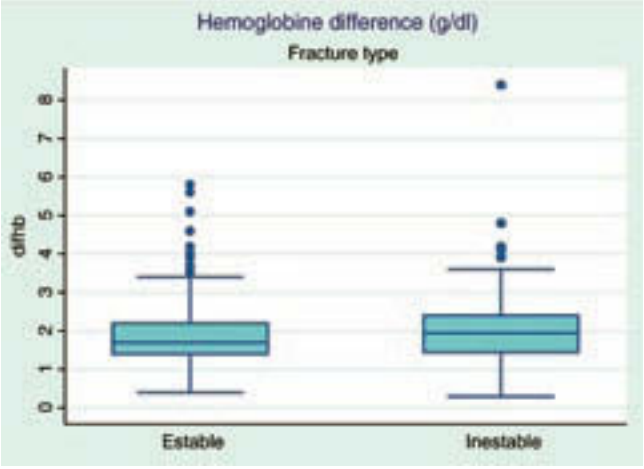

Figure 2 Relationship between the type of hip fracture and the reduction in the haemoglobin value after surgery (box-plot graph).

Table 3 Complications and mortality while in hospital and after one year of follow-up

	In hospital			Post-operative		
		N	%		N	%
Complications						
Medical		83	13,6		22	3,6
	Cardiovascular	9	1.5	Cardiovascular	4	0.7
	Pulmonary	6	0.9	Pulmonary	6	0.9
	Gastrointestinal	3	0.5	DVT	5	0.8
	DVT	1	0.2	PTE	3	0.5
	UTI	17	2.8	Others	4	0.7
	Disorientation	47	7.7			
In the wound					55	9.0
				Haematoma	41	6.7
				Superficial infection	13	2.1
				Deep infection	1	0.2
In the implant					31	5,1
				Cut-out	10	2.4
				Varus	8	1.3
				Acetabular penetration	8	1.3
				No consolidation	3	0.5
				Fracture collapse	0	0
				Ps trochanter major	1	0.2
				Dismantling of the plate	1	0.2
Mortality		7	1.15		16	2.6
Total					23	3.8

UTI: urinary tract infection; PTE: pulmonary thromboembolism; DVT: deep vein thrombosis.

Results

The procedure was effected on average 2 days (0 to 21 days) after the accident. In 80%of cases, spinal anaesthesia was applied. The mean duration of the surgery was 32 min (15 to 75 min), using fluoroscopy for a mean time of 40 s (20 to 210 s) and the mean hospital stay was 8 days (3 to 30 days).

Table 2 presents the difference in haemoglobin (Hb) pre- and post-surgery, blood loss after surgery (collected in the drain) and the need for transfusion. The level of post-operative Hb is directly influenced by the type of fracture ($p=0.036$). The mean fall in the value of Hb was 1.9 g/dL (0.3 to 8.4 g/dL), greater in the group of unstable fractures (fig. 2). The mean volume of blood in the drain was 49.8 mL (0 to 300 mL).

In 34%of the cases, it was not considered necessary to place a drain, due to the scant bleeding during surgery and no greater percentage of wound complications was found in this group ($p=0.64$). Only 14.73%of the patients required a blood transfusion, with an average of 0.25 (0 to 3) units transfused. The criterion followed to apply a transfusion was a level of Hb less than 10 g/dL and presence of symptoms related with anaemia (paleness, tachycardia, etc.).

During hospitalization, 13.6% of patients presented medical complications, with the most frequent being disorientation and urinary tract infection (table 3).

All the fractures had consolidated within 3 months of the lesion. During radiographic follow-up, 31 complications were observed (5.07%), three of whom required revision surgery.

The evolution in their ability to walk was satisfactory (table 4). All previously ambulatory patients started walking between the second and third day after the operation, with complete loading of body weight, except for 37 patients (6%) due to their poor general status; 42.3% of patients walked independently 3 months after surgery, and 4.3%had lost the ability to walk.

The total mortality in the first year was 3.8% (23 patients); of these, 7 (1.2%) died during the hospital stay; two because of acute pulmonary oedema and pulmonary thromboembolism, and the rest through a worsening of their previous pathologies. Sixteen patients died in the first year after surgery (table 3).

Discussion

This study has the limitations inherent to its retrospective nature and, in addition, 189 patients were lost by the end

Table 4 Evolution of ambulation in patients treated with PCCP

	Prior (n=611)	%	On discharge (n=604)	%	After 3 months (n=532)	%
Independent	337	55.2	—	—	225	42.3
Assisted	195	31.9	567	93.9	284	53.4
No deambulation	79	12.9	37	6.1	23	4.3

of the follow-up period (31%) because of the advanced age of this population, which would imply an impediment for them or their relatives when it came to returning to the hospital for the necessary clinical and radiological examinations. On the other hand, it has a large number of cases analyzed, which contributed to reduce the onset of errors in the results obtained. Other randomized prospective studies have been carried out but with a lower number of participants, which limits its statistical power.

The indication for surgery on intertrochanteric hip fractures in the elderly, in view of the high morbidity and mortality, is related to a prolonged confinement in bed.[3] The system most commonly used is a compression hip screw (CHS) and its variants (DHS),[11] but numerous studies have not found any significant differences in the clinical and radiological outcomes between screw-plate and intramedullary implants.[12] Initial clinical studies have pointed out the advantages of PCCP and recommend their use in intertrochanteric fractures, due to their lower blood loss and less post-operative pain, which contribute to the recovery of the patient's functional capacity.[13-16] Furthermore, the compression, torsion and axial forces the PCCP is capable of supporting are comparable to other conventional fixation systems.[17,18]

Minimally invasive surgery may improve the result of surgical treatment for hip fractures by reducing peri-operative blood loss, damage to soft tissue, post-operative pain and associated morbidity, providing that the stability of the fracture can be guaranteed in order to facilitate faster recovery of function.[19] The insertion of both intra- and extra-medullary implants through open surgery is associated with muscular lesions and wound complications in the post-operative period.[9,20]. PCCP, with percutaneous insertion of the plate under the vastus lateralis without damaging the gluteus medius, contributes to earlier, faster and more effective recovery[13]

Surgery time with PCCP is lower than with CHS,[8,13,20] except in one study, probably because the surgeons applied practically no learning curve.[14] The present study did not include the first 50 cases operated on as these were considered part of the learning curve, giving a mean surgery time of 31.5 min, with a maximum time of 75 min. Our mean time used with PCCP is lower than that reported by other authors, varying between 47 and 81 min for gamma nails and other intramedullary implants.[5,20,21]

Osteosynthesis with PCCP is associated with less peri-operative blood loss and a lower percentage of post-operative allogenous blood transfusions than CHS.[8,13,14,20] The results are comparable to those in our study with respect to the fall in Hb values, the amount of blood collected in the drain and the number of patients and units transfused. Randomized papers comparing DHS and gamma nails do not find significant differences in blood loss or the number of transfusions; if we compare our results with the DHS series in the study by Pajarinen et al.[22] we find statistically significant differences in intra-operative blood loss (drainage) and in the number of units of blood transfused, whereas comparing them with another DHS series[12] does not reveal any significant differences in blood loss but only in the units of blood transfused.

The percentage of implant failure in our series is 5%, similar to the experience with the same system in other studies and similar to the 4-10% indicated for other osteosynthesis systems,[15,22] PCCP provides at least the same stability as CHS.

The radiological analysis of the outcome of the procedure and the fact that less pain was found and immediate weight-bearing was possible in some studies[13] support the idea of greater torsional stability, possibly thanks to the double-axis fixation of the fracture. Some authors have argued that the implant cannot be universally applied due to its set angle. There are CHS and DHS implants with a variety of varus and valgus angulations, allowing use of whichever one fits the cervical-diaphyseal angle to which the fracture is reduced. On the other hand, PCCP adapts the fracture to the plate, reducing it at a 135° cervical-diaphyseal angle and it does not accept any varus angulation. The rationale for this technique is to keep the fracture and the implant's ability to slide when subjected to compression forces rather than angulation forces in order to favour the controlled impacting of the fracture.[7]

The percentage of post-operative complications observed in our study is comparable to that of other authors with PCCP, between 8 and 30%,[15,19], and less than that found with CHS, between 37% and 64%[8,14,20]

One of the most problematic complications in hip fractures is the onset of cardiovascular events, occurring in 8% to 27% of cases. One prospective study[8] highlighted a trend towards fewer cardiovascular complications with PCCP against CHS. A possible explanation for this result is the combined effect of less bleeding and less post-operative pain observed with PCCP.[20] Although post-operative pain was nor evaluated in our study, minimally invasive surgery is associated with less pain after the procedure and faster mobilization. Janzing et al.[13] showed less post-operative pain with PCCP than with CHS.

A high number of post-operative complications (three or more) is a risk factor for post-surgical mortality, which, in addition, is closely related to the patient's prior pathologies. In our study, only 7% of patients presented this number of complications, giving an annual post-operative mortality rate of 3.8% Further series of a larger sample size would be

required to demonstrate a significant reduction in mortality.

In our retrospective study, the use of the PCCP implant hasmeant ashorter surgerytime, lesssurgical aggressiveness, without lesion to soft tissue and with a scant number of wound complications, and a reduction in blood loss and the number of allogenous transfusions. The stability of the assembly has allowed early weight-bearing in both stable and unstable fractures, facilitating speedy functional recovery with scant post-operative morbidity. On the basis of these results, PCCP is an option for the treatment of intertrochanteric hip fractures, as it allows early recovery of patients, like other internal fixation systems, with the added advantage of being effected through a minimally invasive technique.

Level of evidence

"Before and After" study with evidence level III.

Conflict of interest

The authors declare they have no conflict of interest.

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