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Percutaneous compression plating versus compression hip screw fixation for the treatment of intertrochanteric hip fractures

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Summary Percutaneous compression plate (PCCP) devices are used for the fixation of intertrochanteric hip fractures by a minimally invasive technique. One hundred and eight patients who underwent this procedure were retrospectively compared with 155 patients who underwent compression hip screw (CHS) fixation. The general characteristics of the two groups, including age, sex, side of injury and co-morbidities assessed by the ASA score were similar. The operative time was significantly shorter in the PCCP group (67 versus 87 min, $p = 0.00$). Postoperative blood transfusions were not required in 40% of the patients in the PCCP group compared to 24% of the patients in the CHS group ($p < 0.01$). The rate of systemic postoperative complications was lower in the PCCP group ($p = 0.02$) both in univariate and multivariate analyses. A considerable reduction was observed in cardiovascular complications (OR = 3.1, $p < 0.05$). Length of hospitalisation, implant failure and mortality rates were not significantly different between the two study groups. We conclude that the PCCP device offers several advantages over CHS device and may improve the current treatment of intertrochanteric hip fractures while maintaining a similar success rate in fracture fixation.

Introduction

Minimally invasive surgery has gained popularity in modern orthopaedic trauma, as it is associated with decreased bleeding and postoperative pain, lower risk for postoperative morbidity and faster recovery

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of function.[5] Osteoporotic hip fractures are a "modern epidemic" as the population grows increasingly older.[7] Ninety percent of the patients are 65 or older at the time of the hip fracture and many already suffer from other major co-morbidities.[22] High rates of morbidity and mortality are reported following hip fractures. Currently, the classic compression hip screw (CHS) serves as the benchmark for fixation of intertrochanteric hip fractures with reproducibly reliable results.[9] However, this surgical technique may be associated with significant blood loss, soft tissue damage and may worsen existing co-morbidities of the elderly patients.[22] Therefore, a minimally invasive fixation device for the treatment of hip fractures may potentially improve patients' outcome.

The CHS device has several modes of failure, the most common of which is cut out of screws.[8,25] The single screw in the femoral neck, which provides the main mode of fracture fixation, may be insufficient in providing rotational stability.[6] A large hole (area—123 mm^2) is drilled for the barrel in the lateral aspect of the femur. This hole creates a stress riser, which may lead to a fracture of the lateral femoral cortex and to the detachment of the greater trochanter during the surgery. Another phenomenon involves excessive lag screw sliding that might lead to distal fragment medialisation and even collapse upon weight bearing.[3,12] This phenomenon is mostly observed in unstable fractures with posteromedial discontinuity (AO type 31.A2,[23] Evans type U2[1,17]). These complications do not impede the healing of the intertrochanteric fracture but cause severe pain during walking and hamper rehabilitation.

Several intramedullary implants for the fixation of intertrochanteric hip fractures have been tested.[1,2,10,15] These procedures involve considerable tissue trauma (reaming and violation of the medullary canal) and relatively high bleeding and transfusion rates. Therefore, intramedullary procedures cannot be considered "true minimally invasive". Although there is a tendency towards better fixation of unstable fractures, an increased rate of femoral shaft fractures was observed, especially with early designs of intramedullary nails.[5–7]

The percutaneous compression plate (PCCP) device was developed by Gotfried in the late 90's.[13] The design of the implant enables minimally invasive surgery, requiring two small incisions in order to insert a plate with a distal cutting edge. The device provides rotational stability by means of two hip screws. Lateral cortical support is conferred by a proximal extension of the plate and by the relatively small diameter of the hip screws (9.3 mm; area—68 mm^2 each). Anatomic or near anatomic reduction of the fracture is achieved with the aid of a specially designed posterior reduction device. The purpose of this study is to compare the outcome of PCCP and CHS procedures in large groups of patients.

Patients and methods

Patients

Surgery using the PCCP device was introduced to Hadassah Medical Centre in July 1999. The first year was considered the "learning curve" period and patients treated at that time were not included in the study, due to technical modifications in the implant and surgical instruments. A total number of 130 cases using PCCP device and of 232 cases using CHS device were operated between May 2000 and December 2001. Inclusion criteria were age over 60 years, fracture type—an intertrochanteric fracture amenable to closed reduction (AO 31.A1—A2, Evans S1, S2, U1 and U2).[1,11,17,2] Exclusion criteria were open reduction of the fracture, reverse obliquity fractures (AO 31.A3), pathological fracture or presence of metastatic malignant disease, ipsilateral lower limb surgery or contra-lateral hip fracture within the past 12 months. The surgery was preformed by a highly experienced senior surgeon and a resident, teamed arbitrarily according to the departmental work schedule.

Operative technique

In both surgical techniques, the patient was positioned in a standard fashion on a fracture table. The CHS (Richards, Smith and Nephew, Ltd.) device was inserted using a standard lateral approach. After a guide wire was placed freehanded, the lag screw was placed over it with a variable angle device (mostly 135° or 140°), together with a four-screw side plate and mostly a short compression screw. The PCCP (Efratgo Ltd.) technique has been described previously elsewhere[13] but will be briefly reviewed here. In order to maintain a closed reduction, a posterior reduction device was positioned under the patient's hip to prevent posterior sagging of the fracture. A 2-cm incision was made on the lateral aspect of the thigh at the level of the upper border of the lesser trochanter. The plate, with its cutting distal edge, was inserted beneath the vastus lateralis muscle and attached to the bone. A guiding frame was connected in parallel to the plate through which all the drills and screws were introduced. Through a second incision of the same length, a bone clamp was inserted to fix the plate to the bone and was attached to the guiding frame. The first neck screw was positioned and drilled in the inferior neck border, adjacent to the calcar femorale. Length was measured and a telescoping hip screw was introduced through the drilled hole. Additional three shaft self-tapping screws were placed through the guiding frame and the bone clamp was removed. The second hip screw superior in position to the first screw was then inserted. The wound was irrigated and the skin was closed over a suction drain. Fig. 1 shows an antero-posterior X-ray radiograph of the PCCP device.

Patients in both groups were allowed immediate postoperative full-weight bearing. Prophylactic antibiotics (1 mg cefazoline) were administered and prophylactic low-molecular weight heparin (40 mg $\times$ 1/d clexane) was given subcutaneously for six weeks postoperatively. Most patients were discharged from the hospital after 7—10 days either to their pervious residence or to an inpatient rehabilitation facility for an additional fortnight.

Figure 1 Antero-posterior X-ray radiograph of intertrocanteric fracture fixation with PCCP device.

Outcome measurements

Data was collected from the computerised database of the medical centre (including the operative reports and lab results) and from personal inpatient and outpatient medical charts.

General data were collected regarding the participating patients age, sex, side of injury, American Society for Anaesthesiologists (ASA) score,[24] and haemoglobin level upon hospitalisation. Mild anaemia was defined as admission haemoglobin level between 10.0 and 11.9 g/dL for women and between 10.0 and 12.9 g/dL for men. Severe anaemia was defined as an admission haemoglobin level below 10.0 g/dL for men and women.[14]

The outcome measures include the length of operative procedure from the first incision till the dressing of the surgical wound, number of packed cells units administered to the patient during hospitalisation and length of hospital stay following the surgery. In addition, the postoperative complications during the initial hospitalisation and in the first 6 months following the surgery were collected. These include septic, pulmonary, cardiovascular, thromboembolic, renal and gastrointestinal complications. Orthopaedic complications (cut out, revision surgery) were also recorded. Data regarding rehospitalisation and mortality was available for all patients in the form of computerised patients' records. Follow up in the outpatient orthopaedic clinic of the hospital existed for 55% of the patients and information regarding union rate, use of walking aids and radiographic results was extracted.

Statistical analysis

Comparison of categorical variables was obtained by Pearson χ^2 test and Fisher exact test when appropriate. Continuous variables were compared using the t-test. The logistic regression model or linear model was used to compare the two groups after adjustment for age and for prior cardiovascular condition.

Results

A total of 362 patients underwent surgical fixation of intertrochanteric hip fractures in our medical centre during a period of 19 months from May 2000 till December 2001. According to the study criteria, 155 patients out of 232 were included in the CHS group, and 108 patients out of 130 in the PCCP group. The most common reason for exclusion was an open reduction of the fracture. The characteristics of the two treatment groups are presented in

Table 1 Characteristics of the study groups

	CHS		PCCP	
	N	%	*N*	%
Number of patients	155		108	
Age	80 ± 8.6		81.2 ± 8	
Gender F/M	114/41	74/26	78/30	72/28
Side (R/L)	81/74	52/48	57/51	53/47
ASA score				
1	3	1.9	5	4.6
2	67	43	45	41.7
3	62	40	34	31.5
4	5	3	4	3.7
Admission haemoglobin level				
Mild anaemia	62	40	45	42
Severe anaemia	9	6	8	7.5

Table 1, demonstrating their similar characteristics. Pre-morbid conditions of the patients in the two groups were assessed using the preoperative ASA score and the admission haemoglobin level. Although there was a trend towards fewer patients with ASA 3 in the PCCP group, this difference was not statistically significant ($p = 0.086$).

Data concerning the hospitalisation of the patients are summarised in Table 2. Mean operative time of the PCCP patients (67.5 ± 21 min) was significantly shorter than the CHS patients (82.7 ± 29.9 min) ($p < 0.01$). Six patients (3.9%) in the CHS group and five patients (4.5%) from the PCCP group were treated postoperatively in the intensive care unit. The length of hospital stay was 9.91 ± 4.23 days for the CHS group and 11.5 ± 8.59 in the PCCP groups. The differences in intensive care unit stay and length of hospitalisation between the two groups were not statistically significant.

Blood transfusions were not required in 43 (40%) of the PCCP patients and 38 (24.5%) of the CHS patients, while the transfusion of three or more units of packed cells was needed in nine (8.3%) and 27 (13.4%) of the patients in the PCCP and CHS groups, respectively (Table 3). The reduced need for blood transfusions in the PCCP group was

Table 2 Operative and postoperative data

	CHS	PCCP
Operative time (min)	82.7 ± 26.9*	67.5 ± 21*
Length of hospitalisation (days)	9.91 ± 4.2	11.56 ± 8.6
ICU stay during hospitalisation (%)	3.9	4.5
Re-hospitalisation (within 1 year) (%)	26.4	24

* Statistically significant differences.

Table 3 Blood transfusion requirement in the CHS and PCCP groups

Units of packed blood cells	CHS (%)	PCCP (%)
0	38 (24.5)	43 (40)
1	45 (29)	26 (24)
2	42 (27)	26 (23)
3 and more	27 (17.4)	9 (8.3)

statistically significant ($p = 0.02$). It should be stressed that our policy for blood transfusion administration is identical for all elderly patients and includes haemoglobin level less than 10 g/dL and/or symptoms associated with anaemia (tachycardia, etc.). Furthermore, the two treatment groups were similar in the baseline conditions as reflected in admission haemoglobin levels (Table 1).

The medical complications that have occurred within the 6 months following the hip fracture surgery are detailed in Table 4. In order to quantify the complication rate, patients were sorted according to the cumulative number of postoperative complications, ranging from no complications up to three and more complications. In the PCCP group, 66 (61%) of the patients had no postoperative complications, compared to 71 (46%) of the patients in the CHS group. Overall, the PCCP group displayed less postoperative morbidity ($p = 0.036$). Comparisons of the length of surgery, blood transfusions and number of complications in the two groups yielded similar results after adjustment for age.

Major cardiovascular complications are more frequent in the CHS group (Table 4). These complications include the onset of myocardial ischaemia, major arrhythmia or a cardiac decompensation event requiring treatment in a medical ward.

Table 4 Postoperative complications within 6 months following the fixation of the hip fracture in the two study groups

	CHS (%)	PCCP (%)
UTI	23 (14.8)	14 (13)
DVT	2 (1.3)	2 (1.8)
Duplex	26 (16.8)	14 (13)
Hematoma	16 (10.3)	14 (13)
Wound infection (total)	10 (6.4)	3 (2.8)
Superficial	5 (3.2)	2 (1.8)
Deep	5 (3.2)	1 (0.9)
PE	4.5 (2.9)	1 (0.9)
Cardiovascular	27 (17.4)	8 (7.4)
CVA	4 (2.6)	2 (1.8)
Respiratory	17 (11)	11 (10)
Gastrointestinal	15 (9.7)	12 (11)
Renal	10 (6.4)	13 (12)
Electrolytes imbalance	13 (8.4)	5 (4.6)
Other	16 (10.3)	15 (13.9)

Table 5 Mortality within the first postoperative year

	CHS (%)	PCCP (%)
0—3 months	12 (7.7)	13 (12)
3—6 months	9 (5.8)	2 (1.8)
6—12 months	5 (3.2)	2 (1.8)
Total (in 12 months)	26 (16.8)	17 (15.7)

We have analysed the medical history records of all the patients, with an emphasis on previous cardiovascular disease. Prior to the hip fracture, 33.3% of the PCCP patients and 36% of the CHS patients had a history of cardiovascular disease. Major cardiovascular complications were significantly more frequent in the CHS group (Odds Ratio 3.1, 95% CI, $p < 0.05$), after adjustment for the pre-existing heart condition.

Implant failure occurred in two patients in the PCCP group within the first postoperative week—the first was severe medial displacement and the second was cutting out of the lower hip screw. Both cases were treated by re-operation using CHS device and healed uneventfully. In addition, a single case of non-union after 6 months was treated by revision to CHS. Another patient had a malunited fracture due to excessive shortening but was successfully treated with a heel raise.

In the CHS group, four revisions were performed. One patient had a subcapital fracture leading to non-union and implant failure that was treated by excisional arthroplasty. A case of deep wound infection leading to sepsis required implant removal, antibiotic treatment and re-fixation. Two patients displayed cutting out of the hip screw through the femoral head and required re-fixation with a fixed angle device (blade plate). One of these did not unite and underwent total hip arthroplasty. In two additional cases the implant was removed—in the first case due to pain and in the second after fixation of an ipsilateral femoral shaft fracture with a retrograde intramedullary nail. The total number of these complications did not differ significantly within the two groups.

Overall mortality rates in the first year were similar in the two groups (Table 5). In the CHS group, 26 patients died (16.8%), compared with 17 patients in the PCCP group (15.7%).

Discussion

Minimally invasive surgery may improve treatment outcome by reducing perioperative blood loss, soft tissue damage, postoperative pain and morbidity. The results of our large-scale retrospective study suggest that the new minimally invasive technique for the fixation of intertrochanteric hip fractures is beneficial for the patients. The use of the PCCP device was associated with significant reductions in surgical time and blood transfusion rate. These findings are consistent with the decreased bleeding and tissue trauma associated with the percutaneous nature of the technique. Thus, the elderly patients with associated co-morbidities are less exposed to the hazards of blood transfusion, such as haemodynamic compromise, allergic reactions and potential infection. Recent prospective studies comparing the CHS and PCCP devices have also demonstrated a tendency towards less bleeding with the use of the PCCP device.[4,16,19]

The group of patients undergoing the PCCP surgery experienced less postoperative complications during the 6 months following the surgery. Cardiovascular events have been reported as the most common and hazardous complications of hip fracture surgery, with a rate ranging from 8 to 27%.[20] In our study, 17.4% of the patients in the CHS group experienced a major cardiovascular complication, consistent with rates reported in other studies.[15] A particularly interesting observation is the three-fold reduction in the odds for cardiovascular events in the PCCP group. A recent prospective study has noted a tendency towards less cardiovascular complications in the PCCP group (one out of 52 patients) compared to the CHS group (six out of 56 patients), but this difference was not analysed statistically.[4] A possible explanation for this result is the combined effect of decreased bleeding and reduced postoperative pain associated with the PCCP procedure. A correlation between reduced pain and fewer cardiovascular events in elderly patients with hip fractures has been recently demonstrated.[21] Although postoperative pain was not assessed in our study, minimally invasive surgery is usually associated with less pain immediately following the surgery and with more rapid mobilisation. Furthermore, Janzing et al.[16] observed reduced postoperative pain in their PCCP patients compared to the CHS patients.

Our data suggest that the marked reduction in postoperative complications in general and major cardiovascular complications in particular did not affect the mortality rate in both groups. After 1 year, the mortality rate was approximately 16%, similar to rates obtained in other studies.[15,22] Previous studies have shown that high number of postoperative complications (three and more) is a significant risk factor for postsurgical mortality.[18] In our study, only 6—7% percent of the patients had this number of complications. Therefore, a larger sample size may be required to demonstrate a significant reduction in mortality. Furthermore, a high correlation has been shown between mortality rate and pre-existing medical conditions.[18] This risk factor as reflected in the ASA score is not significantly different between the groups in our study.

The PCCP is performed using a ''no-touch technique'' with decreased tissue exposure. Our data show a tendency towards less infectious complications in the PCCP group with only one case (0.9%) of deep wound infection compared to five cases (3.2%) in the CHS group (Table 4). A larger study sample may be needed for statistical assessment of the infection rate.

Failure rates were similar in the two groups. This implies that the new implant provides at least the same stability as the time honoured CHS. However, the fixation benefits should be studied on a larger population of unstable intertrochanteric fractures (AO type 31.A2 or Evans U1, U2) since they are the less common and more problematic. In the current study, we have not performed a radiological analysis of the fracture outcome to evaluate the potential mechanical advantages of the PCCP technique.

From the technical point of view, the PCCP technique requires anatomical or near anatomical indirect, closed fracture reduction. A posterior reduction device is an integral part of the system, assisting the reduction and preventing posterior sagging of the fracture. This can further improve the results and reduce total surgery time.[4,16] Criticism had been made regarding the technically demanding surgical technique as compared to the relative simplicity of the CHS.[4] According to our experience, after a learning curve of a few cases most of the surgeons could perform this surgery well and in fact required a significantly shorter operating time.

We would like to emphasise the importance of two technical issues regarding PCCP. First, the barrels should be completely tightened to the side plate. If this is not done properly, the barrel might gradually loosen from the plate. Second, care should be taken that the neck screws are in the correct position both on the AP and the lateral views of the intraoperative fluoroscopic images. Since the system is not a cannulated system, the correct positioning of the main-guide does not necessarily ensure that the drilling and the screws will follow the same position. Therefore, intraoperative verification of the correct drilling and positioning of the neck screws is essential.

This study is limited by its retrospective nature. However, it encompasses a large number of patients operated on by several experienced orthopaedic surgeons. The two study groups are similar according to all examined characteristics, including the assessment of co-morbidity by the ASA scores and haemoglobin levels upon hospitalisation. Although prospective, randomised studies comparing the CHS and PCCP techniques were preformed,[4,16,19] the relatively small number of participants restricted their statistical power.

Conclusions

In our retrospective study, the use of PCCP device has resulted in a shorter surgery time and reduced need for blood transfusions. Concomitant with the less traumatic surgery, the postsurgical period is associated with fewer medical complications in general and cardiovascular events in particular. Based on our results, we suggest that the use of the PCCP technique should be considered for patients with increased risk for cardiovascular complications.

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