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*ORIGINAL STUDY*

# The percutaneous compression plate versus the dynamic hip screw : A meta-analysis

Sukhmeet Singh Panesar, Saqeb Mirza, Gaurav Bharadwaj, Victor Woolf, Ratukondla Ravikumar, Thanos Athanasiou

*From North Middlesex University Hospital, London, United Kingdom, Royal Glamorgan Hospital, Llantrisant, United Kingdom, and Imperial College London, London, United Kingdom*

**Intertrochanteric fractures are a significant orthopaedic burden. The aim of this study was to assess how the Percutaneous Compression Plate (PCCP) technique performs compared to the traditional dynamic hip screw (DHS). A meta-analysis of all head to head trials (1995-2006) comparing the two techniques was performed. Early mortality (≤ 1 year) was the major outcome of interest. Secondary outcomes of interest included operation time (minutes), blood transfusion requirements, post-operative infection and length of stay in hospital (days). There was a decreased trend in overall mortality in the PCCP group [CI 0.84, (0.48 to 1.47), Chi-square = 1.36, p = 0.51]. Similar trends favouring the PCCP technique were seen with the other outcomes. PCCP being a relatively new technique has the potential to become the gold standard in the repair of intertrochanteric hip fractures. However, owing to the limitations of this meta-analysis, a large randomised controlled trial is required.**

**Keywords** : hip fractures ; fracture fixation ; mortality ; comparative study ; meta analysis.

### Abbreviations

NNT = number needed to treat
OR = odds ratio
SE = standard error of the mean
LogOR = logarithm of the odds ratio
WMD = weighted mean difference

## INTRODUCTION

Proximal femoral fractures are among the commonest fractures in the elderly population (*7*) and have been described as a modern epidemic (*34*). Ninety percent of patients are over the age of 65 at the time of hip fracture and a large proportion

■ Sukhmeet Singh Panesar, BSc (Hons.) MBBS, Foundation Year 1 doctor.
■ Victor Woolf, MS (Orth) FRCS FRCS (Orth & Trauma), Consultant surgeon in Orthopaedics and Trauma.
■ Ratukondla Ravikumar MS (Orth) FRCS FRCS (Orth & Trauma), Consultant surgeon in Orthopaedics and Trauma.
■ Thanos Athanasiou MD PhD FECTS, Consultant Surgeon and Senior lecturer.
*North Middlesex University Teaching Hospital, London, United Kingdom.*
■ Saqeb Mirza, MBChB MRCS MSc, Research Fellow.
*Royal Glamorgan Hospital, Llantrisant, United Kingdom.*
■ Gaurav Bharadwaj, MRCS AFRCS MS (Orth) FRCS (Orth & Trauma), Orthopaedics registrar.
Correspondence : Sukhmeet S. Panesar, Imperial College London, Division of Surgery, Oncology, Reproductive Biology and Anaesthetics, Department of Biosurgery & Surgical Technology, 10th Floor, QEQM Building, St. Mary's Hospital, Praed Street, London W2 1 NY, United Kingdom.
E-mail : sukhmeet.panesar@imperial.ac.uk




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suffer from major comorbidities (*27*). An ageing population, increasing life expectancy combined with an increasing population growth means that the frequency of these fractures is expected to increase exponentially over the next few decades (*12*) with significant medical and socioeconomic consequences (*9,10*).

Approximately half of hip fractures are intertrochanteric (*11*). The Dynamic Hip Screw (DHS) has become the standard and is currently the most common implant used to fix intertrochanteric fractures (*18,21,24*). Treatment essentially involves closed reduction of the fracture with open internal fixation. This entails at least a 10 cm split of the vastus lateralis muscle, an operation which may be associated with significant blood loss and soft tissue damage, both of which may have a negative impact on elderly patients with multiple comorbidities (*27*).

Minimally invasive surgery is gaining popularity in trauma surgery, with potential benefits including decreased bleeding and post-operative pain, a lower risk of post-operative morbidity and faster mobilisation (*4*). The Percutaneous Compression Plate (PCCP) was developed by Gotfried (*13*) as a minimally invasive implant for intertrochanteric fracture fixation. It consists of a plate with a bevelled end that can be introduced through the vastus lateralis muscle by means of two small (2 cm) skin incisions. Two telescoping neck screws are activated by the surgeon to compress the fracture and three shaft screws are used for distal fixation. A locking plate is an additional feature in cases of lateral wall instability (*13*).

There are only a few studies evaluating the efficacy of PCCP in the treatment of intertrochanteric fractures (*3,13,18,20,22,29*) and all have small sample sizes.

This study aims to answer the following questions :

1. Is the PCCP technique associated with reduced mortality compared to the DHS procedure ?
2. Does PCCP reduce the operating time when compared to DHS ?
3. Is there a decreased need for blood transfusion post-operatively in the PCCP group as compared to the DHS group ?
4. Does PCCP reduce the incidence of infection when compared to DHS ?
5. Is there any difference in length of hospital stay between PCCP and DHS groups ?
6. Is there any significant heterogeneity between studies and if so how can this be explained ?

## PATIENTS AND METHODS

### Literature search

A literature search (MEDLINE) was performed on all the studies published in the English language between 2000 and 2006 reporting elderly patients undergoing PCCP, with emphasis on comparisons between PCCP and DHS techniques. The following MeSH search headings were used : "Bone plates", "Bone screws", "Fracture fixation/methods*", "Hip fractures/surgery*", "Mortality", "Comparative study". The articles were also identified by using the function "related articles" in PubMed. All the abstracts, studies, and citations scanned were reviewed. The search results are shown in fig 1.

### Data Extraction

Data extraction was conducted by two reviewers (SP and SM) and in the case of discrepancy the decision was taken by consensus. The following information was extracted from each study : first author, year of publication, study population characteristics, study design (prospective, retrospective or other), inclusion and exclusion criteria, number of subjects operated on with each technique, quality of study and early post-operative outcome measures.

The study was performed in line with the recommendations of the proposal for reporting meta-analysis of observational studies in epidemiology (MOOSE), which was produced in Atlanta (*31*). The quality of the non-randomised studies was assessed by using the Newcastle-Ottawa Scale (NOS) with some modifications to match the needs of this study (*33*). The quality of the studies was evaluated by examining three items : patient selection, comparability of the PCCP and DHS groups and assessment of outcomes. For the comparability between the two groups, we focused on the following variables which have been identified as independent predictors of mortality by previous multivariate studies : age and sex. We also compared groups based on the stability of the fracture and the need for conversion from PCCP to DHS. Other factors that negatively influence mortality

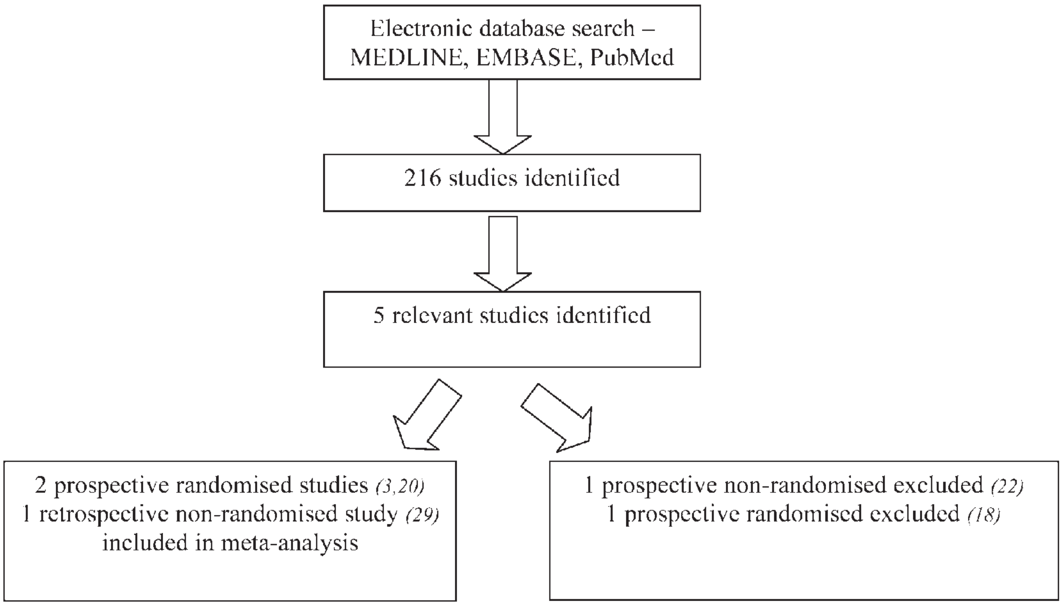


***Fig. 1.*** — Search results

are cardiac complications, dementia, waiting time before operation and stroke (*12*).

Studies were graded on an ordinal star scoring scale with higher scores representing studies of higher quality. A study can be awarded a maximum of one star for each numbered item within the selection and exposure categories and a maximum of two stars can be given for the comparability of the two groups. This is shown in tables I, II, III and IV. The demographics of the patients and the types of fractures included in all the studies are shown in tables III and IV.

**Inclusion Criteria**

The following criteria were used in order to include studies into our analysis :

1. Only studies comparing PCCP with DHS were included.
2. Where several articles reported on the same patient material, we selected the most recent article or the article with the greatest detail of information.
3. Where studies originated from the same institution and had the same authors, the one that focused on the oldest patient group was used.

**Exclusion criteria**

The following criteria were used in order to exclude studies from our analysis :

1. Studies in which the surgical technique (whether PCCP or DHS) could not be defined.
2. Studies in which the outcome of comparison of both techniques was not reported or it was not possible to calculate this from the published results.

**Outcomes of Interest and Definitions**

PCCP and DHS were compared, with early mortality being the major outcome of interest. It was defined as the total early mortality that occurred up to the end of the follow-up period in the study. This ranged from 2 to 12 months. Secondary outcomes of interest included operation time (minutes), blood transfusion requirements (both number of units transfused and number of patients receiving a transfusion), post-operative infection and length of stay in hospital (days). Mortality was defined as short-term mortality (up to 1 year). We extracted the "mortality" statistics as they appeared in the post-operative outcomes tables of the various studies.

Table I. — Checklist for quality assessment and scoring of studies

| Check-list |
|---|
| Selection |
| 1. Assignment for treatment-Any criteria reported ? (if yes-1star) |
| 2. How representative was the reference group (DHS) in comparison to the general DHS population for repair of neck of femur fracture ? (if yes-1 star, no star if the patients were selected or selection of group was not described) |
| 3. How representative was the treatment group (PCCP) in comparison to the general PCCP population for repair of neck of femur fracture ? (if drawn from the same community as the reference group-1 star, no star if drawn from a different source or selection of group was not described) |
| |
| Comparability |
| 4. Group comparable for 1 – 7, if yes-2 stars, One star was assigned if ≥3 but < 5 characteristics had been controlled for. No star was assigned if the two groups differed |
| Comparability Variables : 1 = age, 2 = sex, 3-stable/unstable fracture, 4-cardiac complications, 5 = dementia, 6 = waiting time before re-operation and 7 = stroke, 8 = anaemia, 9 = ASA score |
| |
| Outcome Assessment |
| 5. Clearly defined outcome of interest (yes-1star for information ascertained by record lineage or interview, no star if this information was not reported) |
| 6. Adequacy of follow-up (1 star if follow-up > 90%) |

We did not analyse the different modifications in the operative technique used by different surgeons.

## Statistical Analysis

The technique in which the DHS was used was considered as the reference group, and that in which PCCP was used, the treatment group. The Mantel-Haenszel method was used to combine the odds ratio for the outcomes of interest. Yate's correction was used for those studies that contained a zero in one cell for the number of events of interest in one of the two groups. These "zero cells" create problems with the computation of ratio measure and its standard error of the treatment effect. This was resolved by adding the value 0.5 in each cell of the $2 \times 2$ table for the study in question, and if there were no events for both PCCP and DHS groups the study was discarded from the meta-analysis.

In this study both fixed and random effect models were used. In a fixed effect model it is assumed that the treatment effect in each study is the same, whereas in a random effect model it is assumed that there is variation between studies and the calculated odds ratio thus has a more conservative value. In surgical research, meta-analysis using the random effect model is preferable particularly because patients that are operated on in different institutions have varying risk profiles and selection criteria for each surgical technique.

In the tabulation of our results, squares indicate point estimates of treatment effect (odds ratio), with 95% confidence intervals indicated by horizontal bars. The diamond represents the summary odds ratio from the pooled studies with 95% confidence intervals. For continuous variables such as length of stay, statistical analysis was carried out using the random effect weighted mean difference (WMD) as the summary statistic.

Two strategies were employed to quantitatively assess heterogeneity. First, data was re-analysed using both fixed and random effect models. Second, graphical exploration with funnel plots was used to evaluate publication bias. This scatter plot of the treatment effects is estimated from individual studies on the horizontal axis (OR) against a measure of study size on the vertical axis (SE [logOR]).

Analysis was conducted by using the statistical software SPSS version 12.0 for Windows (SPSS Inc., Chicago, IL, USA), Intercooled Stata version 7.0 for Windows (Stata Corporation, USA), Review Manager Version 4.2 (The Cochrane Collaboration, Software

Table II. — Assessment of quality of studies

| Author (year) | Selection | | | Comparability | Outcome assessment | | Score |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 5 | 5 | 6 | |
| Brandt SE *(3)* | * | * | * | * | * | * | ****** |
| Kosygan KP *(20)* | * | * | * | * | * | * | ****** |
| Peyser A *(29)* | * | * | * | * | * | * | ****** |

Table III. — List of studies comparing PCCP with DHS

| Author (year) | PCCP / DHS | Exclusion criteria | Matching criteria | Criteria scoring | Conversion from PCCP to DHS |
|---|---|---|---|---|---|
| Brandt SE *(3)* | 33/38 | 2,5,8 | 1,3,4 | 3 | 0 |
| Kosygan KP *(20)* | 52/56 | 3, 7 | 1, 3,5 | 1 | 3 |
| Peyser A *(29)* | 108/155 | 1,2,3,4,5,6 | 1,2,8 | 3 | 3 |
| | | | | | |
| Matching criteria : 1 = age, 2 = sex, 3-stable/unstable fracture, 4-cardiac complications, 5 = dementia, 6 = waiting time before re-operation and 7 = stroke, 8 = anaemia, 9 = ASA score | | | | | |
| | | | | | |
| Exclusion criteria : 1 = open reduction of the fracture, 2 = reverse obliquity fractures, 3 = pathological fracture, 4 = presence of metastatic malignant disease, 5 = ipsilateral lower limb surgery, 6 = contra-lateral hip fracture within the past 12 months, 7 = sub-trochanteric and intertrochanteric fractures, 8 = bilateral fractures | | | | | |
| Criteria scoring : 1 = matched for 0-2 criteria, 2 = matched for 3-5 criteria, 3 = matched for 6-9 criteria | | | | | |

Table IV. — Types of fractures included in studies

| Author (year) | Mean age (range) of patients | Type of fracture (number of patients) |
|---|---|---|
| Brandt SE *(3)* | | |
| PCCP | 80.1 (63 - 96) | Evans 1A (33), Evans 1B (10), Evans 1C (14) and Evans 1D (4) |
| DHS | 81.6 (61 - 97) | Evans 1A (38), Evans 1B (4), Evans 1C (19) and Evans 1D (4) |
| Kosygan KP *(20)* | | |
| PCCP | 82.7 (53 - 93) | Stable (24), unstable (28) |
| DHS | 82.8 (57 – 97) | Stable (25), unstable (31) |
| Peyser A *(29)* | | |
| PCCP | 81.2 (73 - 89) | Both groups included fractures that were AO31.A1-A2, Evans S1, S2, U1 and U2 – no exact breakdown available |
| DHS | 80 (71 - 89) | |

Update, Oxford) and the Sample Power 2.0 (SPSS Inc., Chicago, IL, USA) for power analysis calculations.

**Sample size considerations**

Mortality is a rare categorical outcome and was indeed our major outcome of interest. The incidence of mortality in the DHS group was 38/249 (15%), allowing us to assume that in order to rule out a 50% relative risk reduction (from 15% to 8%) with a 5% significance level and 90% power, a traditional randomised controlled trial would require 4,729 patients. Based on 3:1 ratio (DHS : PCCP), this equates to 3,547 : 1,182 respectively.

## RESULTS

### Selected studies

Using the previously mentioned criteria, five studies comparing PCCP and DHS were identified (*3,18,20,22,29*). We excluded one study (*22*) as it assessed purely functional outcomes after the procedure. Two other studies (*3,18*) used the same data set. We selected the former as it was more informative and had more clinical outcomes of interest.

On review of the data extraction there was 100% agreement between the two reviewers and the agreement on quality score of the individual studies was very high (weighted Kappa = 0.96).

### Clinical outcomes

There was a decreased trend in overall mortality in the PCCP group with 24/193 (12.4%) versus 38/249 (15.3%) episodes of early mortality in the DHS group [CI 0.84, (0.48 to 1.47), Chi-square = 1.36, p = 0.51]. This is illustrated in fig 2. Sensitivity analysis for mortality did not identify any significant differences in the odds ratios and heterogeneity using both random and fixed effect models. This is shown in fig 3.

Similarly, there was a trend towards a decreased incidence of post-operative infections in the PCCP group. The average operating time also appeared to be decreased with the use of PCCP. However, no trend could be ascertained with regard to the length of hospital stay (days). These data are shown in fig 4.

### Comment

The results of our meta-analysis show a reduction in the incidence of early mortality, post-operative infections, operating time (minutes) and length of stay in hospital (days).

Previous studies have commented on the exponential increase in fractures of the proximal femur and on their expected increase over the next few decades (*2,3*). They often occur in the elderly who commonly also suffer from multiple comorbid conditions that may be made worse by the surgical trauma associated with a major operation. Therefore, the development of a minimally invasive technique of fracture fixation, causing less tissue damage and bleeding and shorter operation times in addition to providing a good fixation, may potentially lead to better outcomes especially in an elderly population.

Several intramedullary devices have been used in the past to fix intertrochanteric fractures (*1,8,17*). Femoral reaming when used, however, can been associated with high bleeding and transfusion rates (*29*). This is in addition to longer term complications like secondary fracture displacement (*25*) or periprosthetic fracture (*2,28,30*). Such complications may not apply to unreamed devices. The DHS is the commonest extramedullary device used for intertrochanteric fractures (*21,24*) with reasonable results. However, insertion requires a 10 cm incision splitting the vastus lateralis, causing considerable bleeding and damage to overlying soft tissues. It is also a single-axis fixation device with a single screw in the femoral neck providing the main mode

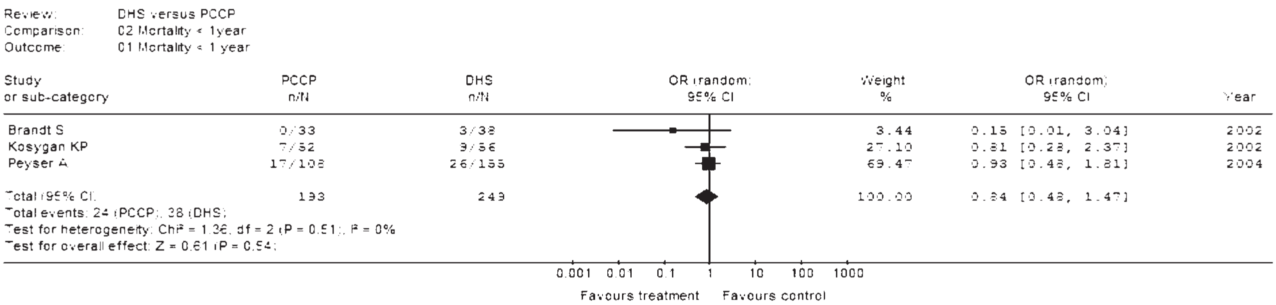


***Fig. 2.*** — Early mortality

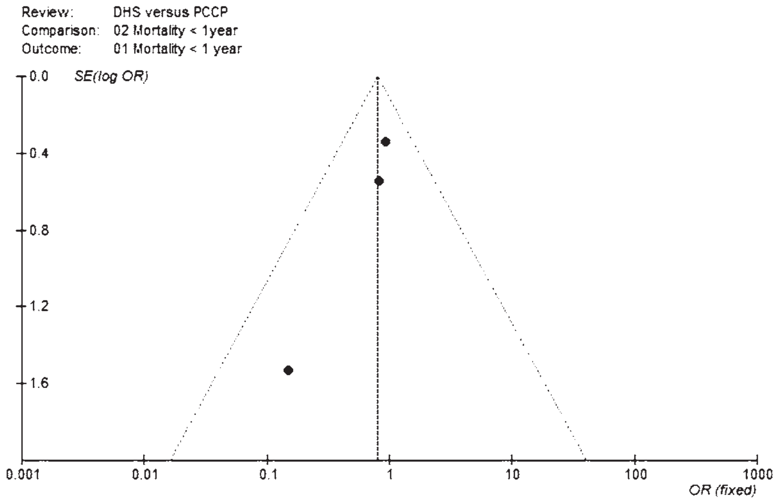


***Fig. 3.*** — Sensitivity analysis for early mortality

of fixation. It is thought that this may provide insufficient torsional stability and may contribute to increased postoperative pain (*5,32*). The DHS is also known to produce fracture collapse rather than controlled fracture impaction resulting in poor functional outcome.

The use of minimally invasive techniques in trauma surgery is associated with decreased bleeding and postoperative pain, faster recovery of function and lower postoperative morbidity (*4*). Indeed such techniques have been used for fixation of proximal femoral fractures (*6,35*) and their use is associated with a better clinical outcome and reduced postoperative morbidity. The PCCP was developed recently as a novel method of intertrochanteric fracture fixation. Due to its percutaneous method of insertion, it is thought that it causes minimal operative trauma, a feature particularly appealing for fracture fixation in a vulnerable elderly population (*13,14*). It is thought that minimal exposure and periosteal stripping and preservation of soft tissue cover would provide optimum conditions for union of fracture (*20*).

Our study indicated a decreased trend toward the incidence of all postoperative infections in the PCCP group. The PCCP is performed using a "no-touch technique". The plate is inserted by means of two 2cm stab incisions, minimising tissue exposure to the external environment. The minimal tissue dissection and damage characteristic of this technique is a possible explanation for these trends. Development of wound haematomas have also been shown to be reduced using the PCCP implant (*3*). The lack of significant differences in wound infections despite trends toward a lower infection rate found in some studies could be due to small sample sizes (*3*).

Most studies in the literature report a significantly shorter operation time with the use of PCCP compared with the DHS (*3,18,29*). Only one study (*20*) indicated a longer operation time for PCCP. However, the learning curve for PCCP in this study consisted only of two cases. Combining the results of these studies our meta-analysis showed a decrease in average operating time with the PCCP compared to the DHS as shown in fig 4. According to the literature, after a learning curve of only a few cases, most surgeons, whatever their level, could perform this surgery well and required a shorter operating time than the DHS group (*29*). A reduced operating time, especially in elderly patients with comorbid conditions or poor cardiopulmonary reserve is desirable as it reduces temporal exposure to the risks of general anaesthetic. This, combined with reduced surgical trauma, may play a significant part in reducing postoperative morbidity and mortality in such patients.

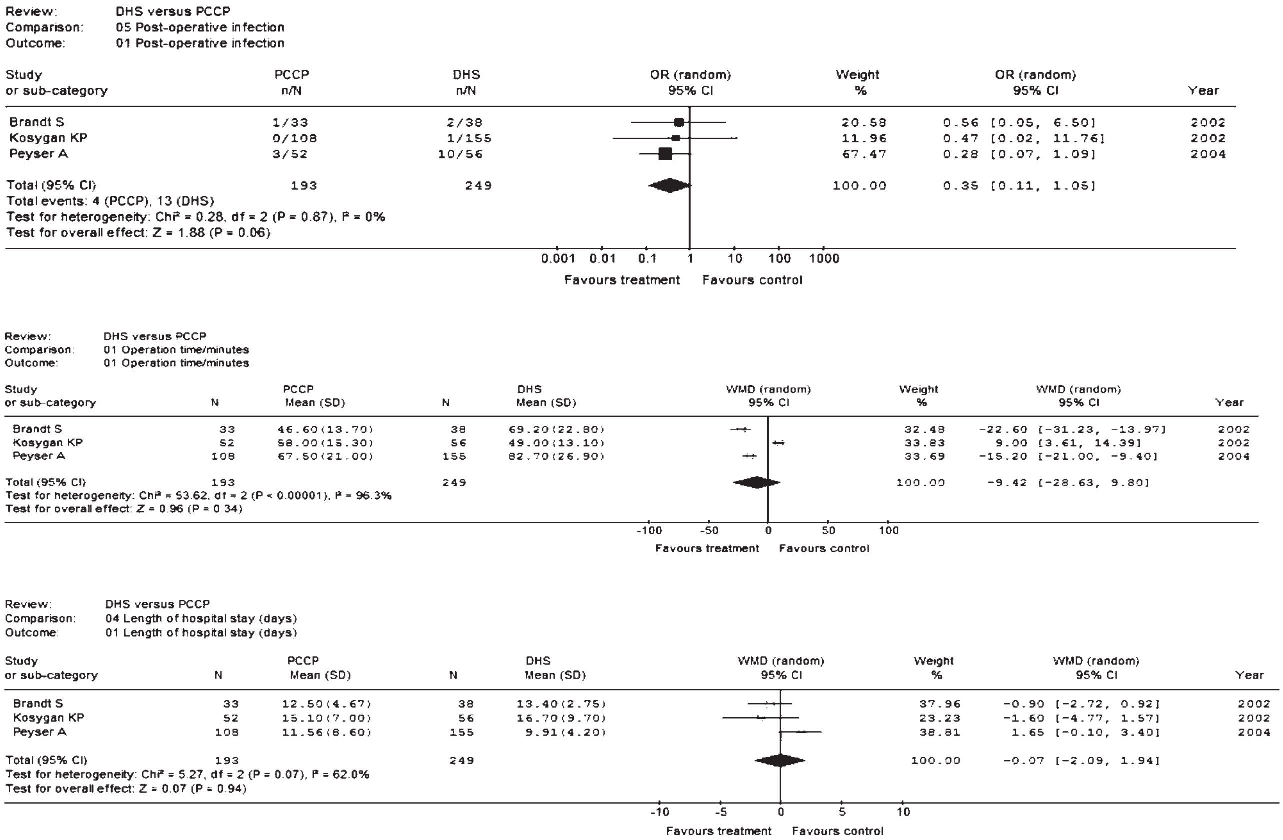


***Fig. 4.*** — Post-operative infections, operation time (minutes) and length of hospital stay (days)

Our main outcome measure was early mortality rate with 12.4% in the PCCP and 15.3% in the DHS group thus suggesting that the use of PCCP reduces mortality secondary to fracture fixation. Some of the most common complications of hip fracture surgery are cardiovascular events, occurring in up to 27% of patients undergoing such operations (*23*). Decreased bleeding and reduced postoperative pain are thought to be possible explanations for the reduced cardiovascular complications associated with PCCP in comparison to other methods of fixation (*29*). A recent study found a correlation between reduced pain in elderly patients undergoing proximal femoral fracture fixation and fewer cardiovascular events (*26*), indicating that a reduction in postoperative pain may be beneficial in reducing cardiac stress. A reduced operation duration, less bleeding and transfusion requirements, less postoperative pain and earlier ambulation may indeed all be contributory factors for a more favourable outcome in terms of early mortality in the PCCP group. Indeed previous studies have shown that occurrence of three or more postoperative complications contributes significantly to surgical mortality after hip fracture (*33*). These factors may explain the differences in early mortality in the postoperative period in the PCCP group compared to the DHS group. However, it is difficult to explain the more favourable mortality in the PCCP beyond the immediate postoperative period.

It has been shown that patients undergoing PCCP for the fixation of intertrochanteric fractures suffer less postoperative pain than their counterparts undergoing a DHS procedure (*18*). Laufer *et al* (*22*) demonstrated a higher level of comfort and significantly less pain on walking in the PCCP compared to the DHS group. It is generally accepted that early postoperative mobilisation is vital for the prevention of medical complications especially in elderly patients (*36*). Therefore it is possible that an increased level of comfort and reduced pain after PCCP may facilitate easier postoperative mobilisation and reduced postoperative morbidity, which may in turn have a favourable effect on mortality.

Our study did not formally assess bleeding and transfusion requirements. The literature suggests that the PCCP procedure is associated with a decreased blood loss (*3,20,29*) and reduced transfusion requirements with one study showing an absolute risk reduction for blood transfusion of 45% (*3*). This has been attributed to the percutaneous nature of the technique causing less tissue trauma, as well as the reduced operation times. However, there are limitations to measuring blood loss including whether or not drains were used post-operatively, whether the amount of blood on swabs was included and whether post-operative haemoglobin was measured and at what time. It was not the purpose of this meta-analysis to look at these factors. The same study showed a decreased incidence of wound haematomas. Elderly patients are therefore less likely to be exposed to the ill-effects of transfusion including blood-borne infections, fluid overload and allergic reactions.

Our meta-analysis failed to demonstrate any differences in the length of stay between the two groups. It is thought that the patients' premorbid physical activity levels and mental profiles determine the ultimate rate of rehabilitation and that the choice of implant is of secondary importance as long as stable fixation with controlled collapse at the fracture site is obtained (*20*). Moreover, hospital stay is affected by prevailing social, medical and economic conditions such as availability of nursing home care, rehabilitation units and local discharge protocols (*3*). This makes comparison of data from different studies difficult. However, reduced post-operative pain with the use of PCCP fixation may encourage earlier mobilisation and, in principle, may facilitate earlier discharge from hospital.

The PCCP is a fixed angle device and requires anatomic or near anatomic reduction of the fracture (*13*) unlike the DHS in which implants come in a variety of angles. This makes the DHS more versatile ; enabling the implant to be adapted to the fracture configuration i.e. it does not require perfect anatomic reduction of the fracture. Thus, there are certain situations in which the use of PCCP is restricted. Use of the posterior reduction device supplied as an integral part of the system assists in reduction and prevents posterior sagging of the fracture and may reduce total surgical time (*3,18*).

In addition to the outcomes demonstrated in this meta-analysis, two features of the PCCP deserve mention. The inventor indicates two distinct advantages of this device over the DHS. The compression, bending and torsional strength of the PCCP is comparable to that of the DHS (*15*). It differs from the DHS in that it has double telescoping screws rather than the single DHS screw. It is argued that double screws offer additional rotational stability and reduce rotational torque (*13,15*), allowing more efficient controlled fracture impaction and reducing the risk of femoral head cut-outs. Secondly, lateral cortical support which is central for fracture stability (*16*), is maintained by smaller diameter femoral head screws (*13,29*) and gradual drilling from 7.0-9.3 mm compared with the 16 mm holes used in DHS fixation. This, theoretically reduces the risk of stress risers and fracture collapse (*13*) particularly in unstable intertrochanteric fractures. Furthermore in our meta-analysis only 6 cases were converted from PCCP to DHS, showing the robustness of the former.

Early data regarding functional recovery after PCCP show favourable results with an enhanced functional recovery score (*37,38*) including activities of daily living and less use of external support for mobilisation at two years compared with the DHS (*22*).

However, there are some potential disadvantages of the PCCP technique. Optimists will say that there is hardly any learning curve (*3*). Others will say that great care must be taken in the first few steps of performing the PCCP procedure to prevent frequent mechanical problems. Correct positioning of the patient, maintenance of posterior reduction, correct alignment of the aiming guide and strict adherence to the successive steps of the procedure are all crucial to ensure correct insertion of the PCCP. Furthermore, the two telescoping screws of the PCCP must be inserted with care to ensure adequate, long-term fracture reduction. All the above-mentioned steps are prone to mechanical problems.

Our study made no attempt at evaluating the cost effectiveness of the PCCP procedure. However, considering the reduced blood transfusion requirements, operation time, the minimally invasive nature of the operation potentially dispensing with the cost of an assistant and the minimal suture material required as well as potential earlier mobilisation and discharge from hospital with this procedure, there are clear opportunities to make savings. This is however a novel method of intertrochanteric fracture fixation and it is expected that as experience with this procedure increases, more data will become available regarding its effects on patient outcomes. Once the learning curve is overcome, considering the above results, the PCCP may actually become the gold standard for treating such fractures particularly in the elderly or in those with comorbid conditions.

### Limitations of the study

Although every effort was made to ensure our results were accurate, it was impossible to quantify potential biases of the studies, and adjust for inadequate study design. It was not the purpose of this study to assess different modifications of the PCCP technique or the seniority of the surgeons. It is also worth noting that some of the PCCP cases were converted to DHS cases and that this may have affected the outcomes as individual data were not available on these converted cases. Despite our efforts at standardisation, our outcome measures were less well defined and therefore less absolute than we would have ideally liked. Third, neither the allocation of treatment, nor the assessment of outcome was blinded, with much variation in the instrumentation used. Fourth, it is important to bear in mind publication bias, particularly in meta-analytic research based on published studies. Finally, there was variation in inclusion criteria, type of randomisation used, treatment protocols, and outcome assessment between studies. It is also worth bearing in mind that negative results are less likely to be published.

## CONCLUSION

Our study demonstrates a decreasing trend in overall early mortality, operating time and postoperative infection rate with the use of PCCP in comparison to the DHS. Considering these findings, as well as a demonstrated reduction in bleeding and transfusion requirements, postoperative pain, and favourable functional recovery rates with this device, the PCCP may become the implant of choice for intertrochanteric fractures in elderly patients with multiple comorbidities. The possible negative consequences of a conversion of PCCP to DHS have to be considered in decision making. However, a large multi-centre randomised controlled trial is indeed required to assess the true worth of the PCCP technique.

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