ORIGINAL ARTICLE

The percutaneous compression plate versus the dynamic hip screw for treatment of intertrochanteric hip fractures: A systematic review and meta-analysis of comparative studies

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KEYWORDS
Trochanteric fracture; Percutaneous compression plate; Fracture fixation; Systematic review; Meta-analysis; Hip fractures

Summary

Background: The use of a percutaneous compression plate (PCCP) provides a minimally invasive technique for the fixation of stable intertrochanteric femoral fractures. It has several theoretically potential advantages over the dynamic hip screw (DHS) such as shorten incision and lower incidence of wound infection.

Hypothesis: PCCP have several advantages than DHS, such as reduced blood loss, transfusion, mortality, shorter operative time, and lower incidence of complications. This systematic review and meta-analysis was performed to identify the clinical outcomes and safety of patients with stable intertrochanteric hip fractures operated on using PCCP compared with DHS.

Materials and methods: A systematic search of all studies published through April 2012 was conducted using the Medline, Embase, Scieddirect, OVID and the Cochrane Central database. The randomized controlled trials (RCTs) and quasi-randomised control trials (qRCTs) that compared PCCP with DHS in treating adult patients with stable intertrochanteric hip fractures and provided data on safety and clinical effects were identified. Demographic characteristics, adverse events and clinical outcomes were manually extracted from all of the selected studies.

Results: Nine studies encompassing 914 patients met the inclusion criteria. Overall, the result of meta-analysis indicated that over DHS, PCCP allowed significantly shorter operative time,
Introduction

Minimally invasive surgery has gained popularity in modern orthopaedic and traumatology, as it is associated with decreased postoperative pain, reduced bleeding, faster recovery of function and lower risk of postoperative morbidity [1]. Osteoporotic proximal femoral fractures are a modern epidemic problem as the population grows increasingly older [2]. Ninety percent of patients with a hip fracture are over the age of 65, with other major co-morbidities, which contribute high rates of mortality [3]. There is broad consensus in the medical profession that the return to safe mobility is the primary goal of surgery, which depends on the strength and stability of the fracture fixation [4]. At present, the classic dynamic hip screw (DHS) serves as the benchmark for fixation of intertrochanteric hip fractures [5]. However, DHS entails at least 10 cm incision, which may be associated with significant blood loss, soft-tissue damage, and worsening of existing co-morbidities in the elderly patients [3]. It also has several modes of failure, the most common being cutting-out of lag screw from femoral head and collapse resulting from a lack of lateral cortical support [6–8].

The Gotfried percutaneous compression plate (PCCP, Orthofix McKinney, Texas, USA) provides a minimally invasive method of fixation for proximal femoral fractures (Fig. 1) [9]. This device is indicated for the treatment of pertrochanteric and bascervical fractures with intact lateral walls (AO type A1, A2, B2.1), consisting of a plate of a predetermined length with three 4.5 mm diaphyseal screws and two telescopic cervical screws (9.3 mm; area = 68 mm² each) angled at 135° to the plate to allow controlled fracture compression [10]. The theoretical advantages of this design are the provision of rotational stability, by using two screws in the femoral neck, and a reduction in the lateral cortical damage, which can be created by a 12-mm single drill hole [11].

Recently, there have been several randomized or quasi-randomized controlled trials (RCTs or qRCTs) comparing PCCP versus DHS in treating intertrochanteric fractures [12–14]. RCTs were regarded as the most reliable clinical evidence of determining the effectiveness of specific therapies [15,16]. On the other hand, the randomization method of qRCT was on the basis of the birth day, in-hospital number, or odd-even number. However, these current data have not been pooled for evaluation of overall outcomes. Although a previous meta-analysis was performed, there has no significant difference in any result between PCCP and DHS [17]. It limited the statistical efficiency that only three studies were included in the previous analysis. We hypothesize that PCCP have several advantages than DHS, such as reduced blood loss, transfusion, mortality, shorten operative time, and lower incidence of complications. Therefore, the purpose of our study was to use meta-analytical techniques to evaluate clinical outcomes and safety of PCCP from RCTs or qRCTs compared with DHS.

Materials and methods

Search strategy and eligibility criteria

To assemble all of the relevant literature, a PRISMA-compliant search of Medline, Embase, Sciencedirect, OVID and the Cochrane Central database was conducted for all peer-reviewed studies published between 2000 and April 2012 based on RCTs or qRCTs comparing PCCP to DHS in patients with intertrochanteric hip fractures. The following terms were adopted for database search: trochanteric fracture, percutaneous compression plate, minimally invasive surgery, fracture fixation. Different search strategies were used for different databases. We placed no restrictions on the language of publication.

Secondary investigation into unpublished literature was performed by searching the WHO International Clinical Trials Registry database, Current Controlled Trials, European Federation of National Associations of Orthopaedics and...
Table 1 Inclusion/exclusion criteria.

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomised control trials (RCTs)</td>
<td>Case reports</td>
</tr>
<tr>
<td>Quasi-randomised control trials (qRCTs)</td>
<td>Abstracts/presentations/posters</td>
</tr>
<tr>
<td>Age of 18 years or older</td>
<td>Cadaver or model studies</td>
</tr>
<tr>
<td></td>
<td>Reverse obliquity fractures</td>
</tr>
<tr>
<td></td>
<td>(AO 31.A3)</td>
</tr>
<tr>
<td></td>
<td>Pathological</td>
</tr>
<tr>
<td></td>
<td>fractures/metastatic</td>
</tr>
<tr>
<td></td>
<td>malignant disease</td>
</tr>
<tr>
<td></td>
<td>Contra-lateral hip fracture/previous fractures</td>
</tr>
</tbody>
</table>

Traumatology and British Orthopaedic Association Annual Congress, and the ISTP database (Index to Scientific & Technical Proceedings).

The complete articles by the above search methodology were retrieved and assessed against the inclusion/exclusion criteria outlined in Table 1. Moreover, references from relevant articles were also reviewed.

Study selection

Two reviewers (Xing Dan and Ma Jian-Xiong) independently screened the titles and abstracts based on the eligibility criteria. Then, intensive reading of the full texts was performed when those studies met the inclusion criteria. We resolved disagreements by discussion to reach a consensus.

Data extraction

Two of the authors (XD and MJX) independently extracted the following data from the qualifying articles. The data extracted from the studies included the study design, patient characteristics, interventions and patient-based outcomes measures. The corresponding author of each study was contacted to obtain any missing information that was required. The extracted data were rechecked by an additional author (MXL).

Outcomes

The clinical outcomes included: operative time, blood loss, requirement for blood transfusion, transfusion volume per person, length of hospital stay, mobility, early mortality. The early mortality was defined as the total mortality that occurred up to the end of follow-up in the study, ranging from 2 to 12 months. Complications outcomes were wound infection, respiratory, cardiovascular events, cerebrovascular accident, deep-vein thrombosis (DVT), pulmonary embolism and re-operation rates.

Assessment of methodological quality

According to Cochrane Handbook for Systematic Reviews of Interventions 5.0, the risk of bias included studies was assessed by two authors (XD and MJX) independently. Disagreement was resolved by discussion. A third author (MXL) was the adjudicator, when no consensus was achieved. We applied the "assessing the risk of bias" table, which include the following key domains: adequate sequence generation, allocation of concealment, blinding, incomplete outcome data, free of selective reporting and free of other bias.

Data synthesis and analysis

We performed all meta-analysis with the Review Manager software (RevMan Version 5.1; The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). The assessment for statistics heterogeneity was calculated through $\chi^2$ and $I^2$ test. When the $\chi^2$ was $P > 0.05$, or $I^2 < 20$% indicating low statistical heterogeneity, a fixed effect model was used. A random effect model was used when $\chi^2$ was $P < 0.05$, and $I^2 > 20$%. For continuous data, means and standard deviations were pooled to a weighted mean difference (WMD) and 95% confidence interval (CI) in the meta-analysis. For binary data, odds ratio (OR) and 95% confidence interval (CI) were assessed [18]. A probability of $P < 0.05$ was regarded as statistically significant. In instances in which a standard error for the final value outcome was not reported, we calculated the standard error of mean differences across groups by converting the P-value to a z-score and solving for the standard error with the formula: $z$-score = mean difference/standard error [19]. Sensitivity analysis was performed by rejecting the study with higher statistical heterogeneity. Publication bias was assessed by using a funnel plot of the most frequently reported outcome.

Results

Search results

A total of 231 relevant studies were identified through computerized search and hand search, in which nine eventually satisfied the eligibility criteria. This included five RCTs [12,13,20–22] and four qRCTs [14,23–25]. The literature search procedure was shown in Fig. 2. Although two studies [13,25] were performed in the same institution, the time period of patients collection were different. Other two studies [20,22], performed in the same center, had different inclusion criteria for type of fractures. Therefore, the above studies were all included. This diagram had been designed in according with the Preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [26].

Quality assessment

Among the nine included studies, five RCTs [12,13,20–22] had a low risk of bias, and other four qRCTs [14,23–25] had a high risk of bias. All 5 RCTs [12,13,20–22] reported adequate generation of allocation sequence, and only two trials [12,13] reported allocation concealment. Whilst
Figure 2 PRISMA chart according with the Preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [26].

surgeon blinding would have been inappropriate in this study design, eight studies did not blind their assessors to patients group. Only one trial [12] performed the single blinding to assessors. Two studies [12,13] reported that they received no grant in support of their research. The methodological quality of included studies was presented in Fig. 3. Judgments about each risk of bias item presented as percentages across all included studies in Fig. 4.

Demographic characteristics

The demographic characteristics of studies included are summarized in Table 2. Five RCTs and four qRCTs involving 914 patients were eligible for inclusion, with individual sample size ranging from 26 to 263 patients. Four hundred and thirty-five patients were treated with a PCCP and 479 with a DHS. Two studies [20,22] did not state the gender of their cohorts. There were three studies undertaken in

Figure 3 Methodological quality of included studies. This risk of bias tool incorporates assessment of randomization (sequence generation and allocation concealment), blinding (participants, personnel and outcome assessors), completeness of outcome data, selection of outcomes reported and other sources of bias. The items were scored with "yes", "no", "unsure".

Israel, two in Belgium, one respectively in USA, Mexico, Germany, and England. All the included studies had definite inclusion/exclusion criteria. All studies recruited patients as following:

Figure 4 Risk of bias. Each risk of bias item presented as percentages across all included studies, which indicated the proportion of different level risk of bias for each item.
Table 2  Study characteristics.

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Country</th>
<th>Study design</th>
<th>Sample size</th>
<th>Mean age (range)</th>
<th>Gender (M/F)</th>
<th>Side of fracture (R/L)</th>
<th>Intervention of control</th>
<th>Follow-up (mo)</th>
<th>Conflicts of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yang et al. [12]</td>
<td>2011</td>
<td>USA</td>
<td>RCT</td>
<td>33</td>
<td>76 (30–100)</td>
<td>11/22</td>
<td>N/S</td>
<td>DHS</td>
<td>12</td>
<td>No</td>
</tr>
<tr>
<td>Janzing et al.</td>
<td>2002</td>
<td>Belgium</td>
<td>RCT</td>
<td>53</td>
<td>82 (65–96)</td>
<td>83 (64–98)</td>
<td>N/S</td>
<td>DHS</td>
<td>12</td>
<td>N/S</td>
</tr>
<tr>
<td>Romero et al.</td>
<td>2008</td>
<td>Spain</td>
<td>qRCT</td>
<td>13</td>
<td>80 (66–102)</td>
<td>12/1</td>
<td>N/S</td>
<td>DHS</td>
<td>12</td>
<td>N/S</td>
</tr>
<tr>
<td>Knobe et al.</td>
<td>2010</td>
<td>Germany</td>
<td>qRCT</td>
<td>63</td>
<td>76.9 (28–96)</td>
<td>19/44</td>
<td>28/35</td>
<td>DHS</td>
<td>18</td>
<td>N/S</td>
</tr>
<tr>
<td>Peyser et al.</td>
<td>2007</td>
<td>Israel</td>
<td>RCT</td>
<td>50</td>
<td>78.9 (62–95)</td>
<td>16/34</td>
<td>27/23</td>
<td>DHS</td>
<td>6</td>
<td>No</td>
</tr>
<tr>
<td>Peyser et al.</td>
<td>2005</td>
<td>Israel</td>
<td>qRCT</td>
<td>108</td>
<td>81.2 ± 8</td>
<td>30/78</td>
<td>51/57</td>
<td>DHS</td>
<td>12</td>
<td>N/S</td>
</tr>
<tr>
<td>Laufer et al.</td>
<td>2005</td>
<td>Israel</td>
<td>qRCT</td>
<td>30</td>
<td>80 ± 6</td>
<td>10/20</td>
<td>14/16</td>
<td>DHS</td>
<td>12</td>
<td>N/S</td>
</tr>
<tr>
<td>Brandt et al.</td>
<td>2002</td>
<td>Belgium</td>
<td>RCT</td>
<td>33</td>
<td>80.1 (63–96)</td>
<td>N/S</td>
<td>16/17</td>
<td>DHS</td>
<td>3</td>
<td>N/S</td>
</tr>
<tr>
<td>Kosygan et al.</td>
<td>2002</td>
<td>England</td>
<td>RCT</td>
<td>52</td>
<td>82.7 (53–93)</td>
<td>8/44</td>
<td>N/S</td>
<td>DHS</td>
<td>6</td>
<td>No</td>
</tr>
</tbody>
</table>

PCCP: percutaneous compression plate; DHS: dynamic hip screw; RCT: randomised controlled trial; qRCT: quasi-randomised controlled trial; Conv: conventional surgery; M: males; F: females; mo: months; N/S: not stated; R: right; L: left.
Figure 5  Weighted mean difference (WMD) estimate for operative time.

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>PCCP Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Mean Difference IV, Random, 95% CI</th>
<th>Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brandt [20]</td>
<td>46.6</td>
<td>13.7</td>
<td>38</td>
<td>69.2</td>
<td>22.8</td>
<td>38</td>
<td>13.2%</td>
<td>-22.60 [−31.23, −13.97]</td>
<td></td>
</tr>
<tr>
<td>Kogayam [21]</td>
<td>50.5</td>
<td>15.4</td>
<td>52</td>
<td>49.13</td>
<td>13.1</td>
<td>52</td>
<td>14.1%</td>
<td>-9.03 [−16.1, 4.19]</td>
<td></td>
</tr>
<tr>
<td>Remen [23]</td>
<td>48.2</td>
<td>12.5</td>
<td>13</td>
<td>65.45</td>
<td>15</td>
<td>13</td>
<td>7.1%</td>
<td>-37.00 [−62.39, −11.61]</td>
<td></td>
</tr>
<tr>
<td>Yang [12]</td>
<td>49.3</td>
<td>31.5</td>
<td>33</td>
<td>78.25</td>
<td>25.5</td>
<td>33</td>
<td>11.2%</td>
<td>-30.00 [−43.62, −16.17]</td>
<td></td>
</tr>
</tbody>
</table>

Total (95% CI)  
Heterogeneity: Tau² = 156.61; Chi² = 61.14, df = 7 (P = 0.00001); I² = 91%  
Test for overall effect: Z = 2.81 (P = 0.006)

Figure 6  Weighted mean difference (WMD) estimate for blood loss.

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>PCCP Mean</th>
<th>SD</th>
<th>Total</th>
<th>Mean</th>
<th>SD</th>
<th>Total</th>
<th>Weight</th>
<th>Mean Difference IV, Random, 95% CI</th>
<th>Mean Difference IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peyser [13]</td>
<td>161</td>
<td>119.5</td>
<td>50</td>
<td>374</td>
<td>242.3</td>
<td>53</td>
<td>33.6%</td>
<td>-213.00 [−285.07, −141.93]</td>
<td></td>
</tr>
<tr>
<td>Romen [23]</td>
<td>73.4</td>
<td>40</td>
<td>13</td>
<td>373</td>
<td>208</td>
<td>13</td>
<td>29.6%</td>
<td>-200.03 [−415.14, −184.86]</td>
<td></td>
</tr>
<tr>
<td>Yang [12]</td>
<td>41.9</td>
<td>40.9</td>
<td>33</td>
<td>101</td>
<td>89.6</td>
<td>33</td>
<td>36.2%</td>
<td>-98.09 [−338.30, −26.48]</td>
<td></td>
</tr>
</tbody>
</table>

Total (95% CI)  
Heterogeneity: Tau² = 1499.76; Chi² = 28.47, df = 2 (P = 0.00001); I² = 92%  
Test for overall effect: Z = 2.50 (P = 0.01)

Outcomes analysis

Relevant outcomes of the nine trials comparing PCCP with DHS can be pooled by meta-analytical method.

Clinical outcomes

In eight studies [12,13,20–25] providing operative time between PCCP and DHS, the pooled WMD was −13.51 (95% CI: −22.95 to −4.08). There was significant difference between the two groups (Fig. 5). Sensitivity analysis resulted in no change of the current result.

The intraoperative blood loss was calculated for only three studies [12,13,23]. The available data demonstrated that blood loss of operation was significantly reduced in PCCP groups compared with DHS groups (WMD = −183.56 95% CI: −327.52 to −39.59) (Fig. 6). Peyser et al. [13] reported the measurement of blood loss, which was measured by the summation of the blood collected from a plastic bag, taped to the surgical drapes, below the operative field, and from the weighed swabs. However, two studies did not report the method of assessment of blood loss. To a certain degree, the current result had sufficient stability after sensitivity analysis.

Only four trials [12,13,21,22] reported the transfusion units per person. There were statistically less transfusion units in the PCCP group compared to DHS group (WMD = −0.30 95% CI: −0.53 to −0.07) (Fig. 7).

From four studies [13,20,23,25] reporting requirement of blood transfusion, the reduced rate for blood transfusion in the PCCP group was statistically significant, compared with DHS group (OR = 0.33 95% CI: 0.15 to 0.70) (Fig. 8).

Regarding length of hospitalisation, there was no statistically significant difference between the PCCP and DHS in five studies (WMD = −0.33 95% CI: −2.27 to −1.61) [13,20,21,23,25] (Fig. 9). Three studies [12,14,22] reported postoperative mobilization. The rate of walking without help was pooled for only two studies [14,22]. No significant difference was found between PCCP groups and DHS groups (OR = 0.79 95% CI: 0.33 to 1.88) (Fig. 10). Yang et al. [12] reported that more patients in the PCCP group returned to their original living environment, and fewer patients in the group (40% vs. 59%)

Figure 7  Weighted mean difference (WMD) estimate for transfusion units per person.

- an age of 18 years or older;
- an A1 or A2 AO/OTA, and Evans type 1A-D intertrochanteric proximal femoral fracture;
- no existing or previous fractures of the same or contralateral hip;
- no other injuries or fractures;
- no reverse obliquity fractures, pathological fractures or the presence of metastatic disease and ipsilateral lower-limb surgery.
required the help of walking than the DHS group, but neither difference was significant. Although PCCP groups had a decreased trend of early mortality compared to DHS groups from the pooled results, the difference was not statistically significant (OR = 0.71 95% CI: 0.49—1.03) (Fig. 11).

Complications
There were no statistically significant differences between PCCP and DHS for complications such as wound infection rates, respiratory, pulmonary embolism, cerebrovascular accident, DVT or re-operation rates. There was however a statistically significant difference in respect to cardiovascular events (OR = 0.33, 95% CI: 0.15—0.72) (Table 3).

Publication bias
The funnel plot of mortality demonstrated limited evidence of small study exclusion and publication bias with an asymmetrical diagram with few studies plotted on the right side of the funnel (Fig. 12).

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**Figure 8** Odds ratio (OR) estimate for rate for blood transfusion.

**Figure 9** Weighted mean difference (WMD) estimate for length of hospitalization.

**Figure 10** Odds ratio (OR) estimate for rate of walking without help.

**Figure 11** Odds ratio (OR) estimate for mortality.
Table 3  Meta-analysis results of complications comparing PCCP with DHS.

<table>
<thead>
<tr>
<th>Complications</th>
<th>Group (n)</th>
<th>Studies (n)</th>
<th>Overall effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PCCP</td>
<td>DHS</td>
<td>Effect estimate</td>
</tr>
<tr>
<td>Respiratory</td>
<td>210</td>
<td>264</td>
<td>3</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>210</td>
<td>264</td>
<td>3</td>
</tr>
<tr>
<td>Cardiovascular event</td>
<td>160</td>
<td>211</td>
<td>2</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
<td>210</td>
<td>264</td>
<td>3</td>
</tr>
<tr>
<td>DVT</td>
<td>210</td>
<td>264</td>
<td>3</td>
</tr>
<tr>
<td>Infection</td>
<td>256</td>
<td>315</td>
<td>5</td>
</tr>
<tr>
<td>Re-operation</td>
<td>389</td>
<td>433</td>
<td>7</td>
</tr>
</tbody>
</table>

DVT: deep-vein thrombosis; PCCP: percutaneous compression plate; DHS: dynamic hip screw; CI: confidence interval.

There was a statistically significant difference between PCCP and DHS.

Discussion

High incidence of hip fractures among the elderly is a worldwide major health problem with severe medical consequences affecting quality and mortality of life among the aging population [27]. The goal of the surgery is to return prefracture condition as quick as possible with low incidence of complications. Elderly patients who suffer from multiple may be worse by the surgical trauma associated with a major operation. Minimally invasive techniques are thought to improve surgical outcomes by reducing soft-tissue damage, blood loss, postoperative pain, and morbidity [28]. Therefore, the development of minimally invasive technique of fracture fixation would likely help patients avoid the hazards of long anesthesia times, tissue trauma, and return to prefracture function. As a minimal technique, the PCCP has been used for fixation of intertrochanteric fracture. Although some literature demonstrated that PCCP provided minimal exposure, reduced blood loss, it exists some controversial topics such as transfusion, mortality, and incidence of complications. This systematic review and meta-analyses demonstrated that there were significant differences between PCCP and DHS in operative time, blood loss, transfusion units per person, rate of transfusion, and incidence of cardiovascular events. However, there were no significant differences in length of hospitalization, rate of walking without help, early mortality and other complications.

The methodological quality assessment identified a number of limitations to the current evidence base:

- all of the qRCTs had insufficient information on randomization methods. These were largely cited as poor allocation concealment, permitting selection and allocation bias, not blinding surgeon, patients and assessors to their surgery, allowing assessor and expectation bias and potential for type II statistical errors regarding these outcomes. The efficacy of statistics could be further improved in the future by including more RCTs;
- although included RCTs were performed, the relatively small number of participants restricted statistical power;
- follow-up duration of included studies only range from 3 to 12 months. Long-term follow-up results may change the current conclusions;
- to some extent, clinical heterogeneity may be caused by the preexisting conditions of patients, various indication for surgeries, experience level of orthopaedic surgeons, fracture type, different methods for measurement and the age of fractures (fresh or non-recent fractures). Although we performed the sensitivity analysis, the heterogeneity cannot be resolved absolutely;
- meta-analyses are subject to bias and provide inappropriate estimates for the effect of treatment when compared to successive large RCTs [29]. It is also important to bear in mind that publication bias may exist, since the negative results are less likely to be published. Accordingly, while the results of this systematic review should be considered appropriate, these methodological defects should be considered when interpreting the findings.

In our meta-analysis, a significant reduction of operative time was found with PCCP in comparison with DHS. The reduced operative time is consistent with decreased bleeding and tissue trauma associated with the percutaneous nature of the technique. A reduced operative time is desirable as it reduces temporal exposure to the risks of general anesthesia, especially in elderly patients with poor cardiopulmonary reserve. However, Kosygan et al. [21] confirmed that the operative time was slightly longer with PCCP compared with DHS. Surgical learning curve is an important factor that may have accounted for the differences.
in the learning period. The operative time particularly during the learning period is longer than that in conventional open operations. Most of the surgeons could perform PCCP surgery well in a significantly short operative time after a learning curve of a few cases [25]. In addition, Janzing et al. [22] reported that the fracture type had a clear but less important influence on the operative time. According to Peyser et al. [25], operating time may be prolonged by anatomical indirect and closed fracture reduction. Some literature reported that the use of a posterior reduction device may also reduce surgical time [12,20,22].

From the length of hospitalization, there was no significant difference between PCCP and DHS. It is difficult to compare these results between studies, which is more depend on prevailing medical/economic/social conditions, such as the prefracture co-morbidities, rehabilitation duration, severity of medical complications or the availability of nursing-home care, than a direct result of the implant used. The above factors make comparison of data from different trials difficult.

The blood loss in PCCP was reduced significantly compared with DHS. The pooled result may be implied by the reduced skin incision and less soft-tissue damage in minimally invasive technique. However, bleeding may be measured by different approaches between included studies, such as collection from a plastic bag taped to the surgical drapes, suction drain, or from the weighed swabs. Therefore, the reason noted above may exert instability on the consistency of the outcome.

From the pooled results, DHS groups received larger blood transfusion units per person, and a higher rate of need for blood transfusion than the patients with PCCP, which could be attributed to the reduced surgical exposure. These findings are consistent with the decreased bleeding with the minimally percutaneous technique. Elderly patients with associated co-morbidities may avoid the hazards of blood transfusion. Previous literature showed that the relative risk reduction of 71% and the absolute risk reduction of 45% represented an important advantage of the PCCP and for every 2.2 patients treated with PCCP rather than DHS, a blood transfusion may be prevented, which is considering the rising costs of homologous blood transfusions, disease transmission, risk of transfusion reactions and immunomodulation [30–32]. In contrast, Peyser et al. [13] reported that the number of blood transfusion was inconsistent with blood loss during operation, since the principle blood loss occurred from the fracture site itself and not from the surgical exposure. Additionally, the different indications for blood transfusion and the perioperative hemoglobin level determined the rates or the units of transfusion, which was of high relevance to the hospital of included trials.

The primary goal of surgery is the patient’s return to the prefracture level of functional independence. Although a better functional recovery can be found in PCCP groups, the pooled value showed that there was no statistical difference in walking without help between PCCP and DHS. Im et al. [6] reported that iatrogenic comminution of the lateral cortex with the use of DHS was the important factor associated with loss of initial reduction, which led to poorer functional recovery. Koval et al. [33] reported that restricted weight-bearing can delay functional recovery of the elderly patients. Kosygan et al. [21] believed that the patient’s premorbid mental and physical profiles determine the ultimate rate of functional rehabilitation, and that the choice of implant is of secondary importance providing it allows stable fixation with controlled collapse at the side of the fracture. Therefore, factors, which might be taken into consideration in functional recovery, included fixation devices, weight-bearing, prefracture conditions, co-morbidities, and the use of walking support devices. However, because the follow-up of five included studies, which reported the walking mobility was 12 months, further follow-up studies may exert instability on the consistency of the outcome.

Although overall mortality rate of PCCP has a decreased trend compared with DHS group, there was no statistically significant difference between two groups. A reduced operating time, less bleeding and transfusion units or earlier ambulation may contribute to the lower mortality with PCCP, while several studies comparing these two devices have reported no influence on morbidity [20–22]. Peyser et al. [25] suggested that reduction in overall complications and cardiovascular complications did not affect the mortality in both groups. Furthermore, Kenzora et al. [34] showed a high correlation between mortality rate and preexisting medical conditions.

Complications rates were similar in both PCCP and DHS group statistically, although some complications including cerebrovascular accidents, respiratory, pulmonary embolism, infection, DVT and re-operation appeared to be fewer in the PCCP group. However, the incidence of cardiovascular events in PCCP was lower than DHS significantly. Some of the most common and hazardous complications of hip fracture surgery are cardiovascular events, with a rate ranging from 8 to 27% [35]. Peyser et al. [25] reported that reduced surgical trauma and decreased bleeding are thought to be possible explanations for the reduced cardiovascular complications with PCCP. Matot et al. [36] found a correlation between fewer cardiovascular events and reduced pain in elderly patients with proximal femoral fracture. Although postoperative pain was not assessed in our meta-analysis, the minimally invasive surgery is usually associated with less pain. The PCCP is performed using a “no-touch technique” with less tissue exposure, which may cause a tendency towards less infection. For re-operation rate, the two screws PCCP may offer greater rotational stability [10] and small diameter of the holes at the drilling site [11]. These advantages may be responsible for the preservation of the lateral wall [37], decreased incidence of cutting-out and collapse. But Janzing et al. [22] reported that one of the technical pitfalls in PCCP was incomplete reduction by closed fracture reposition, which led to a second operation. Intraoperative verification of the correct drilling and positioning of the neck screw is essential, which may help to decrease the rate of re-operation. However, the small number of included studies reporting overall complications dose not allow for definitive conclusions regarding the use of PCCP over DHS for the prevention of such complications. Furthermore, inferences made on rates of complication and mortality may be instability because of the dissimilarities between the groups presurgically in term of associated co-morbidities, functional condition and type fracture.

In conclusion, the PCCP system provides a minimally invasive technique for the treatment of intertrochanteric fractures. Compared with the DHS, PCCP resulted in a
shorter operative time, decreased blood loss, reduced transfusion requirement, lower incidence of cardiovascular events, while maintaining at least equivalent hospitalization, functional recovery, mortality rate and other complications such as infection or re-operation rate. Accordingly, PCCP system may become the implant of choice for intertrochanteric fractures, especially in elderly patients with co-morbidities. This study, based on the current evidence, may help the orthopaedic community to clearly define what variables need to be evaluated in the future RCTs. Because the overall quality of included studies and length of follow-up is low. Therefore, large multi-center RCTs are needed to assess the safety and efficiency of the PCCP technique.

Disclosure of interest

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