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Original article

Percutaneous poking reduction and fixation versus open reduction and fixation in the treatment of displaced calcaneal fractures for Chinese patients: A systematic review and meta-analysis

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ABSTRACT

Purpose: To compare the efficacy of percutaneous poking reduction and fixation with open reduction and fixation in the treatment of displaced calcaneal fractures.
Methods: Reports of studies using case-controlled trials (CCT) to compare the percutaneous poking reduction and fixation with the open reduction and fixation in the management of calcaneal fractures were retrieved from the Cochrane Library, PubMed Database, CNKI, Chinese Biomedical Database, Wanfang Data (from January of 2005 to August of 2015). Methodological quality of the trials was critically assessed, and relevant data were extracted. Statistical software Revman 5.0 was used for data-analysis.
Results: Fifteen articles were included in the meta-analysis. Comparison of the efficacy of percutaneous poking reduction and fixation with open reduction and fixation in the treatment of calcaneal fractures revealed statistical significance in the incidence of complications after operation [$RR = 0.32$, *95% CI* (0.20, 0.5), $p < 0.05$]. However, there were neither statistical significance in the degrees of recovery for calcaneal Bohler angle [WMD $= -1.65$, *95% CI* (-3.43, 0.14), $p > 0.05$] and calcaneal Gissane angle [WMD $= -3.21$, *95% CI* (-6.75, 0.33), $p > 0.05$], nor statistical significance in the rate of good foot function after operation [$RR = 0.95$, *95% CI* (0.90, 1.00), $p > 0.05$].
Conclusion: For the treatment of calcaneal fractures, percutaneous poking reduction and fixation is superior to open reduction and fixation in terms of the incidence of postoperative complications. But both techniques can obtain satisfactory clinical function.

Introduction

Calcaneal fractures account for approximately 2% of all fractures and are the most common fracture type of the foot tarsal bone in adults.[1,2] Moreover, 70% of them are displaced intra-articular calcaneal fractures.[3] The management methods for displaced intraarticular calcaneal fractures have been controversial for a long time. However most of the scholars believe that surgery is the best choice.[4–6] The treatment goal is to restore the walking ability and eliminate standing pain or even to enable the patient to wear a pair of normal shoes.

As for surgeries, a number of authors prefer open reduction and fixation in terms of shaping the anatomical structure of the whole bone and its surrounding joint surfaces, as well as calcaneal and subtalar joint. But the reported rate of wound edge necrosis varies from 2% to 11% due to the thin and vulnerable skin over the lateral calcaneal wall, and the infection rate of calcaneal nearby soft tissue varies from 1.3% to 7% after open reduction fixation via an extended lateral approach.[7] However some clinical doctors suggest that considering the occurrence of complications, percutaneous poking reduction and fixation is a better way for intraarticular calcaneal fractures.[8,9] In their reports, it is showed that there is a higher functional score and a lower incidence of posttraumatic subtalar arthritis after using the method of closed percutaneous poking reduction. So abundant case-controlled trials (CCTs) have been

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conducted to compare the outcomes and complications of two methods for the surgical treatment of intra-articular calcaneal fractures, but the clinical advantages and disadvantages of the two methods still remain debatable. There is a need to systematically review the available evidence for the two methods in treating displaced intra-articular calcaneal fractures so as to make an optimal treatment choice.

The aim of the present study was to perform a meta-analysis including all the CCTs on Chinese people in the last ten years to determine whether there were any significant differences in the incidence of postoperative complications, the recovery degrees of calcaneal Bohler angle and Gissane angle, and the rate of good foot function after surgery.

Materials and methods

Search strategy

We searched CCTs including randomized controlled study (RCT) and retrospective case study that compared closed percutaneous poking reduction with open reduction fixation in the treatment of calcaneal fractures for Chinese patients from the Cochrane Library, PubMed, CNKI, Chinese Biomedical Database, Wanfang Data (from January of 2005 to August of 2015). The searched key words were: calcaneal fractures treatment, percutaneous poking reduction, open reduction.

Inclusion criteria

The inclusion criteria were: (1) adults with calcaneal fractures; (2) CCTs; (3) comparison of percutaneous poking reduction and open reduction for the treatment of calcaneal fractures; (4) the outcome being measured by the incidence of postoperative complications, recovery degrees of calcaneal Bohler angle and Gissane angle, and the good rate of foot function after operation.

Exclusion criteria

The exclusion criteria were: (1) case-based reports or reviews; (2) study objective or intervention measures failed to meet the inclusion criteria; (3) the original documents of experimental design being not precise; (4) studied with incomplete data.

Data extraction and quality assessment

Inclusion decisions were made independently by two reviewers participated according to the pre-stated eligible criteria. Disagreement between the two reviewers was resolved by discussion or consulting to a third reviewer when necessary. The criteria for article quality assessment included five items as follows: (1) whether to adopt the random sequence generation; (2) whether to use the principle of allocation concealment; (3) whether to use the principle of blinding for the subjects, implementers and measurement; (4) whether to use incomplete data and selective reporting; and (5) whether there is any other bias. Relevant data were recorded in this analysis, including: first author's name, published year, sample size of closed percutaneous poking reduction and open reduction fixation in the treatment of calcaneal fractures, revised Jadad score, duration of follow-up, postoperative complications, the recovery degrees of calcaneal Bohler angle and Gissane angle, the rate of good postoperative foot function, etc.

Statistical analysis

Data were independently entered into the RevMan 5.0 software by two reviewers. Dichotomous outcomes were expressed in terms of relative risk (*RR*) and the weighted mean difference (*WMD*) was used for continuous outcomes, both with 95% confidence intervals (*95% CI*). Heterogeneity was tested using both chi-square test and I^2 test. A fixed-effects model was chosen when there was no statistical evidence of heterogeneity and random-effects model was adopted if significant heterogeneity was found. If the heterogeneity was found, we checked the study population, treatment, outcome and methodologies to determine the source of heterogeneity. If it could not be quantitatively synthesized or the event rate was too low to be measured, we used qualitative evaluation. A funnel plot was applied to assess the presence of publication bias.

Results

A total of 651 potentially relevant articles were identified. After screening of the titles and abstracts, 606 were excluded. Then the full-text of the 45 studies was read, which found 15 studies including 1056 patients met all the inclusion criteria (Fig. 1).[10–24] There were 2 English articles and 13 Chinese articles, all on Chinese people. The article quality was evaluated by Jadad score.[25] The total score is 7 points: ≤3 points defined as low quality study and ≥4 points as high quality paper. There were 12 studies that are qualified as high quality papers and 3 as medium quality papers[13,15,18] (Table 1).

Incidence of postoperative complications

Fourteen trials[10–13,15–24] compared the incidence of postoperative complications. Results showed that there was a low evidence of heterogeneity among all these studies ($I^2 = 0\%$, $p > 0.05$), and the fixed model was performed. There was statistical difference between two technique groups [$RR = 0.32$, *95% CI* (0.20, 0.52), $p < 0.05$, Fig. 2]. The results suggested that open reduction and fixation had a higher incidence of postoperative complications than the method of percutaneous poking reduction and fixation.

Recovery degree of calcaneal Bohler angle

Thirteen trials[10–17,20–24] reported the recovery degree of calcaneal Bohler angle. Results showed that there was a high evidence of

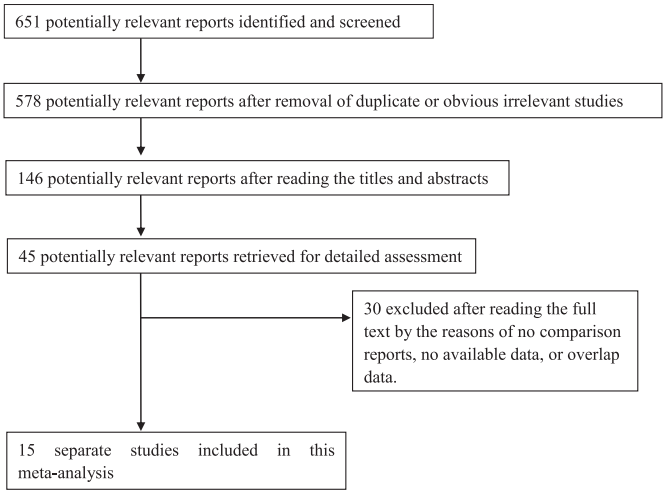

Fig. 1. Flow diagram of the study selection process.

Table 1
General data of the included articles.

Author	Published year	Study design	Surgery		Follow-up time (month)
			Percutaneous	Open	
Chen et al[10]	2011	Retrospective	38	40	24
Xia et al[11]	2014	RCT	70	57	19
Xu et al[12]	2014	RCT	15	15	8
Yan et al[13]	2014	RCT	25	25	12
Gao et al[14]	2011	Retrospective	23	23	12
Wang et al[15]	2012	Retrospective	25	28	20
Wu et al[16]	2012	Retrospective	22	28	15
Sun et al[17]	2012	Retrospective	18	18	12
Zhang et al[18]	2013	Retrospective	30	26	12
Qi et al[19]	2009	RCT	40	40	12
Yang et al[20]	2014	Retrospective	15	15	36
Zhang et al[21]	2013	RCT	46	46	12
Gu et al[22]	2015	RCT	45	45	12
Sha et al[23]	2015	RCT	61	61	38
Xiong et al[24]	2013	RCT	27	29	12

heterogeneity across the studies ($I^2 = 91\%$, $p < 0.05$), and the random model was performed. There was no statistical difference between two technique groups [*WMD* = −1.65, *95% CI* (−3.43, 0.14), $p > 0.05$, Fig. 3].

Recovery degree of calcaneal Gissane angle

Twelve trials[11–17,19,20,22–24] reported the degree of recovery for calcaneal Gissane angle. Results showed that there was a high evidence of heterogeneity among the studies ($I^2 = 90\%$, $p < 0.05$), and the random model was performed. There was no statistical difference between two groups [*WMD* = −3.21, *95% CI* (−6.75, 0.33), $p > 0.05$, Fig. 4].

Rate of good function of operational foot

Thirteen trials[10,11,13–18,20–24] applied the good function rate of Maryland score to assess the functional outcome of the treatment. Results showed that there was a low evidence of heterogeneity among the studies ($I^2 = 36\%$, $p > 0.05$), and the fixed model was performed. There was no statistical difference between two treatments [*RR* = 0.95, *95% CI* (0.90, 1.00), $p > 0.05$, Fig. 5].

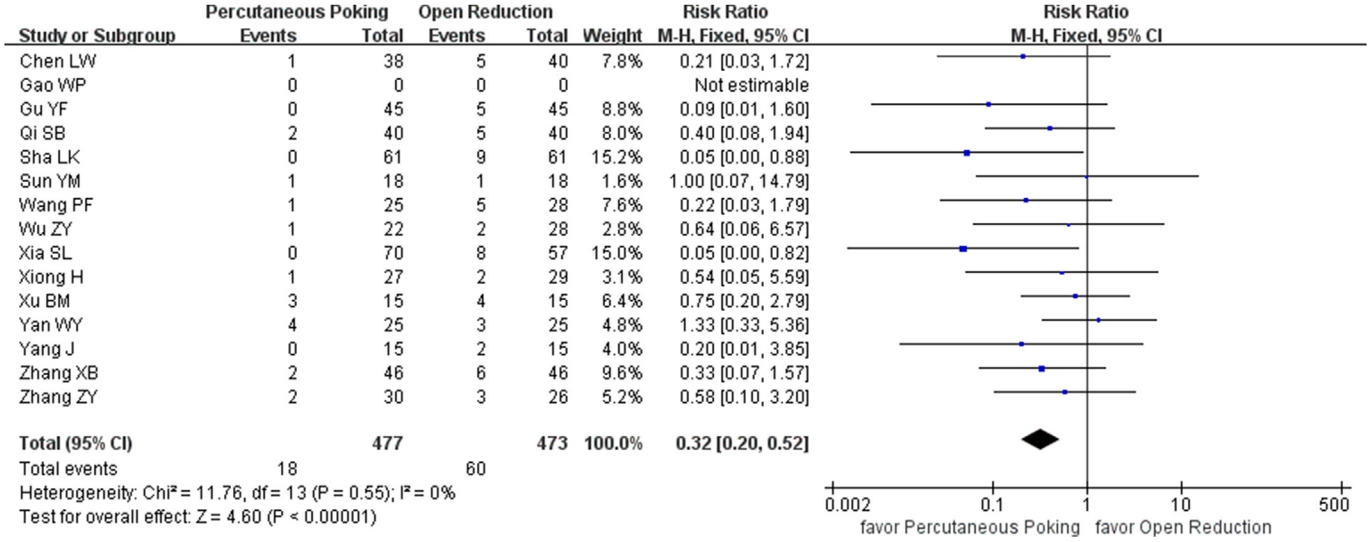

Fig. 2. The forest plot of the incidence of postoperative complications between two therapies.

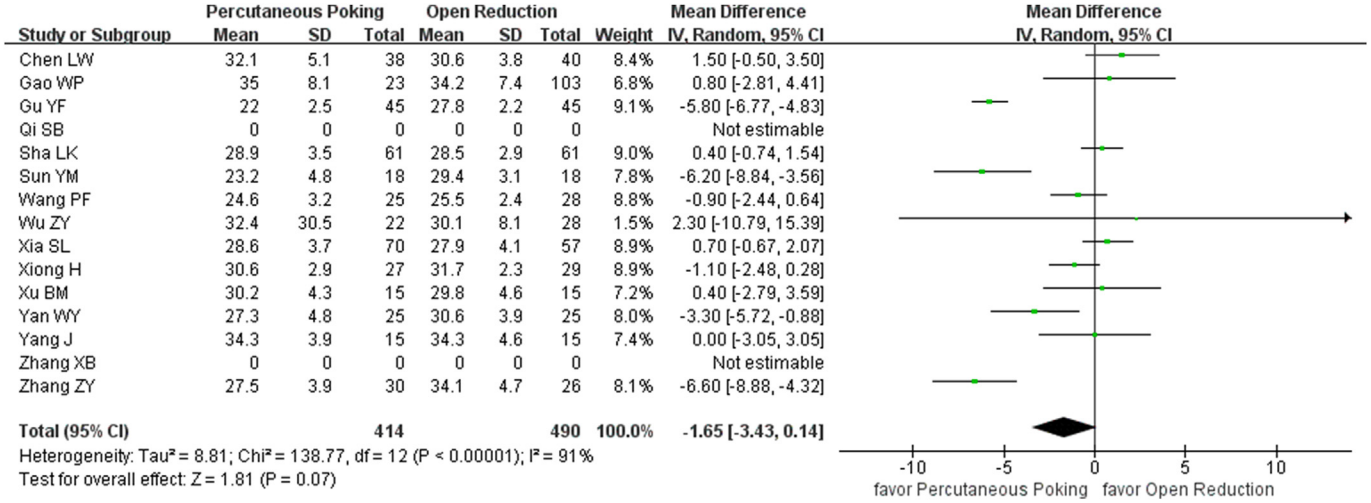

Fig. 3. The forest plot of the recovery degree of calcaneal Bohler angle between two therapies.

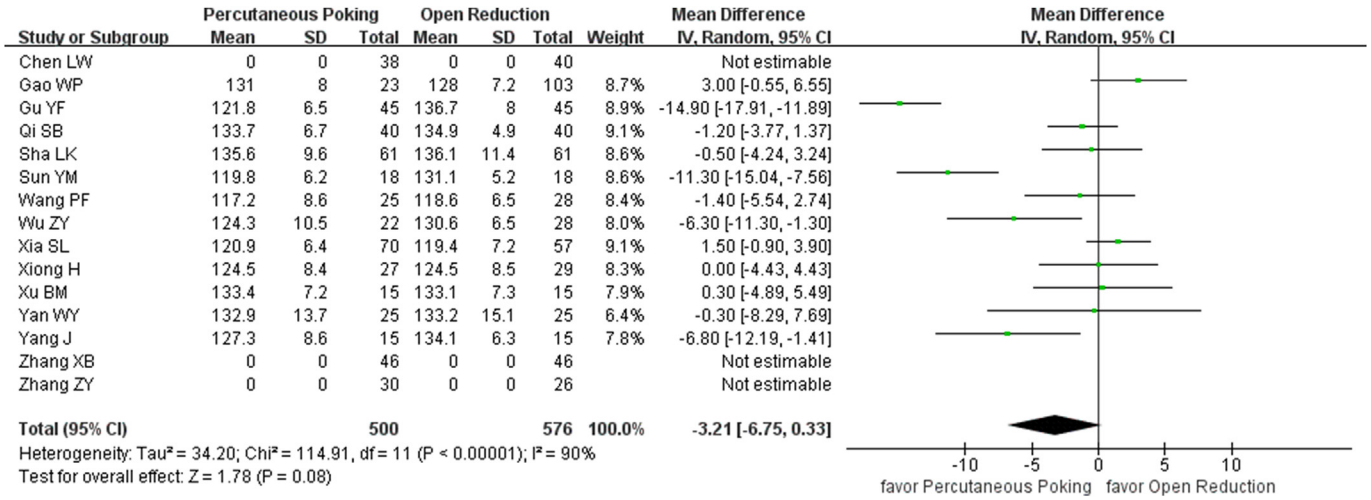

Fig. 4. The forest plot of the recovery degree of calcaneal Gissane angle between two therapies.

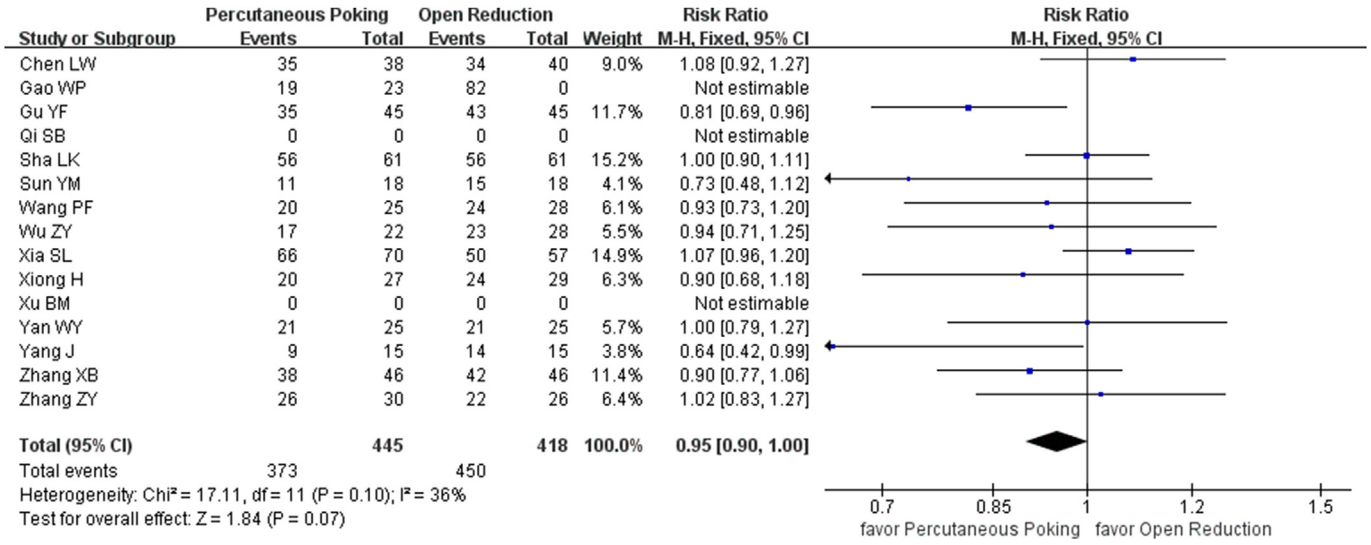

Fig. 5. The forest plot of the good functional recovery rate of the involved foot between two therapies.

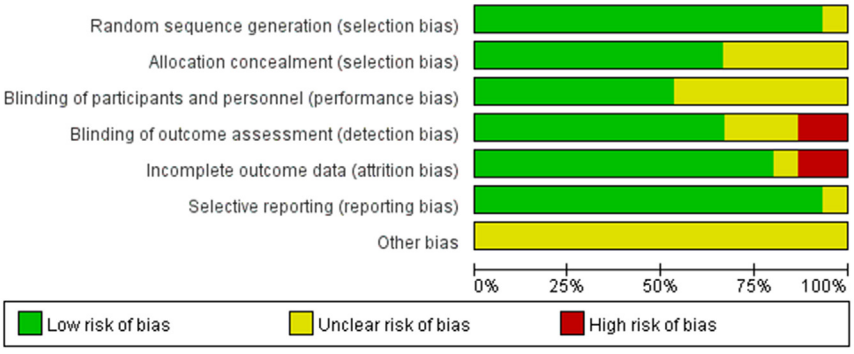

Fig. 6. Risk of bias. Each risk of bias item is presented as a percentage across all included studies and indicates the proportional level for each risk of bias item.

Publication bias

All the 15 studies included in this meta-analysis had gone through a strict quality assessment. All of them were CCTs and the possibility of a bias was low. But the funnel figure showed that there was a small bias, which may be associated with the incomplete collection of relevant literature, insufficient sample size and the different level of clinical physicians. Sensitivity analysis showed a good overall result (Figs. 6 and 7).

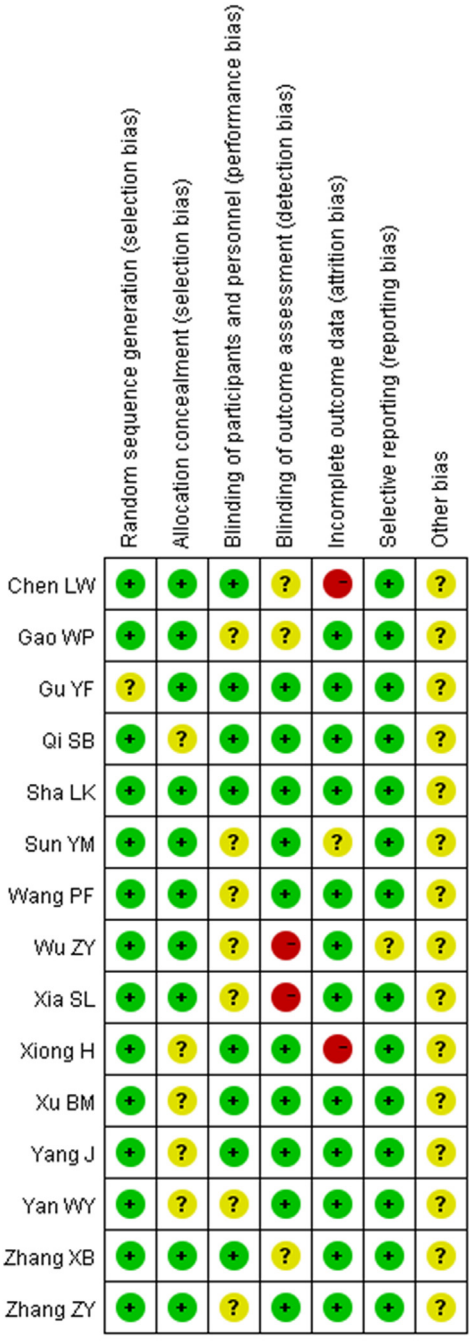

Fig. 7. Methodological quality of the included studies. This risk of bias tool incorporates assessment of randomization (sequence generation and allocation concealment), blinding (participants, personnel and outcome assessors), completeness of outcome data, selection of outcomes reported and other sources of bias. The items were scored with "yes", "no", or "unsure".

Discussion

The calcaneal fractures result in heal in improper anatomical position which will lead to static and dynamic malfunctions of the whole foot with consequent limited load bearing capacity and walking ability. Surgery is the favored technique for closed intra-articular calcaneal fracture displacement.[26,27] At present, there are lots of operative methods for the treatment of calcaneal fractures. Among that, the open procedures using internal fixation have been favored for surgical therapy of the calcaneal fractures. This kind of method has many advantages, at the same time also has many disadvantages, such as skin necrosis and wound infection may be difficult to avoid.

Some scholars presented a minimally invasive technique for the treatment of intraarticular, dislocated calcaneus fractures and were able to produce results comparable to open techniques with a lower rate of serious complications. Although better outcomes were obtained by surgical treatment in anatomical restoration and functional recovery, patients treated with open procedure had a significantly higher risk of complications than the percutaneous ones. In order to reduce the high complication rate caused by open repair surgery, recently, percutaneous repair surgery has been applied in clinical treatment and shows promising results. Schepers[28] indicated percutaneous distractional reduction and fixation to be a safe technique with overall good results and an acceptable complication rate. Dewall[29] in a retrospective cohort study found that the percutaneous method of reducing and fixing calcaneus fractures minimised complications. Results from Woon[30] showed that the percutaneous approach could avoid soft tissue complications associated with open reduction.

The purpose of this review was to provide additional insight into the options for treating displaced calcaneal fractures, focusing on the efficacy and safety of percutaneous poking reduction compared with open reduction. The short-term complications evaluated included skin necrosis and wound infection; while the long-term complications evaluated incorporated secondary surgery and progression of arthritis. From this meta-analysis, the incidence of complications after operation showed statistical difference between percutaneous poking reduction and open reduction for displaced calcaneal fractures. In other words, the incidence of complications after operation occurred significantly higher in open reduction and fixation group. Then we further compared the degrees of recovery for calcaneal Bohler angle and Gissane angle between the two therapies, and found no statistical difference. A good ankle joint function after surgery has a great impact on the quality of patient's life. In present meta-analysis, there was no difference in the rate of good post-operative foot function between two treatments.

The treatment of displaced calcaneal fractures is a clinical problem that has bothered orthopaedic surgeons for a long time. We believe that this study can provide some evidence to guide clinical practice. But our meta-analysis has some limitation. First only 15 CCTs were included in this study. Second, the follow-up periods of most studies were not long enough to confirm the results. Third, most of the retrieved documents were Chinese articles and there may be language bias.

In conclusion, this study shows that the foot function can be restored by both percutaneous poking reduction and open reduction despite the latter has a higher rate of complication after operation. In future studies, more multicentre, large-scale and high quality CCTs should be analyzed to further prove the conclusion.

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