Comparison of clinical outcomes with proximal femoral nail anti-rotation versus InterTAN nail for intertrochanteric femoral fractures: A meta-analysis

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Research

Keywords: unstable femoral intertrochanteric fractures, proximal femoral nail anti-rotation, InterTAN nail, meta-analysis

Posted Date: April 24th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-21889/v1

Version of Record: A version of this preprint was published on October 29th, 2020. See the published version at https://doi.org/10.1186/s13018-020-02031-8.

Abstract

Objective: To access the efficacy and safety of proximal femoral nail anti-rotation (PFNA) and InterTAN nail for intertrochanteric femoral fractures.

Methods: According to the Cochrane systemic analysis method, randomized control trials (RCTs) and retrospective comparative observational studies which were related to the comparison of PFNA and InterTAN nail in the treatment of the elderly with intertrochanteric fractures were retrieved. Data were independently extracted from the included studies by two reviewers and analyzed using RevMan 5.3 , and the quality of the studies was assessed.

Results: Two RCTs and seven observational studies were recruited, which consisted of 681 patients with PFNA and 651 patients with InterTAN nail. The meta-analyses showed no significant differences between the two approaches on Harris Hip Score, operation time, blood loss, time to union, mean hospital stay, union problems, intraoperative complications, hematoma, infection, other complication in both RCTs and observational studies. In terms of other outcomes, for the RCTs, results showed that there were shorter tip–apex distance, reduced pain at thigh or hip in InterTAN nail than in PFNA; however, InterTAN nail was not superior to PFNA in cutout, reoperation, and femoral shaft fracture; for observational studies, the risk of the screw migration (RR=5.13, 95%CI: [1.33,19.75], P=0.02), cutout (RR=3.26, 95%CI: [1.64,6.47], P=0.0008), the varus collapse of the femoral head (RR=7.19, 95%CI: [2.18,23.76], P=0.001), femoral shaft fracture (RR=5.73, 95%CI: [2.24,14.65], P=0.0003) treated by InterTAN nail were significantly decreased, compared with those by PFNA; however, no significant differences was observed in the aspects of tip–apex distance and pain at thigh or hip between these two groups.

Conclusion: Analysis of a large number of relevant clinical indicators available shows that InterTAN nail has better clinical manifestation than PFNA in treating unstable femoral intertrochanteric fractures.

Introduction

In the aged population, intertrochanteric fractures, leading to severe functional impairments, are one of the most frequent fractures; besides, it has become a severe health issue due to the rapid increase in the aged population in recent years [1-4]. Some studies reported that the annual incidence of hip fractures exceeds 320,000 cases in North America, and by 2050, this number is projected to rise to 6 million with an average annual mortality rate of more than 20% for hip fractures and intertrochanteric fractures; besides, in 2011, 316,000 hip fracture patients in the United States were hospitalized for $ 4.9 billion, while in the United Kingdom, Wales and Northern Ireland, national health services for hip fracture patients cost up to £ 1 billion [5]. Given this, the disease has high economic and social costs and may have a devastating impact on patients, such as impaired mobility, poor quality of life and low postoperative survival.

Consideration of priority for scientists and surgeons should be to develop surgical fixation devices that better fit the physiological and anatomical characteristics of the human body. More minimally invasive and delicate surgical approaches are expected to be adopted to achieve lower intraoperative anatomical damage, faster postoperative limb function recovery, lower pain scores, lower infection and implant-related complications, and most importantly, lower mortality. For the treatment of unstable intertrochanteric fractures, the surgical fixation options mainly are composed of extramedullary and intramedullary fixation; the latter further includes proximal femoral nail anti-rotation (PFNA) and InterTAN nail, and others. Dynamic hip screws in extramedullary fixation has been widely used and was considered as the gold standard for extracapsular fractures previously [4]. However, with the recent advances in materials and technology for intramedullary fixation devices, various intramedullary fixations favored by surgeons, especially young doctors, have proven to be safe and effective intraoperatively, and they have become the main treatment method for intertrochanteric fractures [6]. Multiple meta-analyses have shown that intramedullary fixation, compared with extramedullary fixation, is beneficial for patients with unstable femoral intertrochanteric fractures, allowing for reduced risk of implant failure and reoperation rates, and improved postoperative functional scores [7, 8]. PFNA has a large area of spiral blade, which can achieve tighter bone compaction and femur alignment than traditional screws, providing optimal anchoring and stability for intertrochanteric fractures, thus effectively preventing femoral head/neck rotation and the varus collapse, especially in patients with osteoporosis [9-11]. Indeed, more research works related to femoral intertrochanteric fractures have demonstrated that PFNA is associated with smaller incisions, lower complication rates, and shorter length of stay compared to dynamic hip screws [2]. In addition, InterTAN nail, as another type of intramedullary fixation, uses an integrated interlocking lag nail system in which the main tension screw and the compression screw are trapezoidal in outline. The advantages of such design are to limit movement of the femoral head, reduce fracture fragments, decrease the loss of fracture reduction during surgery, and avoid the collapse of the femoral head [6, 12, 13]. These two kinds of third-generation intramedullary nails avoid the "Z" effect, which often occurs in the second-generation intramedullary nails [14]. For example, biomechanical studies reveal that the stress pattern of InterTAN nail similar to that of the natural femur, suggesting that InterTAN nail is less likely to cause stress fractures in osteoporotic intertrochanteric fractures [15]. Besides, many clinical studies related to intertrochanteric fractures have proved that InterTAN nail has a favorable prognosis, high healing rate and few complications [13, 16, 17]. Lu *et al.* have shown that compared with the artificial hip replacement, patients in the InterTAN treatment group have a similar prognosis and quality of life, with the advantages of short surgical time and less blood loss [18].

The huge clinical benefits of these two types of intramedullary fixation have prompted surgeons and researchers to compare the clinical outcomes of PFNA and InterTAN nail; however, the date on this aspect are so far insufficient or even controversy. For example, through CT analysis of a large number of Chinese cadaver femurs and comparison using 3D calculation models, Zhang et al. have found that PFNA-II may be more suitable for Chinese femurs than InterTAN, with higher anatomical similarity, however, the distal part of InterTAN may be superior to PFNA-II [19]. A previous meta-analysis by Ma *et al.* showed the clinical outcomes including cutout and femoral fracture fractures in favor of the InterTAN nails group when compared to the PFNA group [20]. However, the small sample size of this research reduces the credibility of the results.

Accordingly, the current meta-analysis was conducted to comprehensively compared clinical outcomes of two techniques, and further determines the optimal treatment for patients with intertrochanteric fractures.

Methods

Search strategy

According to the search strategy of the Cochrane Collaboration, the following databases were searched for related articles published before February 2020: MEDLINE, Web of Science, Scopus, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE; the references listed in relevant literature were further screened to ensure the comprehensiveness and diversity of the review. The search terms are presented in supplemental List 1, and details of the selection process is outlined in a flow chart (Figure 1).

Inclusion and exclusion criteria

All of the titles and abstracts were screened by two authors independently using the PICO framework as follows: (1) population: individuals with intertrochanteric fractures or pertrochanteric fractures; (2) intervention: PFNA; (3) comparator: InterTAN nails; (4) outcomes: Harris Hip Score (HHS), blood loss, cutout, tip–apex distance, operation time, reoperation, femoral shaft fractures, infection, intraoperative complications, length of hospital stay, hematoma, pain at thigh or hip, time to union, union problems, femoral head abnormalities, screw migration, other complications; (5) study design: several studies (prospective, randomized controlled trials (RCTs) or comparative observational studies published in any language) were eligible for inclusion. The present study included clinical trials with at least one main clinical outcome described above, even though the follow-up in some studies was less than 12 months. Nevertheless, review articles, biomechanical researches, trials in animals, uncontrolled experiments and duplicate or multiple publications of the same study were excluded. The reviewers resolved any disagreements and differences through discussion and consensus or, if required, by consulting corresponding author.

Data extraction

Relevant data in the eligible studies were independently extracted by the two authors using predefined data extraction sheets, then cross-checked; besides, the reviewers resolved any differences by conseneus. Data mainly included the main authors of the study, year of publication, sample size, patient baseline characteristics (e.g., gender and age), fracture types of patients, the follow-up time, the reported outcomes, which were summarized in Table 1.

Statistical analysis

A meta-analysis was conducted using *RevMan 5.3 software*. The relative risk (RR) was used for evaluating dichotomous outcomes such as cutout, tip–apex distance, reoperation, femoral shaft fractures, infection, intraoperative complications, hematoma, pain at thigh or hip, union problems, femoral head abnormalities, screw migration. For continuous data, the mean difference (MD) with a 95%

confidence interval was recorded, and P value below 0.05 was deemed as statistically significant. The heterogeneity test was performed on the studies using P and I2 statistics; besides, a fixed-effects model was applied where the heterogeneity between studies was not substantial, otherwise, a random-effects model was selected. Meanwhile, subgroup analysis was applied according to different types of included studies. A combined analysis was used to make full use of the available data when heterogeneity between studies is not significant. Moreover, a sensitivity analysis was performed by iteratively excluding one study at a time to confirm the robustness of the results. Funnel plot was performed for evaluating the presence of potential publication bias. Funnel plot was not reported due to insufficient literature included.

Results

Baseline characteristics of included studies

In total, 308 articles were initially collected from various electronic databases and managed using the Endnote X9, and 136 were excluded by preliminary screening; further careful screening of the full text excluded 161 articles leaving 9 studies for detailed evaluation. Nine studies (n=1332 patients) published between January 2013 and December 2019 that fulfilled the inclusion and exclusion criteria, including 2 RCTs and 7 observational studies [14, 21-28]. A total of 1332 patients were relatively evenly distributed in PFNA (n=681 patients) and InterTAN nail groups (n=651 patients), and the proportion of the two surgical procedures in A1, A2, and A3 fractures is 88/80, 479/460, 113/112, respectively. All of the studies were followed up for at least 12 months, except for ref [20]. Of these, five studies only included patients with unstable intertrochanteric fractures (e.g., AO/OTA classification A2-A3 fractures), and the other 4 had a mixed type of intertrochanteric fractures. In addition, other characteristics of patients including age and gender were similar, which was summarized in Table 2. All RCTs were classified as unclear risk of bias since no blind methods were reported in included studies, and most observational studies were considered adequate quality based on the GRACE checklist [29].

Clinical outcomes

Primary outcome. *HHS.* HHS was recorded in all 9 studies (n=1243). Overall, there were no significant differences between PFNA and InterTAN nails in both RCTs (MD=-0.31, 95%CI: [-3.83, 3.21], P=0.86; Figure 2) and observational studies (MD=-0.12, 95%CI: [-1.44, 1.20], P=0.86; Figure 2) using the random-effects model as a result of moderate heterogeneity in two subgroups. To verify the robustness and reliability of the present results, a sensitivity analysis was performed by presenting similarly heterogeneity before and after each of the study removed.

Secondary outcomes. *Operation time.* Operation time was reported in 7 studies (n=1058 patients). No significant differences were observed in PFNA versus InterTAN nails in both RCTs (MD=-6.85, 95%CI: [-18.49, 4.79], P=0.25; Figure 2) and observational studies (MD=-8.05, 95%CI: [-16.66, 0.56], P=0.07; Figure 2) using the random-effects model with the statistical heterogeneity that maybe related to different measurement methods.

Blood loss. Five studies consisting of 1 RCT and 4 observational studies showed the outcome of blood loss. No significant differences was observed in PFNA versus InterTAN in both RCT (MD=-37.80, 95%CI: [-79.72, 4.12], P=0.08; Figure 2) and observational studies (MD=-19.11, 95%CI: [-40.10, 1.88], P=0.07; Figure 2) using the random-effects model.

Tip–apex distance. Data from 2 RCTs and 5 observational studies (n=1078 patients) showed tip–apex distance postoperatively. Subgroup analysis showed significant difference in RCTs subgroup (MD=3.54, 95%CI: [2.11, 4.97], P<0.00001; Figure 3) but not in observational studies subgroup. (MD=-0.75, 95%CI: [-2.53, 1.03], P=0.41; Figure 3) using the random-effects model. A combined analysis of subgroups was not performed due to the relatively large heterogeneity of subgroups.

Time to union. Data from 5 studies (n=544 patients) reported time to union. No significant differences were found between PFNA and InterTAN nails through subgroup analysis in both RCTs (MD=1.39, 95%CI: [-1.67, 4.44], P=0.37; Figure 3) and observational studies (MD=0.41, 95%CI: [-0.25, 1.07], P=0.23; Figure 3) using the random-effects model as a result of moderate to high heterogeneity in two subgroups.

Length of hospital stay. 1 RCT and 2 observational studies (n=543 patients) showed the mean hospital stay. No significant differences were found between PFNA and InterTAN nails through subgroup analysis in both RCTs (RR=-0.30, 95%CI: [-0.83, 0.23], P=0.27; Figure 3) and observational studies (RR=0.69, 95%CI: [-0.07, 1.46], P=0.08; Figure 3). The random-effects model was adopted, as the heterogeneity analysis had shown a significant difference, which may be related to the different health status of the patients in each group.

Cutout. A total of 8 studies with 1256 patients reported the outcome of the cutout. It showed no significant differences comparing PFNA with InterTAN for RCTs subgroup, However, significant difference was present in observational subgroup (RR=3.26, 95%CI: [1.64, 6.47], P=0.0008; Figure 4). A combined analysis was performed and the differential effect between PFNA and InterTAN remains significant (RR=3.34, 95%CI: [1.71, 6.53], P=0.0004; Figure 4). A fixed-effects model was choosed, as the heterogeneity analysis had not shown a significant difference.

Pain at thigh or hip. 6 studies (n=1150 patients) reported the outcome of pain at the thigh or hip. In subgroup analysis, a significant difference existed in RCTs subgroup (RR=2.48, 95%CI: [1.02, 6.02], P=0.04; Figure 4), but not in the other subgroup (RR=1.72, 95%CI: [0.87, 3.39], P=0.12; Figure 4). Notably, Duramaz *et al.'* [21] study was found to be the origin of the heterogeneity occurred in observational studies subgroup when sensitivity analysis was performed, I2 statistics changed from 63% to zero when the study was removed (Supplemental list 1). Furthermore, significant differences were found in both subgroups, and combined analysis showed a significant difference (RR=2.46, 95%CI: [1.55, 3.91], P=0.0001; Figure 4) after the study was excluded.

Reoperation. 7 studies with 1109 patients reported on the reoperation. A significant difference existed in observational subgroup (RR=3.20, 95%CI: [1.77, 5.80], P=0.0001; Figure 5) but not in RCT subgroup (RR=1.53, 95%CI: [0.27, 8.75], P=0.63; Figure 5). Combined analysis was used due the low heterogeneity and a significant difference (RR=2.99, 95%CI: [1.71, 5.23], P=0.0001; Figure 5) in total between PFNA and InterTAN was reported.

Union problems. 3 studies (n=550 patients) reported on union problems consisted of delayed union, malunion and nonunion. No significant difference was found between PFNA and InterTAN no matter in RCTs subgroup (RR=7.15, 95%CI: [0.38, 134.66], P=0.19; Figure 5) or observational subgroup (RR=0.65, 95%CI: [0.26, 1.64], P=0.36; Figure 5) or in combined analysis (RR=0.93, 95%CI: [0.41, 1.64], P=0.86; Figure 5). No significant heterogeneity was found, then the results were synthesized using the fixed-effects model.

Screw migration. 5 studies (n=712 patients) reported on the screw migration problems. A significant difference was found in both observational studies subgroup (RR=5.13, 95%CI: [1.33, 19.75], P=0.02; Figure 6) and combined analysis (RR=5.81, 95%CI: [1.72, 19.63], P=0.005; Figure 6). We performed fixed-effects model to calculate a pooled effect as no significant heterogeneity was found (I2=0).

Femoral shaft fracture. 4 studies (n=697 patients) reported on the femoral shaft fracture outcome. Despite a significant difference (RR=3.06, 95%CI: [0.13, 73.33], P=0.005; Figure 6) was not found between PFNA and InterTAN in a single RCT study, a significant difference can be found in the other subgroup (RR=5.73, 95%CI: [2.24, 14.65], P=0.0003; Figure 6), Due to a lack of heterogeneity (I2=0), a combined analysis was performed and a significant difference (RR=5.49, 95%CI: [2.23, 13.48], P=0.0002; Figure 6) between PFNA and InterTAN nail in total was observed. No significant heterogeneity was found, then the current results were synthesized using the fixed-effects model.

Femoral head abnormalities. Femoral head abnormalities included the femoral head necrosis and the varus collapse of the femoral head/neck. 3 studies with 530 patients reported the varus collapse of the femoral head/neck while 3 studies from the same or different teams described above with 604 patients reported on the necrosis of the femoral head. A subgroup analysis was used and a significant difference existed (RR=7.19, 95%CI: [2.18, 23.76], P=0.001; Figure 7) in PFNA and InterTAN referring to the rate of varus collapse of the femoral head/neck postoperatively, while no significant difference (RR=0.78, 95%CI: [0.18, 3.42], P=0.74; Figure 7) presented about the necrosis of the femoral head between the two kinds of the nail. The pooled effect was calculated by fixed-effects model as no significant heterogeneity was found (I2=0).

Intraoperative complications. Intraoperative complications included fractures occurred in greater trochanter, lateral cortex or femoral shaft, changes in distal interlocking position, penetration of trochanter or femoral head. Overall, 1 RCT and 1 observational study reported on the intraoperative complications, including 260 patients. No significant difference was found in PFNA and InterTAN nail in either RCTs (RR=0.92, 95%CI: [0.40, 2.08], P=0.83; Figure 7) or observational studies (RR=1.44, 95%CI: [0.76,2.72], P=0.26; Figure 7). A combined analysis showed no significant difference (RR=1.21, 95%CI: [0.74, 2.00], P=P=0.45; Figure 7) between PFNA and InterTAN nail in intraoperative complications. A fixed-effects model was performed, as no heterogeneity was shown in heterogeneity analysis (I2=0).

Hematoma. The outcome of hematoma was reported in 3 studies (n=366 patients). No significant difference was found in PFNA and InterTAN in subgroups of RCTs (RR=0.87, 95%CI: [0.23, 3.36], P=0.84; Figure 8) and observational studies (RR=0.53, 95%CI: [0.10, 2.83], P=0.46; Figure 8). Correspondingly, combined analysis showed no significant difference (RR=0.71, 95%CI: [0.25, 2.02], P=0.52; Figure 8). A fixed-effects model was performed, as no heterogeneity was shown in heterogeneity analysis (I2=0).

Infection. The outcome of infection included superficial infection and deep infection around the wounds. 4 studies with 552 patients reported on these outcomes. No significant difference was found in both subgroups of RCTs (RR=0.61, 95%CI: [0.16, 2.42], P=0.48; Figure 8) and observational studies (RR=0.60, 95%CI: [0.25, 1.43], P=0.25; Figure 8) using the fixed-effects model. Due to a lack of heterogeneity (I2=0) between studies, a combined analysis was used and no significant difference was found.

Other complications. Other complications included deep venous thrombosis, pulmonary embolism, decompensated heart failure, urinary tract infection, pneumonia, pressure ulcer. 4 studies (n=649 patients) reported on these outcomes. Overall, we found no significant difference in both subgroup analysis of RCTs (RR=1.18, 95%CI: [0.76, 1.82], P=0.47; Figure 9) and observational studies (RR=1.03, 95%CI: [0.71,1.50], P=0.87; Figure 9), which was consistent with the pooled result of combined analysis. A fixed-effects model was performed, as the heterogeneity analysis had not shown a significant difference (I2=0).

Sensitivity analysis and publication bias. We performed sensitivity analysis by iteratively excluding one study at a time to confirm the robustness of the results. All the results were robust except for the outcome of pain at the hip or thigh. When a certain study resulting in heterogeneity was removed, no heterogeneity was found in the remaining studies, which could be explained by the different surgical skills of the surgeons between included studies.

Discussion

PFNA and InterTAN nails are commonly used intramedullary fixation devices to treat for intertrochanteric fractures, but there is controversy as to which one has more clinical advantages. With the extension of human life expectancy, the elderly population, no matter with or without osteoporosis, will increase, thus the number of patients with intertrochanteric fractures will continue to increase. In view of this, many patients will benefit greatly from surgical options that can lead to better clinical outcomes. Although a previous meta-analysis reported a comparison of clinical outcomes of PFNA and InterTAN intramedullary nails, a relatively small sample size of five studies with only 592 patients reduced its testing capability for statistical analysis [20]. The present analysis included 9 studies with 1,243 patients, which allowed us to compare more clinical outcome indicators. An updated comparison of clinical outcomes between the two nailing systems can provide additional evidence for the choice of clinical treatment options of intertrochanteric fractures.

In terms of HHS, blood loss, time to union, length of hospital stay, the present evidence is consistent with the findings of previous studies, showing that PFNA and InterTAN are similar in these clinical outcomes.

previous study has shown that shorter operation time can be obtained with PFNA [20]. However, our analysis showed no statistically significant difference for the outcome of operation time between the two intramedullary nails, as evidenced by both results of the RCT subgroup and observation subgroup analysis, such result is consistent with one new study we included published in 2017(ref 23). It's not hard to understand that with the popularity of InterTAN applications and the surgeon's familiarity with this device, the time required to perform surgery using InterTAN may have been reduced. In addition, some other clinical outcomes were compared and analyzed, including intraoperative complications such as fractures occurred in greater trochanter, lateral cortex or femoral shaft, changes in distal interlocking position, penetration of trochanter or femoral head, postoperative union problems, hematoma, and infection, and other complications. Overall, these clinical outcomes of intertrochanteric fractures treated with these two types of intramedullary nails were similar, with no statistically significant difference.

Due to the T-shaped design of InterTAN nail compared with PFNA, the stronger compression of the broken end is linked with the reduced risk of the cutout, varus collapse, femoral shaft fracture, and screw displacement. For example, a retrospective study of 101 patients in 2018 reported that implant-related complications of PFNA for intertrochanteric fractures treatment were as high as 15.84%, of which 7 were cut out (6.93%), and 2 were secondary varus displacements (1.98%), while TAD > 25mm and malposition of the spiral blade in the femoral head were found to be important risk factors for secondary varus displacement and screw cutout of the fracture [30, 31]. Consistent with these findings, the current pooled data show that PFNA has a higher risk of screw migration and cutout. Interestingly, the higher risk of high postoperative TAD and femoral head collapse in the PFNA group was also found compared with the InterTAN nail group. Generally, for intertrochanteric fractures, especially unstable ones, it is particularly important to provide strong and stable intersegmental compression by intramedullary nails after fracture reduction. Seyhan *et al.* measured the postoperative fracture gap after intertrochanteric fracture treatment with InterTAN and PFNA intramedullary nails and showed that the InterTAN group significantly reduced the postoperative fracture gap compared to the PFNA group, providing greater compression and fixation capacity for the fracture end to maintain the stability of the fracture [14]. This may explain why InterTAN is superior to PFNA in clinical outcomes such as cutout, femoral head varus collapse, which is consistent with the present analysis results. The relatively high risk of cutout or cut through of PFNA has been confirmed in multiple studies and is thought to be related to the design of the spiral blade [14, 32]. In response to such problem, bone cement-enhanced PFNA designs with perforated spiral blades may provide stronger fixation of fractured femoral head-neck ends, none of 59 patients was found to undergo screw cutouts, cut through, blade displacement, implant loosening or disruption during a mean follow-up of 4 months [33]. It should be pointed out that inadequate surgeon experience may also increase the risk of screw cutout [34].

Postoperative pain is an element that affects patients' quality of life. Screw failure, femoral shaft fracture, and other implant failure-related complications may lead to long-term pain [35]. The results of the present analysis results are consistent with the findings of the above research. Lower risk of femoral shaft fractures and postoperative pain was found in InterTAN than in PFNA. This may be related to InterTAN nails' ability to provide stronger fracture compression fixation. Furthermore, 4 of 6 studies showed significantly reduced postoperative pain in the InterTAN nail group compared to the PFNA group [23, 25-27]. The occurrence of screw cutout, femoral shaft fracture, and femoral head varus collapse inevitably increased the probability of reoperation, which was confirmed by this study in which InterTAN nail significantly decreased the risk of reoperation compared with the PFNA. Notably, studies have shown that patients with intertrochanteric fractures undergo cutout or cut through after PFNA fixation, often require total hip arthroplasty (THA) to obtain better reoperation outcomes, while the effect of reintramedullary nail fixation was not satisfactory [36]. Hence, careful consideration of the surgical options is key when reoperation is performed on patients with intertrochanteric fractures.

In addition, the present study has some limitations. First, although observational studies can provide a larger number of patients, allowing comparison of the two types of intramedullary nails in a larger patient population, there are relatively few RCT studies in the included studies, which may increase potential bias to a certain extent, thus affecting the accuracy of RCTs study evaluation, if more RCT studies can be included, the present results will be more convincing. Second, there is some heterogeneity between included studies, under such circumstances a pooled analysis was not preformed again, however, a sensitivity analysis shows that most of this meta-analysis results except for pain outcome assessments are robust. Finally, among the 1243 patients, 168 patients presented in 4 studies were stable fractures, and further subgroup analysis was not conducted, in other words, a comparison of clinical outcomes based on fracture stability was not reported in this study.

Conclusion

PFNA and InterTAN nail are two common intramedullary nails for the treatment of intertrochanteric fractures. In this meta-analysis, PFNA has not found to be superior to InterTAN nail in terms of HHS, operation time, mean length of hospital stay, time to union, union problems, intraoperative complications, hematoma, infection, and other complications. However, since the present analysis reveals that patients received surgery with InterTAN nail had a lower risk of the screw migration, pain at thigh or hip, cutout, varus collapse of the femoral head, femoral shaft fracture, most importantly,a lower risk of reoperation, it is concluded that InterTAN may be recommended as a preferred clinical treatment for intertrochanteric fractures in comparison to PFNA.

Abbreviations

PFNA: Proximal femoral nail anti-rotation; RS: Retrospective study; RCTs: Randomized control trials; HHS: Harris hip score; RR: The relative risk; MD: The mean difference; AO/OTA: Arbeitsge-meinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

Declarations

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: Not applicable.

Competing interests: The authors declare that they have no competing interests.

Funding: Not applicable.

Authors' contributions: LW and LJ collected the data and drafted the manuscript. JGR revised the manuscript. All authors have read and approved the final manuscript.

Acknowledgements: The authors are grateful the friends who gave us help in the creation and revision of the final manuscript.

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Tables

Table 1 The characteristics of included studies.

Study, year	PFNA[a]/IT[b]						Length of follow-up (months)	Type of study[e,f]
	sample size	age (years)	Gender (% male)	Fracture type (number)				
				AO/OTA-A1[c]	AO/OTA-A2	AO/OTA-A3		
Duramaz, 2019 [21]	100/86	PFNAII=61.0±16.6 IT=61.5±15.8	43.6[d]	28/34	49/32	23/20	25.9	RS
Gavaskar, 2018 [22]	50/50	PFNAII=78±8 IT =77±7	42.0/42.0	0/0	31/31	19/19	12	RS
Seyhan, 2015 [14]	43/32	PFNA=75.9±13.77 IT =75.3±13.52	25.6/25.0	44142	16/13	44181	19.4 (mean)	RCT
Wang, 2013 [28]	36/20	PFNAII=76.8±9.5 IT=73.5±11.3	47.2/55	7/2	26/13	3/5	4.1 (mean)	RS
Yu, 2016 [25]	72/75	PFNAII=74.2±9.1 IT=75.2±8.8	44.4/46.7	0/0	35/40	37/35	20 (mean)	RS
Zehir, 2015 [26]	96/102	PFNA=77.2±6.8 IT=76.8±6.7	38.5/38.2	0/0	92/93	43930	16.06/16.00	RS
Zhang, 2013 [27]	56/57	PFNAII=72.4±8.7 IT=72.9±7.6	33.9/40.4	0/0	45/45	44147	18.36	RCT
Zhang, 2017a [24]	88/86	PFNAII=74.6±6.3 IT=72.7±7.6	38.6/34.9	42/37	46/49	0/0	41.51/40.84	RS
Zhang, 2017b [23]	139/144	PFNA/IT=76.1[d]	38.1/44.4	0/0	139/144	0/0	39.1/38.7	RS

Data are presented as n or mean±standard deviation.

[a]proximal femoral nail anti-rotation, [b]InterTAN nail, [c]Arbeitsge-meinschaft für Osteosynthesefragen/Orthopaedic Trauma Association, [d] population parametes, [e]retrospective study, [f]randomized Controlled Trial.

Supplemental List

Figure 1 A forest plot diagram showed pain at thigh or hip when the study [21] was removed.

Figures

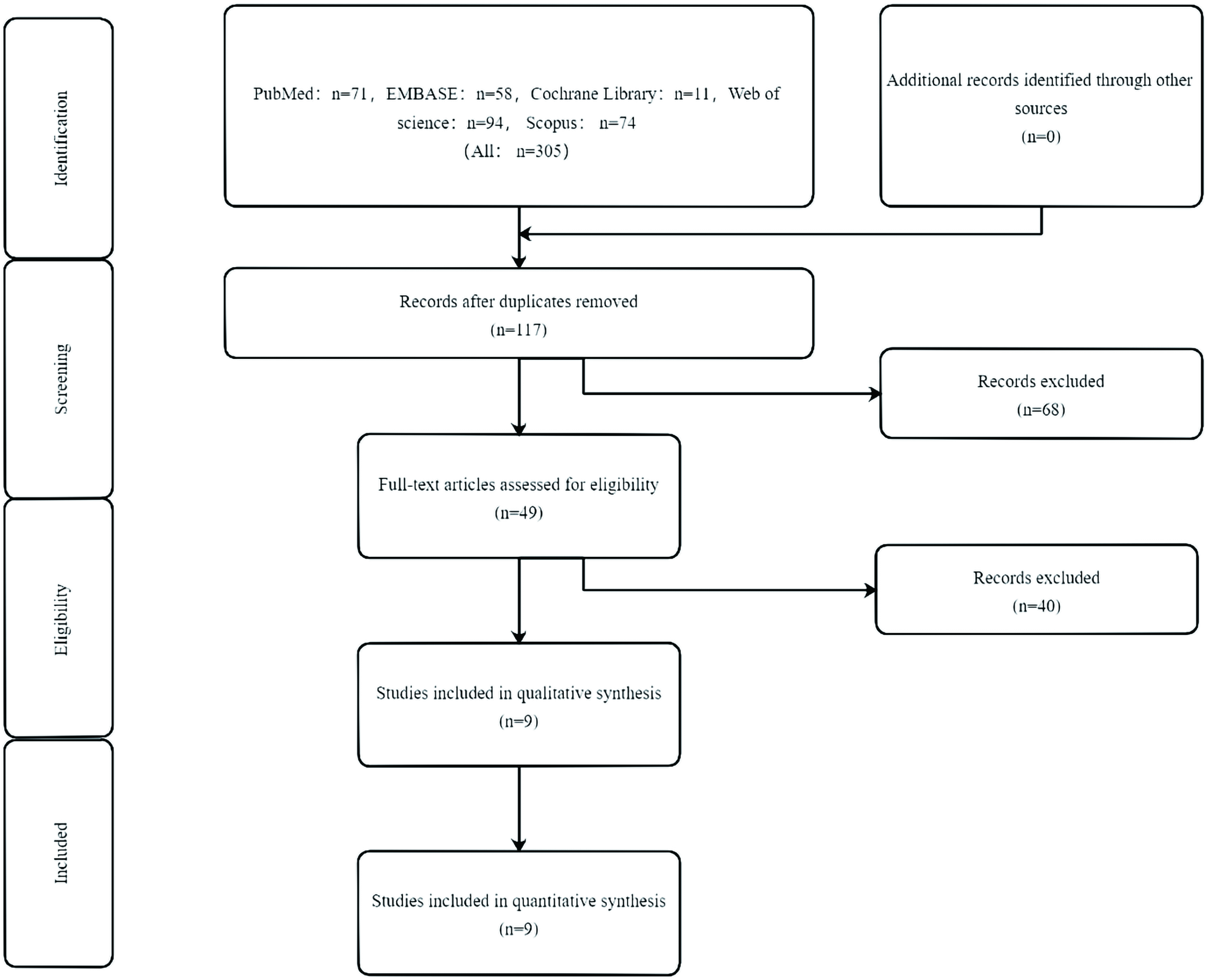

Figure 2

Flow diagram of literature selection.

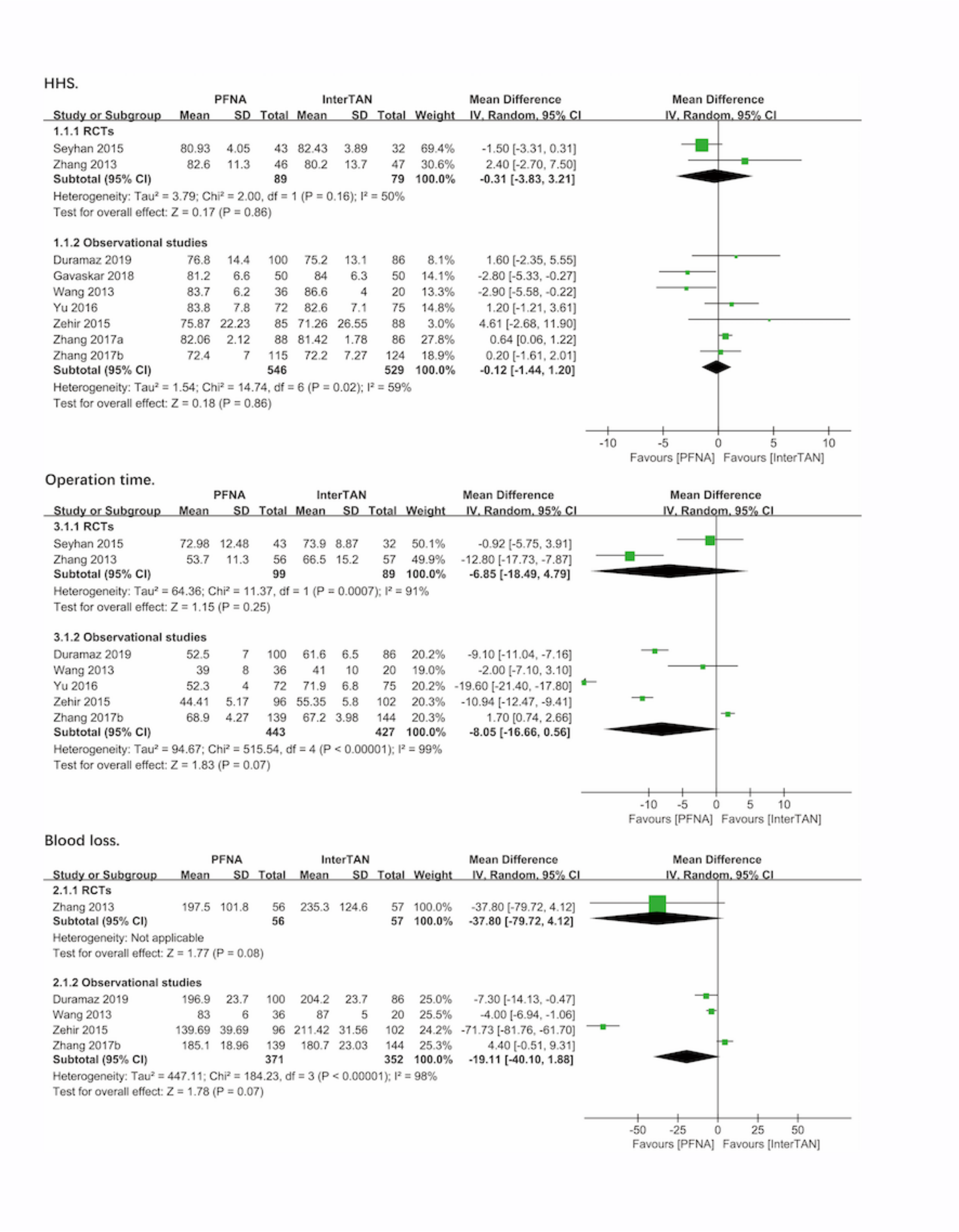

Figure 3

A forest plot diagram showed HHS, operation time, and blood loss.

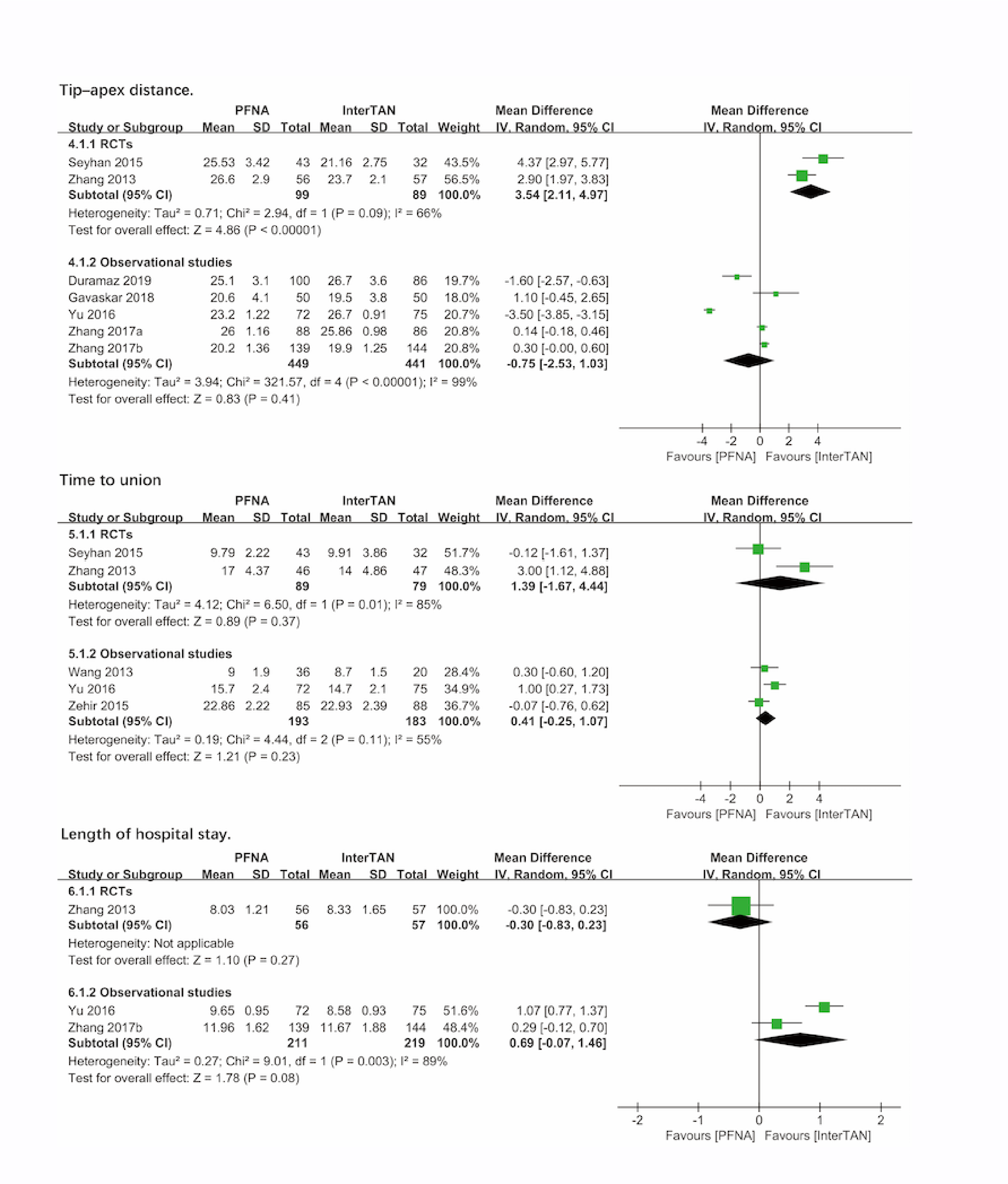

Figure 5

A forest plot diagram showed TAD, time to union, and length of hospital stay.

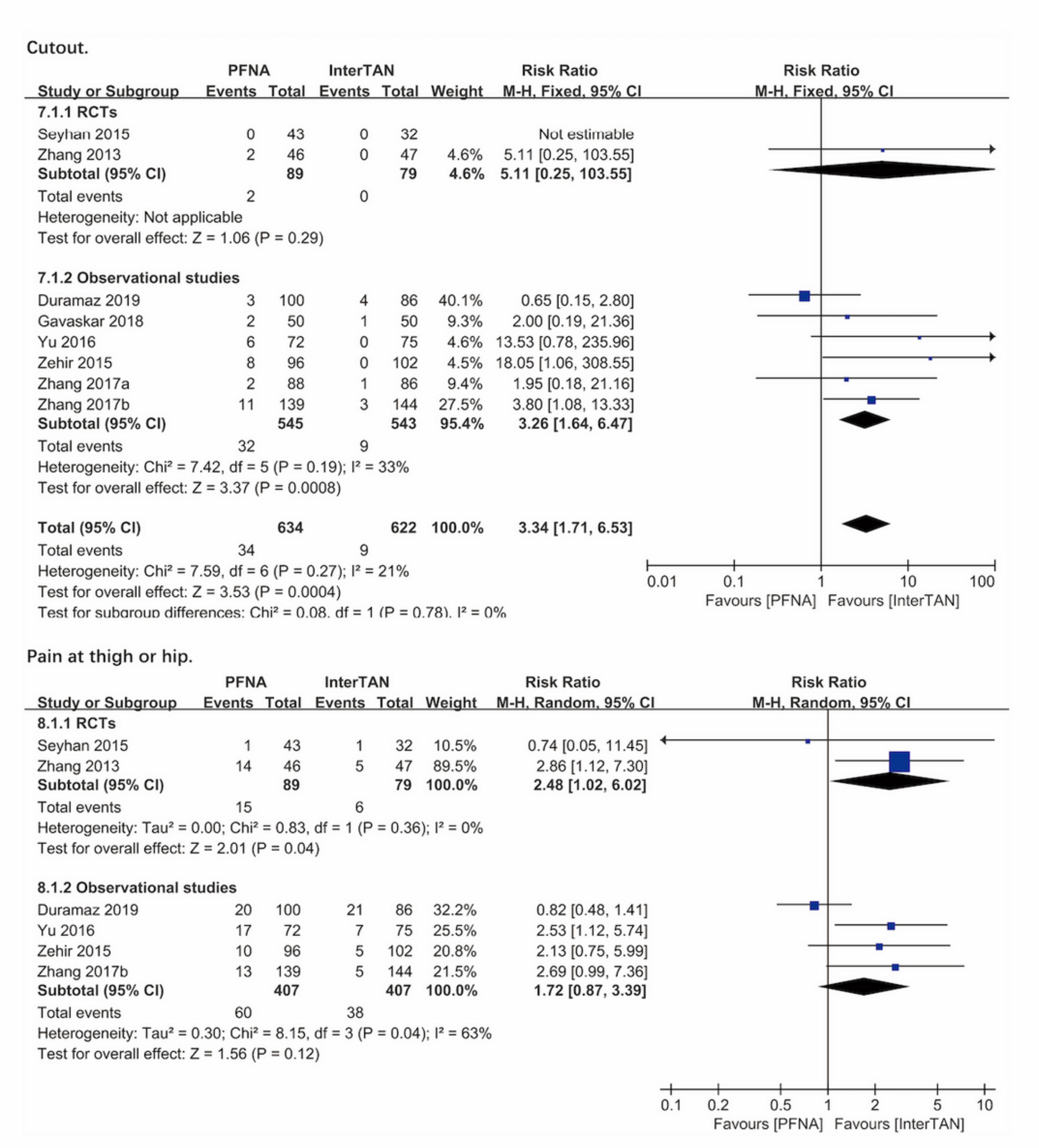

Figure 8

A forest plot diagram showed cutout and pain at thigh or hip.

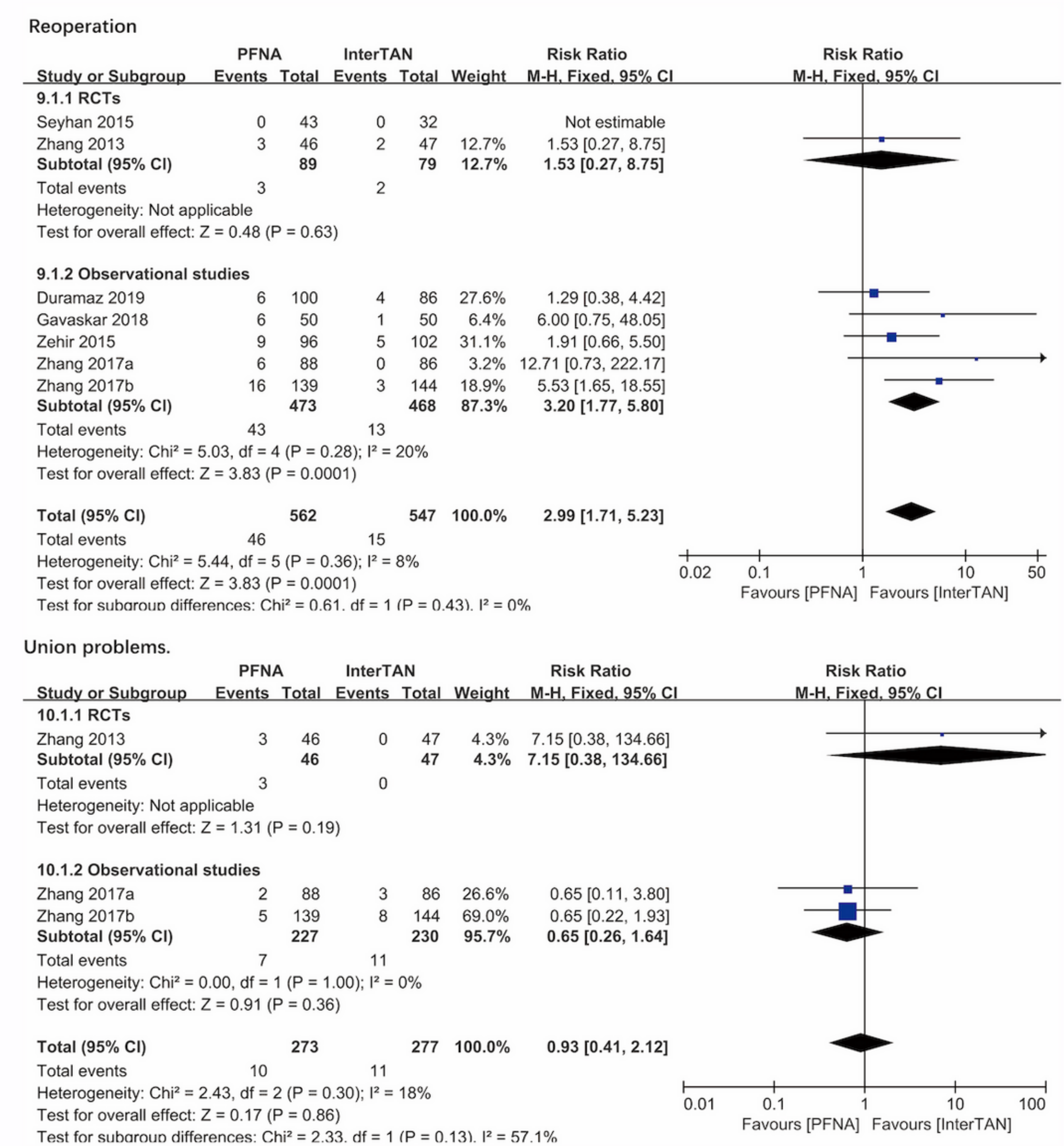

Figure 10

A forest plot diagram showed reoperation and union problems.

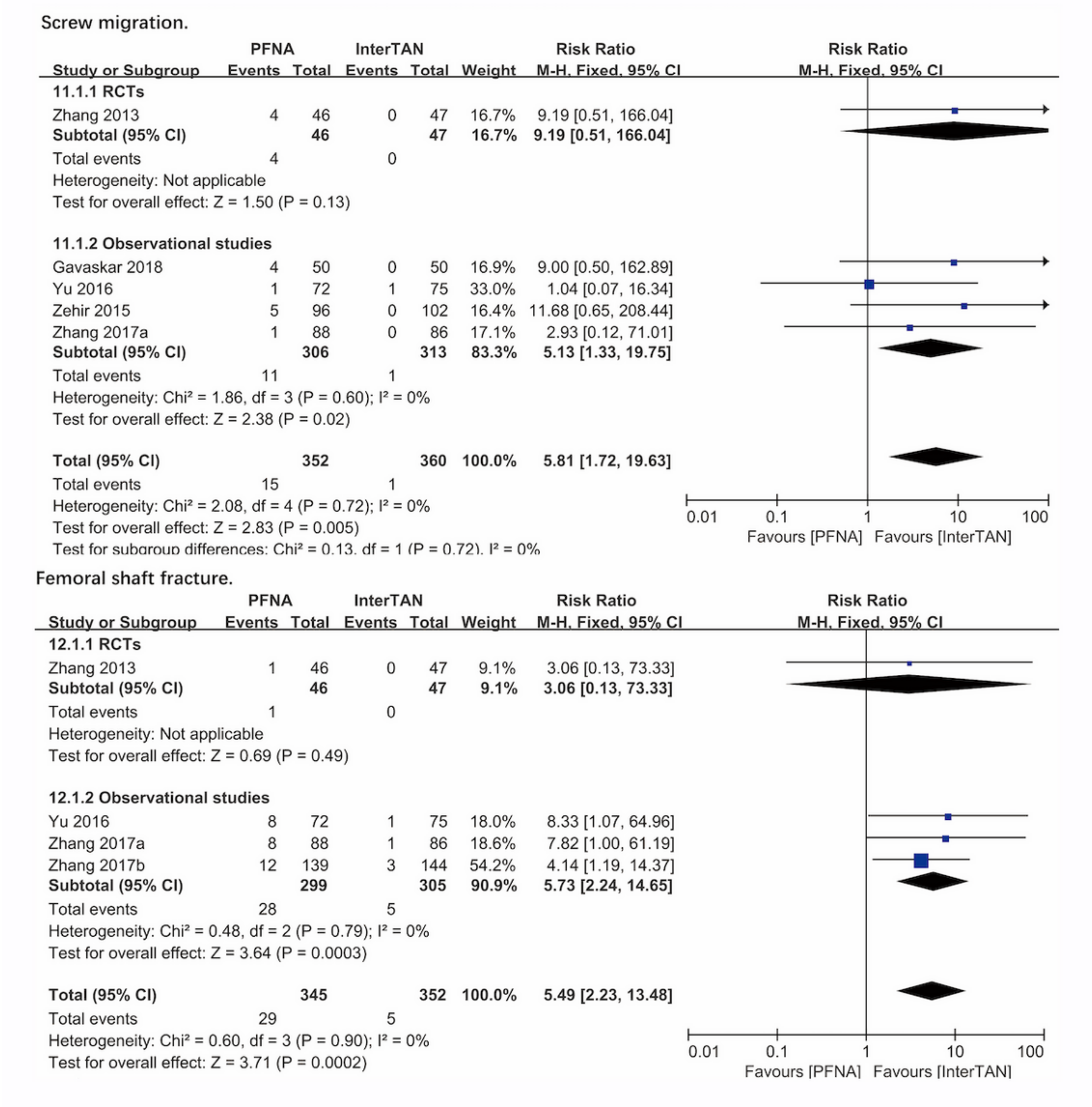

Figure 12

A forest plot diagram showed screw migration and femoral shaft fracture.

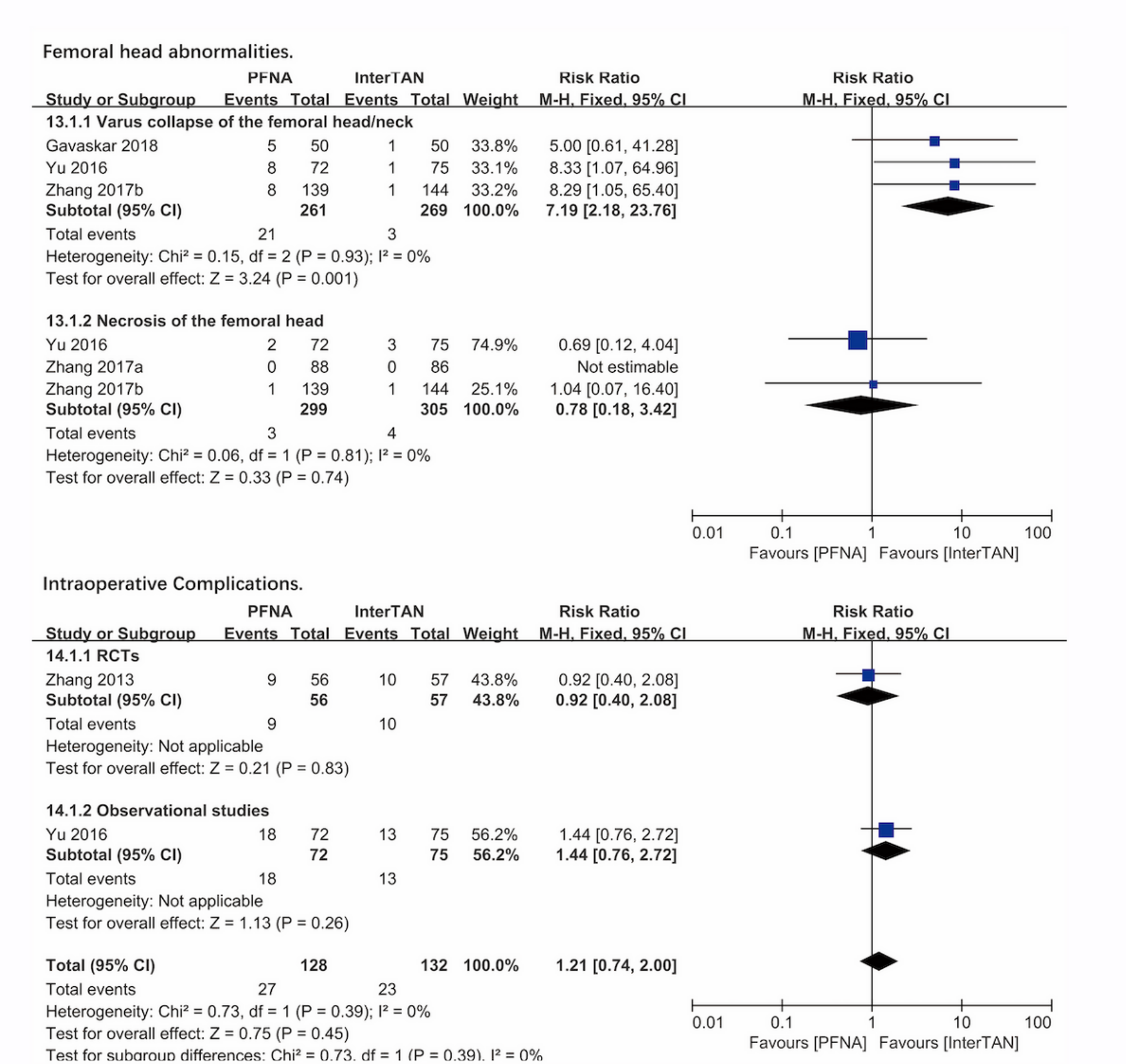

Figure 13

A forest plot diagram showed femoral shaft fracture and intraoperative complications.

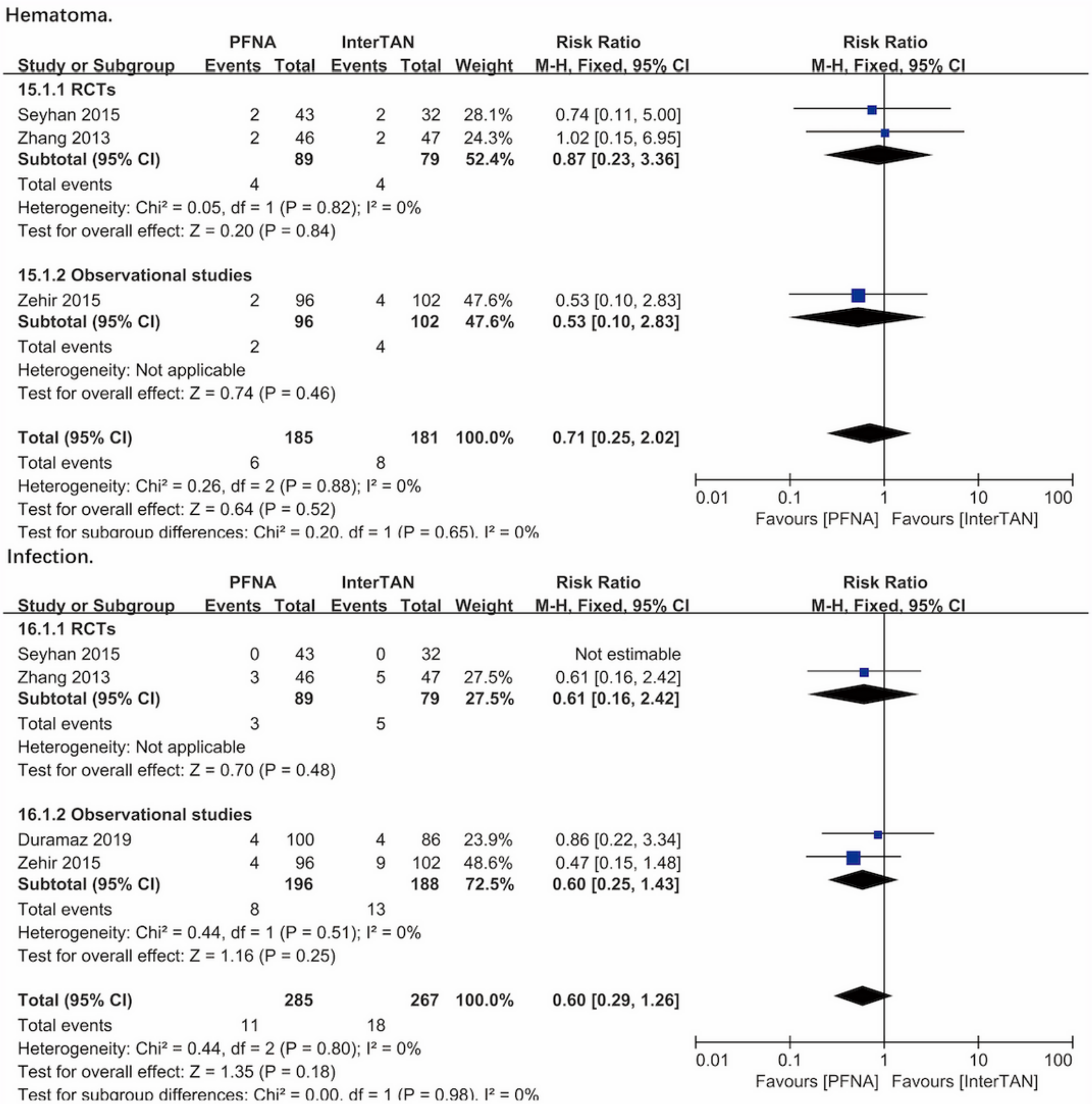

Figure 15

A forest plot diagram showed hematoma and infection.

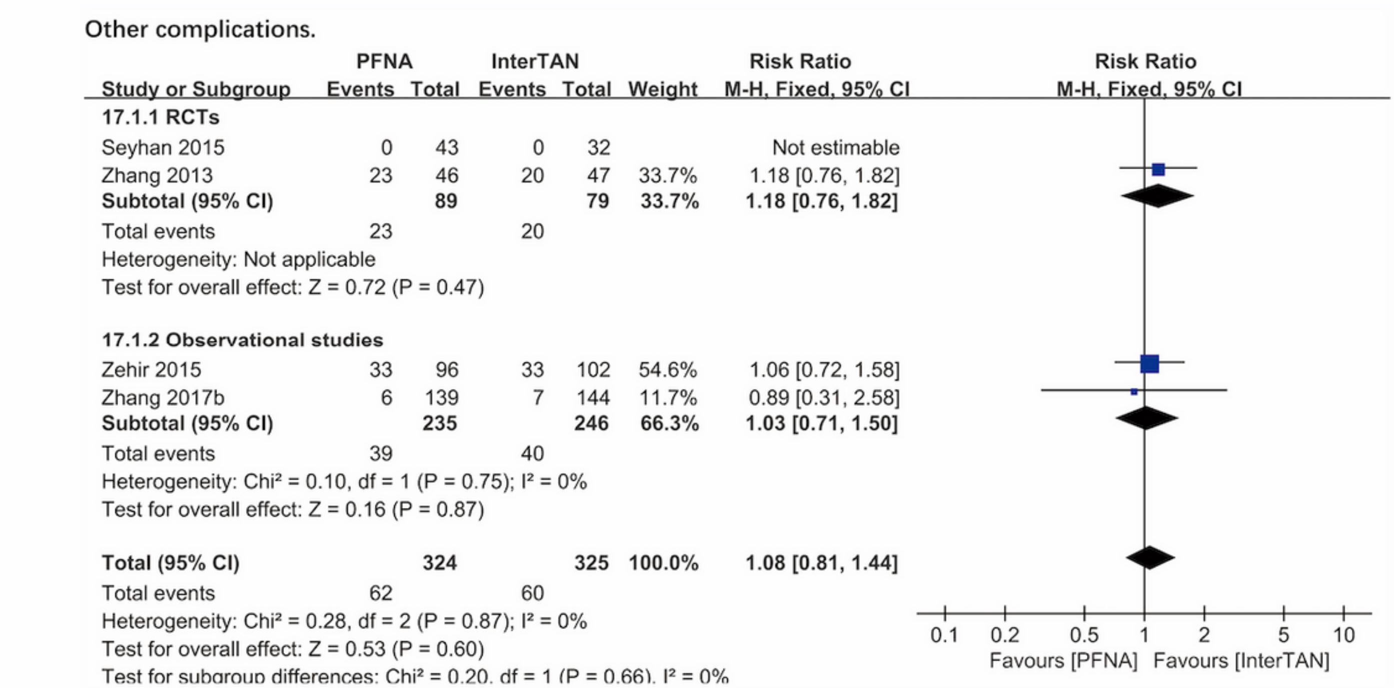

Figure 18

A forest plot diagram showed other complications.

Supplementary Files

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- S1.tif