

Arthroplasty Is Not Superior Than Internal Fixation for Intertrochanteric Fractures in the Elderly: a Meta-analysis

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Abstract

Background: Surgical treatment is the first choice for intertrochanteric fractures in the elderly as it allows early rehabilitation and functional recovery. Recently, more and more surgeons prefer arthroplasty instead of internal fixation in the treatment of senile intertrochanteric fractures. However, there is conflicting evidence as to which is the best surgical treatment for them. In this article, we performed a systematic review and meta-analysis to compare the clinical effectiveness of internal fixation (IF) and arthroplasty (AR) for intertrochanteric fractures in the elderly.

Methods: The online databases of PubMed, Cochrane Database, and Web of Science were searched to include studies conducted from 01/01/2000 to 11/30/2018 in English using keywords to identify articles relevant to this study. All studies had to have evaluated the treatment of patients with intertrochanteric fractures in the elderly (≥ 60 years of age). The quality of the trials was assessed and meta-analyses were conducted using the Cochrane Collaboration's RevMan 5.3 version.

Results: A total of 14 studies involving a total of 1588 patients were suitable for inclusion in this meta-analysis. There was no significant difference between the IF and AR groups for postoperative complications-related general condition (OR=1.24; 95% CI= 0.90, 1.70; $P=0.19$), hospital stay (SMD=0.16; 95% CI= -0.5, 0.82; $P=0.64$), and Harris hip score (SMD= -0.12; 95% CI= -0.79, 0.54; $P=0.71$). AR group had a significantly lower rate of complications-related operation (OR= 2.21; 95% CI= 1.41, 3.45; $P=0.0005$) and reoperation (OR=2.74; 95% CI= 1.57, 4.76; $P=0.0004$). However, compared with AR group, IF group could reduce the blood loss (OR=-4.08; 95% CI=-4.58, -3.59; $P<0.00001$), transfusion requirement (SMD= -0.67; 95% CI= -1.08, -0.26; $P=0.001$), operation time (SMD= -0.80; 95% CI= -1.47, -0.12; $P<0.00001$), and have a lower rate of mortality within 1-year (OR= 0.67; 95% CI= 0.52, 0.86; $P=0.002$).

Conclusion: AR is associated with less rates of complications-related operation and reoperation but has an increased risk of blood loss, transfusion, operation time and mortality within 1-year. Our findings demonstrated that AR does not have significant advantages over IF for intertrochanteric fractures in the elderly.

Introduction

Intertrochanteric fracture (ITF) is one of the common fractures in the elderly, and its incidence is also increasing with the rapid growth of the aging population.^{1,2} Recent epidemiologic studies reported that about 1.7 million new ITFs occur in the world every year, which account for 8–10% of all fractures, and the number is expected to double by the year 2040.^{3,4} It presents a major public health concern for current society.⁵ The ITFs in the elderly usually result from minor trauma, but they are very difficult to achieve and maintain a stable fixation because of their poor bone quality.⁶ The treatments for the ITF normally include surgical and non-surgical treatment. The non-surgical treatment has been not adopted basically with reported mortality rates ranging from 15–30%, and complications such as pneumonia, urinary tract infection and cardiovascular events.^{7,8} The surgical treatment has been demonstrated that it can decrease the mortality rates, complications and significantly improve the quality of life of the patients after surgery.^{9–12} Therefore, it has been considered as first choice for the elderly patients with ITFs.

The surgical options include the open or closed reduction internal fixation (OR/CRIF) and arthroplasty (AR). The IF has been the preferred treatment for the elderly patients with ITFs over the years, because it can enable the patient to have postoperative early mobilization, less complications, and good functional recovery.^{13–15} However, with the development of prosthesis design, the AR has gradually become another considerable treatment for the elderly patients with ITFs.¹⁶ There have been a few nonrandomized and randomized studies comparing IF and AR for the treatment of ITFs, but which is the best surgical treatment for the elderly patients with ITFs has been controversial in

the past ten years.^{17–22} The nonrandomized clinical studies have been limited due to lack of the assessments of possible confounding variables, independent outcome, and possible bias associated with unmeasured or unknown confounders inherent in observational studies.²³ Even if randomized controlled trials (RCTs) have decreased bias through randomization and overcome the limitations of nonrandomized studies. However, it is obvious that human subjects cannot ethically be randomized to exposure to a potentially noxious factor and alternative therapies for the same disease are so different that it is unlikely that patients would be indifferent to their choices to the degree that they consent to randomization. Sometimes, it is not possible to randomize exposure to a risk factor at all.²⁴ Thus, the purpose of the current meta-analysis is to assess the evidence from the previous RCTs and non-RCTs that have compared the clinical efficacy of IF and AR for treating the elderly patients with ITFs.

Materials And Methods

Search Strategy

The sources included PubMed, Cochrane Database, and Web of Science databases were searched from 01/01/2000 to 11/30/2018. The search terms included intertrochanteric, or pertrochanteric, or trochanteric; internal fixation; and arthroplasty, or hip replacement, or prosthetic replacement. All searches were limited to the English language. Information was carefully extracted from all the eligible studies by two investigators independently, using a standardized data extraction form. Any disagreement was resolved by discussion during a consensus meeting with other investigators.

Inclusion Criteria and Data Extraction

The selection criteria used to determine the eligible studies included: (1) the objects of study were elderly patients (≥ 60 years age) with ITFs; (2) the literature was RCT or non-randomized comparative study; (3) the treatment was internal fixation versus arthroplasty; (4) the comparative data must include at least one of the following results: available operative time, blood loss volume, transfusion, hospital stay, mortality, reoperation rate and major method/general-related complication data; (5) limited to patients with normal mental; (6) no serious known metastatic disease or terminal illness; (7) the follow-up period was at least 6 months.

We extracted data from relevant studies using an electronic data collection form prepared in Stata software. We contacted study authors, where appropriate, to request further information, such as missing results. The following information was extracted from the eligible studies: first author's name, year of publication, participants' age and gender, number of participants in each group, study design (cohort, case-control, cross-sectional), follow-up time, and the major outcomes.

Statistical Analysis

The statistical analysis was conducted using the Cochrane Collaboration's Rev Man 5.3 software (Nordic Cochrane Centre, Copenhagen, Denmark). The summary odds ratio (OR) was used as the effect parameter for this meta-analysis, and a 95% confidence interval (CI) was used to interpret the results. Heterogeneity was assessed using the I^2 value and Chi-square test. It was conducted to determine whether the results of various studies and the overall effects are consistent or not. If the outcome data was low heterogeneity ($P \geq 0.05$, $I^2 \leq 50\%$), a fixed-effect model would be used for analysis. If there was statistical heterogeneity ($P < 0.05$, $I^2 > 50\%$) in the data, the sensitivity analysis was conducted to determine whether the remaining results would be markedly affected after removing outlier studies one by one. If it was not of clinical heterogeneity, a random effect model would be used. If the heterogeneity was too large

to be carried out meta-analysis in the studies, the data will be analyzed one by one to be found out the reasons, and descriptive analysis will be used finally. Continuous data were expressed as standardized mean differences (SMD) and 95% CI. Dichotomous data were presented as ORs with 95% CI. $P < 0.05$ was considered statistically significant.

Results

Literature search

A total of 491 records was preliminarily identified after systematically searching the mentioned databases based on our search strategy using different search term combinations. We screened the titles and abstracts and excluded 456 irrelevant records. We scrutinized full texts of the remaining 35 papers for eligibility, and 14 papers, on a total of 1588 elderly patients with ITFs, remained for meta-analysis finally. The detailed selection process is shown in Figure 1.

Characteristics of included studies

Table 1 summarizes the characteristics of included studies. A total of 774 IF and 814 AR cases with ITFs in the elderly from 14 studies were included. Seven studies were from the Asia (China^{Chang,Shen,Tang,Yang}, South Korea^{Kim,Kim,Park}),²⁵⁻³¹ 6 studies were from the Europe (Turkey^{Kayali, Görmeli, Desteli, Özkayın,Güven}, France^{Bonnevialle}),³²⁻³⁷ and 1 study was from Africa^{Gashi}.³⁸ Among these eligible trials, the AR included hemiarthroplasty and total hip arthroplasty, the IF included intramedullary system (GN, PFN, PFNA, IN) and extramedullary system (CHS, DHS), which represented the commonly used implants in clinical practice. Table 2 presents the quality of the included studies. They included three RCTs (Kim 2005; Desteli 2015, Özkayın 2015); two nonrandomized prospective studies (Bonnevialle 2011; Gashi 2018), and nine retrospective analyses (Kayali 2006, Chang 2011, Shen 2012, Kim 2014, Tang 2012, Görmeli 2015, Park 2015, Güven 2016, Yang 2017).

Outcome measures

Operative time

Ten studies covered the operative time,^{25-27,29,30-35,38} but only the data from 8 studies,^{25,26, 29,30,32-35} including 753 patients were eligible in the form of mean and standard deviation. High heterogeneity was present in these studies ($\text{Chi}^2=129.74$; $P < 0.00001$; $I^2=95\%$). The sensitivity analysis indicated that no significant change was found in the results after the deletion of any literature, and suggested the result is reliable. Therefore, a random effect model was conducted, and the result showed that there was a significant difference in the operative time between two groups (SMD= -0.80; 95% CI= -1.47, -0.12; $P = 0.02$) (Fig.2). Compared with the IF group, AR group needed more operative time.

Blood loss and Transfusion

Blood loss was documented in 5 studies,^{25,27,29,31,33} and 2 of them including 201 patients were eligible in the form of mean and standard deviation.^{29,33} The result of fixed-effect model showed that there was a significantly different in the blood loss between the two groups (SMD=-4.08; 95% CI=-4.58, -3.59; $P < 0.00001$) with no heterogeneity ($\text{Chi}^2=0.20$; $P = 0.65$; $I^2 = 0\%$) (Fig.3). IF group was superior to AR group in the blood loss.

Eight studies covered the blood transfusion,^{25-27,29,30,32,33,38} but only 4 studies of them provided the media volume of transfusion.^{26,29,30,32} 358 patients were included in the remaining 4 literatures which were eligible in the form of mean and standard deviation. The heterogeneity test indicated there was a moderate heterogeneity ($\text{Chi}^2=10.40$, $P = 0.02$,

$I^2=71\%$). However, sensitivity test was unnecessary because significant difference was observed in each trial, indicating the result reliable. The result of random effect model showed that the IF group has less transfusion than AR group (SMD= -0.67; 95% CI= -1.08, -0.26; $P=0.001$) (Fig.4).

Complications-related general condition

The general complications after surgery were reported in 8 studies (1221 patients, 189 events),^{26,27,29,30,32,33,37,38} which mainly included pneumonia, cardiovascular complication, urinary tract infection, neurologic complication, thromboembolic complication, pressure sores and wound infection. The heterogeneity test showed a low level among these studies ($\text{Chi}^2=8.75$, $P=0.27$, $I^2=20\%$) and fixed-effect model was adopted. The incidence of postoperative complications-related general condition in AR group (91/634, 14.4%) was slightly less than that of the IF group (98/587, 16.7%), but there was no significant difference between the two groups (OR= 1.24; 95% CI= 0.90, 1.70; $P=0.19$) (Fig.5).

Complications-related operation

Ten studies,^{25-27,29,30-32,35,37,38} on a total of 1212 patients, covered major method-related complications, which mainly included the dislocation, loosening, cut out, breakage, intra-operative fracture of femur, postoperative fracture of femur, nonunion, delayed union and malunion. The heterogeneity test showed a low level among these studies ($\text{Chi}^2=14.48$, $P=0.11$, $I^2=38\%$) and fixed-effect model was adopted. The result indicated that there is a significant difference between AR and IF groups in the complications-related operation (OR= 2.21; 95% CI= 1.41, 3.45; $P=0.0005$) (Fig.6), and it was clear that AR is superior to IF for the complications-related operation.

Reoperation

The rate of reoperation was reported in 7 studies.^{27,29,31,32,33,37,38} The total reoperation rates in the AR and IF groups were 3.83% (19/496) and 9.83% (45/458), respectively. A fixed effect model was followed to conduct due to a low heterogeneity ($\text{Chi}^2=8.07$; $P=0.15$; $I^2=38\%$), and the result showed that the AR group has a significant lower rate of reoperation than IF group (OR= 2.74; 95% CI= 1.57, 4.76; $P=0.0004$) (Fig. 7).

Hospital stay

Nine studies covered the hospital stay,^{25,27,29-31,32-34,38} but just 6 studies including 575 patients were eligible in the form of mean and standard deviation.^{25,29,30,32-34} The heterogeneity test showed a high level in these studies ($\text{Chi}^2=73.14$, $P<0.0001$, $I^2=93\%$) and random effect model was conducted. The sensitivity analysis indicated that no significant change was found in the results after the deletion of any literature, suggesting the result reliable. A random effect model was followed to conduct, and the result showed that there is no significantly different between two groups in the hospital stay (SMD= 0.16; 95% CI= -0.50, 0.82; $P=0.64$) (Fig. 8).

Harris hip score

Nine studies reported the HHS after surgery,^{25-27,29,31,33,35,36,38} but just 7 eligible studies including 704 patients in the form of mean and standard deviation were performed in the forest plot diagram.^{25,27,29,33,35,36,38} The heterogeneity test showed a high level among these studies ($\text{Chi}^2=101.52$, $P<0.00001$, $I^2=94\%$) and random effect model was conducted. The sensitivity analysis indicated that no significant change was found in the results after the deletion of any literature, suggesting the result reliable. The result indicated that there is no significant difference between two groups in the HHS (SMD= -0.12; 95% CI= -0.79, 0.54; $P=0.71$) (Fig. 9).

Mortality within 1-year

A total of 10 studies reported the mortality after surgery,^{25-27,28,29,31-33,37,38} but just 8 of them, on a total of 1919 patients, provided the valid mortality with 1-year after surgery.^{25,27,29,31-33,37,38} A fixed-effect model was adopted due to no heterogeneity in these studies ($\text{Chi}^2=3.78$, $P=0.88$, $I^2=0\%$). The result showed that IF has a statistically less mortality with 1-year than AR (OR= 0.70; 95% CI= 0.51, 0.97; $P=0.03$) (Fig. 10).

Discussion

It is a common understanding that ITFs need surgical treatment because of its high mortality and disability. In the past decades, DHS was the 'gold standard' for the treatment of the ITFs.^{39,40} With the development of biomaterials science and biomechanics, artificial hip joints and internal fixation devices have brought more choices for the treatment of ITFs. However, no consensus has been reached regarding which one leads to better clinical outcomes for the ITF. In the current systematic review and meta-analysis, we tried to resolve the contradiction raised by divergent results reported by trials comparing for IF and AR.

The combined results of meta-analysis showed no significant difference in HHS, hospital stay and complications-related general condition between the two methods. AR group had a significantly lower rate of complications-related operation and reoperation. However, compared with AR group, IF group could reduce the blood loss, transfusion requirement, operation time, and have a lower rate of mortality within 1-year.

Operative time, blood loss and transfusion

In general, relatively few operative time, intraoperative and postoperative blood loss can avoid some serious complications associated with surgery, especially for the elderly patients. Bohl et al. reported that, following adjustment for baseline characteristics, an increase in operative time by 15 minutes increased the risk of anemia requiring transfusion by 9%, wound dehiscence by 13%, renal insufficiency by 9%, sepsis by 10%, surgical site infection by 9% and urinary tract infection by 4%.⁴¹ The other previous studies also indicated that prolonged operative time are associated with increased rates of postoperative complications, such as the surgical site infection and delayed wound healing.⁴²⁻⁴⁴ In the current study, our results showed that IF has a less operative time than AR. Although Park et al. reported that the operative time of IF group is similar with that of AR group,³¹ the other 10 included studies reported the similar result with that of meta-analysis.^{25-27,29,30,32-35,38} Therefore, we think that the overall data of IF group is superior to AR group in the operative time.

Normally, the shorter the operation time, the less blood loss associated with the operation. Additionally, the effect of different surgical methods on blood loss is also very important. In the current study, the initial meta-analysis is reliable, but obviously, the data only including 201 cases may be not enough. Therefore, the described analysis was conducted, and it was confirmed that the included 5 studies, on a total 552 cases, all reported the same result, which is that the blood loss in the IF group is statistically less than that of AR group. Correspondingly, the current meta-analysis indicated that internal fixation was superior to arthroplasty in terms of blood transfusion volume. In the last ten years, the devices of intramedullary fixation, such as PFN, PFNA, GN and IN, have been widely used. The postoperative hidden blood loss caused by the intramedullary fixation has attracted more and more attention. A few literatures showed that the postoperative hidden blood loss is more than intra-operative blood loss.⁴⁵⁻⁴⁷ Unfortunately, this presented meta-analysis didn't analyze the hidden blood loss. Therefore, only analyzing intraoperative blood loss may be unfair for the AR group. We suggest that the hidden blood loss should be included in the comparison of IF and AR for the blood loss.

Postoperative complications and Reoperation

The analysis of postoperative complications is helpful to prevent their occurrence and improve the success rate of surgery. For elderly patients with hip fractures, the general complications include hematoma, infection, bedsore, pneumonia, urinary tract infection and thromboembolism. In this meta-analysis, eight articles reported postoperative general complications,^{26,27,29,30,32,33,37,38} and the result showed that there was no significant difference in the postoperative general complications between IF and AR group. This is consistent with previous reports.^{48,49} In contrast to the incidence of general complications after surgery, our results showed that the complications-related operation and rate of reoperation of the AR group are better than that of the IF group. A total of ten articles compared the complications-related operation of the two groups.^{25-27,29-32, 35,37,38} In the IF group, the lowest incidence of complications-related operation was approximately 4.8% (1/21), and the highest incidence of complications-related operation was approximately 24.1% (7/29). In the AR group, the lowest incidence of complications-related operation was 0%, and the highest incidence of complications-related operation was approximately 22.7% (5/22). In the IF group, 5 articles reported that the incidence of complications-related operation was over 10%. However, in the AR group, only 1 article reported a complication rate of more than 10%, and even two reported were zero. Obviously, the incidence of complications-related operation in the AR group was significantly lower than that in the IF group. Certainly, complications do not necessarily mean reoperation. However, it is clear that failure of internal fixation is one of the main causes of reoperation. Therefore, we also analyzed the reoperation rate of the two groups through this meta-analysis. The results showed that the reoperation rate of the AR group is also significantly lower than that of the IF group. It suggested that more attention should be paid to the properties of biomaterials and biomechanics for the future development of internal fixation devices.

Hospital stay, Harris hip score

Early discharge and a good postoperative joint function are essential for the elderly with fractures. In general, relatively larger operation may result in longer hospital stay for the senile patients. In the current study, the results showed that there is no essentially difference in the hospital stay between the IF and AR groups. It has been reported in the literatures that patients with AR can bear weight earlier than those with IF,^{3,6,8,11} but there was no statistical difference in the final HHS after a follow-up period of more than half a year between the two groups. However, early weight bearing helps reduce bedridden-related complications, such as the deep venous thrombosis, pneumonia and urinary tract infection.⁵⁰⁻⁵³ Therefore, AR appears to be superior to IF in terms of early weight bearing.

Mortality within 1-year

Mortality rate after surgery is an important indicator to evaluate the surgical effectiveness. The current meta-analysis showed that the mortality rate within 1-year of the IF group was lower than that of the AR group. Another meta-analysis also showed that the mortality rate within 1-year in the intramedullary fixation group was reduced significantly compared with the AR group.⁵⁴ In addition, it has been reported that the IF group has a lower 3-year mortality rate than the AR group.^{2,9}

Limitations

Some limitations in the present systematic review and meta-analysis should be noted. First, we limited the published language in English and this might lead to a certain degree of bias. Second, the number of inclusive studies and patients are relatively few which only 14 publications met the eligibility criteria. Third, we did not analysis the effect of treatments on ITF according to different ages and fracture classifications because of the limitation of the studies

included, which may affect the results. Fourth, our study may also be influenced by the lack of data for long-term and different follow-up duration of included studies. Furthermore, meta-analysis is a retrospective research tool that is subject to methodological deficiencies.

In conclusion, the present study suggests that AR provides less complications-related operation and reoperation rate when compared with IF for the elderly with ITFs, but has no obvious statistical difference in terms of hospital stay, postoperative functional assessment and complications-related general condition. However, IF is superior to arthroplasty in terms of operative time, blood loss, transfusion and mortality within 1-year. Obviously, AR does not offer a clear advantage over internal fixation for the elderly with ITFs. Therefore, in view of the current dominance of internal fixation, we suggest that larger and well-designed, randomized controlled studies with longer-term follow-ups are needed to verify whether arthroplasty should be the optimal treatment for the elderly patients with ITFs in the future.

Declarations

Ethics approval and consent to participate

The Medical Ethical Commission of the Chongqing Traditional Chinese Medicine Hospital approved this study.

Consent for publication

Participants will sign informed consent form before participation.

Availability of data and materials

The research related data used to support the findings of this study are restricted by the Ethics Committee of the Chongqing Traditional Chinese Medicine Hospital. In order to protect patient privacy, data are available from the Corresponding author Zhenyu Dai, for researchers who meet the criteria for access to confidential data.

Competing interests

The authors report no conflicts of interest in this work.

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Authors' contributions

Kexiao Yu, Zhenyu Dai: planned, performed, analyzed the data and wrote the manuscript. Zhenyu Dai, Weizhong Lu: conceived the idea and designed the study. Qiuke Xiao, Ruijie Wan, Lujue Dong: primarily responsible for the data collection and analysis. All authors discussed the results and commented on the manuscript.

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Tables

Table. 1. Characteristics of the included studies

Studies	Year	No. of patients		Mean age(y)		Interventions		Follow-up (AR/IF, months)	Outcomes
		AR	IF	AR	IF	AR	IF		
Kim	2005	29	29	82.0±3.4	81.0±3.2	HA	PFN	35(24-58)/34(24-57)	1-9
Kayali	2006	42	45	73(60-103)	75(62-82)	HA	DHS	24(12-40)/29(12-52)	1,3-8
Bonnevialle	2011	134	113	85.9	85.5	HA/THA	GN	6	4-6,8
Chang	2011	70	42	81.81±4.8	83.46±5.1	HA	DHS	>12	1-4,7-9
Shen	2012	60	64	78.2(70-101)	76.8(70-98)	HA	DHS/IN	24	1-4,6,8,9
Kim	2014	46	43	79.7± 6.5	75.5±6.4	HA	CHS	25.2±18.0/28.8±19.2	1,3,4,6,7
Tang	2012	156	134	81.1±5.8	80.6±6.9	HA	PFNA	44.2±6.9/35.9±8.6	1-9
Görmeli	2015	75	68	76.2±7.9	77.4±8.4	HA	PFN	29.6±10.3/32.3±8.9	1-3,5-9
Park	2015	22	31	76.9(70-84)	78.1(73-86)	HA	PFN/PFNA	24	1,2,4,5,7 -11
Desteli	2015	44	42	65.0±1.52	67.0±1.21	HA	PFNA	24	1,7
Özkayın	2015	33	21	83.94±4.92	79.57±4.83	HA/THA	PFN	31.33±10.65/32.33±10.97	1,4,6,9
Güven	2016	16	21	79±5.7	78±6.8	HA	DHS	30±7.3/36±8.4	9
Yang	2017	27	83	79.98±6.0	78.87±7.72	HA/THA	DHS	51.6 ± 26.5/45.4 ± 30.4	8
Gashi	2018	60	38	76.15±67.2	79.3±11.0	HA	DHS	13.66±5.9/11.8±2.7	1,3,4-9

AR indicates arthroplasty; IF, Internal fixation; DHS, dynamic hip screw; HA, hemiarthroplasty; THA, total hip arthroplasty; PFN, proximal femoral nail; PFNA, proximal femoral nail anti-rotation; IN, interTan; CHS, compression hip screw; GN, gamma nail.

Outcomes: 1. Operative time; 2. Operative blood loss; 3. Transfusion; 4. Complications-related operation (included the dislocation, loosening, cut out, breakage, operative fracture of femur, later fracture of femur, nonunion, delayed union and malunion); 5. Reoperation; 6. complications-related general condition (included the pneumonia, thromboembolic complications, deep or superficial infection, pressure sores, hematoma); 7. Length of hospital stay; 8. Mortality; 9. Harris hip score

Table. 2. Quality of included studies

Studies	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other Bias
Kim2005	Low risk	Low risk	Unclear	Unclear	Low risk	Low risk	Low risk
Kayali2006	High risk	Low risk	Unclear	Unclear	Low risk	Low risk	Low risk
Bonnevialle2011	High risk	Low risk	Unclear	High risk	Low risk	Low risk	Low risk
Chang2011	High risk	Low risk	Unclear	Unclear	Low risk	Low risk	Low risk
Shen2012	High risk	Low risk	Low risk	High risk	Low risk	Low risk	Low risk
Kim2014	High risk	Low risk	Unclear	Unclear	Low risk	Low risk	Low risk
Tang2012	High risk	Low risk	Unclear	Unclear	Low risk	Low risk	Low risk
Görmeli2015	High risk	Low risk	Unclear	High risk	Low risk	Low risk	Low risk
Park2015	High risk	Low risk	Low risk	High risk	Low risk	Low risk	Low risk
Desteli2015	Low risk	Unclear	Low risk	Unclear	Low risk	Low risk	Low risk
Özkayın2015	Low risk	Low risk	Low risk	Unclear	Low risk	Low risk	Low risk
Güven2016	High risk	Low risk	Unclear	Unclear	Low risk	Low risk	Low risk
Yang2017	High risk	Low risk	Unclear	High risk	Low risk	Low risk	Low risk
Gashi2018	Low risk	Low risk	Low risk	Unclear	Low risk	Low risk	Low risk

Figures

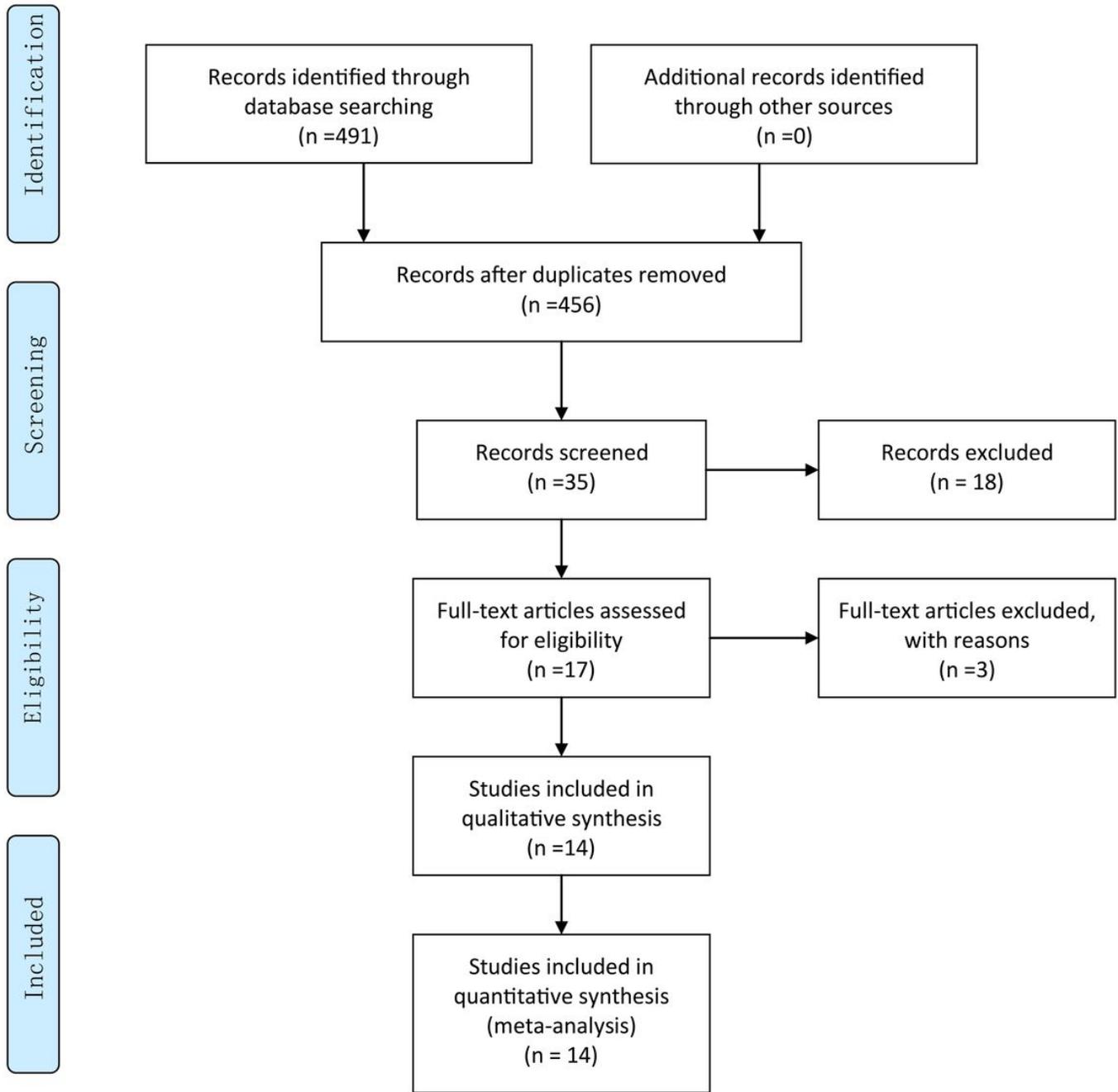


Figure 1

PRISMA flow diagram of study selection process.

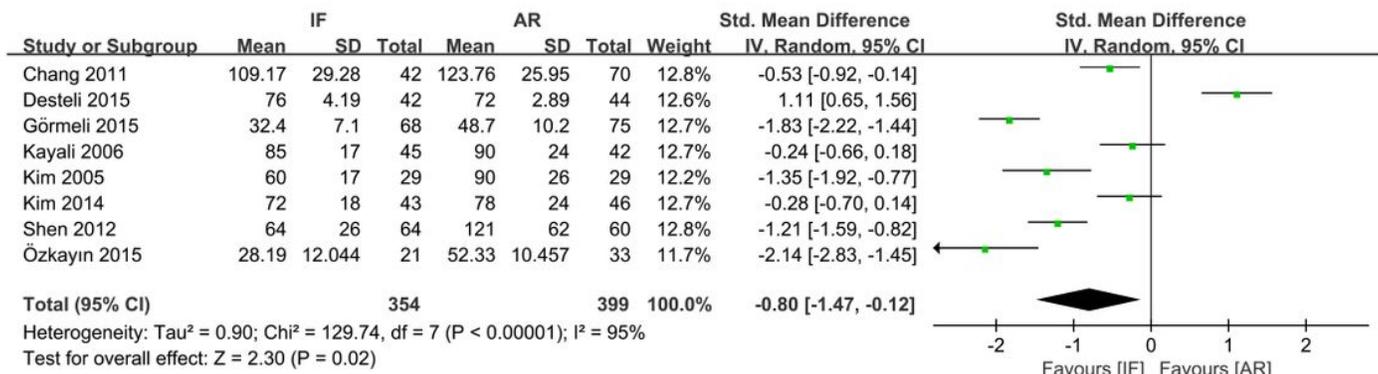


Figure 2

The comparison of operative time between IF and AR groups.

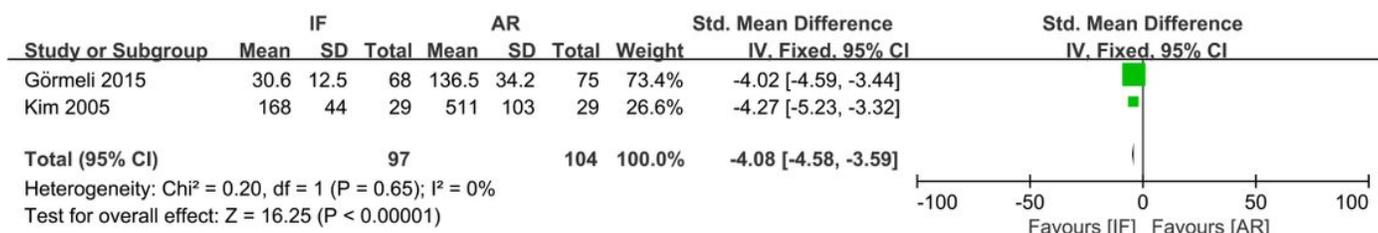


Figure 3

The comparison of blood loss between IF and AR groups.

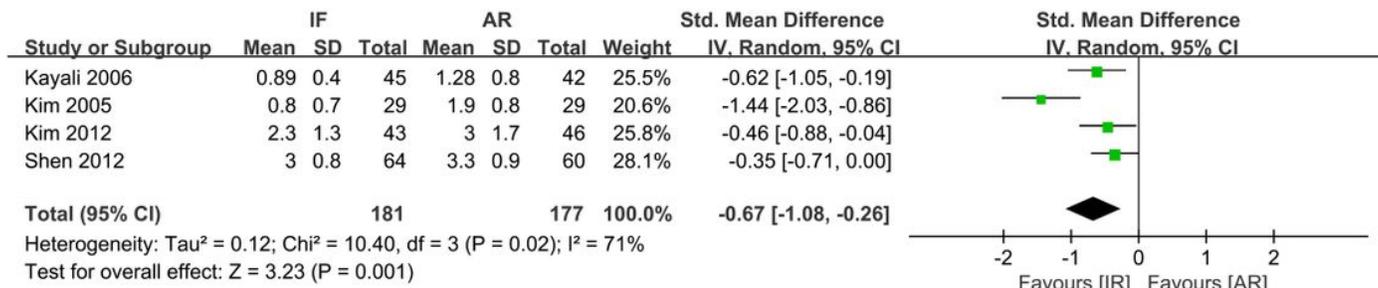


Figure 4

The comparison of transfusion between IF and AR groups.

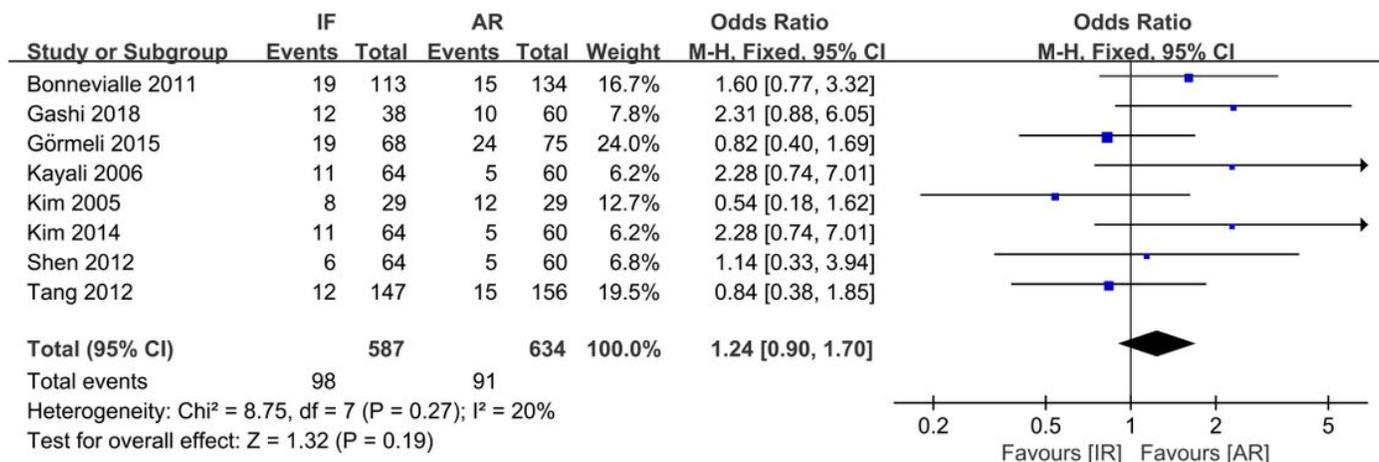


Figure 5

The comparison of postoperative complications-related general condition between IF and AR groups.

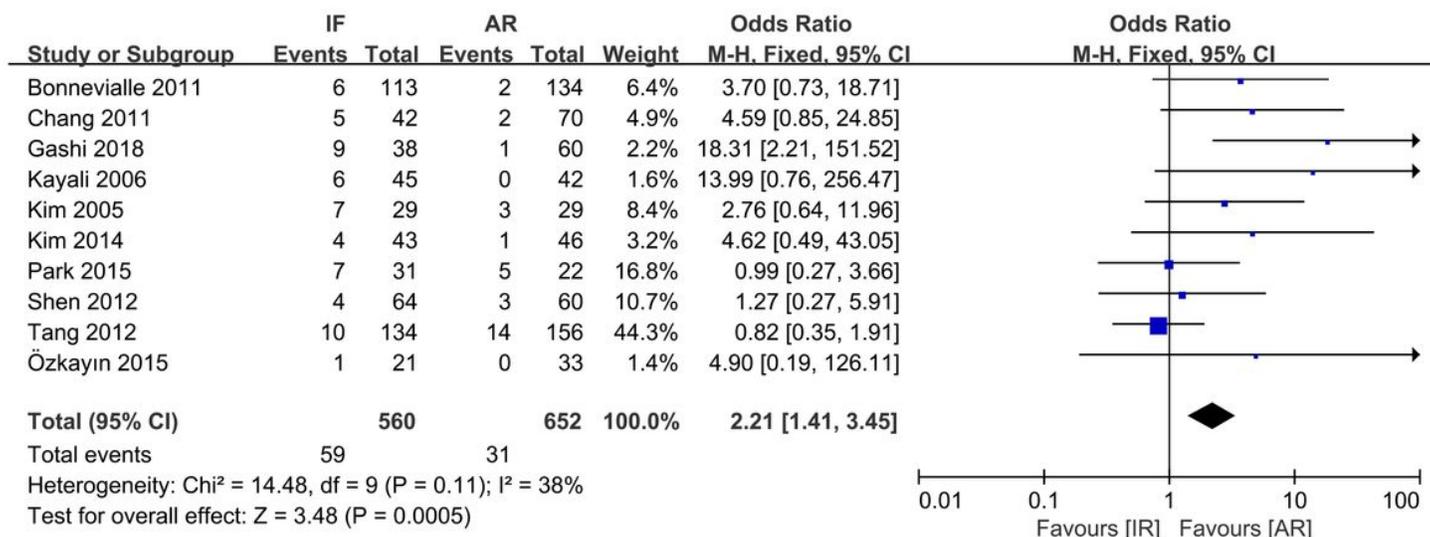


Figure 6

The comparison of postoperative complications-related operation between IF and AR groups.

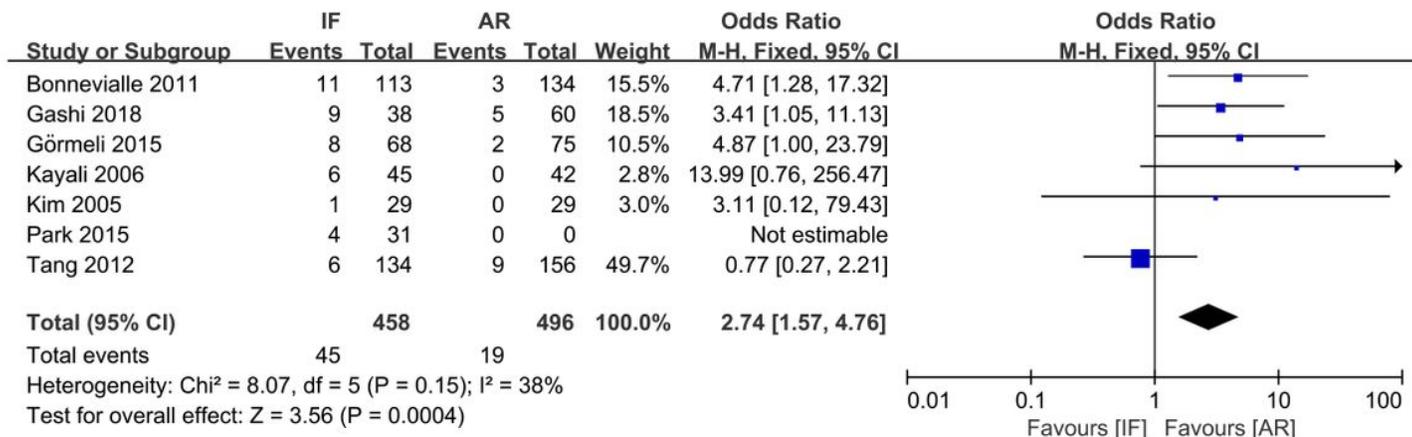


Figure 7

The comparison of reoperation between IF and AR groups.

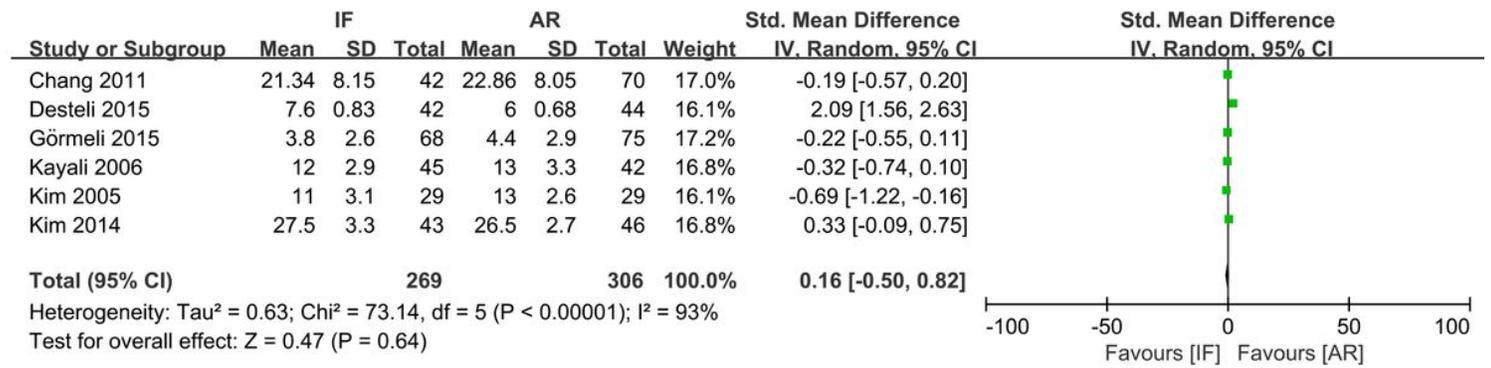


Figure 8

The comparison of hospital stay between IF and AR groups.

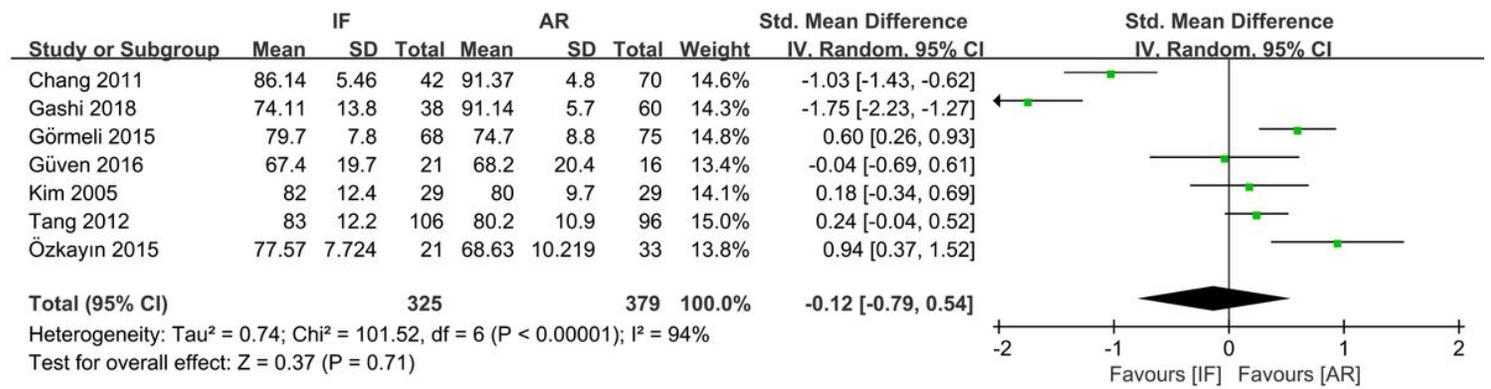


Figure 9

The comparison of Harris hip score between IF and AR groups.

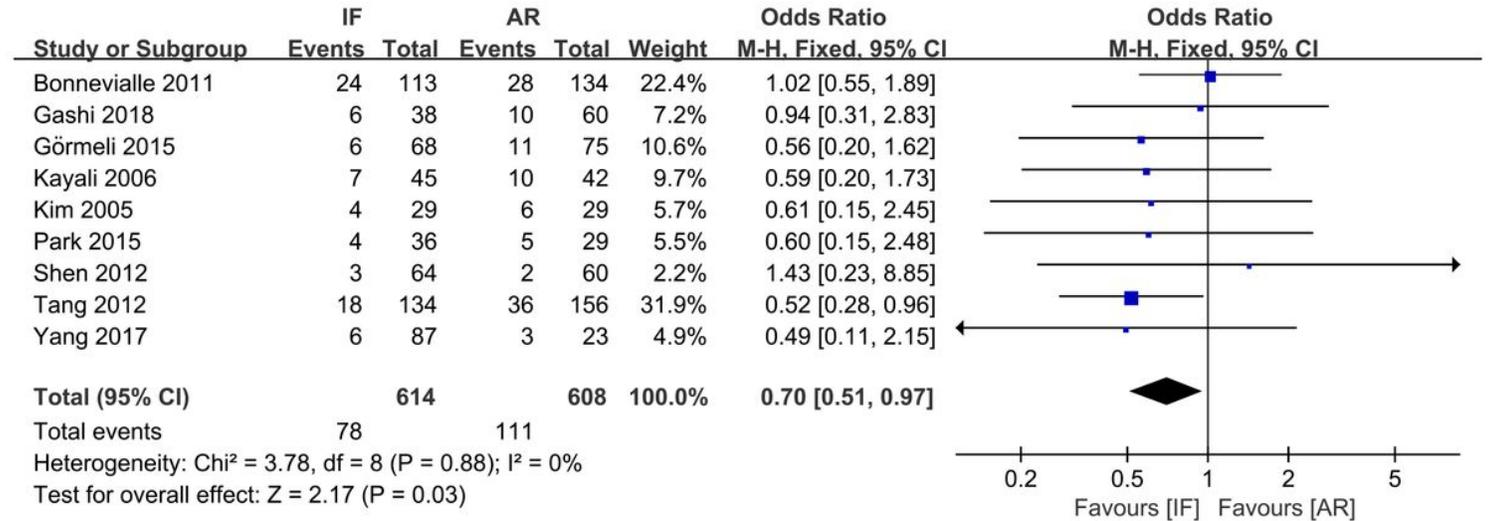


Figure 10

The comparison of mortality within 1-year between IF and AR groups.