

Arthroplasty versus Internal Fixation for Displaced Intracapsular Femoral Neck Fracture in the Elderly: Systematic Review and Meta-analysis of Short- and Long-term Effectiveness

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Abstract

Background: There is conflicting evidence as to whether the femoral head should be preserved or replaced in elderly patients with displaced intracapsular femoral neck fractures. In this article, we performed a systematic review and meta-analysis to compare the short- and long-term effectiveness of arthroplasty (AR) and internal fixation (IF).

Methods: PubMed, Embase, and the Cochrane Library were searched systematically up to January 2016. All randomized controlled trials directly comparing the effectiveness of AR and IF for displaced intracapsular fracture were retrieved with no limitation on language or publication year.

Results: In total, eight prospective randomized studies involving 2206 patients were included. The results of our study showed that patients in the AR group reported significantly lower complication (risk ratio: 0.56, 95% confidence interval [CI] = 0.38–0.80), re-operation (risk ratio: 0.17, 95% CI = 0.13–0.22), revision rates (risk ratio: 0.11, 95% CI: 0.08–0.16), and better function compared with their IF counterparts, and they were less likely to suffer postoperative pain. No statistically significant differences for the rates of mortality, infection, and/or deep vein thrombosis between AR and IF were found.

Conclusions: Based on our analysis, we recommend that AR should be used as the primary treatment for displaced intracapsular femoral neck fractures in the elderly. However, IF may be appropriate for those who are very frail.

Key words: Arthroplasty; Internal Fixation; Femoral Neck Fracture

INTRODUCTION

Femoral neck fractures are one of the most common orthopedic injuries in the elderly.^[1-4] About 1.6 million individuals suffer from femoral neck fractures every year, of which more than 50% are intracapsular fractures.^[5,6] According to several epidemiological studies, the incidence of femoral neck fracture will continue to increase, with an estimated incidence of 6.26 million in 2050.^[6-8]

A displaced intracapsular femoral neck fracture is associated with a high incidence of nonunion and femoral head necrosis, as well as a significant mortality and disability.^[9,10]

Although most femoral neck fractures in young, active patients are treated using reduction with internal fixation (IF),^[11] there

is conflicting evidence regarding the choice of surgical treatment for elderly patients with displaced intracapsular femoral neck fractures. Indeed, it has frequently been termed “the unsolved fracture.”^[2,4,9]

Currently, this type of fracture is typically managed by arthroplasty (AR) or IF.^[1,4] IF, including screw and plate

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fixation, has been reported to cause minor damage to soft tissue and to have shorter operation times and less intraoperative blood loss when compared with AR.^[12-14] However, IF is also related to high morbidity of nonunion and femoral head avascular necrosis (with reported incidences of 20–35%, and 5–30%, respectively).^[14] AR, including hemiarthroplasty (HA) and total hip arthroplasty (THA), entails replacing the femoral head with an artificial hip joint, which avoids the risk of nonunion or femoral head necrosis. The reported advantages of AR also include a low re-operation rate and early functional recovery.^[14-16] However, AR involves more extensive soft tissue damage and a high risk of aseptic loosening.^[1,10,14] Several short-to-intermediate term studies and the most recent systematic review indicated that AR may have an advantage over IF in terms of functional outcomes and re-operation rate.^[9,17] However, to our knowledge, to date, very few systematic review or meta-analysis regarding long-term (>10 years postsurgery) results of AR and IF has been published. Thus, the supposed long-term superiority in the outcome of AR has not yet been clearly demonstrated.

We conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) for the following purposes: (1) To investigate and compare the short- (<5 years) and long-term (>10 years) clinical effectiveness of AR and IF in elderly patients with displaced intracapsular femoral neck fractures, including the rates of complications, mortality, and revision and postoperative functional scores and (2) to do subgroup analysis of THA and HA with IF for further comparison.

METHODS

This study was approved by the Ethics Committee of the Second Affiliated Hospital of Zhejiang University, School of Medicine, and followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines^[18] and the methods established in the *Cochrane Handbook for Systematic Reviews of Interventions* (version 5.0.2).

Literature search

Three independent investigators (Chen-Yi Ye, An Liu, and Ming-Yuan Xu) searched electronic databases (PubMed, the Cochrane Library, and Embase) with no language restriction through January 2016. The following Medical Subject Headings or key words were used: “femoral neck fracture” or “intracapsular” or “intraarticular” or “cervical” or “subcapital” and “arthroplasty” or “joint replacement” or “total hip arthroplasty” or “THA” or “total joint replacement” or “TJR” or “hemiarthroplasty” or “HA” and “internal fixation” or “IF” or “plate” or “screw.” We also manually searched reference lists for additional studies. The Clinical Trial Registry, the Current Controlled Trials databases, and the National Institutes of Health were also searched for unpublished trials and for those in progress.

Inclusion criteria

Two independent reviewers (Chen-Yi Ye and An Liu)

screened manuscript titles and abstracts and identified articles that met the following eligibility criteria: (1) Randomized controlled design, (2) direct comparison of the AR and IF techniques reporting clinical outcomes, (3) enrollment of elderly individuals (≥ 60 years) with an acute displaced intracapsular femoral neck fracture (Garden III and IV classification), and (4) a minimum follow-up of 12 months. We excluded (1) articles that did not satisfy the inclusion criteria, (2) animal studies, cadaver studies, letters, abstracts, case reports, reviews, conference proceedings; (3) studies with no comparative data provided, and (4) studies with follow-up <1 year.

Data extraction

Three reviewers (Chen-Yi Ye, An Liu, and Ming-Yuan Xu) independently obtained relevant data and assessed accuracy. The following information was extracted from each study: family name of the first author, year of publication, study design, patient demographics (age, gender, interventions, and sample size), length of follow-up, complication rate, mortality rate, revision rate, and postoperative functional scores. We also attempted to contact the corresponding authors to verify the accuracy of the data, as well as to obtain any further data for the analysis.

Quality assessment

Two investigators (Chen-Yi Ye and An Liu) independently assessed the quality of the methodological data included in the studies based on the 12-item scale.^[19] The 12-item scale comprised the following: adequately randomized, allocation concealed, patient blinded, outcome assessor blinded, care provider blinded, similar baseline, similar timing, similar or avoided cofactors, patient compliance, avoided selective reporting, acceptable dropout rate, and intention-to-treat analysis. Divergences were evaluated using kappa test, and consensus was obtained by discussion with the corresponding author (Rong-Xin He).

Statistical analysis

RevMan software (version 5.3; The Nordic Cochrane Centre, Copenhagen, Denmark) was used to pool the data. STATA 11.0 software (Stata Corp., College Station, TX, USA) was used to evaluate publication bias. $P \leq 0.05$ was considered statistically significant. Relative risk (RR) and 95% confidence intervals (CIs) were calculated as summary statistics for dichotomous outcomes, while weighted mean differences (WMDs) or standardized mean differences (SMDs) with 95% CIs were calculated for continuous data.^[20] Chi-square test on $N - 1$ degrees of freedom was used to evaluate statistical heterogeneity, with significance set at 0.05. I^2 ($I^2 = [(Q - df)/Q] \times 100\%$) was used to evaluate the percentage of the variability in effect estimates according to the heterogeneity. I^2 values of 25%, 50%, and 75% were considered to indicate low, medium, and high heterogeneity, respectively.^[21] If no statistical heterogeneity was detected ($I^2 < 50\%$), a fixed-effects model was used; otherwise, we used a random-effects model. If substantial heterogeneity across studies ($I^2 > 50\%$) was

detected, *post hoc* sensitivity analysis was performed by omitting the outlier studies to determine the sources of heterogeneity. Begg's rank correlation test and Egger's regression test were used to assess publication bias.

RESULTS

Literature search

In total, the search identified 5106 candidate publications; however, 5083 were excluded due to duplications, nonrelevance, or because they were not RCTs. After assessing the 23 potentially relevant articles, eight RCTs involving 2206 patients met the inclusion criteria.^[22-29] The primary reasons for exclusion were as follows: six were review articles,^[11,30-34] six reported data that did not pertain to intracapsular hip fractures,^[3,15,35-38] one was a correspondence letter,^[39] and two studies were excluded because they were not RCTs.^[40,41] Details of the selection process are shown in Figure 1. The weighted kappa for the agreement on eligibility between the reviewers was 0.88 (95% CI [0.83–0.94]).

Study characteristics

The characteristics and quality assessment results of the

eight RCTs are summarized in Tables 1 and 2. Five studies compared HA with IF,^[23,24,26,27,29] two studies compared both THA and HA with IF,^[22,25] and one study compared THA and IF.^[28] The mean length of follow-up ranged from 1 to 17 years. In total, 2206 patients were included in the analysis: 435 males and 1771 females aged from 62 to 103 years. Of these, 1184 patients received AR and 1022 patients received IF.

Outcome measures

The pooled results are shown in Table 3.

Mortality of 30 days, 3–6 months, and up to 1, 2, and 10 years

No statistically significant difference was found regarding mortality between AR and IF at 30 days and 3–6 months postoperatively ($RR = 1.27$, 95% $CI = 0.74-2.17$; $P = 0.38$ and $RR = 1.21$, 95% $CI = 0.88-1.65$; $P = 0.25$, respectively). In addition, there was also no statistically significant difference between groups in 1 or 2 years postoperatively ($RR = 1.06$, 95% $CI = 0.86-1.30$; $P = 0.58$ and $RR = 1.15$, 95% $CI = 0.98-1.34$; $P = 0.08$, respectively). No evidence of significant heterogeneity ($I^2 = 0$) was observed within any

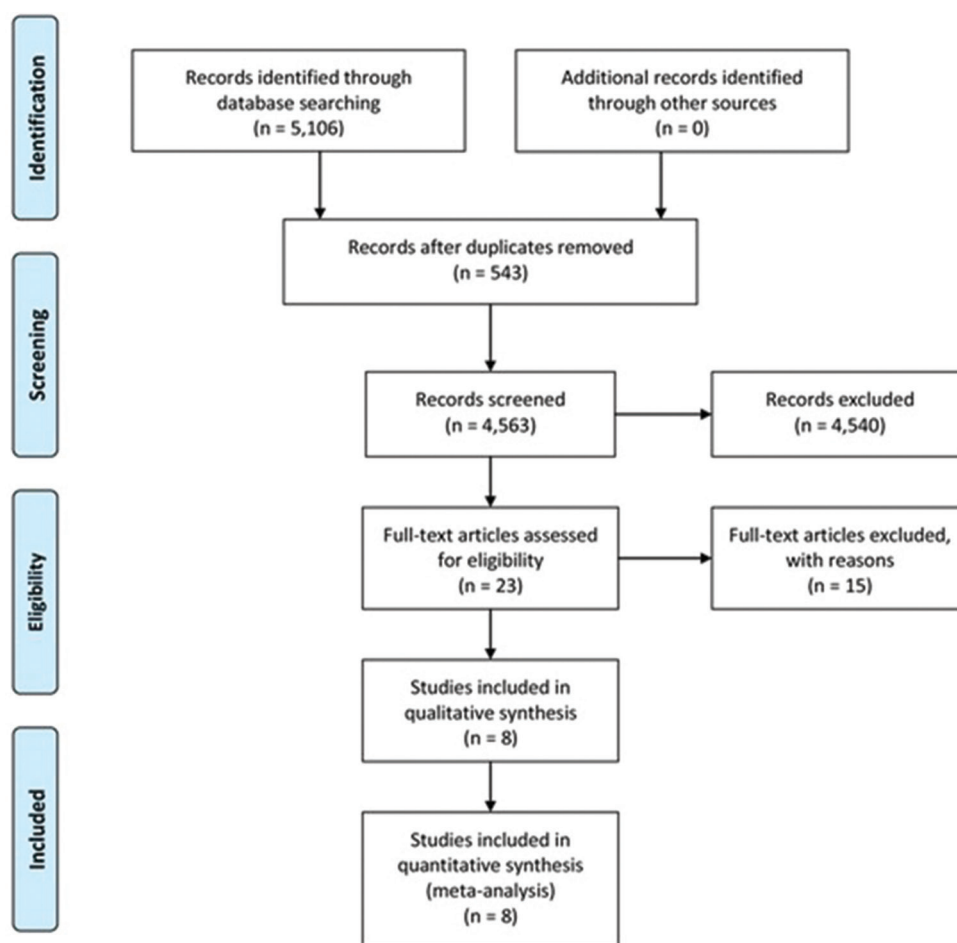


Figure 1: A Preferred Reporting Items for Systematic Reviews and Meta-analyses flowchart illustrated the selection of studies included in our systematic review.

Table 1: Methodological quality of the included studies based on the 12-item scoring system

Study	Randomized adequately*	Allocation concealed	Patient blinded	Care provider blinded	Outcome assessor blinded	Acceptable dropout rate†
Ravikumar and Marsh, 2000 ^[22]	Yes	Yes	Unclear	Unclear	Unclear	Yes
Davison <i>et al.</i> , 2001 ^[23]	Yes	Yes	Unclear	Unclear	Unclear	Yes
Parker <i>et al.</i> , 2002 ^[24]	Yes	Yes	Unclear	Unclear	Unclear	Yes
Keating <i>et al.</i> , 2006 ^[25]	Yes	Yes	Unclear	Unclear	Yes	Yes
Frihagen <i>et al.</i> , 2007 ^[26]	Yes	Yes	Unclear	Unclear	Unclear	Yes
Parker <i>et al.</i> , 2010 ^[27]	Yes	Yes	Unclear	Unclear	Unclear	Yes
Chammout <i>et al.</i> , 2012 ^[28]	Yes	No	No	No	No	Yes
Parker, 2015 ^[29]	Yes	Yes	Unclear	Yes	Unclear	Yes

Study	ITT analysis‡	Avoided selective reporting	Similar baseline	Similar or avoided cofactor	Patient compliance§	Similar timing	Quality
Ravikumar and Marsh, 2000 ^[22]	Unclear	Unclear	Yes	Yes	Yes	Yes	High
Davison <i>et al.</i> , 2001 ^[23]	Unclear	Unclear	Yes	Yes	Yes	Yes	High
Parker <i>et al.</i> , 2002 ^[24]	Unclear	Unclear	Unclear	Yes	Yes	Yes	Moderate
Keating <i>et al.</i> , 2006 ^[25]	Unclear	Unclear	Yes	Yes	Yes	Yes	High
Frihagen <i>et al.</i> , 2007 ^[26]	Unclear	Unclear	Yes	Yes	Yes	Unclear	Moderate
Parker <i>et al.</i> , 2010 ^[27]	Unclear	Unclear	Yes	Yes	Yes	Yes	High
Chammout <i>et al.</i> , 2012 ^[28]	Unclear	Unclear	Yes	Yes	Yes	Yes	Moderate
Parker, 2015 ^[29]	Unclear	Unclear	Yes	Yes	Yes	Yes	High

*Only if the method of sequence made was explicitly introduced could get a “yes;” sequence generated by “dates of admission” or “patients’ number” receives a “no;” †Dropout rate <20% could get a “yes;” otherwise “no;” ‡ITT: Intention-to-treat, only if all randomized participants were analyzed in the group they were allocated to could receive a “yes;” §More than 75% of the patients wore respective devices for at least 3 weeks means “yes;” otherwise “no;” ||“Yes” items >7 means “high”; “Yes” items more than 4 but no more than 7 means “Moderate”; “Yes” items <4 means “Low”.

Table 2: Study characteristics and details of interventions of the included studies

Studies	Study design	Age		Gender male/female	Number of patients	
		AR	IF		AR	IF
Ravikumar and Marsh 2000 ^[22]	RCT	81.55 ± 3.36	79.73 ± 2.49	27/244	180	91
Davison <i>et al.</i> , 2001 ^[23]	RCT	75.48 ± 1.61	73 ± 1.75	67/213	187	93
Parker <i>et al.</i> , 2002 ^[24]	RCT	82.4 ± 7.5	82.2 ± 8	91/364	229	226
Keating <i>et al.</i> , 2006 ^[25]	RCT	75.32 ± 6.62	74.68 ± 6.74	81/286	180	187
Frihagen <i>et al.</i> , 2007 ^[26]	RCT	82.5 ± 7.32	83.2 ± 7.65	57/165	110	112
Parker <i>et al.</i> , 2010 ^[27]	RCT	82.4 ± 7.5	82.2 ± 8	91/364	229	226
Chammout <i>et al.</i> , 2012 ^[28]	RCT	78 ± 6.25	79 ± 6	21/79	43	57
Parker, 2015 ^[29]	RCT	81.2 ± 6.5	81.5 ± 8	0/56	26	30

Studies	Interventions		Follow-up (years)	Prostheses	
	AR	IF		AR	IF
Ravikumar and Marsh 2000 ^[22]	HA/THA	Screw/plate	13	HA: Austin Moore/THA: Howse II	Sliding compression screw plate
Davison <i>et al.</i> , 2001 ^[23]	HA	Screw/plate	5	Thompson HA/Monk bipolar HA	Sliding compression screw plate
Parker <i>et al.</i> , 2002 ^[24]	HA	Screw	3	Austin Moore	AO cancellous screws
Keating <i>et al.</i> , 2006 ^[25]	HA/THA	Screw/plate	2	NA	NA
Frihagen <i>et al.</i> , 2007 ^[26]	HA	Screw	2	Charnley–Hastings bipolar HA	Olmed screw
Parker <i>et al.</i> , 2010 ^[27]	HA	Screw	11	Austin Moore	AO cancellous screws (Stratec Ltd.)
Chammout <i>et al.</i> , 2012 ^[28]	THA	Screw	17	Bi-metric	Olmed screw
Parker, 2015 ^[29]	HA	Screw/plate	1	Exeter trauma stem	Targon femoral plate

AR: Arthroplasty; IF: Internal fixation; THA: Total hip arthroplasty; HA: Hemiarthroplasty; NA: Not applicable; RCT: Randomized controlled trial.

subgroup, except a low heterogeneity ($I^2 = 59\%$) regarding the mortality rate of >10 years postoperatively. However,

due to the limited number of available studies ($n = 2$), a sensitivity analysis was not possible.

Table 3: The statistical comparison in outcomes between AR and IF

Outcomes	Studies (n)	Participants	Event (n/N)		Mean (95% CI)	I ² (%)	P
			AR	IF			
Total mortality rate - RR	6	1826	587/954	501/872	1.02 (0.96, 1.08)	25	0.63
Mortality rate within 1 year	5	1284	167/732	126/552	1.06 (0.86, 1.30)	0	0.58
Mortality rate within 2 years	4	1324	221/706	180/618	1.15 (0.98, 1.34)	0	0.08
Mortality rate >10 years	2	726	362/409	290/317	0.97 (0.90, 1.06)	59	0.52
Total re-operation rate - RR	6	1738	63/864	378/874	0.17 (0.13, 0.22)	10	<0.00001
Re-operation rate within 1 year	2	336	3/213	28/123	0.07 (0.02, 0.22)	0	<0.00001
Re-operation rate within 2 years	3	869	28/477	138/392	0.19 (0.13, 0.27)	0	<0.00001
Re-operation rate >10 years	2	371	39/223	67/148	0.44 (0.31, 0.62)	0	<0.00001
Total revision rate - RR	7	1838	33/907	314/931	0.11 (0.08, 0.16)	35	<0.00001
Revision rate within 1 year	2	327	16/206	31/121	0.29 (0.16, 0.52)	30	<0.00001
Revision rate within 2 years	2	502	5/297	39/205	0.08 (0.03, 0.21)	0	<0.00001
Revision rate >10 years	2	555	16/272	112/283	0.15 (0.09, 0.25)	8	<0.00001
Total complication rate - RR	5	1415	177/742	294/673	0.56 (0.38, 0.80)	76	<0.01
Total patients with pain - RR	4	776	53/423	105/353	0.31 (0.23, 0.41)	30	<0.00001
Patients with pain within 1 year	2	551	97/409	69/317	0.50 (0.07, 3.55)	0	0.16
Patients with pain within 2 years	3	869	23/339	39/338	0.70 (0.37, 1.34)	0	<0.05
Patients with pain >10 years	2	371	47/223	73/148	0.83 (0.32, 2.17)	38	<0.00001
Infection rate - RR	6	1598	36/832	30/766	1.06 (0.66, 1.71)	15	0.81
Infection rate within 1 year	2	551	1/367	1/184	0.50 (0.07, 3.55)	0	0.49
Infection rate within 2 years	3	869	14/477	20/392	0.70 (0.37, 1.34)	0	0.28
Infection rate >10 years	2	371	10/223	7/148	0.83 (0.32, 2.17)	0	0.7
Deep vein thrombosis rate - RR	4	1100	7/545	12/555	0.64 (0.27, 1.51)	0	0.31
Harris score within 1 year - WMD	2	589	NA/290	NA/299	6.93 (4.33, 9.53)	0	<0.00001
Harris score within 2 years - WMD	2	589	NA/290	NA/299	3.60 (0.73, 6.47)	0	<0.05
Operation time - WMD	3	878	NA/435	NA/443	19.66 (15.44, 23.87)	58	<0.00001
Blood loss - SMD	2	677	NA/339	NA/338	1.87 (1.69, 2.05)	0	<0.00001
Hospital stay -WMD	3	558	NA/323	NA/235	1.09 (0.46, 1.73)	25	<0.01

AR: Arthroplasty; IF: Internal fixation; RR: Risk ratio; SMD: Standardized mean difference; WMD: Weighted mean difference; NA: Not applicable; CI: Confidence interval.

Re-operation

The incidence of re-operations (including revision surgery, drainage of infected implants, fixation of periprosthetic fractures, removal of implants, reduction of dislocation, and excision AR) was reported in six studies (1738 patients, 441 events). These studies included 864 ARs and 874 IFs (re-operation events occurred in 63 and 378 cases, respectively). The pooled RR for re-operation after AR compared with IF was 0.17 (95% CI = 0.13–0.22; $P < 0.00001$, $I^2 = 10\%$). The re-operation rate following AR was significantly lower than for IF at 1, 2, and >10 years postoperatively ($P < 0.00001$). No evidence of heterogeneity was observed ($I^2 = 0\%$).

Revision

The total revision rates in the AR and IF groups were 33/907 and 314/931, respectively. The pooled RR for revision after AR versus IF was 0.11 (95% CI = 0.08–0.16; $P < 0.0001$, $I^2 = 35\%$). AR was associated with significantly lower revision rates than IF at 1, 2, and >10 years postoperatively ($P < 0.00001$). No evidence of significant heterogeneity was observed ($I^2 < 50\%$).

Complications

Details of complications are shown in Table 3. AR was

associated with significantly fewer total complications (fixation failure, femoral head necrosis, nonunion, dislocation, and perioperative complications, including deep wound infection, deep venous thrombosis (DVT), myocardial infarction, pulmonary embolism, and stroke) than IF (RR = 0.56; 95% CI = 0.38–0.80; $P < 0.01$, $I^2 = 76\%$). No significant difference in infection or DVT rates was found ($P > 0.05$, $I^2 = 0$). A sensitivity analysis was performed for the results of total complication rates, which yielded similar results to those obtained when all studies were analyzed simultaneously.

Pain

Pain was reported in four studies (776 patients, 158 events). Pain was more frequent in patients treated with IF (105/353, 29.7%) than those treated with AR (53/423, 12.5%) (RR = 0.31; 95% CI = 0.23–0.41; $P < 0.00001$, $I^2 = 30\%$). Subgroup analysis regarding the length of follow-up showed no statistically significant difference between AR and IF in 1 year postoperatively. However, patients treated with AR group had significantly less pain than those receiving IF at 2 and >10 years after the operation ($P < 0.05$). Heterogeneity was not significant ($I^2 < 50\%$) [Figure 2].

Functional scores

Functional scores were reported in two studies including

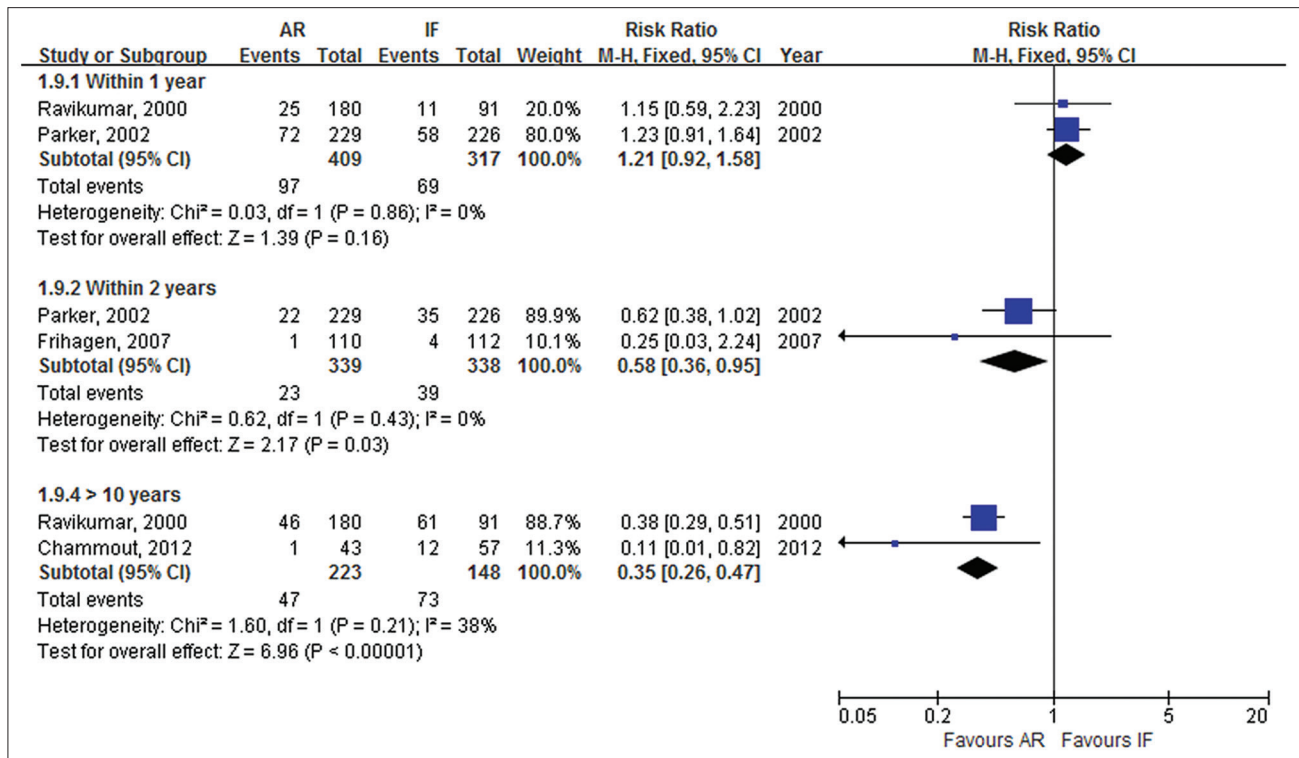


Figure 2: Relative risk and 95% confidence interval for the number of patients with moderate-to-severe pain.

589 patients. The pooled WMDs of mean Harris hip score for AR versus IF was 6.93 (95% CI = 4.33–9.53; $P < 0.00001$, $I^2 = 0$) and 3.60 (95% CI = 0.73–6.47; $P < 0.05$, $I^2 = 0$) at 1 and 2 years after the operation, respectively. Patients treated with AR appear to have had better postoperative function than those treated with IF.

Other data

IF was associated with significantly shorter operation times (WMD, 19.66; 95% CI = 15.44–23.87; $P < 0.00001$, $I^2 = 58\%$), less blood loss (SMD, 1.87, 95% CI = 1.69–2.05; $P < 0.00001$, $I^2 = 0\%$), and fewer in-hospital days (WMD, 1.09; 95% CI = 0.46–1.73; $P < 0.01$, $I^2 = 25\%$) when compared with AR. No statistically significant difference was found between AR and IF.

Subgroup analyses

Results of subgroup analyses of the statistical comparison in outcomes between HA, THA, and IF are shown in Table 4. Both HA and THA were superior to IF in terms of re-operation, revision, and pain, whereas IF was associated with significantly shorter operation times, hospital stays, and less blood loss. No statistically significant difference in mortality, infection, or deep vein thrombosis rates was found.

Publication bias

No substantial asymmetry was identified using Begg's rank correlation test ($Z = 0.75$, $P = 0.452$) or Egger's regression test ($t = 0.17$, $P = 0.874$).

DISCUSSION

In the absence of a new study of the long-term efficacy

for AR and IF, we conducted this systematic review and meta-analysis of eight RCTs, trying to provide updated evidence by comparing the short- and long-term clinical effectiveness of AR and IF for elderly patients with displaced intracapsular femoral neck fractures. The pooled results of long-term follow-up suggest that relative to IF, AR leads to lower total rates of re-operation, revision, and major method-related complications, without increasing the mortality. Moreover, patients treated with AR seemed to suffer less persistent pain and possibly have better postoperative function than those receiving IF.

The most recent previous systematic review about IF versus AR for adults with intracapsular proximal femoral fractures^[9] showed that IF was associated with less operative trauma but had an increased risk of re-operation (40% vs. 11%; $RR = 3.22$, 95% CI = 2.31–4.47). This study also found that IF has a significantly shorter length of operation, less intraoperative blood loss, and less incidence of deep wound infection than AR. No significant difference regarding hospital stay or mortality was observed.^[9] However, due to the limited number of available studies, comparisons regarding long-term re-operation rates, revision rates, and patients with persistent pain between AR and IF were not made. Because AR was not widely used in the 1990s for femoral neck fractures, we excluded RCTs published before 2000. Moreover, we included all RCTs with long-term follow-up (>10 years)^[22,27,28] and all RCTs focusing only on elderly patients. Similar results to the previous study were found regarding short-term mortality, re-operation, incidence of persistent pain, and perioperative parameters,

Table 4: Subgroup analysis of the statistical comparison in outcomes between HA, THA, and IF

Outcomes	Studies	Participants	Event		Mean (95% CI)	I ² (%)	P
			AR	IF			
Subgroup analysis between HA and IF							
Total mortality rate - RR	6	1697	478/892	428/805	1.06 (0.99, 1.14)	15	0.11
Total re-operation rate - RR	6	1600	57/795	351/805	0.16 (0.13, 0.21)	15	<0.00001
Total revision rate - RR	6	1695	29/892	266/803	0.10 (0.07, 0.15)	0	<0.00001
Total complications - RR	4	1088	117/431	191/435	0.55 (0.37, 0.82)	36	<0.01
Total patients with pain - RR	3	859	62/430	89/429	0.69 (0.54, 0.89)	0	<0.01
Infection rate - RR	5	1506	30/797	24/709	1.23 (0.73, 2.08)	27	0.44
Deep vein thrombosis - RR	4	962	3/476	9/486	0.45 (0.15, 1.33)	0	0.15
Harris hip score within 2 years - WMD	2	434	NA/212	NA/222	3.21 (-0.12, 6.53)	0	0.06
Operation time - WMD	2	285	NA/137	NA/148	0.59 (0.11, 1.08)	62	<0.05
Blood loss - SMD	2	677	NA/339	NA/338	1.87 (1.69, 2.05)	0	<0.00001
Hospital stay - WMD	3	558	NA/323	NA/235	1.09 (0.46, 1.73)	25	<0.01
Subgroup analysis between THA and IF - RR							
Total mortality rate	2	318	78/158	91/160	0.87 (0.76, 1.01)	0	0.06
Total re-operation rate	3	418	23/201	94/217	0.28 (0.19, 0.42)	17	<0.00001
Total revision rate	3	418	10/201	78/217	0.15 (0.08, 0.27)	45	<0.00001
Total complications	3	418	33/158	35/160	0.72 (0.38, 1.35)	0	0.81
Total patients with pain	2	280	6/132	73/148	0.09 (0.04, 0.19)	0	<0.00001
Infection rate	3	418	6/201	11/217	0.59 (0.23, 1.54)	0	0.28

HA: Hemiarthroplasty; THA: Total hip arthroplasty; AR: Arthroplasty; IF: Internal fixation; RR: Risk ratio; SMD: Standardized mean difference; WMD: Weighted mean difference; NA: Not applicable; CI: Confidence interval.

including the length of operation and intraoperative blood loss. However, our study indicated the long-term superiority of AR in terms of re-operation, revision, and the incidence of persistent pain. No significant difference regarding infection rate was observed.

The long-term re-operation rate is one of the most important parameters for evaluating AR and IF. It is difficult to pool data regarding re-operation because of the varied definitions across studies. To manage this, we subdivided re-operations into two categories: total re-operation rates and revision rates. The large number of patients requiring a second operation is of concern. Re-operation rates between 30% and 50% have been reported after IF for displaced intracapsular femoral neck fractures.^[14,42] The previous review article indicated that IF was associated with an increased risk of re-operation when compared with AR (40% vs. 11%).^[9] In this study, similar results for IF were observed (43.2%), while the observed re-operation rate in the AR group was lower (7.3%). Our study showed that AR might not only lead to fewer long-term re-operations but also fewer revisions than IF. However, some of these patients had more than one re-operation, and the times of re-operations were often not reported. Moreover, as noted by Parker,^[29] the application of newer implants in IF may be associated with a reduction in the revision rate. More RCTs directly comparing different IF implants are needed in the future, with both short- and long-term follow-ups.

The long-term pain rate was significantly higher for IF group than AR. By conducting a subgroup analysis, we found that this difference existed at 2 and >10 years postoperatively while no statistically significant difference was observed

in the 1st year after the primary surgery. The reasons, we suggest, may be largely related to the high incidence of avascular necrosis, nonunion, and mechanical failure of implants following IF.^[22-29] Attempting to minimize the influence of different descriptions of pain across studies, the analyses only documented the number of patients with persistent pain; results based on different scoring systems were not pooled.

Although IF was favored in terms of perioperative parameters, there was no significant difference between AR and IF with respect to mortality at any follow-up time point, consistent with the results of Parker and Gurusamy.^[9] The reason, we suggest, may be the study population; we included only elderly patients, with a mean age of >70 years, meaning that most of the patients (1088 of 1826 patients in six studies, 59.58%) were lost because of natural death. For the same reason, comparison of long-term mortality rates is of little value.^[17]

With respect to total complications, including fixation failure, femoral head necrosis, nonunion, dislocation, and perioperative complications, the present study indicated a lower total complication rate following AR than IF. The avoided risk of nonunion or femoral head necrosis and the reported low re-operation rate of AR may contribute to this.^[14-16] However, the subgroup analysis revealed that this difference was specific to THA versus IF. Further well-designed RCTs of high quality are needed.

The pooled data for the Harris hip score at 1 and 2 years after surgery showed that AR may increase the chances of early functional recovery. The Harris hip score difference between AR and IF in the present study was 3.6 points at 2 years

postoperatively, which is less than the minimal clinically important difference of 4 points,^[43] suggesting AR might not be preferential to IF in terms of overall functional recovery.

We acknowledge that our study has several limitations. The limitations include: (1) The limited number of RCTs comparing AR with IF with long-term follow-up. Our systematic review and meta-analysis included eight RCTs; three reported results with a follow-up of >10 years. Future RCTs with large samples and long-term follow-up are still needed, (2) the wide range of implants used both for IF and AR may increase bias. However, this variety of usage is likely to continue in clinical practice. Future studies based on different types of prostheses would be of interest, (3) information on cost-effectiveness and long-term function was not available, (4) some caution is needed when considering the results of this study because of the age and the underlying diseases of the included patients, which may influence the results such as infection rate or deep vein thrombosis rates. Future comprehensive analyses regarding the optimal treatment for displaced intracapsular femoral neck fractures are still needed. Despite these limitations, the study does provide useful insights into the long-term effectiveness of AR and IF for displaced intracapsular femoral neck fractures in the elderly.

In conclusion, based on our analysis, we recommend that AR should be used as the primary treatment for displaced intracapsular femoral neck fractures in the elderly. However, IF may be appropriate for those who are very frail.

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Conflicts of interest

There are no conflicts of interest.

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