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Comparison of intramedullary fixation and arthroplasty for the treatment of intertrochanteric hip fractures in the elderly

A meta-analysis

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Abstract

Background: More and more studies conduct to compare intramedullary fixation (IMF) with arthroplasty in treating intertrochanteric hip fractures, but it remains controversy. The aim of this meta-analysis was to find out whether IMF or arthroplasty was more appropriate for treating intertrochanteric hip fractures in elderly patients.

Methods: Relevant studies were searched in the electronic databases of PubMed, Embase, and The Cochrane Central Register of Controlled Trials from January 1980 to September 2016 with English language restriction. Surgical information and postoperative outcomes were analyzed using RevMan 5.3 version.

Results: A total of 1239 patients from 11 studies which satisfied the eligibility criteria were included. Compared with IMF, the use of arthroplasty reduced implant-related complications (odds ratio [OR]: 2.05, $P=.02$) and reoperation rate (OR: 7.06, $P<.001$), and had similar length of hospital stay (weighted mean difference [WMD]: −0.41, $P=.63$). However, IMF reduced blood loss (WMD: −375.01, $P=.001$) and transfusion requirement (OR: 0.07, $P<.001$), shorter operation time (WMD: −18.92, $P=.010$), higher Harris hip score (WMD: 4.19, $P<.001$), and lower rate of 1-year mortality (OR: 0.67, $P=.02$) compared with arthroplasty.

Conclusion: The main treatment of intertrochanteric hip fractures is internal fixation using IMF. In the absence of concrete evidence, arthroplasty should be undertaken with caution in carefully selected patient and surgeon should be aware of the increased complexity of doing the arthroplasty in these elderly patients. Further high-quality randomized controlled trials (RCTs) are needed to provide robust evidence and evaluate the treatment options.

Abbreviations: CI = confidence interval, IMF = intramedullary fixation, OR = odds ratio, RCT = randomized controlled trials, WMD = weighted mean difference.

Keywords: arthroplasty, intertrochanteric hip fractures, intramedullary fixation, meta-analysis

1. Introduction

The morbidity of intertrochanteric hip fractures is displaying a rising trend.[1] Surgical treatment with rigid fixation, which allows early mobilization and reduces complications, has gradually become preferred.[2] Extramedullary fixations have been the standard internal fixation in treating trochanteric fractures.[3] However, when compared with the intramedullary implants, it has a nonnegligible biomechanical disadvantage especially for unstable fractures.[4] Therefore, intramedullary fixations (IMF) become the most commonly used internal device for intertrochanteric fractures.[5] But, internal fixation may fail, particularly in unstable frail fractures. This has led some surgeons to try hip arthroplasty as a primary option in treating intertrochanteric hip fractures. Many reports in the literature consider that prosthetic replacement is the preferred treatment for selected unstable comminuted intertrochanteric fractures in the elderly.[6,7]

Several randomized controlled trials (RCTs) and non-RCTs have been conducted to compare IMF with arthroplasty in treating intertrochanteric hip fractures. However, no consensus has been reached regarding which one leads to superior results and better clinical outcomes. Hence, the purpose of this meta-analysis is to evaluate the evidence from the RCT and non-RCT studies that have compared the safety and efficacy of IMF and arthroplasty for treating patients with intertrochanteric hip fractures.

2. Materials and methods

2.1. Search strategy

In order to aggregate all of the relevant published studies, Preferred Reporting Items for Systematic Reviews and Meta-Analyses-compliant searches were used for all peer-reviewed studies

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published from January1980 to September 2016 that compared IMF with arthroplasty for treating intertrochanteric hip fractures. We conducted a literature search in PubMed, Embase, and The Cochrane Central Register of Controlled Trials using the following keywords: intertrochanteric, or pertrochanteric, or trochanteric, or extracapsular hip fractures; intramedullary fixation, or cephalomedullary nail; and hip arthroplasty, or hip replacement, or endoprothesis. The "related article" function was also used during the search; the references for retrieved articles were manually searched to avoid initial misses.

2.2. Inclusion and exclusion criteria

Included studies had to fulfill the following inclusion criteria: studies were designed as interventional studies (RCTs or non-RCTs); comparison of IMF with arthroplasty techniques in patients treated for intertrochanteric hip fractures; patients older than 60 years; and the articles were restricted to the English language.

Exclusion criteria: type of literature as a "review" and "digest," "talk," "letters," "commentary," and "case report"; cadaver or model studies; data were duplicated or overlapped; and patients had a metastasis or myeloma, infection, or congenital deformity.

2.3. Data extraction

All the titles and abstracts of the relevant studies were first independently categorized by 2 reviewers, and then the full-text articles that met the eligibility criteria were read and selected for inclusion. Whenever necessary, we contacted the authors of the articles to obtain missing data or further information. The detailed data included the title, year of publication, design of study, sample size, age and sex of participants, blinding method, surgical procedures, types of fixation implants, duration of follow-up, and outcome parameters.

2.4. Quality assessment

We assessed the risk of bias of RCTs using a modified version of the Cochrane Collaboration's tool.[8] Other non-RCTs were assessed with the Methodological Index for Nonrandomized Studies.[9] According to the Cochrane Collaboration recommendations, the methodological quality of eligible clinical trials was independently assessed by 2 reviewers. Any disagreements encountered were resolved by discussion. When no consensus could be achieved, a 3rd reviewer was consulted for reconciliation.

2.5. Statistical analysis

Weighted mean differences (WMDs) or odds ratios (ORs) and corresponding 95% confidence interval (CI) were estimated and pooled across studies to assess the discrepancy between the 2 methods with a value of $P<.05$ as statistically significant. Heterogeneity was assessed using the I^2 value and Chi-square test. When the heterogeneity test was $P\geq.05$, or $I^2<50\%$ indicating low statistical heterogeneity, a fixed effect model was used; otherwise, a random effect model was chosen. Sensitivity analysis was evaluated by determining whether the remaining results would be markedly affected after removing outlier studies one by one. Publication bias was not assessed due to the relatively fewer studies included for any variable. All of the meta-analyses were performed with Review Manager software (RevMan Version 5.3, The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark).

2.6. Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

3. Results

3.1. Search results

A total of 532 articles were preliminarily reviewed, and the search and exclusion criteria details were displayed in a flow diagram (Fig. 1). Finally, 11 studies satisfied the eligibility criteria, including 3 RCTs[10–12] and 8 non-RCTs[13–20] associated with IMF versus arthroplasty in treating intertrochanteric hip fractures for senile were identified.

3.2. Quality assessment

The Cochrane Collaboration Risk of Bias Tool applied to evaluate the quality of the RCTs (Fig. 2), and the Methodological Index for Nonrandomized Studies assessment was used for non-RCTs (Table 1). The quality of the RCTs was acceptable, all the RCTs had reported their methods of randomization. Two RCTs[10,11] were conducted through the computer-generated list, and the remaining through a sealed opaque equivalent envelope.[12] None of the included RCTs reported blinding of the surgeons, participants, or assessors, though 1 study mentioned that the randomization list was concealed from the surgeon. All of the studies provided results for a minimum of 95% of the included patients.

3.3. Demographic characteristics

A total of 1239 patients from 11 studies were included. The demographic characteristics are summarized in Table 2. There were 552 patients who underwent IMF and 528 patients who received arthroplasty to treat intertrochanteric hip fractures. The other 159 patients from 2 studies[14,16] underwent extramedullary fixations. Four studies were from Turkey, 3 from Korea, and the others were from France, Germany, China, and Canada, respectively.

3.4. Duration of operation

Eight studies[10–12,14,15,17–19] provided data of operation time, but just 5 studies[10–12,14,18] including 515 fractures were eligible in the form of mean and standard deviation. The pooled results indicated that there was a statistical difference in operation time between the 2 groups (WMD: -18.92, 95% CI: -33.26 to -4.57, $P=.010$) with significant heterogeneity ($\text{Chi}^2=251.19$, $P<.001$, $I^2=98\%$, Fig. 3). However, the result of sensitive analysis by excluding the outlier study[11] did not alter significance, suggesting the result reliable.

3.5. Blood loss and transfusion

There were 3 articles[10,14,18] involving 375 fractures which provided data of intraoperative blood loss. The heterogeneity test indicated there was a statistical heterogeneity ($\text{Chi}^2=190.17$, $P<.001$, $I^2=99\%$), and the outcome shows a significant

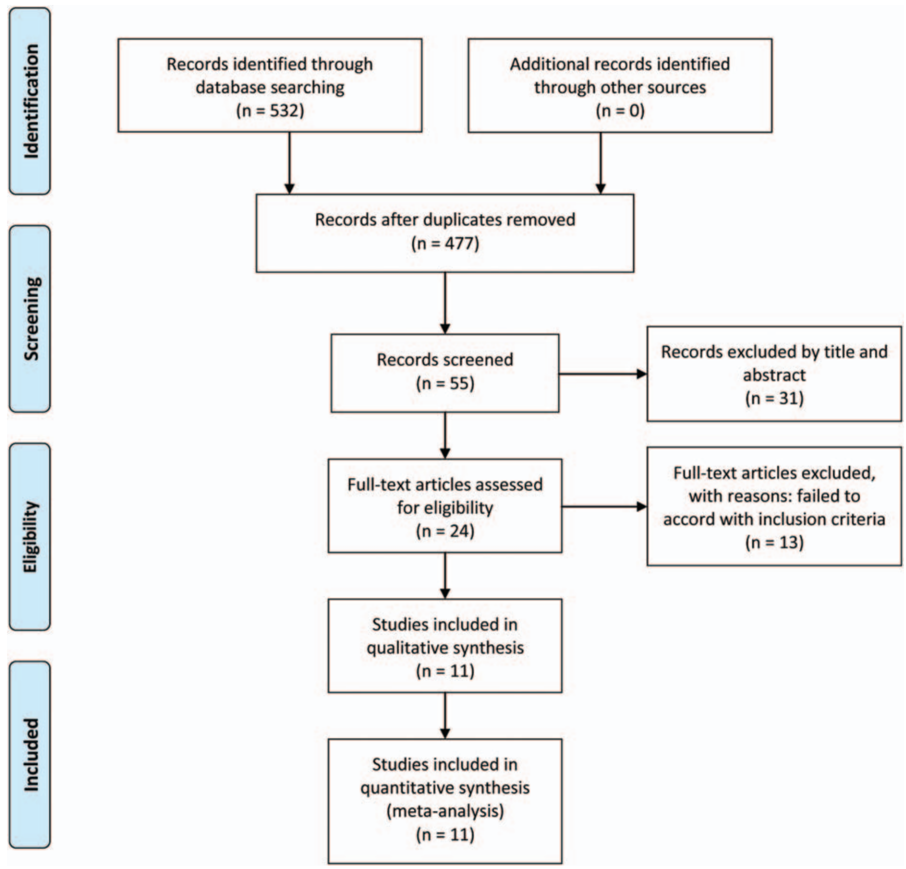

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of study selection.

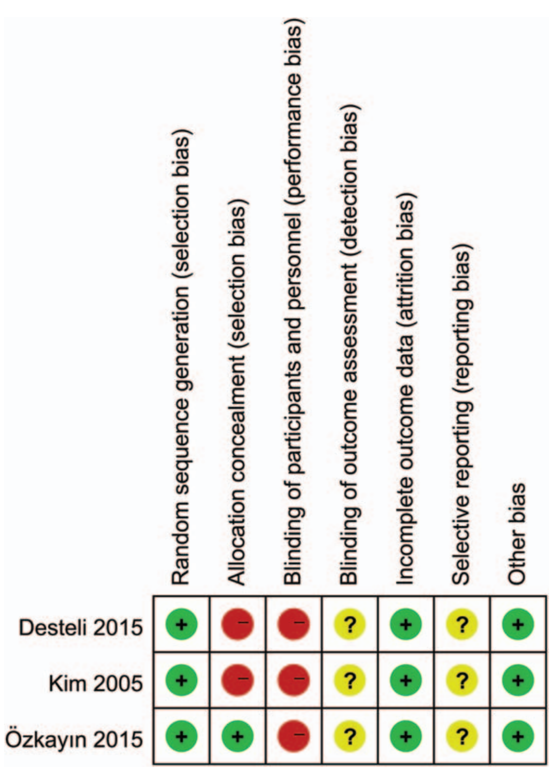

Figure 2. Risk of bias assessment summary of randomized controlled trials.

difference between the 2 groups (WMD: −375.01, 95% CI: −604.60 to −145.41, $P=.001$, Fig. 4). However, no sensitivity test was necessary because significant difference was observed in each trial, indicating the result reliable. Blood transfusion was documented in 2 articles.[10,18] The pooled data indicated the rate for blood transfusion significantly favored IMF (OR: 0.07, 95% CI: 0.03–0.16, $P<.001$) without any heterogeneity ($Chi^2=0.20$, $P=.65$, $I^2=0\%$, Fig. 5).

3.6. Hospital stay

Three studies[10,11,18] reported data of hospital stay. There were a total of 287 patients, with 139 patients in IMF group and 148 in arthroplasty group. There was no statistical difference in hospital stay between IMF and arthroplasty (WMD: −0.41, 95% CI: −2.09 to 1.26, $P=.63$) with significant heterogeneity ($Chi^2=24.25$, $P<.001$, $I^2=92\%$, Fig. 6). A sensitivity analysis found that there was no significant change when any 1 study was omitted.

3.7. Harris hip score of the latest follow-up

Six studies[10,12,15,16,18,20] provided data of Harris hip score and were eligible in the form of standard deviation. There were 594 fractures included, 295 patients with the IMF and 299 with the arthroplasty. The difference between IMF and arthroplasty was significant (WMD: 4.19, 95% CI: 2.48–5.91, $P<.001$) with slight heterogeneity ($Chi^2=6.94$, $P=.23$, $I^2=28\%$, Fig. 7).

Table 1

Quality assessment of nonrandomized studies (methodological index for nonrandomized studies).

	Bonnevialle 2011	Geiger 2007	Tang 2012	Suh 2015	Park 2015	Görmeli 2015	Fichman 2016	Güven 2016
A clearly stated aim	2	2	2	2	2	2	2	2
Inclusion of consecutive patients	2	2	2	2	2	2	2	2
Prospective collection of data	1	2	1	1	2	2	2	2
Endpoints appropriate to the aim of the study	2	2	1	2	1	2	2	1
Unbiased assessment of the study endpoint	0	1	0	0	1	1	1	0
Follow-up period appropriate to the aim of the study	2	1	2	2	2	2	1	2
Loss to follow-up less than 5%	2	2	2	2	2	2	2	2
Prospective calculation of the study size	1	2	1	1	1	1	1	1
An adequate control group	2	2	2	2	2	2	2	2
Contemporary groups	2	1	2	2	2	2	2	2
Baseline equivalence of groups	2	1	2	1	1	1	1	1
Adequate statistical analyses	2	2	2	2	2	2	2	2
Total score	20	20	19	19	20	21	20	19

3.8. Mortality within 1-year

Mortality within 1-year was documented in 6 studies.[10,13–15,17,18] There were 977 fractures included, 422 patients with the IMF and 555 with the arthroplasty. A fixed effects model was applied because no statistical heterogeneity was found between the studies ($Chi^2=2.73$, $P=.74$, $I^2=0\%$). The results indicated that the rate for mortality within 1-year significantly favored IMF (OR: 0.67, 95% CI: 0.48–0.93, $P=.02$, Fig. 8).

3.9. Implant-related complications

Eight articles[10,12,13,15–19] provided data of implant-related complications, while one showed no implant-related complication,[16] which mainly included: femoral shaft fracture, cut-out, barrel loosening, shortening, protrusion of neck screw, fracture of the lateral femoral wall, and breakage of the screw. The pooled data indicated the implant-related complications significantly favored arthroplasty (OR: 2.05, 95% CI: 1.11–3.82, $P=.02$) without any heterogeneity ($Chi^2=5.03$, $P=.54$, $I^2=0\%$, Fig. 9).

Table 2

Characteristics of included studies.

Author	Year	Country	Study design	Comparisons	No. of patients	Mean age, y	Gender (M/F)	Side of fracture (R/L)	Fracture classification	Follow-up, mo	Conflicts of interest
Kim et al[10]	2005	Korea	RCT	PFN	29	81±3.2	8/21	NS	AO/OTA 31.A2	34 (24–57)	No
				HA	29	82±3.4	6/23	NS		35 (24–58)	
Desteli et al[11]	2015	Turkey	RCT	PFNA	42	67.0±1.21	27/15	NS	AO/OTA 31.A1.3, A2.2/3, A3.1/3	24	NS
				BHA	44	56.0±1.52	27/17	NS		24	
Özkayın et al[12]	2015	Turkey	RCT	PFN	21	79.57±4.83	9/12	14/7	AO/OTA 31.A1–A3	32.33±10.97	No
				HA	33	83.94±4.92	10/23	20/13		31.33±10.65	
Bonnevialle et al[13]	2011	France	PNT	GN	113	85.5	30/83	NS	AO/OTA 31.A1–A3	6	No
				Arthroplasty	134	85.9	20/114	NS		6	
Geiger et al[14]	2007	Germany	RCS	DHS	109	79±9	29/80	NS	AO/OTA 31.A1–A3	12	No
				PFN	42	75±12	16/26	NS		12	
				Arthroplasty (BHA, THA)	132	83±7	17/115	NS		12	
Tang et al[15]	2012	China	RCS	PFNA	106	80.6±6.9	36/70	49/57	AO/OTA 31.A1–A3	35.9±8.6	No
				HA	96	81.1±5.8	25/71	44/52		44.2±16.9	
Suh et al[16]	2015	Korea	RCS	CHS	50	77.3±8.8	21/29	NS	AO/OTA 31.A2.2/3	12	NS
				PFNA	50	73.8±9.5	24/26	NS		12	
				BHA	50	81.8±6.9	20/30	NS		12	
Park et al[17]	2015	Korea	RCS	OR-IF (GN, PFN, PFNA)	31	78.1 (73–86)	12/19	NS	AO/OTA 31.A3	24	NS
				BHA	22	76.9 (70–84)	4/18	NS		24	
Görmeli et al[18]	2015	Turkey	RCS	PFN	68	76.2±7.9	27/41	NS	AO/OTA 31.A1–A3	32.3±8.9	No
				BHA	75	77.4±8.4	32/43	NS		29.6±10.3	
Fichman et al[19]	2016	Canada	RCS	CM nail (ITIS/natural nail)	29	82.21 (46–95)	3/26	NS	AO/OTA 31.A2.2/3, A3	22.6 (1.5–93)	No
				Arthroplasty (BHA, THA)	29	82.17 (44–96)	3/26	NS		15 (1.5–63.7)	
Güven et al[20]	2016	Turkey	RCS	PFN	21	78±6.8	6/15	15/6	AO/OTA 31.A1–A3	36±8.4	No
				BHA	16	79±5.7	3/13	12/4		30±7.3	

BHA = bipolar hemiarthroplasty, CHS = compression hip screw, CM nail = cephalomedullary nail, DHS = dynamic hip screw, F = females, GN = gamma nail, HA = hemiarthroplasty, L = left, M = males, NS = not stated, OR-IF = open reduction-internal fixation, PFN = proximal femoral nail, PFNA = proximal femoral nail-antirotation, PNT = prospective nonrandomized trial, R = right, RCS = retrospective comparative study, RCT = randomized controlled trial, THA = total hip arthroplasty.

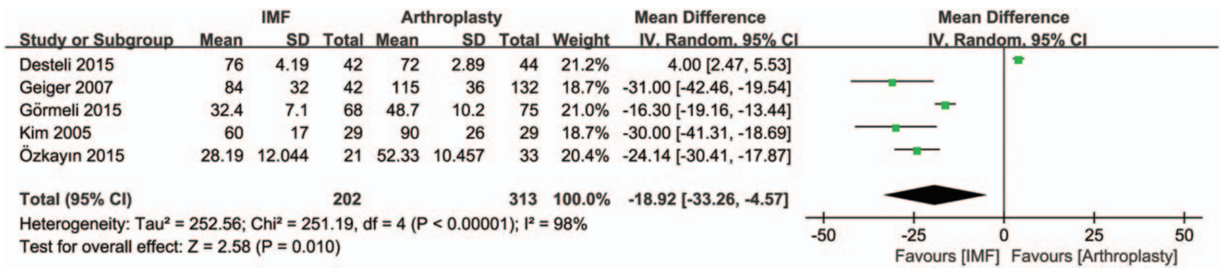

Figure 3. Forest plot diagram of operation time compared between intramedullary fixation and arthroplasty.

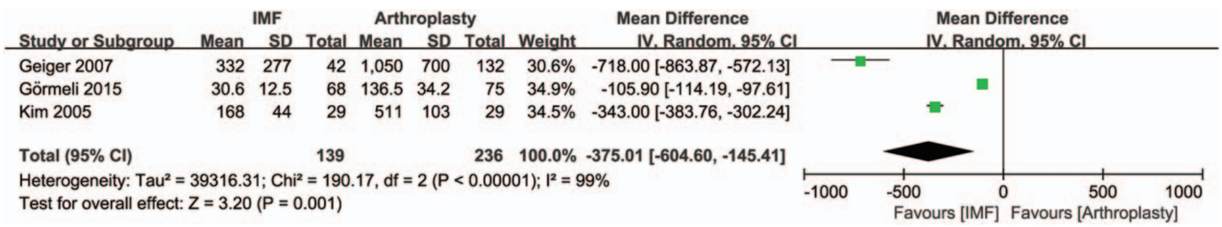

Figure 4. Forest plot diagram of blood loss compared between intramedullary fixation and arthroplasty.

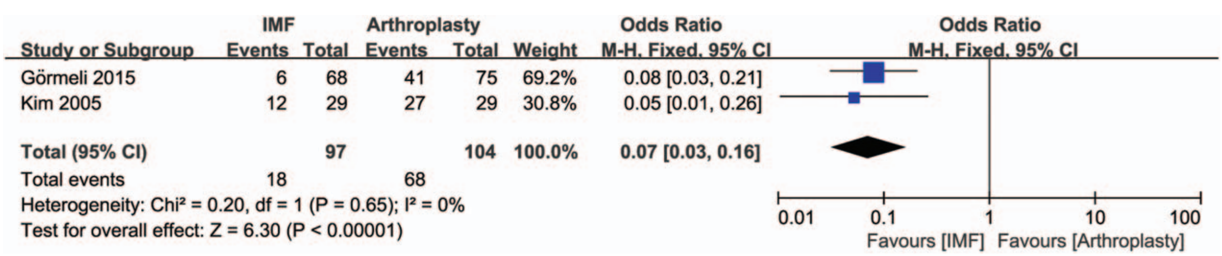

Figure 5. Forest plot diagram of transfusion compared between intramedullary fixation and arthroplasty.

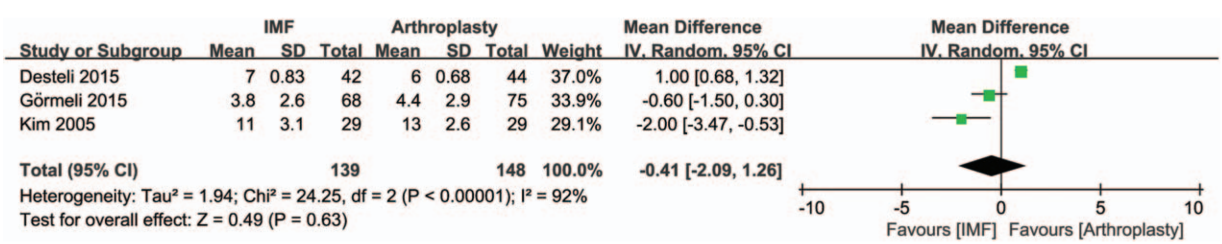

Figure 6. Forest plot diagram of hospital stay compared between intramedullary fixation and arthroplasty.

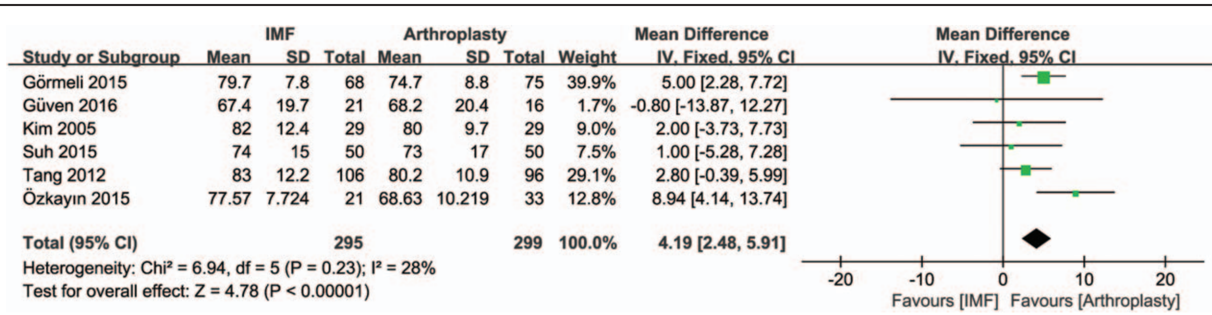

Figure 7. Forest plot diagram of Harris hip score of the latest follow-up compared between intramedullary fixation and arthroplasty.

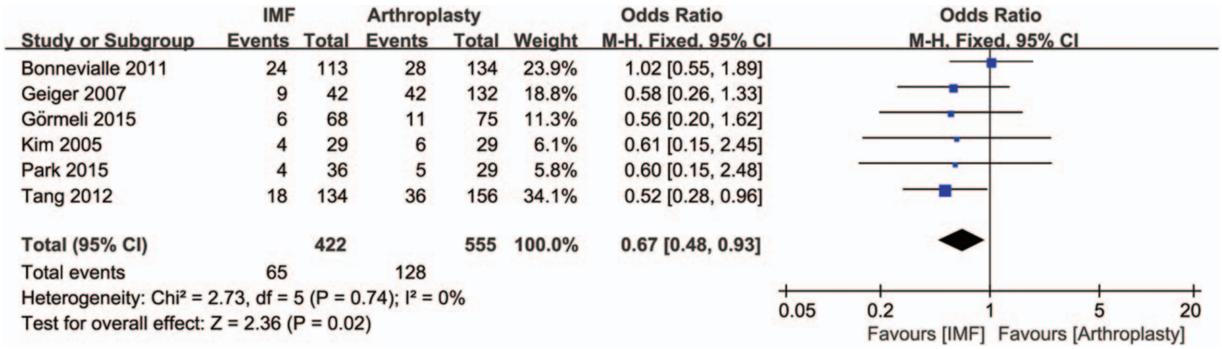

Figure 8. Forest plot diagram of mortality within 1-year compared between intramedullary fixation and arthroplasty.

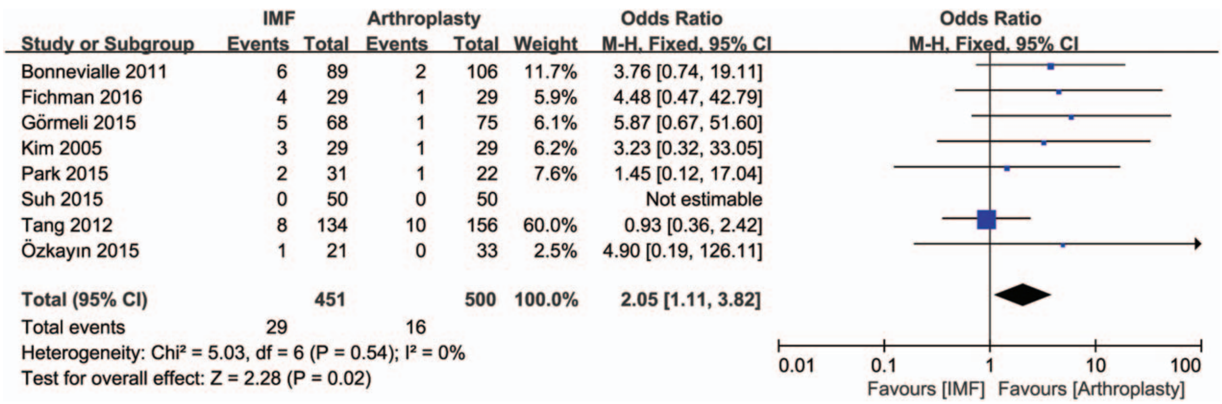

Figure 9. Forest plot diagram of implant-related complications compared between intramedullary fixation and arthroplasty.

3.10. Reoperation

The reasons for reoperation mainly caused by cut-out of femoral head, breakage of the implant, nonunion, and infection. Seven articles[10,12–14,17–19] provided data of reoperation, while one showed no reoperation occur.[12] The pooled results showed no significant heterogeneity ($Chi^2=3.54$, $P=.62$, $I^2=0\%$), and a fixed effects model was used. The available data demonstrated that the reoperation was significantly lower in the arthroplasty group compared with IMF group (OR: 7.06, 95% CI: 3.24–15.36, $P<.001$, Fig. 10).

4. Discussion

The goals of care for patients with intertrochanteric hip fractures include prompt and safe surgical stabilization to enable rapid mobilization and avoidance of medical complications. Currently, intramedullary nails are widely used in treating fractures because of a biological advantage, minimally invasive approach, and easy manipulation.[21] However, in the treatment of unstable intertrochanteric fractures in elderly patients with osteoporotic bones, the internal fixation may fail, which result in poor function and remain problems.[22] In order to allow an earlier postoperative

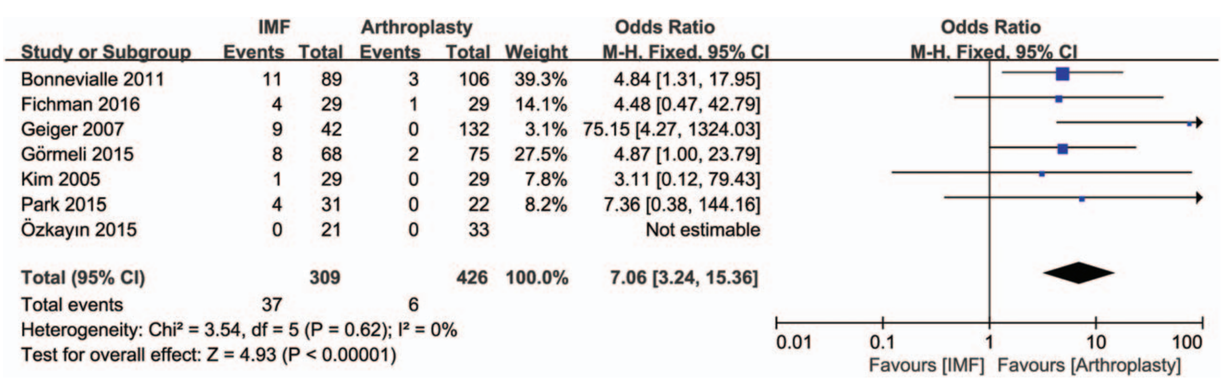

Figure 10. Forest plot diagram of reoperation compared between intramedullary fixation and arthroplasty.

weight-bearing and a rapid recovery and to avoid excessive collapse at the fracture site, some surgeons have turned the treatment regimen into hip prosthetic replacements as the primary treatment method of unstable intertrochanteric fractures.[22,23] Nevertheless, there is no clear evidence from clinical research to indicate that hip arthroplasty is more effective than IMF and vice versa. Therefore, we performed this meta-analysis to compare the advantages and disadvantages of the 2 devices to provide reliable evidence for clinicians in selecting the optimal treatment.

The meta-analysis showed that the IMF group had significantly shorter operation time compared with the arthroplasty group. Same result was shown in the previous study.[15] But there was a notable heterogeneity, which could probably be explained by the different levels of experience of surgeons, and the duration of IMF could be shortened as surgical skills improved. Meanwhile, the arthroplasty for intertrochanteric fractures typically required a more complex surgical procedure,[24] and this could be another probable reason to enlarge the gap of duration.

For blood loss and the rate for blood transfusion, both were reduced significantly in IMF compared with arthroplasty. Same results were shown in previous studies.[15,17] The more complex surgical procedure and more osteotomy during the operation might contribute a more blood loss in arthroplasty group.[25] The number of blood transfusion was consistent with blood loss during operation.[26] Our study showed the same result. In practice, various counting methods of intraoperative blood loss were used in different hospitals, and surgeons usually estimate it. That could explain the significant heterogeneity for blood loss.

Our meta-analysis found that hospital stay was similar in both IMF and arthroplasty group statistically. A sensitivity test was performed, which showed that, in hospital stay, the 2 groups were still similar. Furthermore, the hospital stay was more depend on prevailing medical/economic/social conditions. And the varied physical status and fracture types of patients should also be taken into consideration. That could explain the statistic significant difference of heterogeneity.

In our study, we used Harris hip score of the latest follow-up to show results of hip joint function. And the IMF had significantly higher Harris hip score compared with the arthroplasty. Same result was shown in previous study.[17] Among the above studies, there were 2 studies[12,17] recorded it in different follow-up periods. Özkayın et al[12] reported that the difference between 2 groups was statistically significant in favor of the arthroplasty until 6 months, after that time point, this difference became reverse to the IMF. Although Park et al[17] showed that there was no difference between the groups until 12 months, yet scores were significantly better in IMF group when measured 24 months after the surgery. Delayed full weight-bearing activity in IMF group might explain the reason why Harris hip scores in IMF group were not higher than arthroplasty group in early follow-up periods.

The mortality rate within 1-year in the IMF was reduced significantly compared with the arthroplasty. Hip fractures were associated with a significantly increased mortality risk in 6 to 12 months after the injury, and it became similar to that patients without hip fracture after the 1st year.[27] Hossain et al[28] showed that cement use itself in arthroplasty could lead to an increased embolic load and thus trigger cardiovascular adverse effects causing hypotension and even collapse and death of the patient. Thus, cement used in arthroplasty seemed to be a risk factor affected mortality rate within 1-year.

In our study, the IMF had significantly higher implant-related complication cases compared with the arthroplasty. The frequent problems in patients treated with IMF were cut-out of the hip screw and the 2nd fracture, while dislocation was the major complication in the arthroplasty. Results from recent reports demonstrated that primary bipolar hemiarthroplasty allowed patients to ambulate earlier with a low failure ratio.[29,30] And cut-out complication rates with newer design intramedullary nails were lower.[31] Although the technology of the IMF was continuously improved, the systematical review by Norris et al[32] reported that the incidence of a 2nd fracture after IMF was approximately 1.7%.

Our meta-analysis showed the reoperation rate was consistent with the implant-related complications. IMF had higher reoperation rate than arthroplasty. Aros et al[33] does not support routine use of an IMF for management of all intertrochanteric hip fractures in light of the higher revision surgery rate. And hip arthroplasty was advocated as the main treatment option for salvage.[34,35] Moreover, when patients treated with arthroplasty complained about hip discomfort, we handled it with observation usually. Reoperation rate was also dependent on prevailing medical/economic/social conditions. All these affected the reoperation rate.

Undoubtedly, there were several potential limitations in this meta-analysis. First, the number of studies included was not so sufficient which only 11 publications met the eligibility criteria. Second, the quality of the trials was generally low, except for 3 RCTs and 1 prospective nonrandomized trial, the other 7 studies were retrospective comparative study, and in some of the trials, the demographic characteristics were unclear, which might introduce bias into the results. Third, our inclusion criteria focused on studies in English, which led to selection or allocation biases, affected the results of our meta-analysis. Fourth, different follow-up duration of included studies also reduced the power of our research. Furthermore, the existence of publication bias, which was common to all meta-analyses, might have been unavoidable in our study.

However, to the best of our knowledge, this is the 1st meta-analysis to compare the strengths and weaknesses of IMF and arthroplasty in treating intertrochanteric hip fractures. High-quality clinical trials are required to compare the optimality between IMF and arthroplasty. To some extent, the present study is meaningful for both clinical decision making and fundamental research.

5. Conclusion

Based on this meta-analysis, we find that compared with IMF, the use of arthroplasty can reduce implant-related complications and reoperation rate, but has no obvious statistical difference in terms of hospital stay. However, IMF results in reducing blood loss and transfusion requirement, shorter operation time, higher Harris hip score, and lower rate of 1-year mortality. The mainstay of treatment of intertrochanteric hip fractures is internal fixation using IMF. In the absence of concrete evidence, arthroplasty should be undertaken with caution in carefully selected patient and surgeon should be aware of the increased complexity of doing the arthroplasty in these elderly patients. We suggest that arthroplasty may be considered as a primary treatment in patients with highly unstable factures with poor bone quality, ipsilateral hip arthritis, or other conditions with a higher risk for early failure.

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