Meta-analysis of randomised controlled trials comparing unipolar with bipolar hemiarthroplasty for displaced femoral-neck fractures

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Abstract

Purpose Unipolar and bipolar hemiarthroplasty (HA) are used to treat displaced femoral-neck fractures. However, which type is best for treating displaced femoral-neck fractures in elderly patients remains a subject for debate. Our aim was to review randomised controlled trials to establish which type provides superior clinical outcome for this patient population.

Methods We searched PubMed, Embase and Cochrane Register of Controlled Trials databases and Web of Science for randomised controlled trials (RCTs) comparing unipolar with bipolar HA to treat femoral-neck fracture in the elderly. Risk ratios (RRs) and mean differences (MDs) from each trial were pooled using random-effects or fixed-effects models depending on study heterogeneity. Analysis was performed using RevMan5.2 from the Cochrane Collaboration.

Results A total of 1,100 patients from nine studies were assessed in this meta-analysis. Results showed no significant differences in function score [MD=−0.14, 95% confidence interval (CI) −2.42–2.13], mortality (RR=0.97, 95% CI 0.65–1.46), dislocation (RR=1.33, 95 % CI 0.53–3.34), deep infection (RR=0.79, 95 % CI 0.35–1.79), acetabular erosion (RR=1.99, 95 % CI 0.61–6.52), operating time (MD=2.14, 95 % CI −9.85 to 14.14), blood loss (MD=13.40, 95 % CI −49.60 to 76.39) and length of hospital stay (MD=0.12, 95 % CI −0.49 to 0.73) between unipolar and bipolar HA.

Conclusions Unipolar and bipolar HA achieved similar clinical outcomes in patients with displaced femoral-neck fractures.

Keywords Unipolar · Bipolar · Hemiarthroplasty · Displaced femoral-neck fractures

Introduction

With the growing aging population and high prevalence of osteoporosis, there are approximately 1.5 million hip fractures worldwide per year, and there will be an estimated 3.9 million worldwide in 2050 [1]. Hip fractures in older patients are associated with impaired mobility, excess morbidity and mortality and obvious loss of independence [2, 3]. It is estimated that the annual medical costs owing to hip fractures will be more than US \$15 billion at this time [4].

Displaced femoral-neck fractures account for about 50 % of the total hip fracture population [5]. Operative alternatives for displaced femoral-neck fractures include internal fixation, hemiarthroplasty (HA), and total hip arthroplasty (THA). HA is a common surgical procedure in elderly patients with displaced femoral-neck fractures, especially for the frail [6]. There are two different types of HA: unipolar and bipolar. Compared with unipolar HA with a single joint articulation, bipolar HA articulates at two different levels, and this design is thought to be associated with less acetabular wear and an increased range of motion (ROM) [7]. Theoretically, bipolar HA should decrease the amount of acetabular erosion and reduce pain [8].

Numerous studies [9–17] have compared clinical results of bipolar with unipolar HA. In a long-term follow-up trial comparing bipolar with unipolar prostheses, LaBelle et al. [7] found there was less pain and decreased acetabular protrusion in the bipolar group. In addition, Lestrange et al. [18] reviewed 496 patients with bipolar replacements for displaced femoral-neck fractures and compared them with patients having unipolar replacements. They concluded that the bipolar

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prosthesis offered advantages over one-piece designs in terms of fit, decreased acetabular erosion and improved function. However, in a prospective observational study based on the Swedish Hip Arthroplasty Register, Leonardsson et al. [19] found that bipolar implants had a higher risk of re-operation irrespective of cause (hazard ratio = 1.3), dislocation (1.4), infection (1.3) and periprosthetic fracture (1.7). There is still inadequate evidence to support the choice between unipolar and bipolar HA.

Therefore, we designed this meta-analysis to quantitatively compare the clinical efficacy and complications of bipolar with unipolar HA for displaced femoral-neck fracture.

Methods

This meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [20] for reporting systematic reviews and meta-analyses in healthcare interventions.

Search strategy

We searched four electronic databases (PubMed, Embase, Cochrane Central Register of Controlled Trials, Web of Science) from database inception to February 2014 to identify potential randomised controlled trials (RCTs) using search terms “unipolar”, “Thompson”, “bipolar”, “Monk”, “hemiarthroplasty”, “Prosthesis”. No language, date, or publication status restrictions were imposed. In addition, these searches were supplemented with manual searches of the references lists of included studies and relevant reviews. All processes were performed by two authors independently.

Inclusion criteria

Inclusion criteria for this meta-analysis were RCTs comparing bipolar with unipolar HA in patients with displaced femoral-neck fractures. All patients must be adult and randomised into two groups: one with bipolar and the other with unipolar HA. All patient parameters, such number, age and body mass index (BMI), must have been comparable in both groups. Primary outcomes of our study were function; mortality; complications, including dislocation and deep infection rates. Secondary outcomes were operating time, blood loss and length of hospital stay.

Data extraction and quality assessment

Two investigators critically and independently extracted the following information and entered it into a database: study design, patient characteristics, interventions, comparisons,

outcomes and follow-up. Divergences were resolved by consensus. Two authors independently appraised the quality of the included studies according to the Cochrane Collaboration guidelines (random sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting and other sources of bias) [21]; disagreements between authors were resolved by discussion.

Statistical analyses

Meta-analysis was done using Review Manager 5.2 software. Relative risks (RR) and 95 % confidence intervals (CI) were calculated for dichotomous outcomes, and mean differences (MD) and 95 % CI were calculated for continuous outcomes. We assessed heterogeneity among studies using the I^2 statistic, judging values <50 % as having no significant heterogeneity and those ≥ 50 % as having significant heterogeneity. When heterogeneity was not significant, a fixed-effect model was used; otherwise, a random-effect model was used. For outcome measures, a P value <0.05 was considered statistically significant.

Results

Search results and study description

Our search strategy found 107 articles; nine studies [9–17] involving 1,100 patients met inclusion criteria (Fig. 1).

Table 1 summarises the key characteristics of the included studies; sample sizes ranged from 48 to 261 cases, with an average patient age of 65–87.4 years and a follow-up of six to 60 months. In both groups, cemented fixation was used. Based on nine studies, 1,100 patients were available for analysis, of whom 548 received unipolar and 552 bipolar HA. Both groups were well matched for patient number, age, BMI and pre-operative hip function.

Table 2 summarises study methodological quality and characteristics. All nine studies were randomised, and six [9–13, 16] had adequate randomisation procedures; Seven had concealed allocation, and two [16, 17] did not. Six studies used blinding, and three [9, 15, 17] did not.

Outcome measures

Outcome measures are reported in Table 3.

Function score

The Harris Hip Score (HHS) was used for outcome assessment in seven studies [9–13, 15, 16] involving 1,022 patients. Meta-analysis results revealed there was no statistically significant differences between bipolar and unipolar HA (MD=

Fig. 1 Identified studies **Table 1** Characteristics of included studies

Study (year)	Country	Sample size (F/M)		Age (years)	Fixation	Diagnosis	Follow-up (months)	Outcome
		Unipolar	Bipolar					
Calder et al. 1996 [9]	UK	132 (101/31)	118 (114/4)	85/8.5	Cemented/cemented	Displaced intracapsular hip fractures, Garden III/IV	24	a, b, c, d, f
Cornell et al. 1998 [10]	USA	15 (11/4)	33 (25/8)	77.6/78	Cemented/cemented	Displaced femoral-neck fractures	6	a, c, f
Davison et al. 2001 [11]	UK	90 (71/19)	97 (72/25)	76/75	Cemented/cemented	Displaced intracapsular fracture of the proximal femur	60	a, b, c, d, e, f
Hedbeck et al. 2011 [14]	Sweden	60 (49/11)	60 (42/18)	87.4/85.5	Cemented/cemented	Displaced femoral-neck fracture, Garden III/IV	12	a, b, c, d, e, f
Inngul et al. 2013 [15]	Sweden	60 (49/11)	60 (42/18)	87.4/85.5	Cemented/cemented	Displaced femoral-neck fracture, Garden III/IV	48	a, c, d, e, f
Jeffcote et al. 2010 [13]	Australia	27 (21/6)	24 (18/6)	81.4/80.1	Cemented/cemented	Displaced subcapital fracture, Garden III/IV	24	a, b, e
Malhotra et al. 1995 [17]	India	36 (16/20)	32 (14/18)	68/65	NR	Femoral-neck fracture	26	c, d, e, f
Raia et al. 2003 [12]	USA	60 (41/19)	55 (42/18)	81.8/82.4	Cemented/cemented	Displaced femoral-neck fracture. Garden III/IV	24	a, b, c, f
Stoffel et al. 2013 [16]	Australia	128	133	81.9/82.9	Cemented/cemented	Femoral-neck fracture. Garden III/IV	12	a, c, d, f

a Function outcome, b mortality, c dislocation, d acetabular erosion, e deep infection, f clinical outcomes, including blood loss, operating time, length of hospital stay

Table 2 Risk of bias in included studies

Study	Adequate sequence generation	Allocation concealment	Blinding	Incomplete outcome data	Selective reporting	Other bias
Calder et al. 1996 [9]	Computer generation	Sealed envelope	Unclear	No	Unclear	Unclear
Cornell et al. 1998 [10]	Randomisation table	Sealed envelope	Yes	No	Unclear	Unclear
Davison et al. 2001 [11]	Computer generation	Sealed envelope	Yes	No	Unclear	Unclear
Hedbeck et al. 2011 [14]	Unclear	Sealed envelope	Yes	No	Unclear	Unclear
Inngul et al. 2013 [15]	Unclear	Sealed envelope	Unclear	No	Unclear	Unclear
Jeffcote et al. 2010 [13]	Randomisation table	Sealed envelope	Yes	No	Unclear	Unclear
Malhotra et al. 1995 [17]	Unclear	Unclear	Unclear	No	Unclear	Unclear
Raia et al. 2003 [12]	Computer generation	Sealed envelope	Yes	No	Unclear	Unclear
Stoffel et al. 2013 [16]	Unclear	Unclear	Yes	No	Unclear	Unclear

−0.14, 95 % CI (−2.42 to 2.13). No significant heterogeneity was observed ($P=0.39$, $I^2=5$ %).

Mortality

Mortality data were provided in four studies [9, 11–13]. The number of events was 41 for bipolar ($n=318$) and 38 for unipolar ($n=294$) HA. Meta-analysis results demonstrated there was no significant difference in mortality rate between groups (RR=0.97, 95 % CI 0.65–1.46). Substantial heterogeneity was not observed ($P=0.43$, $I^2=0$ %).

Dislocation rates

Dislocation rates were available in seven studies (1,049 patients, 18 events) [9–12, 15–17]. Pooled data showed 521 bipolar and 528 unipolar HA (re-operations were ten and eight cases, respectively). Meta-analysis results found no statistically significant difference between bipolar and unipolar groups (RR=1.33, 95 % CI 0.53 to 3.34). There was no significant heterogeneity ($P=1.00$, $I^2=0$ %).

Deep infection

Five studies [9, 11, 13, 15–17] provided data on deep infection: nine of 473 (1.9 %) in bipolar compared with 11 of 464 (2.3 %) unipolar HA. Meta-analysis results demonstrated no statistical difference between bipolar and unipolar HA (RR=0.79, 95 % CI 0.35–1.79). No significant heterogeneity was found ($P=0.68$, $I^2=0$ %).

Acetabular erosion

Data was available in three studies [11, 15, 17] regarding acetabular erosion: nine bipolar ($n=152$) and four unipolar ($n=150$). Meta-analysis results demonstrated no significant difference between groups (RR=1.99, 95 % CI 0.61–6.52). Substantial heterogeneity was not observed ($P=0.79$, $I^2=0$ %).

Surgical outcomes

Seven studies [9–12, 14, 16, 17] reported blood loss, operating time and length of hospital stay. Meta-analysis results revealed

Table 3 Outcomes of meta-analysis

Outcomes	No. of studies	No. patients		MD or RR (95 % CI)	P value	Heterogeneity
		Unipolar	Bipolar			
Function score	7 [9–13, 15, 16]	506	516	−0.14 (−2.42 to 2.13)	0.44	$I^2=5$ %
Mortality	4 [9, 11–13]	41/318	38/294	0.97 (0.65–1.46)	0.89	$I^2=0$ %
Dislocation	7 [9–12, 15–17]	10/521	8/528	1.33 (0.53–3.34)	0.54	$I^2=0$ %
Deep infection	5 [9, 11, 13, 15–17]	9/473	11/464	0.79 (0.35–1.79)	0.57	$I^2=0$ %
Acetabular erosion	3 [11, 15, 17]	9/152	4/150	1.99 (0.61–6.52)	0.25	$I^2=0$ %
Operating time	2 [14, 17]	96	92	2.14 (−9.85 to 14.14)	0.73	$I^2=0$ %
Blood loss	3 [12, 14, 17]	156	147	13.40 (−49.60 to 76.39)	0.68	$I^2=0$ %
Length of hospital stay	6 [9–12, 16, 17]	461	468	0.12 (−0.49 to 0.73)	0.70	$I^2=0$ %

no significant differences in blood loss (MD=13.40, 95 % CI –49.60 to 76.39), operating time (MD=2.14, 95 % CI –9.85 to 14.14) and length of hospital stay (MD=0.12, 95 % CI –0.49 to 0.73) between groups.

Discussion

HA is an effective treatment for displaced intracapsular femoral-neck fractures in the elderly. Whether bipolar or unipolar HA is the better treatment option for displaced femoral-neck fractures in elderly patients remains a subject for debate. The objective of our study was to collect a data set as large and inclusive as possible from prospective RCTs to determine which type is superior. To this end, we analysed nine studies that collectively assessed 1,100 patients. Our meta-analysis found no significant differences in function outcomes and mortality, dislocation, deep infection and acetabular erosion rates or operative outcomes, including blood loss, operating time and length of hospital stay between bipolar and unipolar HA.

A Cochrane Review [22] comparing clinical results of bipolar and unipolar HA concluded there was no difference in outcome between bipolar and unipolar prosthesis. However, there were several obvious limitations related to that review: First, data were based on not only RCTs but also quasi-RCTs, which might lower the strength of evidence. Second, seven RCTs were identified in their study, two of which were only reported as a conference abstract with no data; eventually, only five were included for the final analysis. Therefore, that report should be updated, as a number of new, well-designed RCTs [13–16] have since been published. Compared with the Cochrane report, we included four other studies [13–16] and excluded that reported no data. Therefore, we believe our evidence is stronger regarding the efficiency of bipolar versus unipolar HA than the Cochrane Review.

The primary outcomes in our meta-analysis were function score and mortality rate. In theory, the better outcomes in the bipolar group may be related to the ball-in-shell mechanism of the bipolar prosthesis, which allows lower acetabular pressure postoperatively than does unipolar HA. The lower acetabular pressure can result in a faster return of the ability to walk, leading to quicker recovery and thus fewer postoperative complications related to immobility [23]. Jeffcote et al. [13] reported a significant difference in functional outcome in favour of the bipolar group at three months compared with unipolar HA. After three months, there was no further significant difference in functional outcomes. However, our pooled analysis failed to show an advantage of bipolar over unipolar HA in function score. Postoperative mortality is high in elderly patients undergoing surgery for intracapsular femoral-neck fractures [1, 2]. Our meta-analysis showed similar mortality

rates between bipolar and unipolar HA. In an RCT with a four year follow-up, Inngul et al. [15] reported an overall mortality rate ranging from four months to four years, with no statistically significant differences between unipolar and bipolar HA at any time, which was consistent with our results.

With regard to hip complications, we found no significant differences in dislocation, deep infection and acetabular erosion rates between groups. Leonardsson et al. [19] assessed 23,509 HA procedures from the Swedish Hip Arthroplasty Register performed between 2005 and 2010. They found the most common reasons for HA re-operation and revision were implant dislocation and infection, accounting for three quarters of procedures. In our study, there were seven RCTs available for pooled analysis, and results demonstrated no statistically significant differences in dislocation and deep infection rates between groups. Another complication was acetabular erosion, which was believed to cause pain and impaired hip function [12]. Data from national registries indicate that only 5.1 % of revisions in Australia and 4.7 % in Sweden were attributable to acetabular erosion [24]. In theory, bipolar HA reduces stress on the acetabular surface and thereby reduces acetabular erosion. In a one year follow-up of an RCT, Hedbeck et al. [14] found that the bipolar group had superior results with less acetabular erosion compared with the unipolar group; however, our meta-analysis demonstrated no statistically significant difference between groups.

Strengths and weaknesses of this review

Our meta-analysis compiled all available randomised studies of bipolar compared with unipolar HA for femoral-neck fractures in the elderly, which is the highest level of evidence. By including only RCTs, the sample size and robustness of estimates was convincing. It is noteworthy that there are some limitations in our meta-analysis: Firstly, although only RCTs were assessed, the quality of those studies could have been better. For example, three of the nine studies [14, 15, 17] did not report adequate sequence generation for randomisation, which may add a risk of bias. Secondly, follow-up for four years was done in one RCT only [15]; multicentre RCTs with longer-term outcome assessments and more outcome measures are necessary in order to confirm outcomes from our meta-analysis. Furthermore, inclusion criteria were different for each study we included in our analysis, which might influence the obvious consistency of effects across studies, although no obvious between-study heterogeneity was found in this meta-analysis.

Conclusions

Based on the meta-analysis of RCTs, we conclude that no statistically significant differences were seen in any data point

between bipolar and unipolar HA. Large multicentre RCTs with a longer follow-up are needed to confirm our results.

Conflict of interest None.

References

1. Sterling RS (2011) Gender and race/ethnicity differences in hip fracture incidence, morbidity, mortality, and function. *Clin Orthop Relat Res* 469:1913–1918
2. Giannoudis PV, Kontakis G, Christoforakis Z, Akula M, Tosounidis T, Koutas C (2009) Management, complications and clinical results of femoral head fractures. *Injury* 40:1245–1251
3. Yu L, Wang Y, Chen J (2012) Total hip arthroplasty versus hemiarthroplasty for displaced femoral-neck fractures: meta-analysis of randomized trials. *Clin Orthop Relat Res* 470:2235–2243
4. Macaulay W, Pagnotto MR, Iorio R, Mont MA, Saleh KJ (2006) Displaced femoral-neck fractures in the elderly: hemiarthroplasty versus total hip arthroplasty. *J Am Acad Orthop Surg* 14:287–293
5. Stoen RO, Nordsletten L, Meyer HE, Frihagen JF, Falch JA, Lofthus CM (2012) Hip fracture incidence is decreasing in the high incidence area of Oslo, Norway. *Osteoporos Int* 23:2527–2534
6. Bhandari M, Devereaux PJ, Tornetta P 3rd, Swiontkowski MF, Berry DJ, Haidukewych G, Schemitsch EH, Hanson BP, Koval K, Dirschl D, Leece P, Keel M, Petrisor B, Heetveld M, Guyatt GH (2005) Operative management of displaced femoral-neck fractures in elderly patients: An international survey. *J Bone Joint Surg Am* 87: 2122–2130
7. LaBelle LW, Colwill JC, Swanson AB (1990) Bateman bipolar hip arthroplasty for femoral-neck fractures. A five- to ten-year follow-up study. *Clin Orthop Relat Res*:20–25
8. Wathne RA, Koval KJ, Aharonoff GB, Zuckerman JD, Jones DA (1995) Modular unipolar versus bipolar prosthesis: a prospective evaluation of functional outcome after femoral-neck fracture. *J Orthop Trauma* 9:298–302
9. Calder SJ, Anderson GH, Jagger C, Harper WM, Gregg PJ (1996) Unipolar or bipolar prosthesis for displaced intracapsular hip fracture in octogenarians - A randomised prospective study. *J Bone Jt Surg-Br* Vol 78B:391–394
10. Cornell CN, Levine D, O'Doherty J, Lyden J (1998) Unipolar versus bipolar hemiarthroplasty for the treatment of femoral-neck fractures in the elderly. *Clinical Orthopaedics and Related Research*:67–71
11. Davison JN, Calder SJ, Anderson GH, Ward G, Jagger C, Harper WM, Gregg PJ (2001) Treatment for displaced intracapsular fracture of the proximal femur. A prospective, randomised trial in patients aged 65 to 79 years. *J Bone Joint Surg (Br)* 83:206–212
12. Raia FJ, Chapman CB, Herrera MF, Schweppe MW, Michelsen CB, Rosenwasser MP (2003) Unipolar or bipolar hemiarthroplasty for femoral-neck fractures in the elderly? *Clinical Orthopaedics and Related Research*:259–265
13. Jeffcote B, Li MG, Barnet-Moorcroft A, Wood D, Nivbrant B (2010) Roentgen stereophotogrammetric analysis and clinical assessment of unipolar versus bipolar hemiarthroplasty for subcapital femur fracture: a randomized prospective study. *ANZ J Surg* 80: 242–246
14. Hedbeck CJ, Blomfeldt R, Lapidus G, Tornkvist H, Ponzer S, Tidermark J (2011) Unipolar hemiarthroplasty versus bipolar hemiarthroplasty in the most elderly patients with displaced femoral-neck fractures: a randomised, controlled trial. *Int Orthop* 35:1703–1711
15. Inngul C, Hedbeck C-J, Blomfeldt R, Lapidus G, Ponzer S, Enocson A (2013) Unipolar hemiarthroplasty versus bipolar hemiarthroplasty in patients with displaced femoral-neck fractures. A four-year follow-up of a randomised controlled trial. *Int Orthop* 37:2457–2464
16. Stoffel KK, Nivbrant B, Headford J, Nicholls RL, Yates PJ (2013) Does a bipolar hemiprosthesis offer advantages for elderly patients with neck of femur fracture? A clinical trial with 261 patients. *ANZ J Surg* 83:249–254
17. Malhotra R, Arya R, Bhan S (1995) Bipolar hemiarthroplasty in femoral-neck fractures. *Arch Orthop Trauma Surg* 114:79–82
18. Lestrane NR (1990) Bipolar arthroplasty for 496 hip fractures. *Clin Orthop Relat Res*:7–19
19. Leonardsson O, Karrholm J, Akesson K, Garellick G, Rogmark C (2012) Higher risk of reoperation for bipolar and uncemented hemiarthroplasty. *Acta Orthop* 83:459–466
20. Moher D, Liberati A, Tetzlaff J, Altman DG (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* 62:1006–1012
21. Higgins JPT, Green S Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration. Available at: www.cochrane-handbook.org:Accessed February 2, 2012
22. Parker MJ, Gurusamy KS, Azegami S (2010) Arthroplasties (with and without bone cement) for proximal femoral fractures in adults. *Cochrane Database Syst Rev*:CD001706
23. Lin CC, Huang SC, Ou YK, Liu YC, Tsai CM, Chan HH, Wang CT (2012) Survival of patients aged over 80 years after Austin-Moore hemiarthroplasty and bipolar hemiarthroplasty for femoral-neck fractures. *Asian J Surg* 35:62–66
24. Kannan A, Kancherla R, McMahon S, Hawdon G, Soral A, Malhotra R (2012) Arthroplasty options in femoral-neck fracture: answers from the national registries. *Int Orthop* 36:1–8