

Total hip replacement: A meta-analysis to evaluate survival of cemented, cementless and hybrid implants

Phedy Phedy, H Dilogu Ismail, Charles Hoo, Yoshi P Djaja

Phedy Phedy, Departement of Orthopaedic and Traumatology, Fatmawati General Hospital, Faculty of Medicine Universities Indonesia, Jakarta 12430, Indonesia

H Dilogu Ismail, Charles Hoo, Yoshi P Djaja, Departement of Orthopaedic and Traumatology, Ciptomangunkusumo General Hospital, Faculty of Medicine Universities Indonesia, Jakarta 10430, Indonesia

Author contributions: All the authors contributed to the manuscript.

Conflict-of-interest statement: The authors declare no conflicts of interest regarding this manuscript.

Data sharing statement: No data were created no data are available.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

Manuscript source: Unsolicited manuscript

Correspondence to: Phedy Phedy, MD, Spine Consultant, Department of Orthopaedic and Traumatology, Fatmawati General Hospital, Jakarta 12430, Indonesia. phedy.phe@gmail.com
Telephone: +62-813-14010190

Received: September 3, 2016

Peer-review started: September 7, 2016

First decision: September 29, 2016

Revised: October 16, 2016

Accepted: December 7, 2016

Article in press: December 9, 2016

Published online: February 18, 2017

Abstract

AIM

To determine whether cemented, cementless, or hybrid implant was superior to the other in terms of survival rate.

METHODS

Systematic searches across MEDLINE, CINAHL, and Cochrane that compared cemented, cementless and hybrid total hip replacement (THR) were performed. Two independent reviewers evaluated the risk ratios of revision due to any cause, aseptic loosening, infection, and dislocation rate of each implants with a pre-determined form. The risk ratios were pooled separately for clinical trials, cohorts and registers before pooled altogether using fixed-effect model. Meta-regressions were performed to identify the source of heterogeneity. Funnel plots were analyzed.

RESULTS

Twenty-seven studies comprising 5 clinical trials, 9 cohorts, and 13 registers fulfilled the research criteria and analyzed. Compared to cementless THR, cemented THR have pooled RR of 0.47 (95%CI: 0.45-0.48), 0.9 (0.84-0.95), 1.29 (1.06-1.57) and 0.69 (0.6-0.79) for revision due to any reason, revision due to aseptic loosening, revision due to infection, and dislocation respectively. Compared to hybrid THR, the pooled RRs of cemented THR were 0.82 (0.76-0.89), 2.65 (1.14-6.17), 0.98 (0.7-1.38), and 0.67 (0.57-0.79) respectively. Compared to hybrid THR, cementless THR had RRs of 0.7 (0.65-0.75), 0.85 (0.49-1.5), 1.47 (0.93-2.34) and 1.13 (0.98-1.3).

CONCLUSION

Despite the limitations in this study, there was some tendency that cemented fixation was still superior than other types of fixation in terms of implant survival.

Key words: Total hip replacement; Implant survival;

Cemented; Cementless; Hybrid; Meta-analysis

© **The Author(s) 2017.** Published by Baishideng Publishing Group Inc. All rights reserved.

Core tip: To determine whether cemented, cementless, or hybrid implant was superior to the other in terms of survival rate, a meta-analysis of 27 studies, comprising 5 clinical trials, 9 cohorts, and 13 registers, were performed to evaluate the risk ratios of revision due to any cause, aseptic loosening, infection, and dislocation rate. The risk ratios were pooled separately for clinical trials, cohorts and registers before pooled altogether using fixed-effect model. Meta-regressions were performed to identify the source of heterogeneity. Despite the limitations in this study, there was some tendency that cemented fixation was still superior than other types of fixation in terms of implant survival.

Phedy P, Ismail HD, Hoo C, Djaja YP. Total hip replacement: A meta-analysis to evaluate survival of cemented, cementless and hybrid implants. *World J Orthop* 2017; 8(2): 192-207 Available from: URL: <http://www.wjgnet.com/2218-5836/full/v8/i2/192.htm> DOI: <http://dx.doi.org/10.5312/wjo.v8.i2.192>

INTRODUCTION

Rationale

Currently, total hip replacement is one of the most performed orthopaedic surgeries. In Sweden, the number of THR performed increased by 20% from 1986-1997 and up to 68% in Netherland during the same period of observation^[1]. In Organisation for Economic Cooperation and Development countries, the rate of THR increase from 50-130/100000 inhabitants to 60-200/100000 inhabitants in the late 1990s^[2]. In United States, more than 200000 THR are conducted annually^[3].

Superiority of either cemented or cementless implants has been a longstanding debate. Wroblewski *et al*^[4] in 1993 reported the superiority of either implants could not be determined on a scientific basis. Rorabeck *et al*^[5,6] reported similar clinical outcome by any of those implants. Zimmerman *et al*^[7] agreed that no significant differences in clinical and functional outcome between the implants and reported non-cemented prosthesis to be more costly. Emerson *et al*^[8] found cementless titanium stems offered better resistance to osteolysis and mechanical failure.

Morshed *et al*^[9] conducted a meta-analysis in 2007 and found no difference in survival between those two groups. Since then, many larger studies with longer duration of follow-up had been conducted and resulted in different results thus resuming the controversy.

Objective

We conducted a meta-analysis of articles published after January 2000 comparing the cemented, cementless and

hybrid THR implants to evaluate the superiority of each in terms of risk of revision due to any reason, revision due to infection, revision due to aseptic loosening, and dislocation.

MATERIALS AND METHODS

The structure of this study was written in accordance with the PRISMA checklist for systematic review and meta-analysis^[10].

Selection criteria

All studies including randomized clinical trials and cohorts reporting direct comparison between cementless, hybrid and cemented implant in primary THR were included. Recent reports from national registry were also included in this study. The inclusion criteria was pre-determined: (1) all patients over 18 years of age; (2) primary total hip replacement; and (3) revision due to any reason as the primary endpoint. Studies about inverse hybrid arthroplasty were excluded from the analysis. These studies were restricted according to these characteristics: (1) published after January 2000; (2) English language; (3) available abstract; and (4) original research.

Information source and search strategy

In June 2012, literature search was conducted across MEDLINE, CINAHL, and The Cochrane Library using strategies listed in appendices 1. Manual search was also conducted to identify studies that were not included by the initial MeSH keyword search. All identified articles were retrieved from previously mentioned databases.

Study selection

Two reviewers independently performed the study selection in accordance with the aforementioned selection criteria by screening the titles and abstracts. Studies were excluded if they don't meet the selection criteria. If the information required determining eligibility was not found in the abstract, a full-text search was run after data extraction. The studies included were determined from the discussion of two reviewers in accordance with the selection criteria. Reviewers were not blinded to any study characteristic such as journal, author or institution. Algorithm in selecting studies included in this meta-analysis is shown in Figure 1.

Data collection process and data items

All results were checked for consistency between the two reviewers independently. Any discrepancies were be judged by a third independent reviewer. Data extraction was performed using a predetermined standardized form as shown in Tables 1 and 2. Study quality was first assessed using sample size, study design, duration of follow up and variability of result. Overall level of evidence was also assessed.

Synthesis of results

Risk ratios were calculated to determine risk of revision due to any cause, revision due to aseptic loosening,

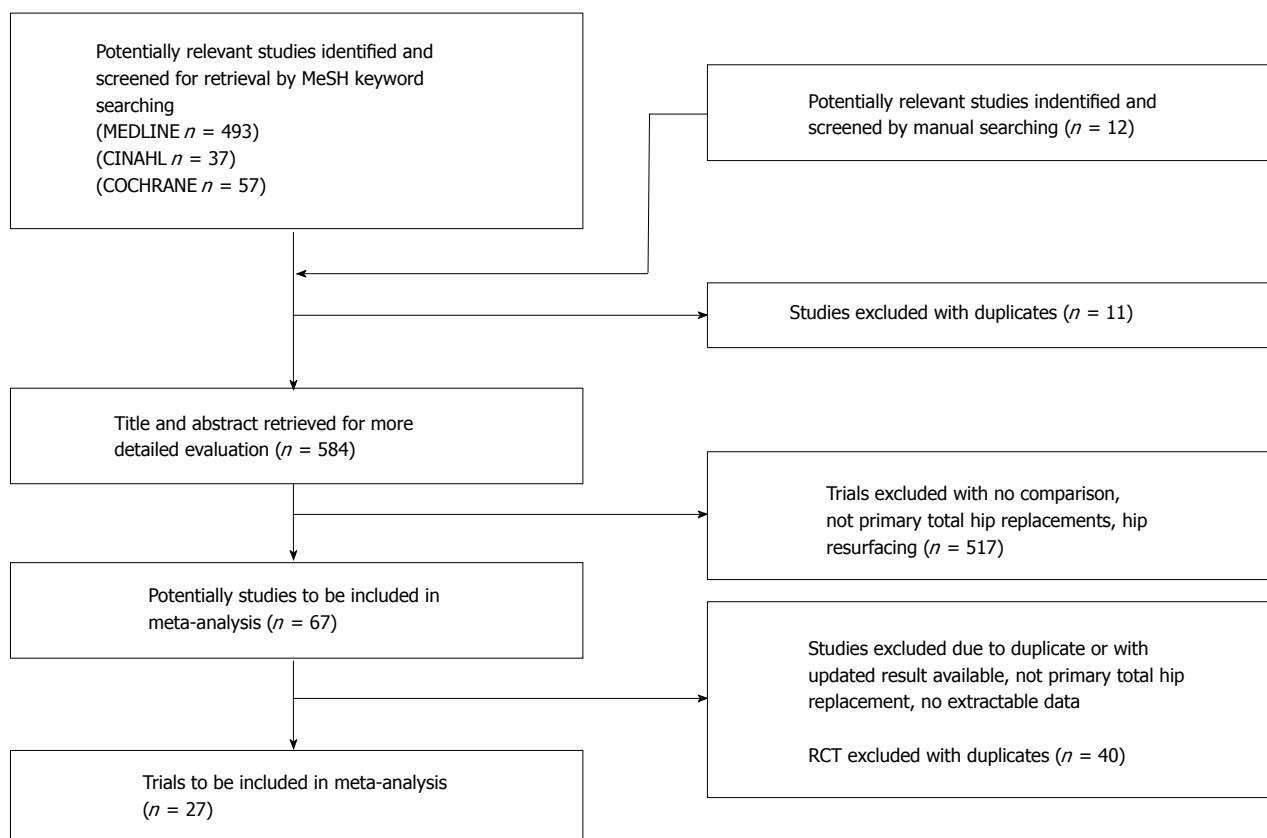


Figure 1 Study selection algorithm.

revision due to infection, and dislocation between each implants. Data were analysed separately for clinical trials, cohorts and registers before pooled altogether. Fixed-effect model was used in the determination of the risk ratio. In comparison with high heterogeneity, we preformed meta-regression to evaluate to identify the source of heterogeneity. Funnel plots for all included trials was constructed to assess the degree of publication bias. The results of the study were graded according to grading system advocated by Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group. Statistical test was performed using the meta-analysis software of Review Manager 5, Meta-regression was conducted using STATA 10, and grading of the results was performed using GRADEprofiler 3.6.

RESULTS

Following algorithm for study selection, 27 studies were left for final analysis^[8,11-36]. Characteristics of the included studies were outlined in Table 1.

Cemented vs cementless THR

Revision of any component due to any reason:

Two RCTs, one cohort, and ten registers addressed revision of any component due to any reason. The RCTs found no differences between cemented and cementless THR. Analysis of registers supported cemented to be

superior to cementless THR (Figure 2) Pooled all studies together, the RR was 0.47 (95%CI: 0.45-0.48) with a heterogeneity of 98%. Meta-regression using age group, diagnosis, length of follow-up, starting year, publication type, and type of funding failed to correct the heterogeneity.

Revision of any component due to aseptic loosening:

Data regarding revision of any component due to aseptic loosening were available in two RCTs and six registers (Figure 3). Controversy existed between result of analysis of RCTs and registers (RR = 2; 95%CI: 1.2-3.1 and RR = 0.88; 95%CI: 0.83-0.94 respectively). Pooled together, the RR was 0.90 (95%CI: 0.84-0.95) with a heterogeneity of 98%. Meta-regression by age group, diagnosis, length of follow-up, starting year, publication type and funding corrected the heterogeneity into 0%, although none of the factors showed significant influence.

Revision of any component due to infection:

One RCT and six registers provided sufficient data for determination of revision of any component due to infection (Figure 4). Analysis of registers favored cementless implant in term of revision of any component due to infection (RR = 1.25; 95%CI: 1.10-1.42). Pooled together, the RR was 1.26 (95%CI: 1.11-1.42) with heterogeneity of 57%.

Table 1 Characteristics of the included studies

Ref.	Age (years old)	Length of follow-up (years)	Diagnosis	Cementing technique (generation)	Comparison		Approach	Comments
Björgul <i>et al</i> ^[11]	65 to 66	14	Osteoarthritis (most)	3 rd	Cemented (<i>n</i> = 120)	Hybrid (<i>n</i> = 120)	direct lateral	
Chandran <i>et al</i> ^[12]	64.5 to 65.5	14	primary Osteoarthritis	2 nd	Cemented (<i>n</i> = 97)	Cementless (<i>n</i> = 105)	anterolateral	
Corten <i>et al</i> ^[13]	64 (mean)	19.5	primary Osteoarthritis	2 nd	Cemented (<i>n</i> = 124)	Cementless (<i>n</i> = 126)	direct lateral	
Kim <i>et al</i> ^[14]	43.4 to 46.8	18.4	Avascular necrosis (most)	3 rd	Hybrid (<i>n</i> = 109)	Cementless (<i>n</i> = 110)	ND	May overlap with Kim <i>et al</i> ^[15]
McCombe <i>et al</i> ^[16]	67.3	6.5 to 8	Primary OA (most)	2 nd	Cemented (<i>n</i> = 84)	Hybrid (<i>n</i> = 78)	posterolateral	
Berend <i>et al</i> ^[17]	67.1	6.8	Osteoarthritis (most)	ND	Cemented (<i>n</i> = 1908)	Cementless (<i>n</i> = 623)	anterolateral and posterior	
Clohisy <i>et al</i> ^[18]	61 to 62	10 to 11	Osteoarthritis	2 nd	Cemented (<i>n</i> = 45)	Hybrid (<i>n</i> = 45)	posterolateral	
Emerson <i>et al</i> ^[8]	55 to 70	6.7 to 7.2	Osteoarthritis (most)	3 rd	Hybrid (<i>n</i> = 113)	Cementless (<i>n</i> = 88)	anterolateral	
Hartofilakidis <i>et al</i> ^[19]	39.6 to 45.4	12.4 to 15.4	Osteoarthrosis secondary to congenital hip disease (most)	2 nd	Cemented (<i>n</i> = 59)	Hybrid (<i>n</i> = 58)	lateral transtrochanteric	
Kim <i>et al</i> ^[15]	64.6	17.3	Avascular necrosis	3 rd	Hybrid (<i>n</i> = 50)	Cementless (<i>n</i> = 98)	ND	May overlap with <i>et al</i> ^[14]
Pospula <i>et al</i> ^[20]	46.7 to 53.7	3 to 5	Avascular necrosis (most)	ND	Cemented (<i>n</i> = 87)	Cementless (<i>n</i> = 95)	cemented posterolateral cementless transgluteal	
Van Stralen <i>et al</i> ^[21]	69.5	2.5	Primary OA (most)		Cemented (<i>n</i> = 746)	Cementless (<i>n</i> = 138)	posterior	
Thomason <i>et al</i> ^[22]	54	7.4	Rheumatoid arthritis	ND	Hybrid (<i>n</i> = 47)	Cementless (<i>n</i> = 51)	posterior	
Zimmerman <i>et al</i> ^[7]	74.9	1	Osteoarthritis	ND	Hybrid (<i>n</i> = 85)	Cementless (<i>n</i> = 174)	anterolateral, posterior	
Conroy <i>et al</i> ^[23]	Any	5	Osteoarthritis	ND	Cemented (<i>n</i> = 8945); hybrid (<i>n</i> = 20445); Cementless (<i>n</i> = 28582)		ND	
Dale <i>et al</i> ^[24]	Any	0 to 20	Osteoarthritis (most)	ND	Cemented (<i>n</i> = 82996)	Cementless (<i>n</i> = 14348)	ND	May overlap with study of <i>et al</i> ^[16]
Engesaeter <i>et al</i> ^[25]	Any	0 to 16	Primary Osteoarthritis	ND	Cemented (<i>n</i> = 51016)	Cementless (<i>n</i> = 5259)	ND	May overlap with <i>et al</i> ^[15]
Eskelinen <i>et al</i> ^[26]	< 55	0 to 24	Rheumatoid arthritis	ND	Cemented (<i>n</i> = 821)	Cementless (<i>n</i> = 724)	ND	
Hailer <i>et al</i> ^[27]	Any	15	Osteoarthritis (most)	ND	Cemented (<i>n</i> = 161460)	Cementless (<i>n</i> = 8593)	ND	
Hooper <i>et al</i> ^[28]	Any	7	ND	ND	Cemented (<i>n</i> = 16005); hybrid (<i>n</i> = 15189)		ND	
Lucht <i>et al</i> ^[29]	Any	4		ND	Cemented (<i>n</i> = 11671); hybrid (<i>n</i> = 4491)		ND	
Mäkelä <i>et al</i> ^[30]	> 55	15	Osteoarthritis	ND	Cemented (<i>n</i> = 9549)	Cementless (<i>n</i> = 10310)	ND	
Mäkelä <i>et al</i> ^[31]	63 to 69 (> 55)	15	Rheumatoid arthritis	ND	Cemented (<i>n</i> = 3440)	Cementless (<i>n</i> = 579)	ND	
Mäkelä <i>et al</i> ^[32]	< 55	15	Osteoarthritis	ND	Cemented (<i>n</i> = 2342)	Cementless (<i>n</i> = 1326)	ND	
Malchau <i>et al</i> ^[33]	All	8	Osteoarthritis (most)	ND	Cemented (<i>n</i> = 178762)	Cementless (<i>n</i> = 6102)	ND	
Pedersen <i>et al</i> ^[34]	Any	0 to 14	Osteoarthritis (most)	ND	Cemented (<i>n</i> = 34656); cementless (<i>n</i> = 25571)		ND	
Roberts <i>et al</i> ^[35]	All	ND	ND	ND	Hybrid (<i>n</i> = 20539)			
					Cemented (<i>n</i> = 92928)	Cementless (<i>n</i> = 69882)	ND	

Dislocation of any component: Data from two cohorts and five registers were available to determine dislocation of any component (Figure 5). Analysis of cohorts found

no difference in dislocation of any component between any types of THR while analysis of registers favors cemented THR (RR = 0.69; 95%CI: 0.29-1.67 and RR

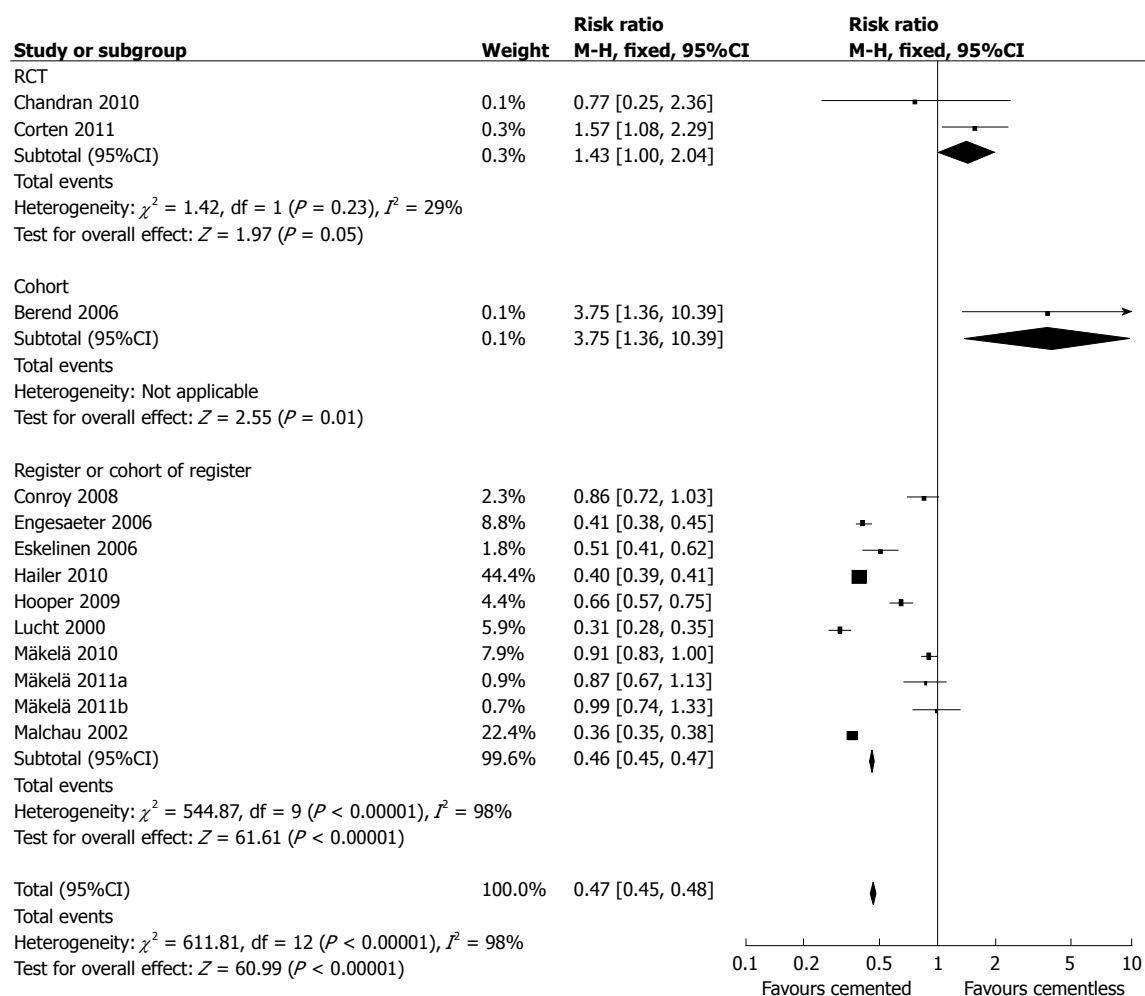


Figure 2 Forest plot of comparison: Cemented vs cementless: Revision of any component due to any reason.

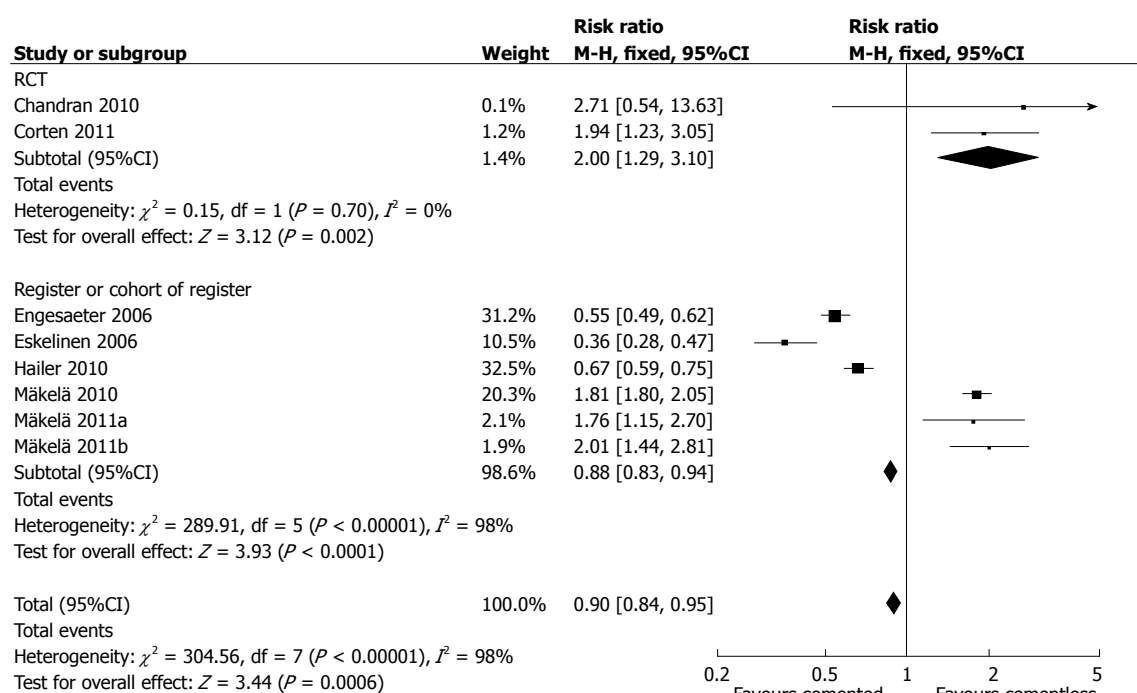


Figure 3 Forest plot of comparison: Cemented vs cementless: Revision of any component due to aseptic loosening.

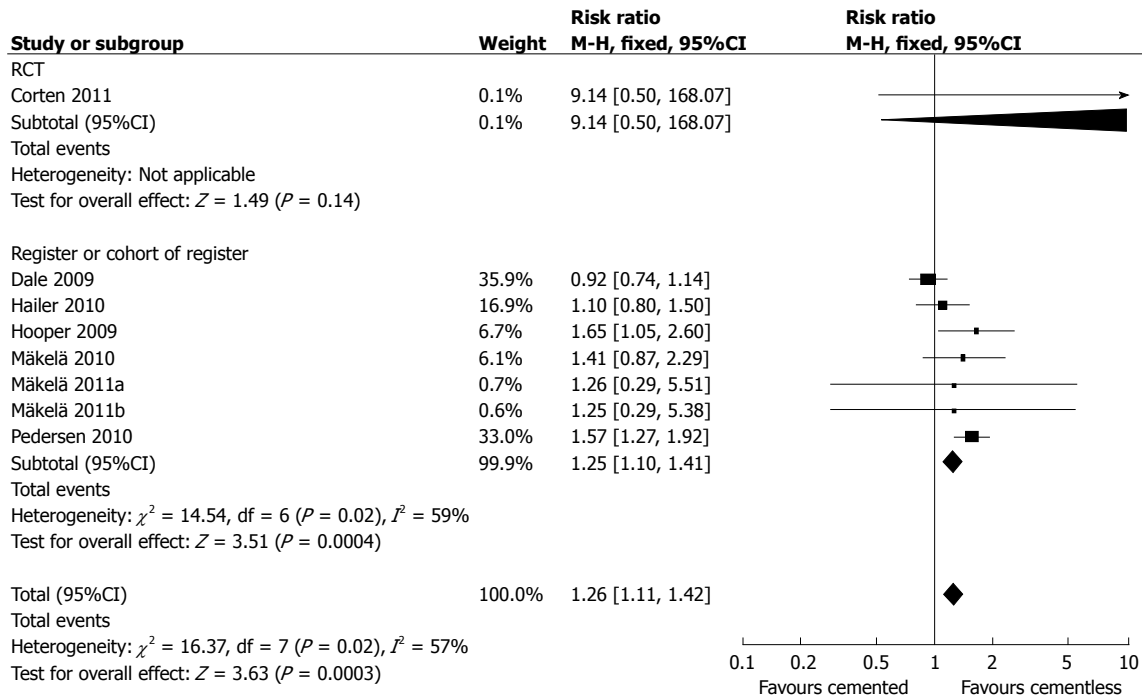


Figure 4 Forest plot of comparison: Cemented vs cementless: Revision of any component due to infection.

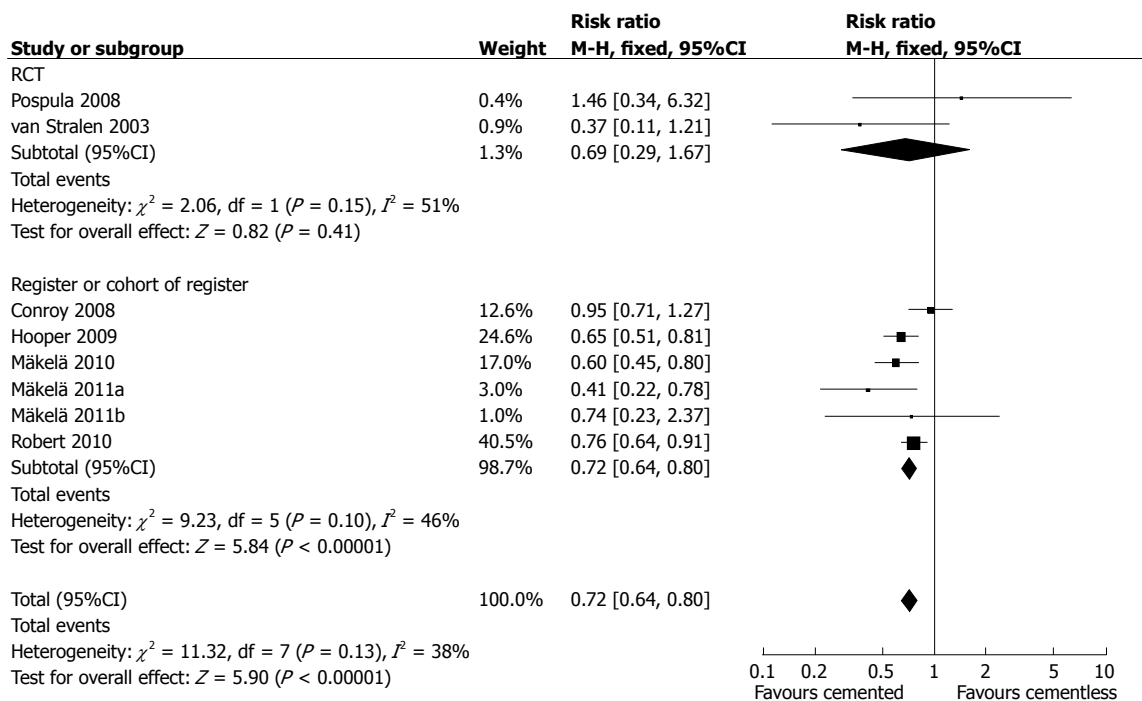


Figure 5 Forest plot of comparison: Cemented vs cementless: Dislocation of any component.

= 0.72; 95%CI: 0.64-0.80 respectively). Pooled RR was 0.72 (95%CI: 0.64-0.80) with heterogeneity of 38%.

Cemented vs hybrid THR

Revision of any component due to any reason:

Revision of any component due to any reason was addressed by two RCTs, one cohort, and three registers (Figure 6). Analysis of RCTs showed similar risk of revision of any component due to any reason while

analysis of registers favored cemented fixation (RR = 0.73; 95%CI: 0.47-1.13 and RR = 0.82; 95%CI: 0.76-0.89 respectively). Pooled all studies together, the RR was 0.82 (95%CI: 0.76-0.89) with a heterogeneity of 41%.

Revision of any component due to aseptic loosening: Only one RCT and one cohort provided information for evaluation of revision of any component

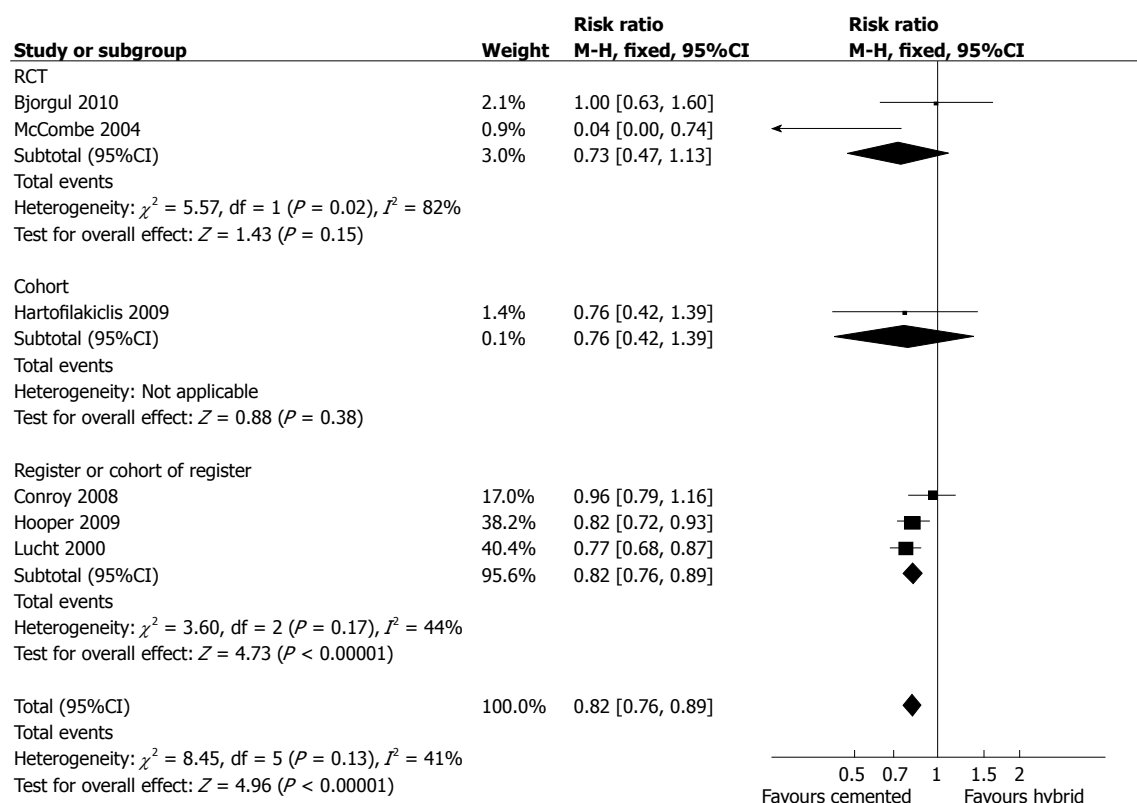


Figure 6 Forest plot of comparison: Cemented vs hybrid: Revision of any component due to any reason.

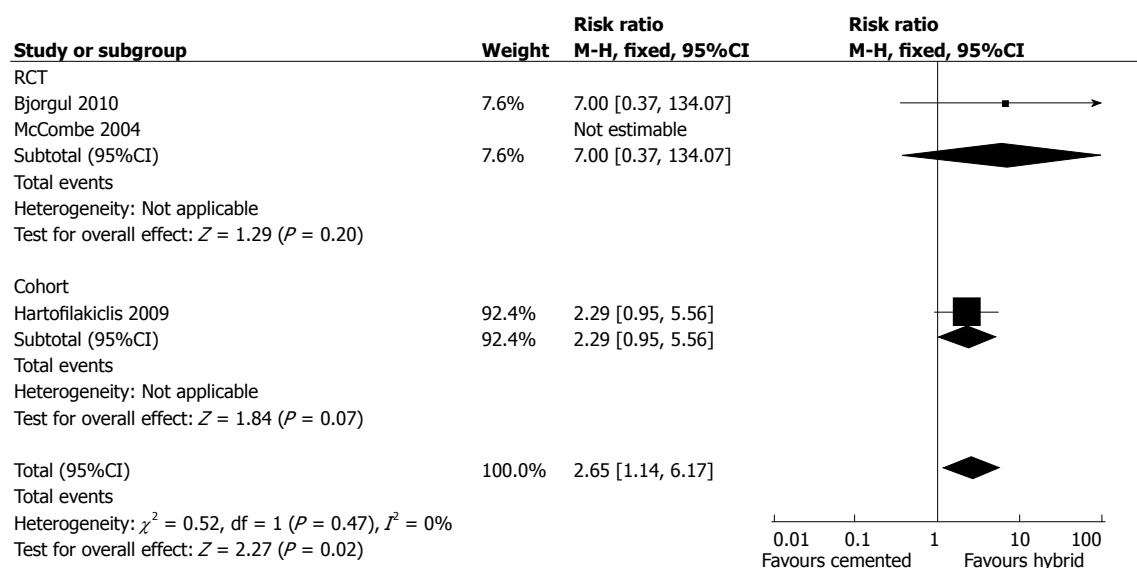


Figure 7 Forest plot of comparison: Cemented vs hybrid: Revision of any component due to aseptic loosening.

due to aseptic loosening (Figure 7). When both studies were pooled, the RR was 2.65 (95%CI: 1.14-6.17) and the heterogeneity was 0%.

Revision of any component due to infection: Two RCTs and one cohort and two registers reported revision of any component due to infection (Figure 8). However, one RCT and the cohort encountered zero-event in both arms, so only meta-analysis of registers could be

conducted, resulting in RR of 0.94 (95%CI: 0.80-1.11). If all types of study were pooled together, the RR was 0.92 (95%CI: 0.78-1.08) with heterogeneity of 42%.

Dislocation of any component: One RCT and two registers addressed dislocation of any component (Figure 9). Analysis of registers found that risk of dislocation of any component in cemented THR was lower than hybrid THR (RR = 0.11; 95%CI: 0.77-1.59). Pooled together,

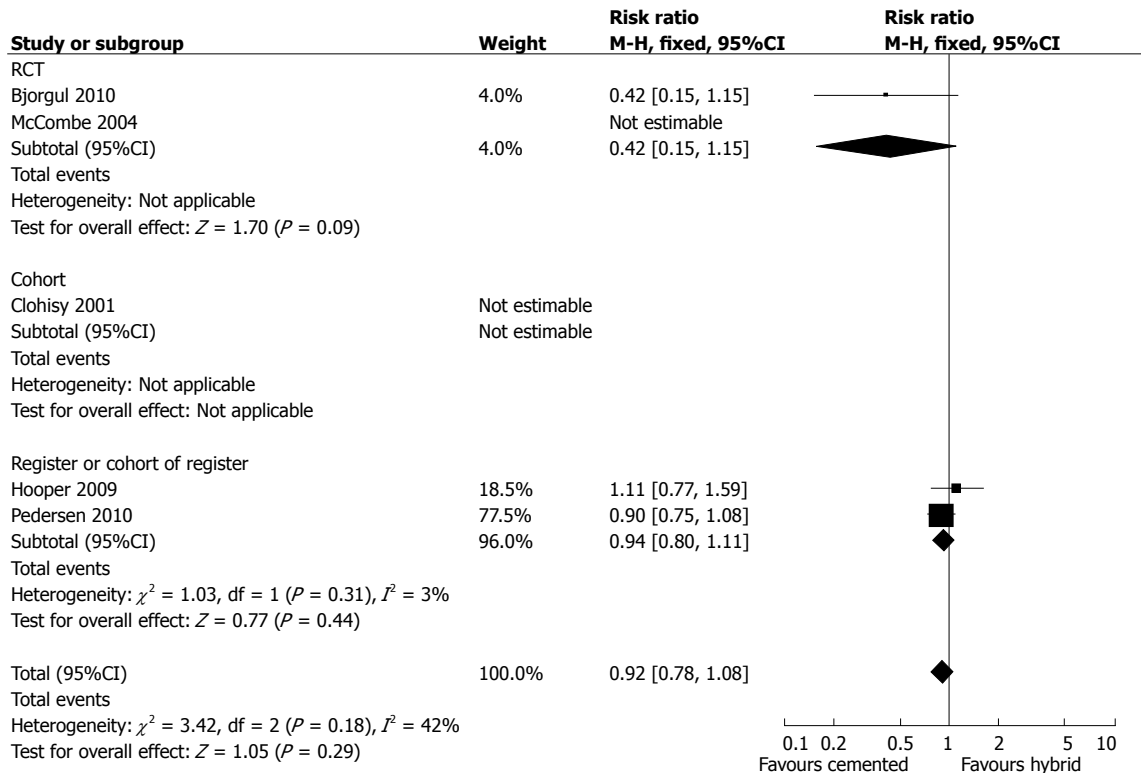


Figure 8 Forest plot of comparison: Cemented vs hybrid: Revision of any component due to infection.

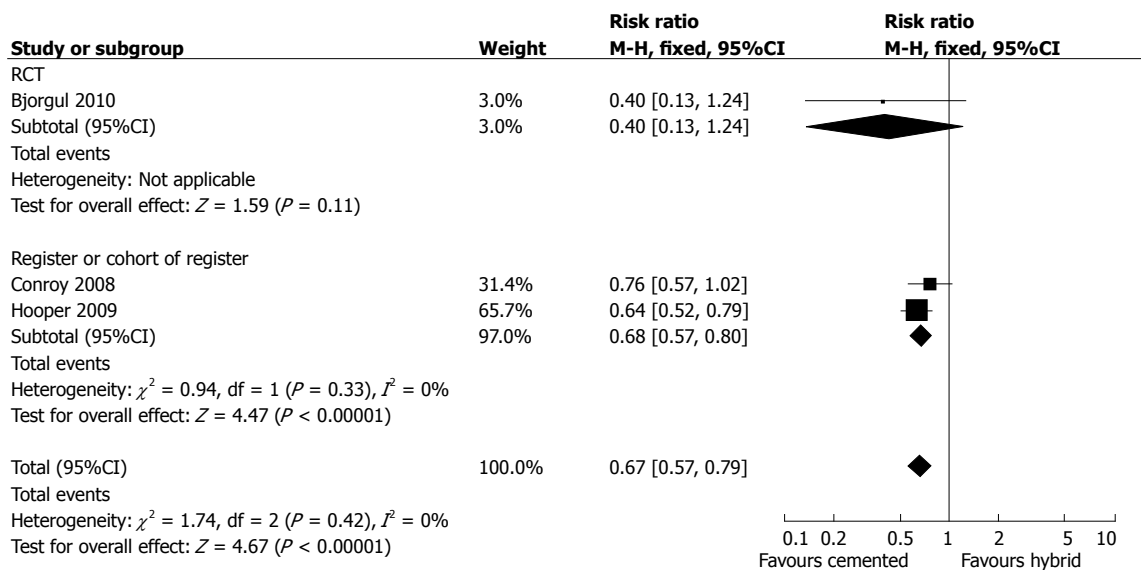


Figure 9 Forest plot of comparison: Cemented vs hybrid: Dislocation of any component.

the RR was 0.67 (95%CI: 0.57-0.79) with heterogeneity of 0%.

Cementless vs hybrid THR

Revision of any component due to any reason: One RCT, four cohorts, and three registers investigated revision of any component due to any reason. Analysis of cohorts found similar risk while analysis of registers favored hybrid THR (Figure 10). Meta-regression reduced the heterogeneity into 23.7% but none of the factors

analyzed (age group, diagnosis, length of follow-up, starting year, publication type, and funding) showed significant influence.

Revision of any component due to aseptic loosening: One RCT and three cohorts addressed risk of revision of any component due to aseptic loosening (Figure 11). However, one cohorts encountered zero-events in both arms so only two cohorts were eligible for further analysis, which revealed no difference (RR = 0.84;

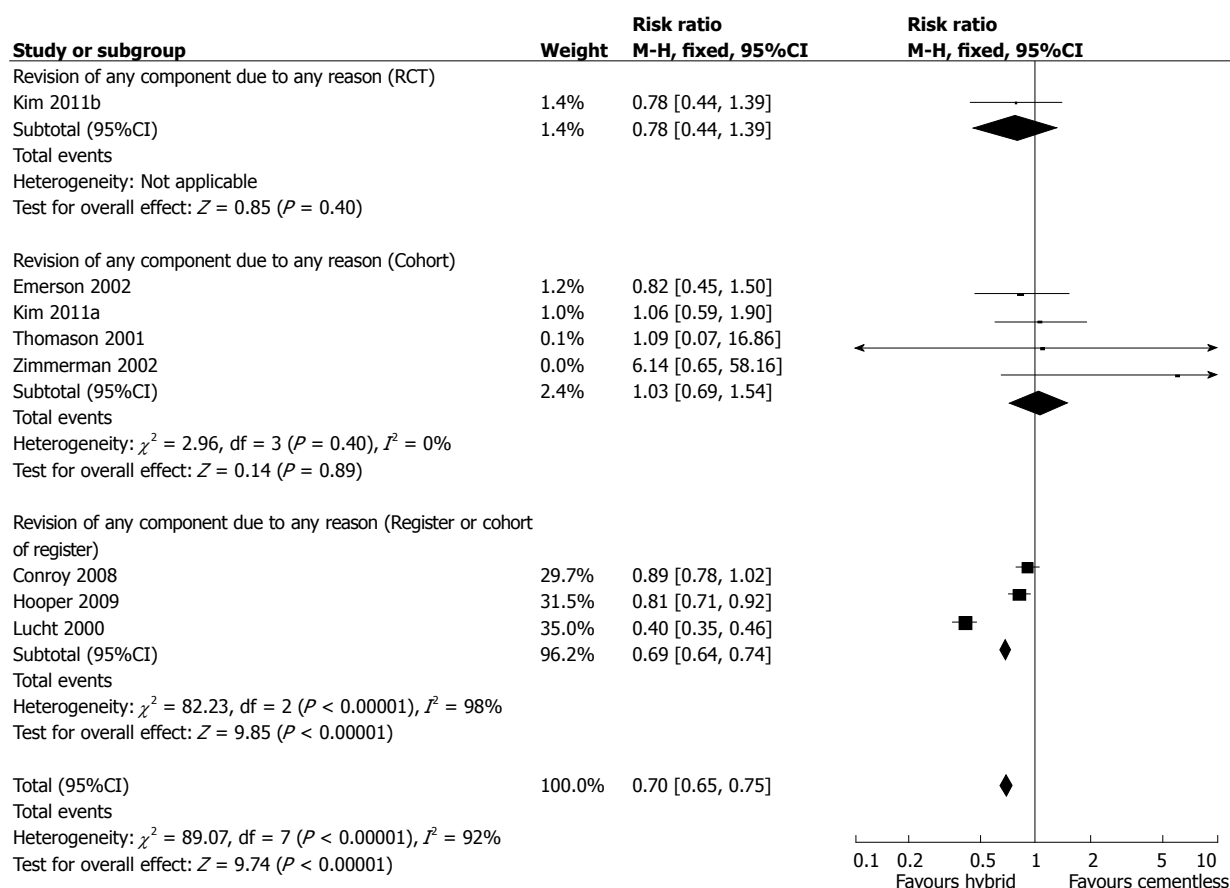


Figure 10 Forest plot of comparison: Cementless vs hybrid: Revision of any component due to any reason.

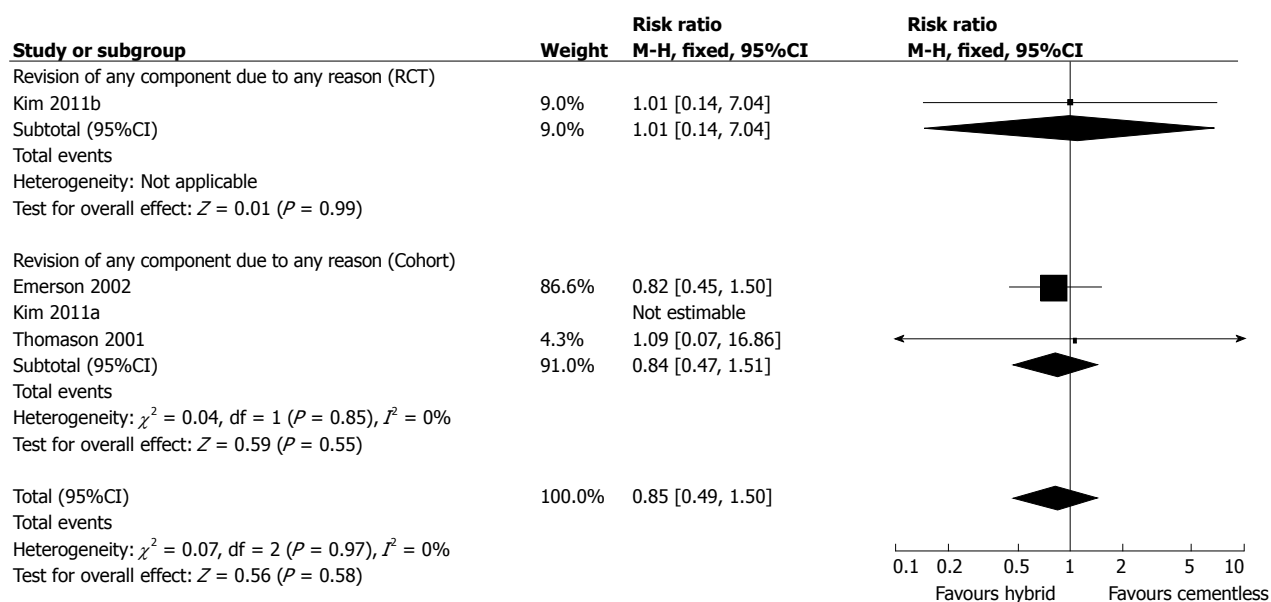


Figure 11 Forest plot of comparison: Cementless vs hybrid: Revision of any component due to infection.

95%CI: 0.47-1.51). Pooled all study types together; the RR was 0.85 (95%CI: 0.49-1.50) with heterogeneity of 0%.

Revision of any component due to infection: One

RCT, three cohorts, and two registers addressed revision of any component due to infection (Figure 12). However, two cohorts encountered zero events in both arm of studies so insufficient cohort was left for further analysis. Analysis of registers revealed RR of 1.69 (95%CI:

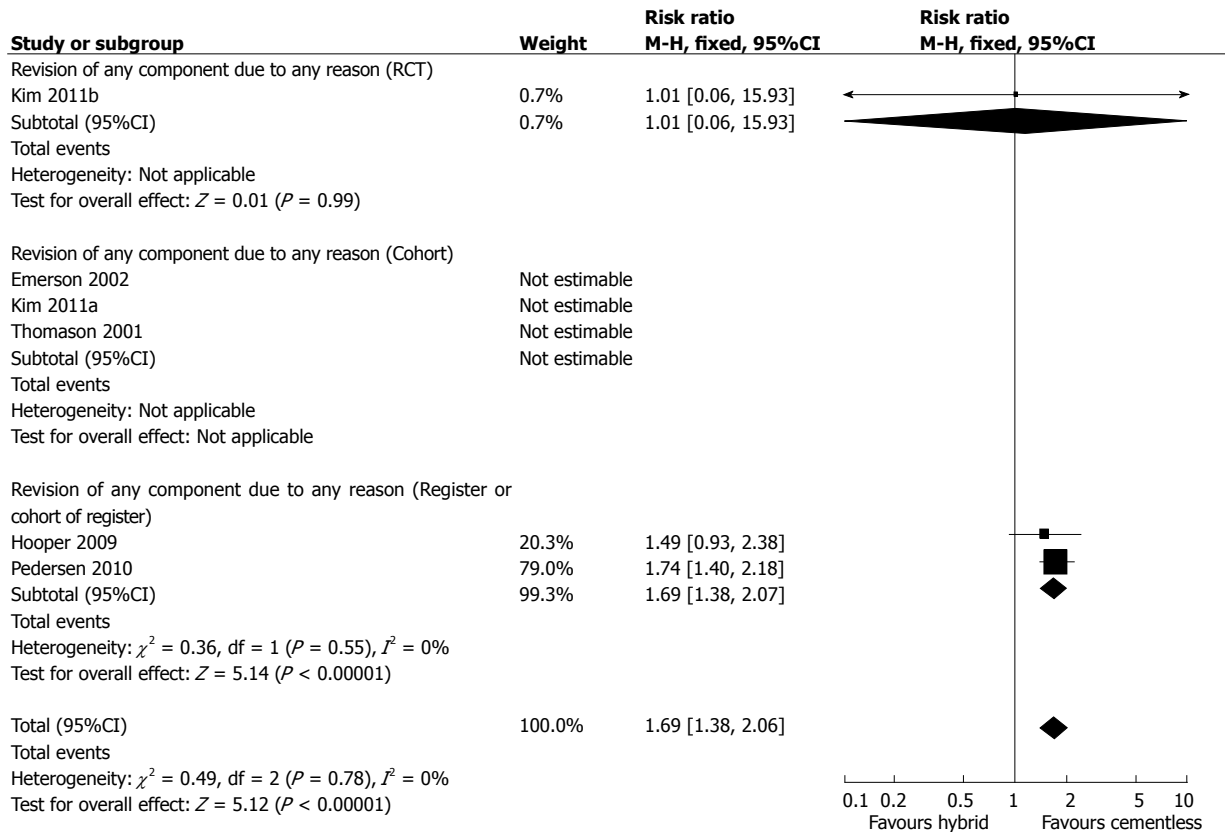


Figure 12 Forest plot of comparison: Cementless vs hybrid: Revision of any component due to infection.

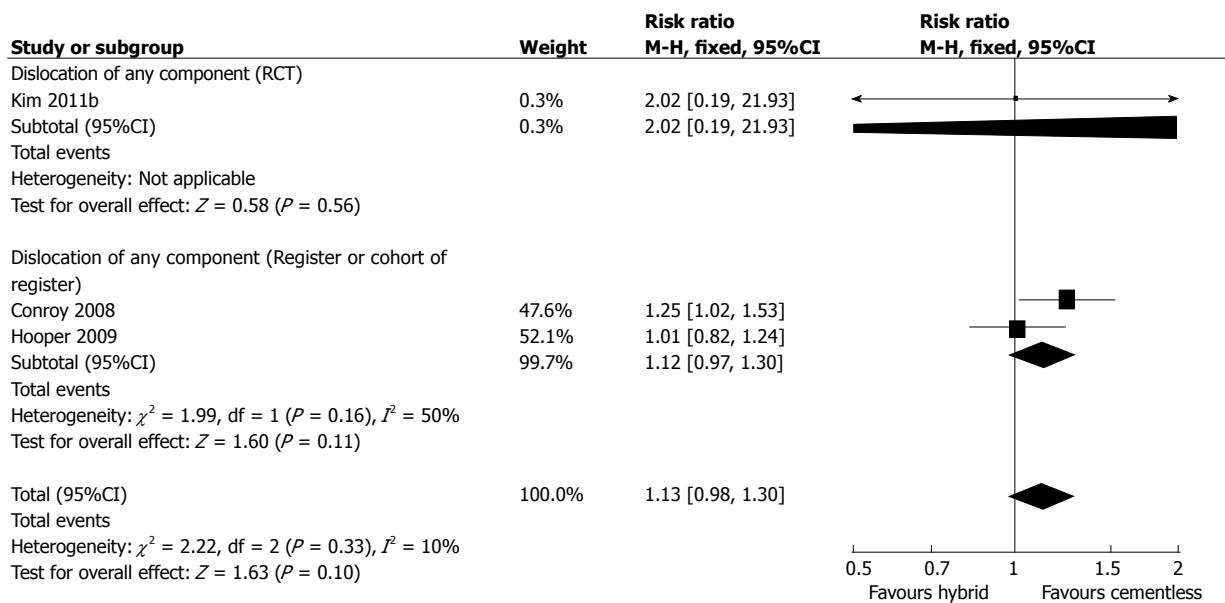


Figure 13 Forest plot of comparison: Cementless vs hybrid: Dislocation of any component.

1.38-2.07). If all available studies were put together, the RR was 1.69 (95%CI: 1.38-2.06) and the heterogeneity was 0%.

Dislocation of any component: One RCT and two cohorts evaluated risk of dislocation (Figure 13). Analysis of the registers resulted in insignificant difference

between any types of THR (RR = 1.12; 95%CI: 0.97-1.30). Pooled all study types together; the RR was 1.13 (95%CI: 0.98-1.30).

Analysis of publication bias: Figure 14 showed funnel plots based on risk of revision of any component due to any reason between cemented and cementless

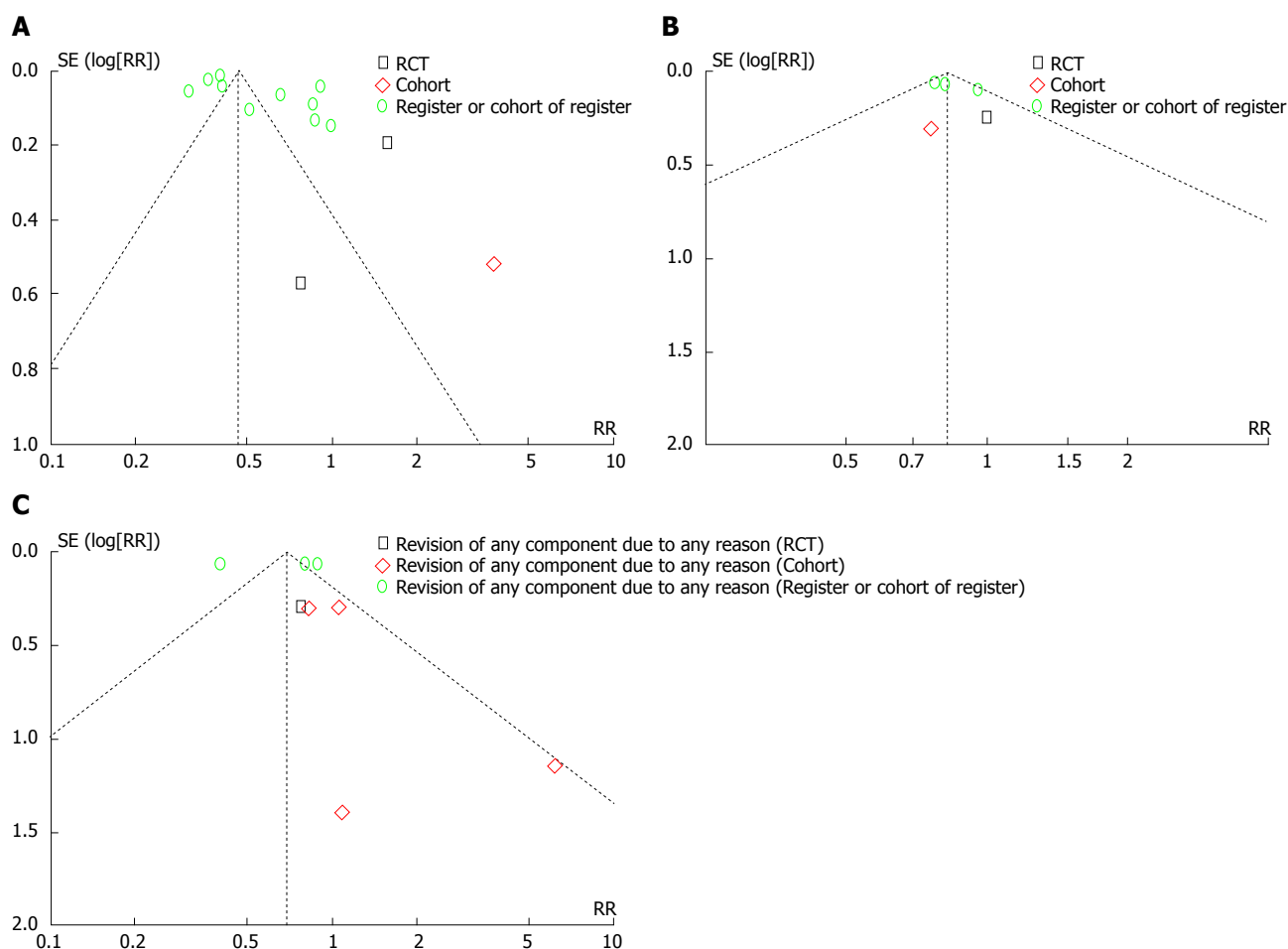


Figure 14 Funnel plot of comparison of revision of any component (A) cementless vs cementless; (B) cemented vs hybrid; (C) cementless vs hybrid.

(a), cemented and hybrid (b), and cementless and hybrid THR (c). Asymmetries were found in these plots suggesting the existence of bias.

Grading of the evidence: Most of the results were of low to very low level of evidence. The summaries of the grading were shown in Tables 2-4.

DISCUSSION

We summarized the evidence from 5 randomized clinical trials, 9 cohorts, and 13 registers or cohorts of register about total hip replacement and found that that cemented THR was superior to cementless THR and hybrid THR in terms of risk of revision due to any reason. Moreover, cemented THR was also more superior compared with cementless THR if revision due to aseptic loosening and revision due to dislocation were used as the endpoint but inferior if revision due to infection was used. Cemented THR was superior to hybrid THR in the risk of revision due to any reason and dislocation. Meanwhile cementless THR was most inferior compared to the others in risk of revision due to any reason.

In our knowledge, Morshed *et al.*^[9] performed the first metaanalysis reviewing the survival and outcome of cemented and uncemented fixation in total hip

replacement in 2007. Although cemented fixation seemed to outperform cementless fixation in large subsets of study population, there was no significant advantages were found for either type of fixation in terms of survival. There was an association between difference in survival and year of publication, with cementless fixation showing relative superiority over time. However, our recent analysis still suggested that cemented fixation continued to outperform uncemented fixation especially in large study populations (registers)^[24,26-33].

Recent metaanalysis by Abdulkarim *et al.*^[37] reviewed 9 RCTs that primarily comparing implants survival between cemented and cementless THR. In their study, no significant differences were found in implant survival especially as measured by the revision rate. By using RCT, which is the gold standard of clinical research, the quality of evidence in GRADE approach should be moderate or even high. However, the average follow up duration were only 4.3 years (2-8 years), which was relatively short to evaluate the implant survival.

In our study, an analysis of 2 RCTs comparing the survival of cemented and cementless implant was performed. As the duration of follow up ranged from 14-19 years, these RCTs would give a better evaluation in terms of implant survival. In this analysis, the relative risk of revision due to any revision was higher in cemented

Table 2 Summary of finding comparing cemented and cementless total hip replacement

	Illustrative comparative risks ⁷ (95%CI)		Relative effect (95%CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Cementless	Cemented				
Revision of any component due to any reason - RCT Follow-up: 14 to 19.5 yr	Study population 165 per 1000 Moderate 156 per 1000	235 per 1000 (165 to 336) 223 per 1000 (156 to 318)	RR 1.43 (1 to 2.04)	452 (2 studies)	++-- low ^{1,2}	
Revision of any component due to any reason - Register or Cohort of register Follow-up: 0 to 24 yr	Study population 99 per 1000 Moderate 122 per 1000	46 per 1000 (45 to 47) 56 per 1000 (55 to 57)	RR 0.46 (0.45 to 0.47)	518774 (10 studies)	+--- very low ^{2,3,4}	
Revision of any component due to any reason - All types of study Follow-up: 0 to 24 yr	Study population 99 per 1000 Moderate 106 per 1000	46 per 1000 (44 to 47) 50 per 1000 (48 to 51)	RR 0.47 (0.45 to 0.48)	521757 (13 studies)	+--- very low ^{2,3,5}	
Revision of any component due to aseptic loosening - RCT Follow-up: 14 to 19.5 yr	Study population 104 per 1000 Moderate 97 per 1000	208 per 1000 (134 to 322) 194 per 1000 (125 to 301)	RR 2 (1.29 to 3.1)	452 (2 studies)	+++-- moderate ²	
Revision of any component due to aseptic loosening - Register or Cohort of register Follow-up: 0 to 24 yr	Study population 47 per 1000 Moderate 48 per 1000	41 per 1000 (39 to 44) 42 per 1000 (40 to 45)	RR 0.88 (0.83 to 0.94)	255779 (6 studies)	+--- very low ^{2,3,4}	
Revision of any component due to aseptic loosening - All types of study Follow-up: 0 to 24 yr	Study population 47 per 1000 Moderate 48 per 1000	43 per 1000 (40 to 45) 43 per 1000 (40 to 46)	RR 0.9 (0.84 to 0.95)	256231 (8 studies)	+--- very low ^{2,3,5,6}	
Revision of any component due to infection - Register or Cohort of register Follow-up: 0 to 20 yr	Study population 5 per 1000 Moderate 4 per 1000	6 per 1000 (5 to 7) 5 per 1000 (4 to 6)	RR 1.27 (1.04 to 1.55)	382433 (6 studies)	+--- very low ^{2,4}	
Revision of any component due to infection - All types of study Follow-up: 0 to 20 yr	Study population 5 per 1000 Moderate 4 per 1000	6 per 1000 (5 to 7) 5 per 1000 (4 to 6)	RR 1.29 (1.06 to 1.57)	382683 (7 studies)	+--- very low ^{2,5}	
Dislocation of any component - Cohort Follow-up: 2.5 to 5 yr	Study population 30 per 1000 Moderate 30 per 1000	21 per 1000 (9 to 50) 21 per 1000 (9 to 50)	RR 0.69 (0.29 to 1.67)	1066 (2 studies)	+--- very low ^{1,2,3}	
Dislocation of any component - Register or Cohort of register Follow-up: 5 to 15 yr	Study population 6 per 1000 Moderate 13 per 1000	4 per 1000 (4 to 5) 9 per 1000 (8 to 10)	RR 0.69 (0.59 to 0.8)	254786 (6 studies)	+--- very low ^{3,4}	
Dislocation of any component - All types of study Follow-up: 2.5 to 15 yr	Study population 6 per 1000 Moderate 14 per 1000	4 per 1000 (4 to 5) 10 per 1000 Ta(8 to 11)	RR 0.69 (0.6 to 0.79)	255852 (8 studies)	+--- very low ^{2,5}	

CI: Confidence interval; RR: Risk ratio; GRADE Working Group grades of evidence; High quality: Further research is very unlikely to change our confidence in the estimate of effect; moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; very low quality: We are very uncertain about the estimate. ¹95% confidence interval around the pooled or best estimate of effect includes both (1) no effect and (2) appreciable benefit or appreciable harm (> 25%); ²No explanation was provided; ³Unexplained heterogeneity; ⁴Indirect studies from registers; ⁵Overall result from all types of study; ⁶High heterogeneity, explained by meta-regression; ⁷The basis for the assumed risk (e.g., the median control group risk across studies) is provided in footnotes. The corresponding risk (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95%CI).

group with RR = 1.43 (1-2.04), which also meant that the cementless implant was superior. But it were pooled together with the cohort studies and registers, the results would be contradictive as it favored the cemented implant with RR = 0.47 (0.46-0.48).

Despite the tendencies of most registers towards cemented implant, there are some studies and even

some registries^[29,30,33] noted that uncemented implant survived better in the group of younger patients. Malchau *et al.*^[33] in their Swedish arthroplasty register, found that uncemented implants had better survival in patients with less than 55 years of age. Similar findings were reported by the Lucht *et al.*^[29] when they evaluated the Danish arthroplasty register. Eskelinen *et al.*^[26] in the Finnish

Table 3 Summary of finding table comparing cemented to hybrid total hip replacement

Outcomes	Illustrative comparative risks ⁶ (95%CI)		Relative effect (95%CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Hybrid	Cemented				
Revision of any component due to any reason - RCT Follow-up: 6.5 to 14 yr	Study population 187 per 1000 Moderate 177 per 1000	136 per 1000 (88 to 211) 129 per 1000 (83 to 200)	RR 0.73 (0.47 to 1.13)	402 (2 studies)	+--- very low ^{1,2,3}	
Revision of any component due to any reason - Register or Cohort of register Follow-up: 4 to 7 yr	Study population 30 per 1000 Moderate 31 per 1000	24 per 1000 (23 to 26) 25 per 1000 (24 to 28)	RR 0.82 (0.76 to 0.89)	76746 (3 studies)	+--- very low ^{3,4}	
Revision of any component due to any reason - All types of study Follow-up: 4 to 15.4 yr	Study population 31 per 1000 Moderate 104 per 1000	25 per 1000 (23 to 27) 85 per 1000 (79 to 93)	RR 0.82 (0.76 to 0.89)	77265 (6 studies)	+--- very low ^{3,5}	
Revision of any component due to aseptic loosening - All types of study Follow-up: 6.5 to 15.4 yr	Study population 23 per 1000 Moderate 0 per 1000	62 per 1000 (27 to 145) 0 per 1000 (0 to 0)	RR 2.65 (1.14 to 6.17)	519 (3 studies)	+--- very low ^{3,5}	
Revision of any component due to infection - Register or Cohort of register Follow-up: 0 to 14 yr	Study population 7 per 1000 Moderate	0 per 1000 (0 to 0)	Not estimable	86389 (2 studies)	+--- very low ^{3,4}	
Revision of any component due to infection - All types of study Follow-up: 0 to 14 yr	Study population 7 per 1000 Moderate 2 per 1000	7 per 1000 (5 to 10) 2 per 1000 (1 to 3)	RR 0.98 (0.7 to 1.38)	86881 (5 studies)	+--- very low ^{1,2,3,5}	
Dislocation of any component - Register of Cohort of register Follow-up: 5 to 7 yr	Study population 11 per 1000 Moderate 11 per 1000	7 per 1000 (6 to 9) 7 per 1000 (6 to 9)	RR 0.68 (0.57 to 0.8)	60584 (2 studies)	+--- very low ^{3,4}	
Dislocation of any component - All types of study Follow-up: 5 to 14 yr	Study population 11 per 1000 Moderate 14 per 1000	7 per 1000 (6 to 9) 9 per 1000 (8 to 11)	RR 0.67 (0.57 to 0.79)	60824 (3 studies)	+--- very low ^{3,5}	

CI: Confidence interval; RR: Risk ratio; GRADE Working Group grades of evidence; High quality: Further research is very unlikely to change our confidence in the estimate of effect; moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; very low quality: We are very uncertain about the estimate. ¹95% confidence interval around the pooled or best estimate of effect includes both (1) no effect and (2) appreciable benefit or appreciable harm (> 25%); ²No explanation was provided; ³Unexplained heterogeneity; ⁴Indirect studies from registers; ⁵Overall result from all types of study; ⁶The basis for the assumed risk (e.g., the median control group risk across studies) is provided in footnotes. The corresponding risk (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95%CI).

arthroplasty register, reported that in age group under 55-years had higher revision rates for aseptic loosening in cemented group compared with proximally coated cementless femoral components. Further analysis of Finnish arthroplasty register in patients aged 55-year and older showed that uncemented femoral stem has better survival in the 55 to 74-year age group while there was no significant difference in 75-year and older patients^[30].

This series of studies might explain the reason why contradictory result occurred in our analysis. In their inclusion criteria, both RCTs used 75 years as the upper age limit without any lower age limit, and the average age in both RCTs was around 64 years^[12,13]. It was seemed that this fact might play a role in our result.

Hybrid THR was first introduced to address the

results of cemented THR in younger patients in whom acetabular failure was the main reason for revision. However, recent studies reported that hybrid THR was the most common THR types to be revised due to dislocation in the first 90 d and even after 90 d after the primary surgery^[28]. In their prospective multicenter study about primary total hip arthroplasty revision due to dislocation, Girard *et al.*^[38] described that, from their revision series, cementless acetabular fixation and cemented femoral stem fixation were involved in a higher number of dislocation which are 63.8% and 53% respectively. However it was not mentioned about the reason why cementless acetabular fixation has a higher chance of dislocation compared to the cemented one. Although there are no supporting data, there was a hypothesis

Table 4 Summary of finding table comparing hybrid and cementless total hip replacement

Outcomes	Illustrative comparative risks ⁷ (95%CI)		Relative effect (95%CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Cementless	Hybrid				
Revision of any component due to any reason - Cohort Follow-up: 1 to 17.3 yr	Study population 105 per 1000 Moderate 106 per 1000	108 per 1000 (72 to 161) 109 per 1000 (73 to 163)	RR 1.03 (0.69 to 1.54)	706 (4 studies)	+--- very low ^{1,2}	
Revision of any component due to any reason - Register or Cohort of register Follow-up: 4 to 7 yr	Study population 33 per 1000 Moderate 39 per 1000	23 per 1000 (21 to 25) 27 per 1000 (25 to 29)	RR 0.69 (0.64 to 0.74)	81635 (3 studies)	+--- very low ^{2,3,4}	
Revision of any component due to any reason - All types of study Follow-up: 1 to 18.4 yr	Study population 34 per 1000 Moderate 116 per 1000	24 per 1000 (22 to 26) 81 per 1000 (75 to 87)	RR 0.7 (0.65 to 0.75)	82560 (8 studies)	+--- very low ^{2,5,6}	
Revision of any component due to aseptic loosening - Cohort Follow-up: 6.7 to 17.3 yr	Study population 76 per 1000 Moderate 20 per 1000	64 per 1000 (36 to 115) 17 per 1000 (9 to 30)	RR 0.84 (0.47 to 1.51)	447 (3 studies)	+--- very low ^{1,2}	
Revision of any component due to aseptic loosening - All types of study Follow-up: 6.7 to 17.3 yr	Study population 58 per 1000 Moderate 19 per 1000	49 per 1000 (28 to 86) 16 per 1000 (9 to 28)	RR 0.85 (0.49 to 1.5)	666 (4 studies)	+--- very low ^{1,2,6}	
Revision of any component due to infection - Register or Cohort of register Follow-up: 0 to 14 yr	Study population 4 per 1000 Moderate	0 per 1000 (0 to 0)	Not estimable	72197 (2 studies)	+--- very low ^{2,4}	
Revision of any component due to infection - All types of study Follow-up: 0 to 18.4 yr	Study population 4 per 1000 Moderate 0 per 1000	6 per 1000 (4 to 10) 0 per 1000 (0 to 0)	RR 1.47 (0.93 to 2.34)	72863 (5 studies)	+--- very low ^{1,2,6}	
Dislocation of any component - Register or Cohort of register Follow-up: 5 to 7 yr	Study population 9 per 1000 Moderate 10 per 1000	10 per 1000 (9 to 11) 11 per 1000 (10 to 13)	RR 1.12 (0.97 to 1.3)	75114 (2 studies)	+--- very low ^{1,2,4}	
Dislocation of any component - All types of study Follow-up: 5 to 18.4 yr	Study population 9 per 1000 Moderate 9 per 1000	10 per 1000 (9 to 11) 10 per 1000 (9 to 12)	RR 1.13 (0.98 to 1.3)	75333 (3 studies)	+--- very low ^{1,2,6}	

CI: Confidence interval; RR: Risk ratio; GRADE Working Group grades of evidence; High quality: Further research is very unlikely to change our confidence in the estimate of effect; moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate; low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate; very low quality: We are very uncertain about the estimate. ¹95% confidence interval around the pooled or best estimate of effect includes both (1) no effect and (2) appreciable benefit or appreciable harm (> 25%); ²No explanation was provided; ³Unexplained heterogeneity; ⁴Indirect studies from registers; ⁵Overall result from all types of study; ⁶High heterogeneity, explained by meta-regression; ⁷The basis for the assumed risk (e.g., the median control group risk across studies) is provided in footnotes. The corresponding risk (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95%CI).

that positioning of acetabular component may be more accurate in cemented components^[23]. Although Parrate and Argenson^[39] didn't include cemented acetabular cup in their study, they showed that 57% cementless cup that inserted in conventional way and 20% navigated were outside of the defined safe zone (outliers). While cementing the acetabular component, few adjustments can be made during insertion and while waiting for the cement polymerization. On the other hand, cementless cup has less adjustability and may change their orientation from the most desired position during the final seating of the component. Despite all, from the economic perspective, hybrid prostheses lead to grater gain in mean postoperative quality of life and the most cost

effective alternative for most patients according to cost effectiveness analysis model by Pennington *et al.*^[40].

Clinical trials, cohorts, and register-based studies were included into our meta-analysis. Inclusion of register based studies had certain benefits and limitations^[30,36]. Register provided large number of samples for analysis and the population data corresponded to the actual population^[36]. Moreover, a poor result in a single center would not have major effect on the result of the study^[30]. Despite RCTs is considered the gold standard design for clinical research, one of its disadvantages is that strict inclusion and exclusion criteria might not reflect the condition of real population, as it often narrowed the samples to a highly selected group of patients that is operated by only a

few surgeons. However, the desired outcome was not the main purpose of the registry. Accuracy of the data might be limited due to inconsistencies or errors in data collection inputted to the register^[41]. Data available in clinical trials and cohorts might also have been included in the register and therefore were used twice in the analysis.

Various implant designs, surgical approaches and techniques (such as cementing technique), rehabilitation protocols, and activity levels were included in our study. Lack of data prevented us to analyze them separately in subgroup analysis or in meta-regression. Therefore, it was understandable that high heterogeneity existed in our study. We explored the heterogeneity to the greatest degree possible, in to a meta-regression, yet very high heterogeneity remained in some comparison.

Very high heterogeneity indicated that effect size of each study varied greatly^[42]. Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working group recommended to lower the quality assessment in study with unexplained heterogeneity^[41]. Even though the result was obtain by a meta-analysis, interpreting the result must be careful.

In conclusion, despite some limitations in the selected studies especially the low quality assessment and heterogeneity, there was some tendency that cemented fixation was still superior than other types of fixation in terms of implant survival. Future high quality randomized clinical trials, preferably multicenter, to obtain larger sample size, considering all factors that may influent results, are required to give definite recommendations regarding the best type of total hip replacement.

COMMENTS

Background

Controversies still persisted on the optimal method of fixation for primary total hip replacement (THR). Previous meta-analysis found no difference between cemented and cementless implant, but since then, many larger studies with longer duration of follow-up had been conducted. In this meta-analysis, more recent studies were enrolled to determine whether cemented, cementless, or hybrid implant was superior to the other.

Research frontiers

Implant survival analysis in different type of THR fixation is still a controversial debate. Worldwide researches are still focused on which type of implant that suits best on patients to provide better care to the patients.

Innovations and breakthroughs

Despite some limitations in the selected studies especially the low quality assessment and heterogeneity, their study presented a metaanalysis of studies with a long duration of follow up, which would give a better perspective in terms of implant survival. There was some tendency that cemented fixation was still superior than other types of fixation.

Applications

There was some tendency that cemented fixation was still superior to other types of fixation.

Peer-review

It is well presented, well-structured and extensively build up and therefore useful for the readers.

REFERENCES

- 1 **Ostendorf M**, Johnell O, Malchau H, Dhert WJ, Schrijvers AJ, Verbout AJ. The epidemiology of total hip replacement in The Netherlands and Sweden: present status and future needs. *Acta Orthop Scand* 2002; **73**: 282-286 [PMID: 12143973 DOI: 10.1080/00016470.2320155257]
- 2 **Merx H**, Dreinhöfer K, Schröder P, Stürmer T, Puhl W, Günther KP, Brenner H. International variation in hip replacement rates. *Ann Rheum Dis* 2003; **62**: 222-226 [PMID: 12594106 DOI: 10.1136/ard.62.3.222]
- 3 **Felson DT**, Zhang Y. An update on the epidemiology of knee and hip osteoarthritis with a view to prevention. *Arthritis Rheum* 1998; **41**: 1343-1355 [PMID: 9704632 DOI: 10.1002/1529-0131(199808)41:8<1343::AID-ART3>3.0.CO;2-9]
- 4 **Wroblewski BM**. Cementless versus cemented total hip arthroplasty. A scientific controversy? *Orthop Clin North Am* 1993; **24**: 591-597 [PMID: 8414424]
- 5 **Rorabeck CH**, Bourne RB, Laupacis A, Feeny D, Wong C, Tugwell P, Leslie K, Bullas R. A double-blind study of 250 cases comparing cemented with cementless total hip arthroplasty. Cost-effectiveness and its impact on health-related quality of life. *Clin Orthop Relat Res* 1994; **(298)**: 156-164 [PMID: 8118970]
- 6 **Rorabeck CH**, Bourne RB, Mulliken BD, Nayak N, Laupacis A, Tugwell P, Feeney D. The Nicolas Andry award: comparative results of cemented and cementless total hip arthroplasty. *Clin Orthop Relat Res* 1996; **(325)**: 330-344 [PMID: 8998896 DOI: 10.1097/00003086-199604000-00044]
- 7 **Zimmerma S**, Hawkes WG, Hudson JI, Magaziner J, Hebel JR, Towheed T, Gardner J, Provenzano G, Kenzora JE. Outcomes of surgical management of total HIP replacement in patients aged 65 years and older: cemented versus cementless femoral components and lateral or anterolateral versus posterior anatomical approach. *J Orthop Res* 2002; **20**: 182-191 [PMID: 11918295 DOI: 10.1016/S0736-0266(01)00090-0]
- 8 **Emerson RH**, Head WC, Emerson CB, Rosenfeldt W, Higgins LL. A comparison of cemented and cementless titanium femoral components used for primary total hip arthroplasty: a radiographic and survivorship study. *J Arthroplasty* 2002; **17**: 584-591 [PMID: 12168174 DOI: 10.1054/arth.2002.32696]
- 9 **Morshed S**, Bozic KJ, Ries MD, Malchau H, Colford JM. Comparison of cemented and uncemented fixation in total hip replacement: a meta-analysis. *Acta Orthop* 2007; **78**: 315-326 [PMID: 17611843 DOI: 10.1080/17453670710013861]
- 10 **Moher D**, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Int J Surg* 2010; **8**: 336-341 [PMID: 20171303 DOI: 10.1016/j.ijsu.2010.02.007]
- 11 **Björgul K**, Novicoff WM, Andersen ST, Brevig K, Thu F, Wiig M, Ahlund O. No differences in outcomes between cemented and uncemented acetabular components after 12-14 years: results from a randomized controlled trial comparing Duraloc with Charnley cups. *J Orthop Traumatol* 2010; **11**: 37-45 [PMID: 20198405 DOI: 10.1007/s10195-010-0082-2]
- 12 **Chandran P**, Azzabi M, Miles J, Andrews M, Bradley J. Furlong hydroxyapatite-coated hip prosthesis vs the Charnley cemented hip prosthesis. *J Arthroplasty* 2010; **25**: 52-57 [PMID: 19056219 DOI: 10.1016/j.arth.2008.10.009]
- 13 **Corten K**, Bourne RB, Charron KD, Au K, Rorabeck CH. Comparison of total hip arthroplasty performed with and without cement: a randomized trial. A concise follow-up, at twenty years, of previous reports. *J Bone Joint Surg Am* 2011; **93**: 1335-1338 [PMID: 21792500 DOI: 10.2106/JBJS.J.00448]
- 14 **Kim YH**, Kim JS, Park JW, Joo JH. Comparison of total hip replacement with and without cement in patients younger than 50 years of age: the results at 18 years. *J Bone Joint Surg Br* 2011; **93**: 449-455 [PMID: 21464481 DOI: 10.1302/0301-620X.93B4.26149]
- 15 **Kim YH**, Kim JS, Park JW, Joo JH. Contemporary total hip arthroplasty with and without cement in patients with osteonecrosis

- of the femoral head: a concise follow-up, at an average of seventeen years, of a previous report. *J Bone Joint Surg Am* 2011; **93**: 1806-1810 [PMID: 22005866 DOI: 10.2106/JBJS.J.01312]
- 16 **McCombe P**, Williams SA. A comparison of polyethylene wear rates between cemented and cementless cups. A prospective, randomised trial. *J Bone Joint Surg Br* 2004; **86**: 344-349 [PMID: 15125120]
 - 17 **Berend ME**, Smith A, Meding JB, Ritter MA, Lynch T, Davis K. Long-term outcome and risk factors of proximal femoral fracture in uncemented and cemented total hip arthroplasty in 2551 hips. *J Arthroplasty* 2006; **21**: 53-59 [PMID: 16950062 DOI: 10.1016/j.arth.2006.05.014]
 - 18 **Clohisey JC**, Harris WH. Matched-pair analysis of cemented and cementless acetabular reconstruction in primary total hip arthroplasty. *J Arthroplasty* 2001; **16**: 697-705 [PMID: 11547367 DOI: 10.1054/arth.2001.24447]
 - 19 **Hartofilakidis G**, Georgiades G, Babis GC. A comparison of the outcome of cemented all-polyethylene and cementless metal-backed acetabular sockets in primary total hip arthroplasty. *J Arthroplasty* 2009; **24**: 217-225 [PMID: 18534419 DOI: 10.1016/j.arth.2007.11.010]
 - 20 **Pospula W**, Abu Noor T, Roshdy T, Al Mukaimi A. Cemented and cementless total hip replacement. Critical analysis and comparison of clinical and radiological results of 182 cases operated in Al Razi Hospital, Kuwait. *Med Princ Pract* 2008; **17**: 239-243 [PMID: 18408394 DOI: 10.1159/000117799]
 - 21 **van Stralen GM**, Struben PJ, van Loon CJ. The incidence of dislocation after primary total hip arthroplasty using posterior approach with posterior soft-tissue repair. *Arch Orthop Trauma Surg* 2003; **123**: 219-222 [PMID: 12684831 DOI: 10.1007/s00402-003-0482-3]
 - 22 **Thomason HC**, Lachiewicz PF. The influence of technique on fixation of primary total hip arthroplasty in patients with rheumatoid arthritis. *J Arthroplasty* 2001; **16**: 628-634 [PMID: 11503123 DOI: 10.1054/arth.2001.23720]
 - 23 **Conroy JL**, Whitehouse SL, Graves SE, Pratt NL, Ryan P, Crawford RW. Risk factors for revision for early dislocation in total hip arthroplasty. *J Arthroplasty* 2008; **23**: 867-872 [PMID: 18534522 DOI: 10.1016/j.arth.2007.07.009]
 - 24 **Dale H**, Hallan G, Hallan G, Espehaug B, Havelin LI, Engesaeter LB. Increasing risk of revision due to deep infection after hip arthroplasty. *Acta Orthop* 2009; **80**: 639-645 [PMID: 19995313 DOI: 10.3109/17453670903506658]
 - 25 **Engesaeter LB**, Espehaug B, Lie SA, Furnes O, Havelin LI. Does cement increase the risk of infection in primary total hip arthroplasty? Revision rates in 56,275 cemented and uncemented primary THAs followed for 0-16 years in the Norwegian Arthroplasty Register. *Acta Orthop* 2006; **77**: 351-358 [PMID: 16819671 DOI: 10.1080/17453670610046253]
 - 26 **Eskelinen A**, Paavolainen P, Helenius I, Pulkkinen P, Remes V. Total hip arthroplasty for rheumatoid arthritis in younger patients: 2,557 replacements in the Finnish Arthroplasty Register followed for 0-24 years. *Acta Orthop* 2006; **77**: 853-865 [PMID: 17260192 DOI: 10.1080/17453670610013132]
 - 27 **Hailer NP**, Garellick G, Kärrholm J. Uncemented and cemented primary total hip arthroplasty in the Swedish Hip Arthroplasty Register. *Acta Orthop* 2010; **81**: 34-41 [PMID: 20180715 DOI: 10.3109/17453671003685400]
 - 28 **Hooper GJ**, Rothwell AG, Stringer M, Frampton C. Revision following cemented and uncemented primary total hip replacement: a seven-year analysis from the New Zealand Joint Registry. *J Bone Joint Surg Br* 2009; **91**: 451-458 [PMID: 19336803 DOI: 10.1302/0301-620X.91B4.21363]
 - 29 **Lucht U**. The Danish Hip Arthroplasty Register. *Acta Orthop Scand* 2000; **71**: 433-439 [PMID: 11186396 DOI: 10.1080/000164700317381081]
 - 30 **Mäkelä KT**, Eskelinen A, Paavolainen P, Pulkkinen P, Remes V. Cementless total hip arthroplasty for primary osteoarthritis in patients aged 55 years and older. *Acta Orthop* 2010; **81**: 42-52 [PMID: 20180718 DOI: 10.3109/17453671003635900]
 - 31 **Mäkelä KT**, Eskelinen A, Pulkkinen P, Virolainen P, Paavolainen P, Remes V. Cemented versus cementless total hip replacements in patients fifty-five years of age or older with rheumatoid arthritis. *J Bone Joint Surg Am* 2011; **93**: 178-186 [PMID: 21248215 DOI: 10.2106/JBJS.1.01283]
 - 32 **Mäkelä KT**, Eskelinen A, Pulkkinen P, Paavolainen P, Remes V. Results of 3,668 primary total hip replacements for primary osteoarthritis in patients under the age of 55 years. *Acta Orthop* 2011; **82**: 521-529 [PMID: 21992084 DOI: 10.3109/17453674.2011.618908]
 - 33 **Malchau H**, Herberts P, Eisler T, Garellick G, Söderman P. The Swedish Total Hip Replacement Register. *J Bone Joint Surg Am* 2002; **84-A Suppl 2**: 2-20 [PMID: 12479335]
 - 34 **Pedersen AB**, Svendsen JE, Johnsen SP, Riis A, Overgaard S. Risk factors for revision due to infection after primary total hip arthroplasty. A population-based study of 80,756 primary procedures in the Danish Hip Arthroplasty Registry. *Acta Orthop* 2010; **81**: 542-547 [PMID: 20860453 DOI: 10.3109/17453674.2010.519908]
 - 35 **Roberts DJS**, Garlick NI. Increased rate of dislocation of total hip arthroplasty with cementless implants: accuracy of acetabular inclination. *Internet J Orthop Surg* 2010; **17**: 1 [DOI: 10.5580/68e]
 - 36 **Skyttä ET**, Jarkko L, Antti E, Huhtala H, Ville R. Increasing incidence of hip arthroplasty for primary osteoarthritis in 30- to 59-year-old patients. *Acta Orthop* 2011; **82**: 1-5 [PMID: 21189098 DOI: 10.3109/17453674.2010.548029]
 - 37 **Abdulkarim A**, Ellanti P, Motterlini N, Fahey T, O'Byrne JM. Cemented versus uncemented fixation in total hip replacement: a systematic review and meta-analysis of randomized controlled trials. *Orthop Rev (Pavia)* 2013; **5**: e8 [PMID: 23705066 DOI: 10.4081/or.2013.e8]
 - 38 **Girard J**, Kern G, Migaud H, Delaunay C, Ramdane N, Hamadouche M. Primary total hip arthroplasty revision due to dislocation: prospective French multicenter study. *Orthop Traumatol Surg Res* 2013; **99**: 549-553 [PMID: 23890966 DOI: 10.1016/j.otsr.2013.03.026]
 - 39 **Parratte S**, Argenson JN. Validation and usefulness of a computer-assisted cup-positioning system in total hip arthroplasty. A prospective, randomized, controlled study. *J Bone Joint Surg Am* 2007; **89**: 494-499 [PMID: 17332097 DOI: 10.2106/JBJS.F.00529]
 - 40 **Pennington M**, Grieve R, Sekhon JS, Gregg P, Black N, van der Meulen JH. Cemented, cementless, and hybrid prostheses for total hip replacement: cost effectiveness analysis. *BMJ* 2013; **346**: f1026 [PMID: 23447338 DOI: 10.1136/bmj.f1026]
 - 41 **Guyatt GH**, Oxman AD, Kunz R, Vist GE, Falck-Ytter Y, Schünemann HJ. What is "quality of evidence" and why is it important to clinicians? *BMJ* 2008; **336**: 995-998 [PMID: 18456631 DOI: 10.1136/bmj.39490.551019.BE]
 - 42 **Thompson SG**, Higgins JP. How should meta-regression analyses be undertaken and interpreted? *Stat Med* 2002; **21**: 1559-1573 [PMID: 12111920 DOI: 10.1002/sim.1187]

P- Reviewer: Antoniadis A, Drosos GI, Li XM **S- Editor:** Qiu S

L- Editor: A **E- Editor:** Lu YJ





Published by **Baishideng Publishing Group Inc**

8226 Regency Drive, Pleasanton, CA 94588, USA

Telephone: +1-925-223-8242

Fax: +1-925-223-8243

E-mail: bpgoffice@wjgnet.com

Help Desk: <http://www.wjgnet.com/esps/helpdesk.aspx>

<http://www.wjgnet.com>

