Systematic Review / Meta-analysis

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Effect of cementing technique on aseptic stem loosening in cemented primary total hip arthroplasty: a systematic review and meta-analysis

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Background and objective: Aseptic stem loosening after total hip arthroplasty surgery is the commonest complication, whether stem is cemented or uncemented. The aseptic cemented stem loosening has been a challenging problem over the years and a leading cause for revision since the inception of total hip arthroplasty. The objective of systematic review and meta-analysis was to determine the impact of cementing technique on aseptic stem loosening in total hip arthroplasty.
Methods: Cochrane, CINAHL, Embase, Google scholar, Medline, PubMed were searched in 13 December 2020. Two independent investigators extracted the data and a third investigator's involvement was reached on consensus. A total of 37 studies of revision rate due to aseptic loosening were reviewed by using fixed/random effects size and were grouped by cementing technique and studies' characteristics. The data were analyzed through Meta-Essentials and RStudio.
Results: In revision total hip arthroplasty, retained femoral components revisions rate due to aseptic loosening were recorded in 37 studies involving 6167 cases. Aseptic loosening rate collectively was 5.8% (CI 95%, 0.03–0.08) and mean follow-up of study was 12.5 years. The average follow-up period, mean age at index revision surgery and percentage of aseptic loosening were insignificantly associated with revision rate ($P \geq 0.05$), in meta-regression univariant analyses.
Conclusion: This investigative analysis showed that there is a minimal difference between results of cementing techniques of total hip arthroplasty in femoral components in long-term follow-ups, and usually have a low risk of failure.

Keywords: arthroplasty, aseptic, cement, hip, loosening, replacement, stem, technique

Introduction

Failure of joint prostheses without any mechanical cause or infection is called aseptic loosening, and is often associated with bone resorption that is osteolysis and inflammatory cellular responses inside the joint. Clinically, on a radiograph, it presents as lucent lines at the interface between bone cement and implant[1,2]. There are multifactorial aetiologies including patient condition, surgeon's expertise, stem design and the cementing technique[3]. Aseptic stem loosening after total hip arthroplasty surgery is the commonest complication, whether stem is cemented or uncemented[2]. The aseptic cemented stem loosening has been a challenging problem over the years and a leading cause for revision since the inception of total hip arthroplasty[4].

Approximately 370 000 total joint arthroplasties (THAs) are done in the United States each year [1, yet only 1–2 out of 10 (14%) use cemented femoral stem fixation. In Europe, however, similar regional patterns are reversed, with 73.1% and 56.7% percentages of cemented femoral stem placement reported in Sweden and the United Kingdom, correspondingly. Overall, fixed and cementless arthroplasties exhibit reliable and predictable results, with estimated 15-year life expectancy of 77–82% or 78–80%, correspondingly. Many studies, though, have shown that cemented femur stem fixation is linked with greater early modification rates than fixed femoral stem stability because to a higher risk of three month surgical injury and/or instability[4].

HIGHLIGHTS

- This systematic review shows there is moderate heterogeneity between the studies. Differences exist between these three generations and comparison is reliable between the series.
- Stem loosening or the cement failure does not only depend on the cementing technique generations, but also on the surgeon's own technique of doing it.
- If he/she has put the cement meticulously, making it white out, no matter which technique he/she has used, it gives better results.

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Table 1

Useful boolean operator.

Boolean operator	Function	Example
AND	Provides results that contain both or all keywords	paradigm AND syntagm
OR	Provides results that contain either keyword	meteor OR meteorite
NOT or AND NOT	Provides results that contain the first keyword but not the second	football NOT soccer
Quotation marks “”	Provides results with the exact phrase	“Newtonian mechanics”
Parentheses ()	Allows you to group together keywords and control the order in which the terms will be searched	(rural OR urban) AND sociology
Asterisk *	Provides results that contain a variation of the keyword	Develop* This will return results containing words such as “development,” “developer,” and “developing.”

Many studies have been done, as well as several new techniques have been developed to combat this issue in the cemented hip replacement. The first generation of cementing technique includes a hard mix with a bony preparation of only rasp. Cement was inserted manually with finger packing and there was no centralization. The second generation also had a hard mix; however, the bony preparation came from aggressive rasping and pulsatile lavage. It was done with a cement gun and canal plug that later showed an early distal centralization. The third generation was also a hard mix but used a technique of vacuum centrifugation and had a bony preparation like that used in the second generation. It was done using a cement gun with pressurized distal canal plug which showed proximal as well as distal centralization and the latest 4th generation cement technique was utilized including medullary plug, pulsatile lavage, vacuum mixing of cement; cement gun, distal centralizer, and proximal rubber seal to pressurize cement[5,6].

The first generation of cemented THA was successful in elderly patients, but in the younger age group, the long-term survival was not encouraging[7]. The risk of revision in primary total hip arthroplasty is increased in younger population who underwent the pathologies of THA other than primary osteoarthritis, because the activity level of a young person after going into THA is greater than the activity level of an elderly patient. This also plays an important role along with other risk factors described[8]. However, good cementing technique showed promising results in both younger and elderly patients’ groups in cemented stems[7]. Over the years, this technique has evolved from first to now fourth generation cementing technique. The advanced technique showed more longevity and survival with lower rates of loosening of the stem in some studies.

It was hypothesized that cementing technique itself has no significant impact on stem loosening. The ultimate goal for a THA surgery, is to have a long-term function of the hip. The study aim was to determine the cementing technique effect on aseptic stem loosening in total hip arthroplasty. The major concern was prevention of patients from complications of cementing techniques in hip arthroplasty. The study also aims to compare systematically all retrospective cohort cementing techniques of THA.

Materials and methods

We conducted this systematic and meta-analysis using a predefined protocol. The studies reporting on femoral components for revision due to aseptic loosening in THA, searched as systematically. The data of studies were collected in 13 December 2020. Our work has been reported in line with AMSTAR-2 (Assessing the methodological quality of systematic reviews) Guidelines. AMSTAR-2 is a vital assessment technique for systematic reviews of health treatments that incorporate either randomised or nonrandomised research, or both. All entries matching the qualifying requirements were evaluated using the AMSTAR-2 checklist. Two separate assessors (J.S.D. and S.D. or C.K. and F.D.) conducted the evaluations[8].

Databases and search engine:

The PRISMA 2020 declaration is primarily intended for systematic evaluations of research investigating the impact of cementing method on aseptic stem displacement in cemented main arthroplasty of the hip. PRISMA is an abbreviation that stands to Preferred Reporting Items for Systematic Reviews and Meta-Analysis[9]. Literature search had been structured and literature searches were done equally between search terms, keywords and phrases. For this purpose, “Cochrane”,

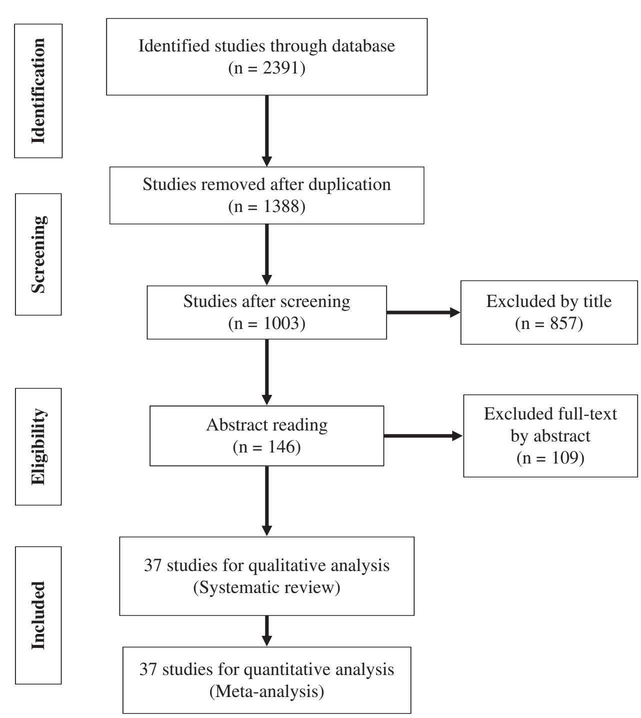


Figure 1. Flow chart of study methods.

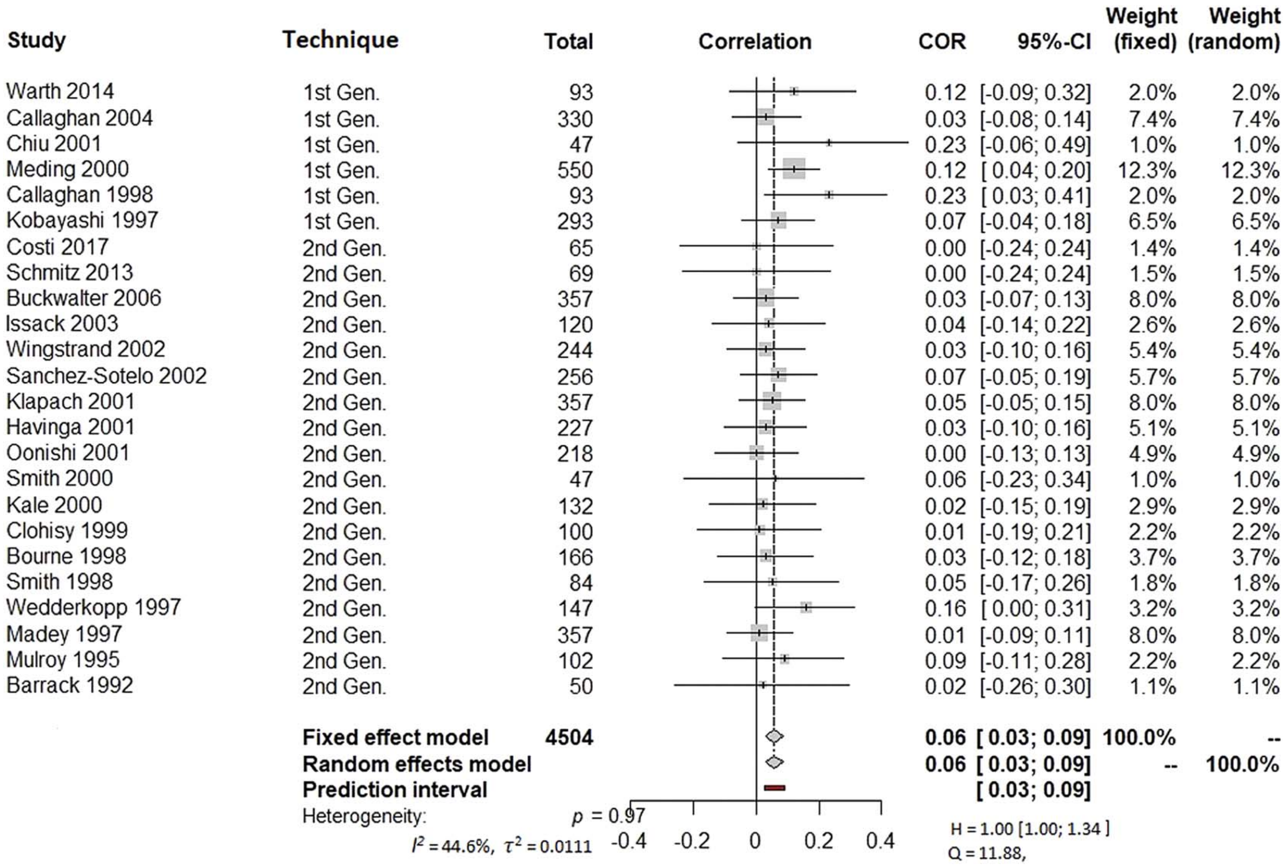


Figure 2. Aseptic loosening of femoral components revision rate. Fixed/random effects models estimate the magnitude of heterogeneity between studies. CI, confidence interval and prediction interval.

"CINAHL", "Embase", "Google Scholar", "Medline", and "PubMed", databases were used to retrieve all the essentials as these were reliable sources and registering by Research Registry UIN 1410[10]. The reference list for each study was updated to find additional relevant studies. Boolean operators for search syntax such as (AND, OR, NOT), field codes and brackets were used to help reduce the chances of errors made in syntax. Search using carefully selected keywords and the same concept of free text. Some of critical keywords that were used include hip and replacement or replacements or arthroplasty or arthroplasties, and loosening or loose, and cement or cementing, and aseptic.

Eligibility criteria

An appropriate method of inclusion and exclusion criteria for studies was developed and the articles found on the site search were reviewed by the reviewers against the terms of inclusion and exclusion. We included 37 qualitative researches, prospective as well as retrospective cohort and randomized controlled trial's studies. If a trial had multiple publications, we had included the first published article. Patients 18 years or older who received primary Total hip replacement (THR) were included in this study. Articles on non-English, unrelated topics, cadaveric and review, case and lab studies were excluded from the study.

Intervention and outcomes

The intervention of interest was the cement loosening due to different cementing methods of cementing techniques used in primary cemented THRs. Failure of the primary procedure objectively measured by the revision rate of stem due to aseptic loosening was the major outcome. The signs of radiological loosening or osteolysis, survival rate, complications, functional

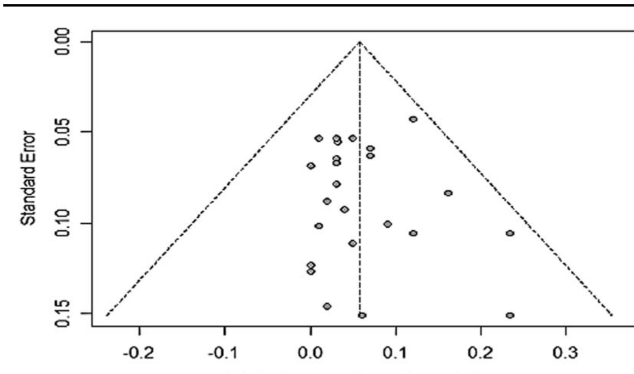


Figure 3. Femoral components revision rates funnel plot for (Technique: 1st and 2nd Gen.). Plot shows the study bias.

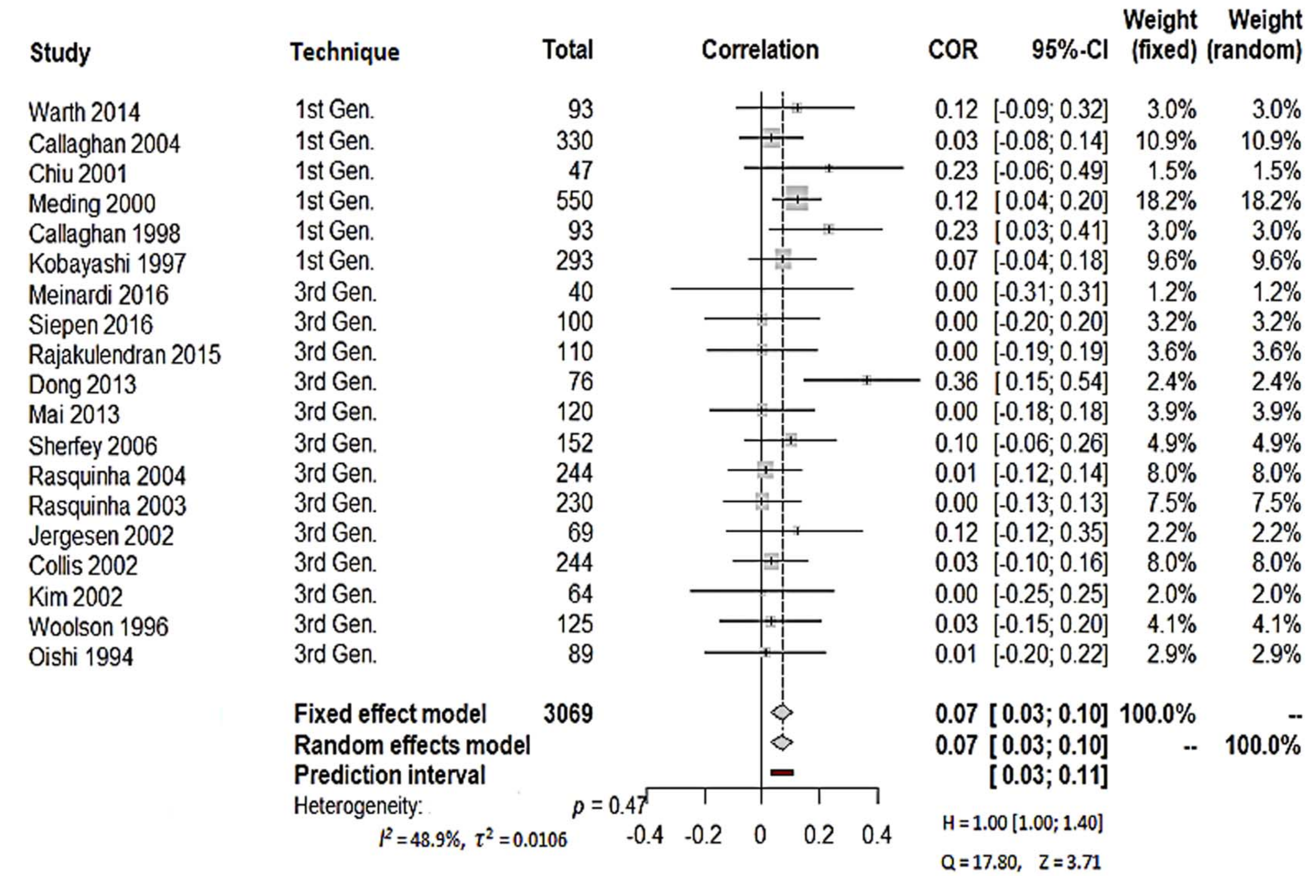


Figure 4. Fixed/random effects models estimate the magnitude of heterogeneity between studies. CI, confidence interval and prediction interval. There is insignificant difference in prediction interval.

scores especially the Harris Hip Score (HHS) and duration of follow-up were the secondary outcomes.

Data collection and assessment

The first review of the articles was done by the main author. Each study was evaluated to be eligible by two reviewers (M. H. and N.A.) independently for inclusion. Any disagreements were resolved amicably. The data were extracted by using a structured predesigned data collection form. The published data included the year of publication (from 1992 to 2017), number of hips, technique which was used, percent of aseptic loosening in years, average follow-up revision of surgery, mean age at surgery, stem type, pre and postoperative HHS, radiographic and osteolytic loosening of femoral components, complications, survival rate and their p value and quality assessment score of studies using Qualsyst score by Kmet and colleagues, guidelines (Table 1).

Statistical analysis

The overall percentage of primary THR first revision rate of aseptic stem loosening by CI 95% was used as primary outcome in all studies. Revision rate was assessed by using fixed/random effects size to reduce the magnitude of the impact between heterogeneity of studies. Meta-analysis for qualitative data was performed by Meta-Essentials Software version 1.5 (Erasmus Research Institute of Management, Netherland) and for forest plot and funnel plot, RStudio version 4.1 was used. Study characteristics including type of generation, sample size, follow-up, quality assay and study area were presented as variables for variance heterogeneity. Univariate meta-regression analysis was used for assessment of follow-up, mean age and survival rate of stem. The funnel plots and linear regression test were used for studies bias.

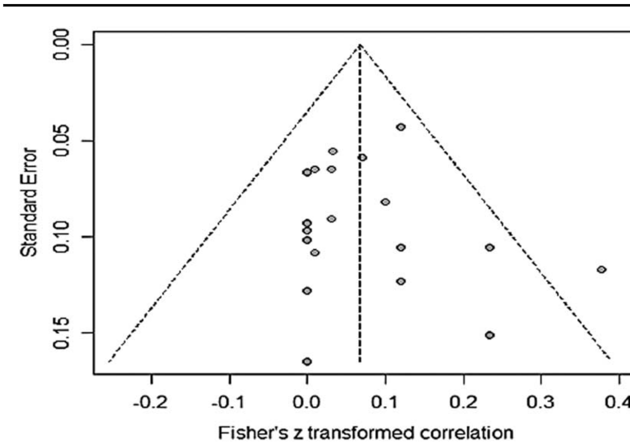
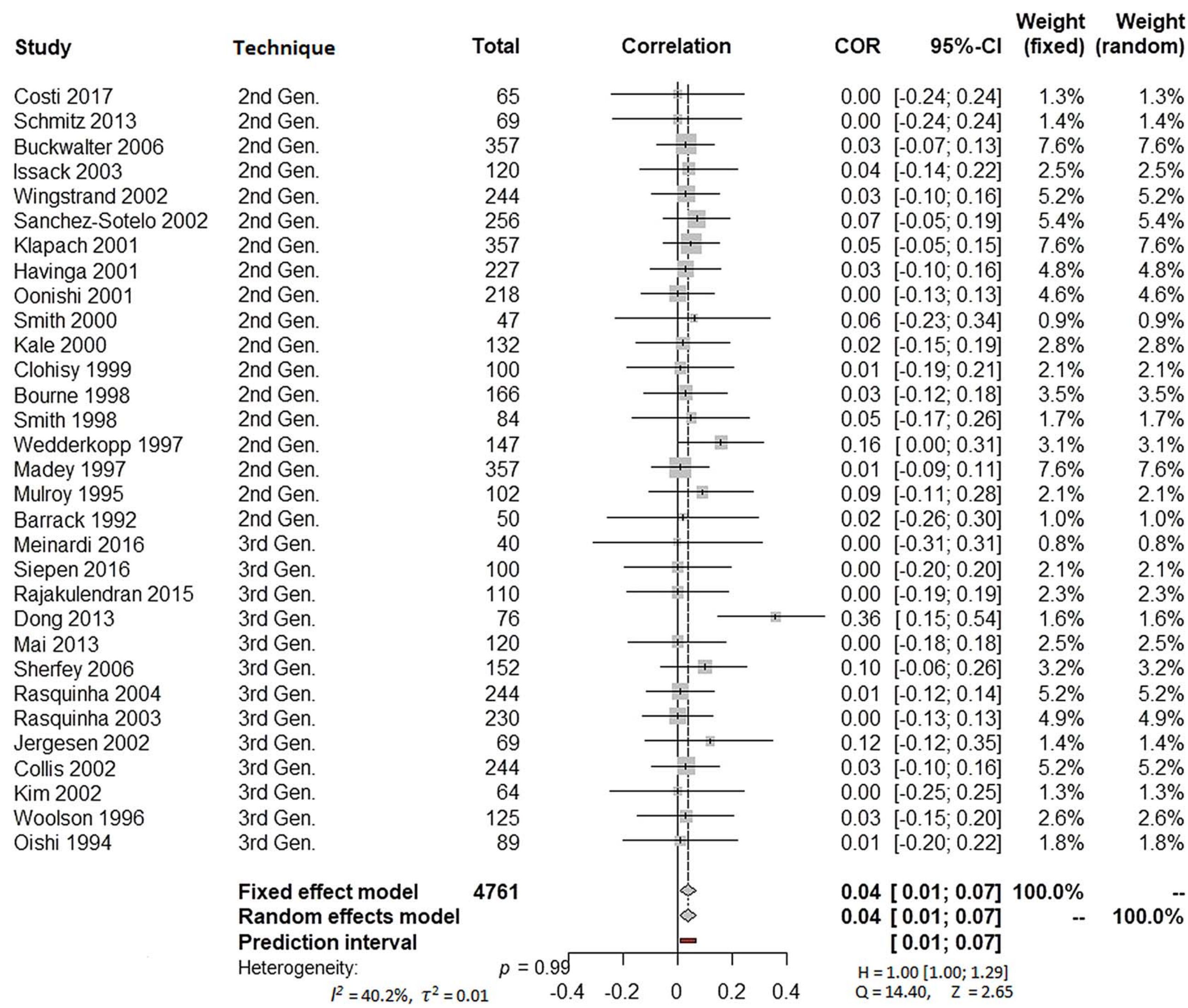


Figure 5. Femoral components revision rates funnel plot for (Technique: 1st and 3rd Gen.). Plot shows the study bias.



Study	Technique	Total	COR	95%-CI	Weight (fixed)	Weight (random)
Costi 2017	2nd Gen.	65	0.00	[-0.24; 0.24]	1.3%	1.3%
Schmitz 2013	2nd Gen.	69	0.00	[-0.24; 0.24]	1.4%	1.4%
Buckwalter 2006	2nd Gen.	357	0.03	[-0.07; 0.13]	7.6%	7.6%
Issack 2003	2nd Gen.	120	0.04	[-0.14; 0.22]	2.5%	2.5%
Wingstrand 2002	2nd Gen.	244	0.03	[-0.10; 0.16]	5.2%	5.2%
Sanchez-Sotelo 2002	2nd Gen.	256	0.07	[-0.05; 0.19]	5.4%	5.4%
Klapach 2001	2nd Gen.	357	0.05	[-0.05; 0.15]	7.6%	7.6%
Havinga 2001	2nd Gen.	227	0.03	[-0.10; 0.16]	4.8%	4.8%
Oonishi 2001	2nd Gen.	218	0.00	[-0.13; 0.13]	4.6%	4.6%
Smith 2000	2nd Gen.	47	0.06	[-0.23; 0.34]	0.9%	0.9%
Kale 2000	2nd Gen.	132	0.02	[-0.15; 0.19]	2.8%	2.8%
Clohisy 1999	2nd Gen.	100	0.01	[-0.19; 0.21]	2.1%	2.1%
Bourne 1998	2nd Gen.	166	0.03	[-0.12; 0.18]	3.5%	3.5%
Smith 1998	2nd Gen.	84	0.05	[-0.17; 0.26]	1.7%	1.7%
Wedderkopp 1997	2nd Gen.	147	0.16	[0.00; 0.31]	3.1%	3.1%
Madey 1997	2nd Gen.	357	0.01	[-0.09; 0.11]	7.6%	7.6%
Mulroy 1995	2nd Gen.	102	0.09	[-0.11; 0.28]	2.1%	2.1%
Barrack 1992	2nd Gen.	50	0.02	[-0.26; 0.30]	1.0%	1.0%
Meinardi 2016	3rd Gen.	40	0.00	[-0.31; 0.31]	0.8%	0.8%
Siepen 2016	3rd Gen.	100	0.00	[-0.20; 0.20]	2.1%	2.1%
Rajakulendran 2015	3rd Gen.	110	0.00	[-0.19; 0.19]	2.3%	2.3%
Dong 2013	3rd Gen.	76	0.36	[0.15; 0.54]	1.6%	1.6%
Mai 2013	3rd Gen.	120	0.00	[-0.18; 0.18]	2.5%	2.5%
Sherfey 2006	3rd Gen.	152	0.10	[-0.06; 0.26]	3.2%	3.2%
Rasquinha 2004	3rd Gen.	244	0.01	[-0.12; 0.14]	5.2%	5.2%
Rasquinha 2003	3rd Gen.	230	0.00	[-0.13; 0.13]	4.9%	4.9%
Jergesen 2002	3rd Gen.	69	0.12	[-0.12; 0.35]	1.4%	1.4%
Collis 2002	3rd Gen.	244	0.03	[-0.10; 0.16]	5.2%	5.2%
Kim 2002	3rd Gen.	64	0.00	[-0.25; 0.25]	1.3%	1.3%
Woolson 1996	3rd Gen.	125	0.03	[-0.15; 0.20]	2.6%	2.6%
Oishi 1994	3rd Gen.	89	0.01	[-0.20; 0.22]	1.8%	1.8%
	Fixed effect model	**4761**	**0.04**	**[0.01; 0.07]**	**100.0%**	**--**
	Random effects model		**0.04**	**[0.01; 0.07]**	**--**	**100.0%**
	Prediction interval			**[0.01; 0.07]**		

Figure 6. Fixed/random effects models estimate the magnitude of heterogeneity between studies. CI, confidence interval and prediction interval. There is insignificant difference in prediction interval.

Results

Through literature search, 2391 citations were identified (Fig. 1), and 37 were screened for eligibility. Two thousand-three hundred and fifty-four (2354) studies were excluded, thirteen hundred and eighty-eight (1388) studies were reporting previously published data, eight hundred and fifty-seven (857) studies were excluded in post stage I, one hundred and nine (109) studies were excluded in post stage II. Thirty-seven (37) studies were downloaded from database and met all of our inclusion criteria for final analysis.

Stem type

Polished taper-slip or matt composite beam has two different designs namely composite beam ("shape-closed") and load-tapered ("force-closed") are defined to fix the cement stem.

Figure 2 & 3: Comparison between 1st and 2nd generation cementing technique of THA.

In comparison of 1st and 2nd generation cementing technique of femoral components in revision THA, a total of 24 studies involving 4504 cases were reported. The mean age was 60.29 years.

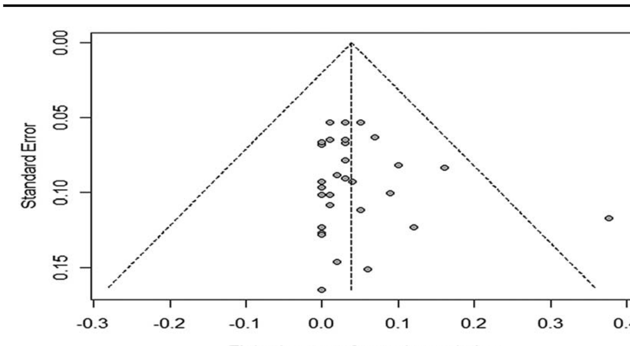


Figure 7. Femoral components revision rates funnel plot for (Technique: 2nd and 3rd Gen.). Plot shows the study bias.

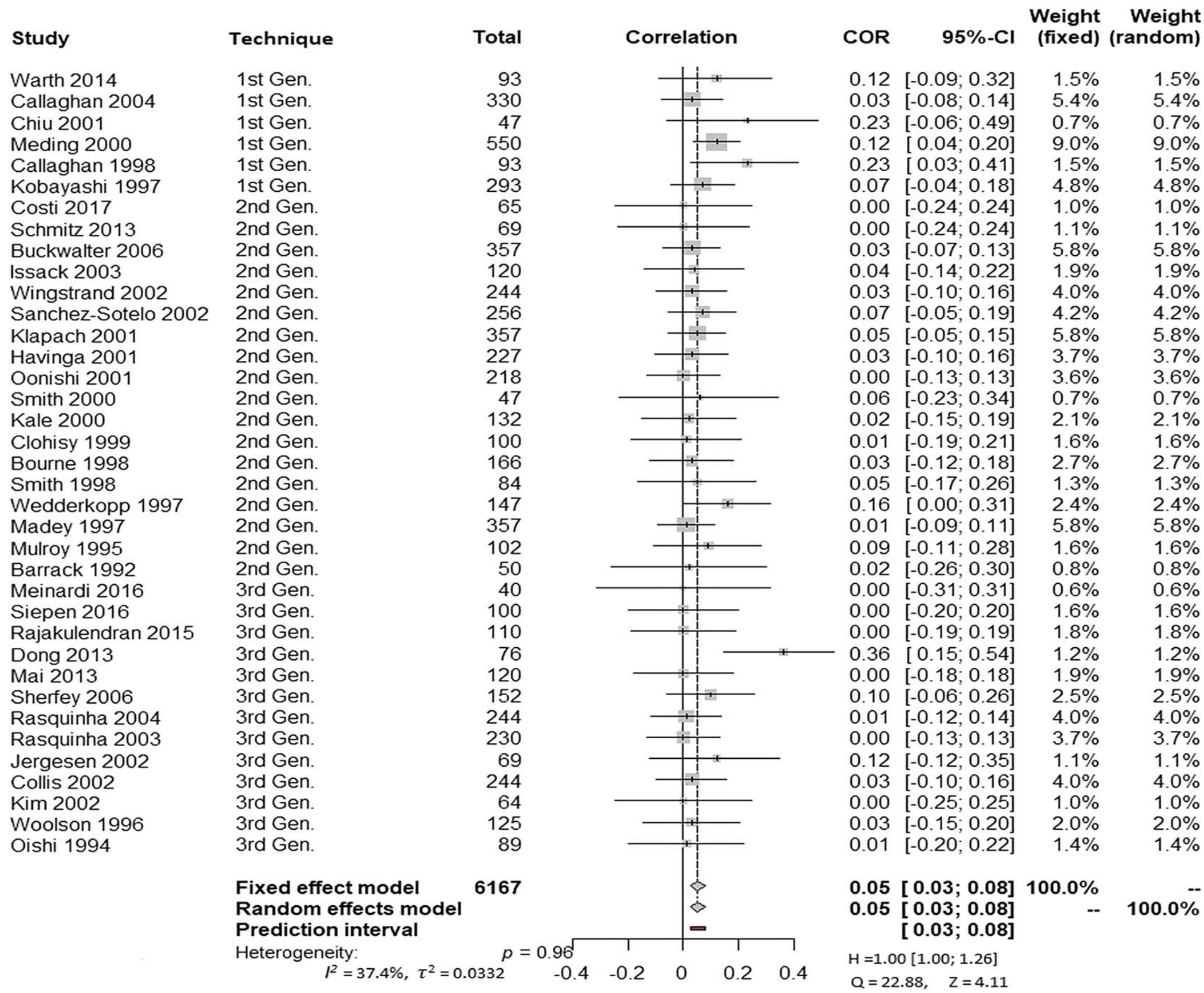


Figure 8. The overall fixed/random effects models estimate the magnitude of heterogeneity between studies. CI, confidence interval and prediction interval. There is insignificant in prediction interval.

The collective aseptic loosening rate was 6.3% (CI 95%, 0.03–0.09) during an average of 15.3 years (weighted mean) of follow-up period (Fig. 2). No heterogeneity evidence is showed between studies ($I^2 = 44.6\%$, 95% CI 0.03–0.09, $P = 0.97$). Subtypes of relevant technique, sample size, percent of aseptic loosening and follow-up years were the outcomes, but these are insignificant. The average follow-up, mean age at index revision surgery and percent of aseptic loosening in meta-regression univariate analyses are insignificant with revision rate ($P \geq 0.05$). Funnel plot and linear regression test show significant ($P = 0.001$) for publication bias.

Figure 4 & 5: Comparison between 1st and 3rd generation cementing technique of THA.

In comparison of 1st and 3rd generation cementing technique of femoral components in revision THA, a total of 19 studies involving 3069 cases were reported. The mean age was 65.63 years. The collective aseptic loosening rate was 7.7% (95% CI 0.03–0.10) during an average of 11.9 years (weighted mean) of follow-up period (Fig. 4). No evidence of heterogeneity is showed between contributing studies ($I^2 = 48.9\%$, 95% CI 0.03–0.10, $P = 0.47$). The average follow-up, mean age at index revision surgery and percent of aseptic loosening in meta-regression univariate analyses, are insignificant with revision rate ($P \geq 0.05$). Funnel plot and linear regression test show significant ($P = 0.001$) for publication bias.

Figure 6 & 7: Comparison between 2nd and 3rd generation cementing technique of THA.

In comparison of 2nd and 3rd generation cementing technique of femoral components in revision THA, a total of 31 studies involving 4761 cases were reported. The mean age was 63.66 years. The collective aseptic loosening rate was 4.4% (95% CI 0.01–0.07) during an average of 10.7 years (weighted mean) of follow-up period (Fig. 6). No heterogeneity evidence is showed between studies ($I^2 = 40.2\%$, 95% CI 0.01–0.07, $P = 0.99$). The average follow-up, mean age at index revision surgery and percent of aseptic loosening in meta-regression univariate analyses, are insignificant with revision rate ($P \geq 0.05$). Funnel plot and linear regression test show significant ($P = 0.008$) for publication bias.

Figure 8 & 9: Overall comparison between cementing technique of THA

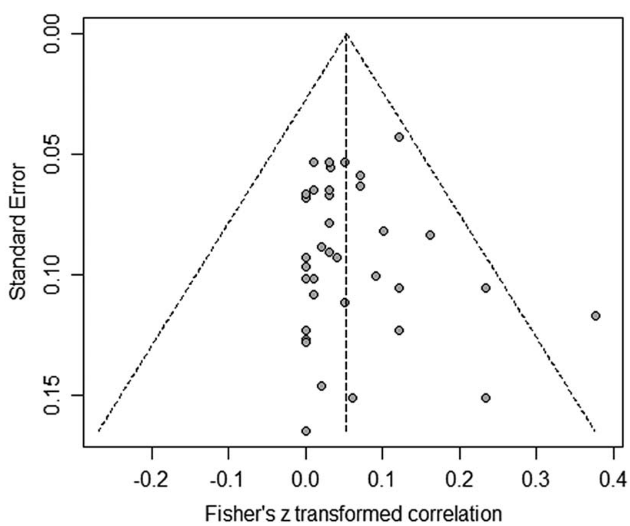


Figure 9. Femoral components revision rates funnel plot for (overall). Plot shows the study bias.

The overall assessment of cementing techniques of femoral components in revision THA, a total of 37 studies involving 6167 cases were reported. The mean age was 63.07 years. The collective aseptic loosening rate was 5.8% (95% CI 0.03–0.08) following 12.5 years an average (weighted mean) of follow-up period (Fig. 8). No evidence of heterogeneity is showed between contributing studies ($I^2 = 37.4\%$, 95% CI 0.03–0.08, $P = 0.96$). The average follow-up, mean age at index revision surgery and percent of aseptic loosening in meta-regression univariate analyses, are insignificant with revision rate ($P \geq 0.05$). Funnel plot and linear regression test show significant ($P = 0.001$) for publication bias.

The assessment of HHS preoperative and postoperative was measured. An average of preoperative HHS was 47 points and postoperative was 88 points. In meta-regression univariate analysis, at index revision surgery HHS was significant ($R^2 = 97.2\%$, $P \leq 0.0001$).

During analysis of survival rate of 1st, 2nd and 3rd generation stem types, an average of survival rate was 87%, 92% and 94% ($P = 0.001$) recorded in 20, 16 and 9 years, respectively.

The common complications recorded were infection, dislocation, avascular necrosis, bursitis, fracture, deep vein thrombosis, nonfatal pulmonary embolism, cerebral vascular accident, urinary tract infection, etc.

Discussion

To our best knowledge, this is the first meta-analysis to describe the effects of cementing technique generations on femoral components during a hip replacement revision. The data show an overall femoral component revision rate is 5.8% due to the aseptic loosening in patients of THA during long-term follow-ups. Across several studies, our findings showed the revision rate is generally consistent. The combined analysis of the retained studies of the femoral component is considered by moderate heterogeneity. The overall quality of the evidence is good.

As evaluation of cementing techniques of THA, Charnley began working with polymethylmethacrylate and THR, much has been learned about cement and the proper methods associated with its use. The first-generation technique (hand mixing of cement), also called Charnley technique was introduced by John Charnley greater than or equal to 45 years ago. In previous studies, the long-term effects of cemented THR are well documented. The challenge arises when patients under the age of 50 have to be considered for surgery. In such case, all technical advancement must be used, if there is a reasonable chance of 20 years or more of trouble-free work. Long-term follow-up of younger patients is important in determining the best THA, as these patients live longer with the use of artificial hip replacement[3]. In this meta-analysis, first-generation survival rate was excellent (87%) in 20 years follow-up period. The incidence of revision rate of femoral components due to aseptic loosening was 5.8% in this meta-analysis. With a minimum 10 years of follow-up period, implanted Charnley prosthesis using early cementing techniques in young patients was reported.

The discrepancies in results of older age as compared with younger age groups may be attributed to some factors. The underlying hip disease is the first factor. It is because cemented THA into young patients suffering from avascular necrosis had increased the risk of failure. The different definitions of young patients are the second factor. Few authors account less than or equal to 30 years old, few account between the age of 50–60 years[1,11], and majority used 40–50 years as a high age limit to describe younger patients. The body weight and activity level of the patients are the third factor. More loose components and revisions are seen in heavy weight and active patients.

The description of second-generation femoral cementing technique is as follows: intramedullary cement plug used and open atmosphere cement mixing by hand. In this meta-analysis, the survival rate of second-generation cementing technique was 92% in 16 years of follow-up period. Johnston's findings on Charnley THA first-generation cementing technique using in 50 years below patients between 20 and 25 years follow-up period, reviewed by Callaghan and colleagues. The prevalence of aseptic femoral loosening in revision was 5%, and 13% the overall prevalence of aseptic femoral loosening was measured. However, we believe that difference exists between two generations, and comparison is reliable between first-generation and second-generation.

An average of 14% in 20–35 years prevalence of aseptic femoral loosening was measured in 6 studies of first-generation series in this meta-analysis (Table 1; percentage of aseptic loosening). Out of 18 studies of second-generation series, 3 reported 0% incidence of aseptic femoral loosening in 5–10 years. Other 15 studies reported 1–8.8% aseptic femoral loosening in 10–20 years (Table 1). The discrepancies in results and the factors are discussed above.

The third-generation femoral cementing technique is described as follows: vacuum mixing, pulsatile irrigation, cement restrictor cement filling by gun, proximal and distal stem centralisers. The specification of the third-generation femoral stem design required the use of a combination of design features reported as beneficial. The long-term performance of the Round-back Charnley low-friction torque arthroplasty polished and part of the Exeter Universal femoral supports the use of polished cement stems[11]. In this meta-analysis, the survival rate of third-generation cementing technique was 94% in 9 years of follow-up period. Regarding the role of surface finish of cemented femoral

Table 2

Studies characteristics in cemented total hip arthroplasty.

Sr. #	1st author and year	No. Hips	Technique	% loosening in years	Average follow-up (year)	Mean age (year)	Stem type	Preoperative HHS	Postoperative HHS
1.	Warth 2014[8]	93	1st Gen.	8–18%, 35 years	36.9	78.6	Charnley	61.9	86.9
2.	Callaghan 2004[9]	330	1st Gen.	3.2% over 15.2 years	25.0	65.1 (29–86)	Charnley stem	NA	NA
3.	Chiu 2001[10]	47	1st Gen.	23% over 14.9 years	14.9	28.8 (17–39)	Charnley stainless-steel round-back femoral stem with a Vaquasheen surface	43.8	87.7
4.	Meding 2000[14]	T-28 = 379 TR-28 = 171	1st Gen.	T-28 = 11.1% over 20.96 years TR-28 = 12.8% over 17.54 years	T-28 = 20.96 TR-28 = 17.54	T-28 = 63.8 (22-89) TR-28 = 64.7 (34–88)	T-28 and TR-28 cemented prostheses (TR-28 is shot-blast chrome and T-28 is polished stainless-steel)	NA	NA
5.	Callaghan 1998[15]	93	1st Gen.	23% over 20 years	20.0	64 (39–76)	Charnley stem	NA	NA
6.	Kobayashi 1997[16]	293	1st Gen.	7.2% over 23 years	13.0	59.4 (30–85)	Charnley stem	NA	NA
7.	Costi 2017[11]	65	2nd Gen.	0 at 5-22 years	14.0	34 (16–40)	35 modular stainless-steel Exeter, 8 stainless-steel CPT, and 22 cobalt-chrome CPT.	39.0	80.0
8.	Schmitz 2013[17]	69	2nd Gen.	0 over 7–23 years	11.5	25 (16–29)	M.E. Müller W straight stem. Charnley Elite (Plus) stem TM. Exeter Stem TM	47	88.3
9.	Buckwalter 2006[18]	357	2nd Gen.	2.8% over 20y	17.5	69 (24–88)	Charnley stem	NA	NA
10.	Issack 2003[19]	120	2nd Gen.	4.2% over 10–15 years	16.0	68.5 (17–85)	Composite beam, matt finished collered stem	53	86.3
11.	Wingstrand 2002[20]	244	2nd Gen.	2.87% over 10 years	10.0	77 (46–96)	Cobalt-chromium femoral component, a 15-cm stem and a collar similar to the Harris "design 2" with a matted finish and a rounded rectangular cross- section	NA	NA
12.	Sanchez-Sotelo 2002[21]	256	2nd Gen.	7.0% over 15 years	15.4	66 (16–89)	Harris Design 2 femoral component	51	91
13.	Klapach 2001[22]	357	2nd Gen.	4.8% over 20 years	20.0	69 (24–88)	Charnley stem	NA	NA
14.	Havinga 2001[23]	227	2nd Gen.	3.3% over 10 years	10.0	71	MEM Composite Beam	NA	NA
15.	Oonishi 2001[24]	218	2nd Gen.	0% over 10.3 years	12.5	58.2 (38–82)	Composite beam matt finished	NA	NA
16.	Smith 2000[25]	47	2nd Gen.	6% over 20 years	18.2	50.0	Monoblock, Bead blasted finish	49.0	87.0
17.	Kale 2000[26]	132	2nd Gen.	2.3% over 10 years	8.1	68.2 (17–85)	"Collared straight cobalt-chrome femoral prosthesis with a 32-mm femoral head".	43.5	91.1
18.	Clohisy 1999[27]	100	2nd Gen.	1% over 10 years	10.0	65 (45–87)	Composite beam stem, with proximal PMMA Coating	48	92
19.	Bourne 1998[28]	166	2nd Gen.	3% over 15 years	12.0	67.9 (31–89)	Composite beam matt finished Harris Design 2	50	89
20.	Smith 1998[29]	84	2nd Gen.	5% over 20 years	17.3	61 (21–85)	Composite beam matt finished, beaded blasted monoblock	51	85
21.	Wedderkopp 1997[30]	147	2nd Gen.	15.6% over 2 years	3.3	66 (25–85)	Charnley stem	NA	NA
22.	Madey 1997[31]	357	2nd Gen.	1% over 15 years	15.0	69 (24–88)	Charnley stem	NA	NA
23.	Mulroy 1995[32]	102	2nd Gen.	8.8% over 15 years	14.0	61 (21–85)	Composite beam grit-blasted	50	86
24.	Barrack 1992[33]	50	2nd Gen.	2% over 10 years	12.0	40.9 (18–50)	Collared cobalt-chrome femoral stem with a rectangular cross-section and rounded corners.	41	88.0
25.	Meinardi 2016[34]	40	3rd Gen.	0% at 10 years	7.0	74 (52–84)	Composite beam, Shape Close, Stanmore	46	84.0
26.	Siepen 2016[42]	100	3rd Gen.	0% over 2 years	2.0	78 (68–93)	Polished taper-slip	56	95
27.	Rajakulendran 2015[35]	110	3rd Gen.	0% at 10 years	8.9	73.5 (65–85)	Tri-taper femoral stem	NA	NA
28.	Dong 2013	76	3rd Gen.	36.1% over 15 years	8.0	58.6 (22–86)	Precoated stems (Harris Precoat Plus in 33 cases and Centralign in 43 cases)	40	87
29.	Mai 2013[12]	120	3rd Gen.	0% over 10 years	8.9	74.5 (61–96)	Composite beam, matt finished	39.5	75.9
30.	Sherfey 2006[13]	118 = Exeter 34 = Endurance	3rd Gen.	0% Exeter 7.5 years Endurance 20.5% over 4.57 years	Exeter = 7.5 End = 4.57	Ext = 71 End = 76	Polished, collarless, tapered Exeter stem and the Endurance stem, a collared, roughened, satin finished stem	Ext = 40 End = 35	Ext = 84 End = 76
31.	Rasquinha 2004[36]	244	3rd Gen.	0.9% and 0% (smooth and rough groups) over 6.5 years	6.5	Smooth group: 73 (52–84) Rough group: 72.2 (54–82)	Smooth and rough both	NA	NA

Table 2

(Continued)

Sr. #	1st author and year	No. Hips	Technique	% loosening in years	Average follow-up (year)	Mean age (year)	Stem type	Preoperative HHS	Postoperative HHS
32.	Rasquinha 2003[37]	230	3rd Gen.	0% over 15 years	13.5	60.0 (50–78)	Collarless, normalized, Omnifit femoral stem with a surface roughness of 30–40 microinches	NA	NA
33.	Jergesen 2002[38]	69	3rd Gen.	11.5% over 5.5 years	5.5	70.0 (65–85)	Titanium alloy and a modular cobalt-chrome head	NA	NA
34.	Collis 2002[39]	244	3rd Gen.	3.2% over 7 years	5.9	70.6 (≤60)	Initial 122 stems had a rough surface and the subsequent 122 stems were polished.	NA	NA
35.	Kim 2002[5]	64	3rd Gen.	0% over 10 years	9.4	43.4 (21–50)	"Smooth/ polished, Elite plus or Elite femoral component (Ortron 90; DePuy,"	44	95
36.	Woolson 1996[40]	125	3rd Gen.	3% over 6 years	6.0	67 (40–88)	Composite beam	47	91
37.	Oishi 1994[41]	89	3rd Gen.	1% over 8 years	7.0	71 (41–92)	Composite beam	50	91

CPT, collarless polished taper; HHS, Harris Hip Score; NA, not applicable.

components in survival rates, the debate continues among supporters of cement fixation in THA. Adjustment of cemented components can be considered as a result of cement-metal adhesion or movement of the cement-metal as a result of slink and resting pressure on the cement by a second stability.[12],[13] The third-generation which combines collarless double-taper geometry using centralizer, has proven long-term results, while flexibility in a more matte finish has led to increased loosening levels. Out of 13 studies of third-generation series, 8 reported 0% incidence of aseptic femoral loosening in 5–10 years. Other 5 studies reported 1–36% aseptic femoral loosening in 5–15 years (Table 1). However, the lack of randomized controlled trials weakens this hypothesis.

The latest changes in cement and arthroplasty are that a large number of cements are available in the market. However, the strength of well-made cement coatings around implants is well matched between cement, products vary in viscosity, duration, and suspension. The surgeon must know the details of the particular cement he/she intends to use, as it will affect the way the cement is made. Operating time and setup time vary between different cements. The data showed that different types of femoral stems should be included with different types of cements. For example, a rougher stem should be placed in the pre-polymerization phase of the cement, while a smooth stem should be placed in the form of an additional dough. Therefore, a surgeon using a smooth stem should use a cement with a long section of dough, whereas a surgeon using a rougher stem should use a long liquid cement. Failure to acknowledge the operating characteristics of different cements may cause problems during surgery[11].

The whole THA cement method has changed from one generation to the third generation. Major improvements between these "generations" have been distinguished in terms of bone repair, cement preparation, and cement delivery (Table 2).

The heterogeneity evidence in this study was only moderate. This study systematically evaluated potential sources of heterogeneity using stratified analyses and meta-regressions among the contributing studies. Since the nature of the published data is limited, we could only evaluate the results of revision by appropriate subgroups such as sample size, percentage of aseptic loosening, mean age, follow-up period, and quality assurance (Table 3).

More than 25–30 years survival of cemented stems placed by Charnley and colleagues by 1st generation cementing technique may be due to his original technique of doing the femoral stem by greater trochanter osteotomy. His follow-up X-rays should allegiantly place reaching all the six zones of femur making no radiolucency between interfaces of stem, cement and bone. The same can be achieved by 2nd and 3rd generation cementing technique without greater trochanter osteotomy.

Our study has some limitations which are the absence of strong evidence of randomized clinical trials and inconsistency of published data due to lack of randomized controlled trial's.

Conclusion

This study concluded that there is moderate heterogeneity between the studies. Femoral stem cementation, on the other hand, provides a safe and practical option to cementless femoral stems and provides improved lifespan in some groups with poor bone strength. This procedure entails adequate femoral broaching including an appropriate glide path, canal order to prepare using

Table 3

Continuity of previous Table 2

Sr. #	1st author and year	% radiographic loosening (year)	% osteolysis	Complications	Survival rate	*p* value	Qualsyst Score
1.	Warth 2014[8]	24.0% (35.0 years)	18.0%	Infection, dislocation	63% (36 years)	≥ 0.05	85%
2.	Callaghan 2004[9]	16.4% (29.6 years)	26.0%	Infection, dislocation	88% (25 years)	≥ 0.05	80%
3.	Chiu 2001[10]	23.0% (15.0 years)	27.7%	Avascular necrosis	100% (5 years) 86.3% (10 years) 27.0% (15 years)	0.016	90%
4.	Meding 2000[14]	T-28 = 11.1% (20.96 years) TR-28 = 15.8% (17.54 years)	T-28 = 1.3% TR-28 = 1.8%	—	84–88% (18 years)	0.0318	80%
5.	Callaghan 1998[15]	23% (23.3 years)	6.0%	Infection, dislocation	89% (20 years) 75% (25 years)	0.082	85%
6.	Kobayashi 1997[16]	7.2% (23 years)	—	Infection, dislocation	90.9% (16 years)	≤ 0.05	75%
7.	Costi 2017[11]	1.8% (12.0 years)	14.0%	Avascular necrosis	88% (16 years)	≥ 0.05	90%
8.	Schmitz 2013[17]	32.1% (6.1 years)	16.0%	Infection, dislocation, neurological deficit, periprosthetic fracture	82% (15 years) 90% (10 years)	≥ 0.05	75%
9.	Buckwalter 2006[18]	6.8% (23.7 years)	17.0%	Infection, dislocation	86% (25y) = Contemporary 83% (25 years) = Hand-packing	0.901	70%
10.	Issack 2003[19]	5.0% (16 years)	7.5%	—	93.9% (16 years)	—	80%
11.	Wingstrand 2002[20]	2.87% (10 years)	—	Infection, dislocation, fracture, DVT	95%	—	70%
12.	Sanchez-Sotelo 2002[21]	7.0% (15.4 years)	8.0%	Peroneal nerve palsy, deep infections, dislocation, periprosthetic fracture,	92.2%	0.0001	90%
13.	Klapach 2001[22]	4.8% (20.0 year)	Zone vii = 41 Zone i-vi = 4	Dislocation, bursitis	88% (20 year)	0.339	85%
14.	Havinga 2001[23]	3.3% (10 year)	—	Infection	94% (10 year)	≥ 0.05	70%
15.	Oonishi 2001[24]	0.5% (10.3 year)	0.9%	No complication was reported	—	—	70%
16.	Smith 2000[25]	6% (20 year)	11.0%	Dislocation, DVT, GT bursitis, periprosthetic fracture	95% (18 year)	0.59	85%
17.	Kale 2000[26]	2.3% (9.6 year)	5.0%	Infection, dislocation	Spectron = 100% (11 year) Charnley = 97% (11 year)	≥ 0.05	85%
18.	Clohisy 1999[27]	3.0% (10 year)	12.0%	Femoral nerve palsy, UTI	99% (10 year)	—	90%
19.	Bourne 1998[28]	2.0% (12 year)	3.0%	Dislocation, pulmonary embolus, grade-III or IV heterotopic bone formation, periprosthetic fracture	—	—	80%
20.	Smith 1998[29]	7.0% (20 year)	2.5%	DVT, nonfatal pulmonary embolus, dislocation, pain, infection, wound haematoma, partial palsies of the sciatic nerve, MI, GI bleed	95% (15 year) 92% (17 year) 88% (20 year)	0.0095	95%
21.	Wedderkopp 1997[30]	15.6% (3.3 year)	—	Infection, dislocation	—	—	70%
22.	Madey 1997[31]	3.0% (15 year)	Zone vii = 41 Zone i-vi = 4	Dislocation, bursitis	88% (20 year)	0.12	85%
23.	Mulroy 1995[32]	7.0% (15 year)	9.0%	Infection, dislocation, fracture	94%	≤ 0.05	90%
24.	Barrack 1992[33]	2.0% (12 year)	12.0%	—	93% (13 year)	—	80%
25.	Meinardi 2016[34]	0% (10.0 year)	0%	Migration of prosthesis, infection, dislocation,	90% (10 year)	≥ 0.05	70%
26.	Siepen 2016[42]	5% (2 year)	2%	Infection	95% (2 year)	—	85%
27.	Rajakulendran 2015[35]	0% (10.0 year)	14.3%	Infection, dislocation, heterotopic ossification, abductor tendonitis, trochanteric bursitis, transient sciatic nerve palsy, lymph oedema in the ipsilateral limb, CVA	96.1% (10 year)	≥ 0.05	80%
28.	Dong 2013	31.6% (8.0 year)	5.5%	Infection, dislocation	76.9% (10 year) = Precoat Plus 76.2% (10 year) = Centralign	0.88	75%

Table 3

(Continued)

Sr. #	1st author and year	% radiographic loosening (year)	% osteolysis	Complications	Survival rate	*p* value	Qualsyst Score
29.	Mai 2013[12]	0% (10 year)	0%	Dislocation, trochanteric fracture, DVT, pulmonary embolism,	97.4% (10 year)	—	90%
30.	Sherfey 2006[13]	Exeter = 0% (7.5 year) Endurance = 20.5% (4.57 year)	0%	Pain	Ext = 0.9566 (10.37 year) End = 0.6635 (5.78y)	≤0.05	90%
31.	Rasquinha 2004[36]	0% (6.5 year)	0%	Infection, dislocation, painful aseptic loosening, DVT, nonfatal pulmonary embolism	95% (≥10 year) Smooth = 99.1% Rough = 98.2%	≥0.05	90%
32.	Rasquinha 2003[37]	0% (13.0 year)	0.44%	Infection, dislocation, DVT, nonfatal pulmonary embolism	100% (15 year)	≥0.05	90%
33.	Jergesen 2002[38]	6.7% (5.5 year)	0%	Infection, dislocation, DVT	88.5% (5.5 year)	≥0.05	70%
34.	Collis 2002[39]	3.2% (7.0 year)	0.8%	Infection, dislocation, DVT	91.9% (7 year) = grit-blasted 100% (7 year) = polished stem	*P* = 0.05	75%
35.	Kim 2002[5]	0% (10 year)	9%	Infection, DVT, dislocation	98% (9.4 year)	≤0.05	90%
36.	Woolson 1996[40]	1.2% (6 year)	8%	wound haematoma, UTI, DVT, nonfatal pulmonary embolus, dislocation	—	—	80%
37.	Oishi 1994[41]	0% (8 year)	—	Implant fracture, nonfatal pulmonary embolism, CVA, MI, UTI	—	—	70%

Qualsyst; Quality assessment system score by Kmet *et al*., 2004.
CVA, cerebrovascular accident; DVT, deep vein thrombosis; GT, greater trochanter; MI, myocardial infarction; UTI, urinary tract infection.

heartbeat lavage and intramuscular injections , vacuum cement integrating, use of a cement silencer, retrogressive cement injections to achieve a 2 mm cement legacy, cement pressurization, and thorough femoral stem induction using a stem centralizer. In order to get good results and reduce revision rates, it is necessary to have a thorough understanding of implant qualities, cement duration time, and the use of the previous three cementation approaches.

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