Improved survival rate and functional recovery of TKA in cementless fixation compared with cemented component: a systematic review and meta-analysis

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Abstract

Background: Whether the cement could be given up in total knee arthroplasty (TKA) was still in controversy. We perform this meta-analysis to compare the rate of revision and functional recovery between two kinds of fixation in TKA.

Methods: Randomized controlled trials (RCTs), prospective/retrospective observational studies from PubMed (on 2019 Sep), EMBASE (on 2019 Sep), and the Cochrane Central Register of Controlled Trials (CENTRAL) and Web of Science (on 2019 Sep) were searched. Continuous outcomes were presented as mean difference or standard mean difference with 95% CI and discontinuous outcomes were reported as relative risk (RR) with 95% CI. Random-effects or fixed-effects model was conducted to analyze the extracted data. The PRISMA guidelines and Cochrane Handbook were adopted to assess the quality of the results reported in included studies to ensure that the results of our meta-analysis were reliable and veritable. The continuous and dichotomous outcome were collected in a standard form, and the data were analysed by using Review Manager 5.3 software. Finally, the results were presented in the Forest plots. The rate of revision and reasons caused revision was the primary outcome of our study.

Results: Twenty-six studies involving 2369 patients in cementless TKA and 2654 patients in cemented TKA were finally included in our meta-analysis. 26 studies were divided into three subgroups according to the length of follow-up. The studies in the first subgroup followed less than 5.5 years, the second followed less than 10.5 years, and the third followed more than 10.5 years. Cementless fixation significantly decreased the rate of aseptic loosing (*p=0.0002*) and revision (*p=0.0002*) in the first subgroup. Other reasons such as periprosthetic joint infection (PJI), instability and polyethylene wear were not significantly different between two groups. Significantly better functional recovery was got in cementless TKA in terms of Knee Society Score (*p=0.004*) and Oxford Knee Score (*p=0.007*). Significantly less patients in cementless group require manipulation under anesthesia (*p=0.007*). However, there was no significant difference regarding the rate of complication between two kinds of fixation in TKA.

Conclusion: Not only the rate of aseptic loosing was decreased, rate of revision was also significantly decreased in cementless TKA within 5.5 years. In addition, the cementless TKA performed better in postoperative functional recovery according to Knee Society Function Score and Oxford Knee Score. However, the rate of complication was not significantly different in two kinds of fixation in TKA.

Background

As the gold standard of fixation method in total knee arthroplasty (TKA), cemented fixation occupied 93.5% implants of TKA in 2010 [1]. There were a series of advantages in conventional cemented fixation in TKA. Firstly, cemented fixation allows for small bone cut defects, which was less technically challenging compared with uncemented fixation [2]. Secondly, cemented fixation could deliver antibiotics into the joint to prevent infection [3]. Thirdly, as an effective barrier, cement could insulate the polyethylene debris from the articular surface and prevent the osteolysis [4]. Therefore, most likely because the greater clinical experience with cemented fixation and better clinical results over cementless fixation, cemented fixation was still most used in TKA. An analysis using New Zealand Joint Registry (NZJR) data revealed that most (91.5%) were fully cemented with 4.8% hybrid and 3.7% uncemented in 96,519 primary TKAs from 1998 to 2017 [5].

However, accompanied with the increasing demanding of TKA, the mean age of patients underwent TKA was decreasing. It was predicted that more than half of patients underwent TKA was contributed by patients younger than 65 years-old by 2030 [6]. This posed a difficulty to the development of TKA, for the more active lifestyle was needed by younger patients. Therefore, the concern of bone resorption in the bone-cement interface would make the dominance of cemented fixation challenging [7]. Although the preliminary results of cementless fixation was proved discouraging, cementless TKA in young patients was found to have comparable midterm results to cemented TKA [8]. With a biologic bone-implant interface, cementless fixation determined to prevent the osteolysis and reduce the risk of aseptic loosening, especially in young patients with enough bone stock. Therefore, with development of prosthesis design and material renovation, cementless TKA has been introduced to extend the life of prosthesis [9].

In recent years, many studies and several meta-analysis have compared cemented with cementless fixation in terms of implant survival, functional recovery and radiological differences. However, there was not still a widely-accepted conclusion formed whether the cement should be used in TKA. To our knowledge, the length of follow-up was an important factor influenced the revision rate of TKA. While there was still no review and meta-analysis divided the studies according to length of follow-up to compare two kinds of fixation. Therefore, we divided the studies included in our meta-analysis into three groups to explore the revision rate and reasons of revision in two groups. We hypothesized that the cementless fixation was not inferior than cemented TKA in terms of revision rate and functional recovery.

Methods

The guidelines listed in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was the basis of this systematic review and meta-analysis [10].

Search strategy

MEDLINE (1950 to date), PubMed (1966 to date), EMBASE (1974 to date), the Cochrane Central Register of Controlled Trials, the Wanfang database (1982 to date), and the Web of Science were systematically searched for studies on cementless fixation in total knee arthroplasty on Aug 30, 2019. “Knee, knee replacement, knee arthroplasty, total knee replacement, TKR, total knee arthroplasty, TKA,” and “cementless, cemented, uncemented” were used as key words in connection with AND or OR. Meta-analyses were identified and screened out of the search results by the third reviewer. Then, the references of these meta-analyses were screened to find additional relevant studies. Another reviewer tried to contact expert informants by email to search for unpublished studies Finally, two reviewers independently assessed the studies, and any discrepancies were resolved by a discussion with the other reviewers.

Inclusion and Exclusion criteria

Studies were included according to the PICOS criteria: (1) Population: patients experiencing TKA who were demographically alike; (2) Intervention and Control: cementless and cemented fixation in TKA; (3) Outcomes: revision rate, reasons of revision, functional recovery, and rate of complication; (4) Study design: randomized controlled trial (RCT), prospective or retrospective observational studies.

Studies were excluded if: (1) relevant outcomes were missing or (2) the quality assessment was low (RCT<5, non-RCTs<20). (3) the groups in study was not fully-cementless and fully cemented, that the hybrid fixation was not included in this study.

Quality assessment

A modified seven-point JADAD scale was adopted to assess the methodological quality of the RCTs. The scale considers five items, namely, randomization, concealment of allocation, double blinding, withdrawals and dropouts [11]. Based on the Cochrane Handbook, two reviewers independently evaluated the quality of the included RCTs. There was no disagreement between the two reviewers' ratings.

Two reviewers evaluated the quality of non-RCTs by using Methodological Index for Non-Randomized Studies scale (MINORS), which has a range of scores from 0 to 24 [12]. Unified consensus was obtained if there were any different opinions.

Data extraction

The relevant data, including the authors, year of publication, country, baseline information of participants, prosthesis design, revision rate, power analysis, the length of follow-up were independently extracted by two reviewers using a standard data extraction form.

To compare the two kinds of fixation in TKA, the outcomes were summarized in three parts. The first part was the rate of revision and reasons of revision, which was the primary outcome of our study. The second part was the postoperative functional recovery, including the Knee Society (KSS) knee and function scores, Oxford knee scores, range of motion (ROM), and manipulation under anesthesia. The third part was the rate of complication, including deep vein thrombosis (DVT) and all infection (superficial wound infection and periprosthetic joint infection).

Statistical analysis

The Review manager 5.3 (Nordic Cochrane Center, Copenhagen, Denmark) was used to perform the meta-analysis. The final results are shown in Forest plots. Mean differences (MD) or standard mean differences (SMD) were used to weigh the effect size for continuous outcomes, and relative risks (RR) were used for dichotomous outcomes. The I^2 statistic was used to test for heterogeneity across the included studies [11]. A p value≤0.1 or an I^2>50% was regarded as proof of heterogeneity. A random-effects model is used to synthesize results with high heterogeneity and is more conservative than a fixed effects model. Therefore, a random-effects model was used to alleviate the effect caused by high heterogeneity, and a fixed effects model was used when statistical evidence showed low heterogeneity.

Results

Search results

As shown in **Fig.1**, among 1787 articles were obtained from the databases via the search strategy. After removing duplicates, 767 articles were screened. From among them 722 articles were removed after reading the title and abstract based on the inclusion criteria. Then, 19 studies were excluded on the basis of exclusion criteria. Finally, 11 RCTs [2,13-22]and 15 non-RCTs [23-37] were included in this study after meeting the inclusion and exclusion criteria.

Baseline information and quality assessment

26 studies involving 2369 patients in cementless group and 2654 patients in cemented group were divided into three subgroups according to the length of follow-up. The length of follow-up ≤5.5 years including 17 studies [14-18,20,21,23-25,27,29,31,32,35-37], which ranged from 2 to 5.3 years. The length of follow-up ≤10.5 years including 6 studies [13,19,26,28,30,33], which ranged from 5.7 to 10.2 years. The length of follow-up >10.5 years including 3 studies [2,22,34], which ranged from 12.1 to 16.6 years. The baseline information including study design, demographical data, revision rate, prosthesis and length of follow-up were clearly listed in **Table 1**.

The JADAD score of 11 RCTs were listed in **Table 2**, both of them were ≧5, four of them [2,15,21,22] got 7 points. The MINORS scores of 15 non-RCTs were listed in **Table 3**, both of them were ≧20, only one of them [37] got 24 points.

Rate of revision and reasons of revision

A total of 22 studies involving 2178 patients in cementless group and 2442 patients in cemented group reported the rate of revision during the follow-up. There were 101(4.6%) and 131 (5.3%) patients in two groups underwent the revision surgery for all kinds of reasons. Among of them, aseptic loosing was the most common reason of revision, next was the periprosthetic joint infection (PJI). The specific number of revisions and all kinds of reasons were listed in Table 4 in detail. In addition, we made a heat-map based on the risk ratio of revision caused by all kinds of reasons in every study (**Fig.2**). We divided 22 studies into three subgroups according to the length of follow-up and reported results as following:

First subgroup: follow-up≤5.5 years

Among 14 studies involving 1251 patients in cementless group and 1450 patients in cemented group followed≤5.5 years reported the rate of revision between cementless and cemented fixation in TKA. There were 32 (2.6%) and 72 (5%) patients in two groups revised, patients in cemented group significantly increased the rate of revision compared with cementless group (RR=0.47, 95% CI: [0.32, 0.70], P=0.0002; **Fig.3**).

8 of 14 studies involving 878 patients in cementlesss group and 1092 patients in cemented group reported the rate of revision caused by aseptic loosing. There were 8 (0.6%) and 35 (2.4%) patients in two groups revised for aseptic loosing, patients in cemented group significantly increased the rate of revision caused by aseptic loosing compared with cementless group (RR=0.28, 95% CI: [0.14, 0.54], P=0.0002; **Fig.4**).

11 of 14 studies involving 1080 patients in cementlesss group and 1270 patients in cemented group reported the rate of revision caused by periprosthetic joint infection (PJI). There were 11 (0.9%) and 11 (0.8%) patients in two groups revised for PJI, and no significant difference between two groups (RR=1.07, 95% CI: [0.51, 2.22], P=0.86; **Fig.5**).

Second subgroup: follow-up≤10.5 years

Among 5 studies involving 697 in cementless group and 762 in cemented group followed≤10.5 years reported the rate of revision between cementless and cemented fixation in TKA. There were 62 (8.9%) and 49 (6.4%) patients in two groups revised, which was not significantly different between two groups (RR=1.22, 95% CI: [0.85, 1.77], P=0.28; **Fig.3**).

All 5 studies involving 697 patients in cementlesss group and 762 patients in cemented group reported the rate of revision caused by aseptic loosing. There were 38 (5.5%) and 22 (2.9%) patients in two groups revised for aseptic loosing, no significant difference between groups (RR=1.61, 95% CI: [0.96, 2.72], P=0.07; **Fig.4**).

All 5 studies involving 697 patients in cementlesss group and 762 patients in cemented group reported the rate of revision caused by periprosthetic joint infection (PJI). There were9 (1.3%) and 16 (2.1%) patients in two groups revised for PJI, and no significant difference between two groups (RR=0.59, 95% CI: [0.26, 1.34], P=0.20; **Fig.5**).

Third subgroup: follow-up>10.5 years

Among 3 studies involving 230 patients in cementless group and 230 patients in cemented group followed>10.5 years reported the rate of revision between cementless and cemented fixation in TKA. There were 7 (3%) and 10 (4.3%) patients in two groups revised, which was not significantly different between two groups (RR=0.73, 95% CI: [0.30, 1.76], P=0.48; **Fig.3**).

All 3 studies involving 230 patients in cementlesss group and 230 patients in cemented group reported the rate of revision caused by aseptic loosing. There were 4(1.7%) and 6 (2.6%) patients in two groups revised for aseptic loosing, no significant difference between two groups (RR=0.71, 95% CI: [0.23, 2.22], P=0.56; **Fig.4**).

Only 1 study involving 100 patients in cementlesss group and 100 patients in cemented group reported the rate of revision caused by periprosthetic joint infection (PJI). There were 0 (0%) and 1 (1%) patients in two groups revised for PJI.

Functional recovery

12 studies involving 652 patients in cementlesss group and 656 patients in cemented group recorded the Knee Society knee score, pooled results revealed there was no significant difference regarding Knee Society knee score between two groups (MD=0.69, 95% CI: [-0.97, 2.35], P=0.42; **Fig.6A**).

9 studies involving 827 patients in cementlesss group and 819 patients in cemented group recorded the Knee Society function score, pooled results revealed that patients in cementless group had a better functional recovery regarding Knee Society function score (MD=1.70, 95% CI: [0.53, 2.86], P=0.004; **Fig.6B**).

5 studies involving 230 patients in cementlesss group and 221 patients in cemented group recorded the Oxford knee score, pooled results revealed that patients in cementless group had a better functional recovery on Oxford knee score (MD=-1.00, 95% CI: [-1.72, -0.27], P=0.007; **Fig.6C**).

7 studies involving 626 patients in cementlesss group and 679 patients in cemented group reported the range of motion (ROM) following TKA, pooled results revealed the ROM was not significantly different (MD=0.90, 95% CI: [-0.72, 2.52], P=0.28; **Fig.7A**). However, 7 studies involving 566 patients in cementlesss group and 588 patients in cemented group revealed that the rate of manipulation under anesthesia was significantly more in cemented group (RR=0.44, 95% CI: [0.24, 0.80], P=0.007; **Fig.7B**).

Complications

7 studies involving 478 patients in cementlesss group and 495 patients in cemented group recorded the rate of deep vein thrombosis (DVT) following TKA. There were 19 (4.0%) in cementless group and 31 (6.3%) in cemented group diagnosed as DVT, while it was not significantly different (RR=0.76, 95% CI: [0.45, 1.27], P=0.30; **Fig.8A**).

20 studies involving 2048 patients in cementlesss group and 2337 patients in cemented group recorded the rate of all infection following TKA. There were 29 (1.4%) in cementless group and 32 (1.4%) in cemented group diagnosed as superficial wound infection or PJI, while it was not significantly different (RR=0.97, 95% CI: [0.61, 1.57], P=0.92; **Fig.8B**).

Discussion

Compared with the published review and meta-analysis [38-41] [42], the most prominent advantage of our study was that we divided studies into three subgroups according to the length of follow-up and got significant difference between cemented and cementless fixation in TKA in the first subgroup.

Survivorship of prosthesis was the most important endpoint in TKA. [43] The rate of revision and reasons caused revision were primary outcomes of our study. Nearly each included study reported the number of revision and reasons caused revision. We found that the rate of revision was not significantly different when all studies were combined, but when data were combined in studies followed less than 5.5 years the cementless fixation TKA presented significant superiority. Although relatively longer follow-up was needed to compare the true difference regarding the rate of revision between two kinds of fixation in TKA. It has been revealed that 3% to 50% primary TKAs underwent revision within the first five years [44, 45]. Therefore, we believe that even we could not get significant difference in all three subgroups, the results from this period of follow-up was very meaningful for the future research. In addition, a potential explanation of non-significant results in subgroups followed longer than 5.5 years was that less articles followed longer than 5.5 years in our systematic research.

From the Table 4 and Fig.2, we found that aseptic loosing was the most common reason caused revision after TKA in our study. A total of 22 studies involving 4620 patients reported 232(5.02%) revision and at least 9 kinds of reasons caused revision. Among the nine reasons caused revision, rate of aseptic loosing was 113(2.45%), followed by the periprosthetic joint infection (PJI, 48(1.04%)), instability (15, 0.32%), exchange of tibia polyethylene insert (11, 0.24%), periprosthetic fracture (6, 0.13%), polyethylene wear (4, 0.09%), patella dislocation (4, 0.09%), patellofemoral arthritis (4, 0.09%), stiffness (3, 0.06%) and other reasons (23, 0.5%). Consistent with the rate of revision, rate of aseptic loosing was significantly decreased in the cementless fixation group in the first subgroup. However, other 8 reasons including PJI was not significantly different between two kinds of fixation (Fig.5 and supplementary material). Therefore, we could conclude that aseptic loosing was significantly easier happened in bone-cement interface in cemented fixation group and lead to revision within 5.5 years after TKA.

As the secondary outcome of our study, the postoperative functional recovery also showed significant difference between two kinds of fixation in TKA. In this study, we used Knee Society/Function Score, Oxford Knee Score, Western Ontario and McMaster Universities Osteoarthritis Index scores (WOMAC), range of motion (ROM) and manipulation under anesthesia to evaluate the difference on clinical recovery. On the one hand, patients in cementless group had better functional recovery in terms of Knee Function Score and Oxford Knee Score compared with cemented group. On the other hand, although ROM was not significantly different, there were significantly less patients in cementless group required manipulation under anesthesia. A possible explanation for the better recovery in cementless TKA was that relevant complications such as osteolysis, anterior knee pain was more common in cemented group. However, rate of complications including DVT and infection was not significantly different between two kinds of fixation in our study.

From the results of previous research, cementless TKA showed inferior clinical outcomes and survivorship compared with cemented component [14, 40]. However, along with the development of manufacture and biomaterials including highly porous metals, cross-linked polyethylene, and corrections in initial cementless designs, some recent publications show successful results in long-term follou-up of cementless fixation [46]. Interest on cementless fixation increased as more young patients underwent TKA. Moreover, cementless TKA presented lower revision rates compared with cemented fixation in morbidly obese patients [25]. A possible reason for this phenomenon was that greater stress was placed on the bone–implant interface when patients were more active or obese [47]. Therefore, inferior performance of cemented TKA in younger and obese patients made the advent of cementless an alternative way to offer long-term results.

In addition, a study published in 2019 compared the actual cost of a cemented and cementless total knee arthroplasty procedure concluded that the overall procedural cost of implanting a cementless TKA was less than implanting a cemented TKA [48]. Therefore, cost alone should not be a barrier to using cementless TKA.

There are some weaknesses in this review and meta-analysis. Firstly, there were small number of studies followed >5.5 years included in our study, and significant difference could be got when more long-term studies were included. Secondly, the prosthesis design used in included studies were not totally same, which might increase bias, while the heterogeneity was not high in our outcomes. Thirdly, in the 26 studies included in our meta-analysis, there were only 11 RCTs included, which decreased the level of evidence of our study. Therefore, more high-level RCTs were needed in futrure research. Fourthly, outcomes regarding complication after TKA was relatively simple, more relevant outcomes such as instability, stiffness, dislocation and osteolysis should be paid attention in future research.

Conclusion

Not only the rate of aseptic loosing was decreased, rate of revision was significantly decreased in cementless TKA within 5.5 years. In addition, the cementless TKA performed better in postoperative functional recovery according to Knee Society Function Score and Oxford Knee Score. However, the rate of complication was not significantly different in two kinds of fixation in TKA.

Declarations

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Conflict of interest: Author Yuan Liu, Author Yi Zeng, Author Yuangang Wu, Author Mingyang Li and Author Huiqi Xie declare that they have no conflict of interest.

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Consent for publication: Author Yuan Liu, Author Yi Zeng, Author Yuangang Wu, Author Mingyang Li, and Author Huiqi Xie declare that they consent the publication of this review and meta-analysis.

Competing interests: Author Yuan Liu, Author Yi Zeng, Author Yuangang Wu, Author Mingyang Li, and Author Huiqi Xie declare that they have no conflict of interest.

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Author's contribution: The following authors have designed the study (SB), gathered the data (LY, LMy), analyzed the data (ZY, WYg), wrote the initial drafts (LY), and ensure the accuracy of the data and analysis (XHq, SB).

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Abbreviations

total knee arthroplasty (TKA); Randomized controlled trials (RCTs); Cochrane Central Register of Controlled Trials (CENTRAL); confidence interval (CI); angle of motion (ROM); deep vein thrombosis (DVT); Mean differences (MD); standard mean differences (SMD); periprosthetic joint infection (PJI).

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Tables

Table 1 The baseline information of studies compared cementless with cement fixation in TKA

			cementless/cement							
studies	country	study design	cases	age	BMI	female	revision rate(%)	prosthesis	power analysis	follow-up
follow-up≦5.5y										
Abu-rajab2006	UK	non-RCT	20/18	69/71	-	11/8	-	-	Y	2y
Anis2019	USA	non-RCT	133/132	60/62	33/33	51/44	2.3/1.5	-	N	2y
Bagsby2016	USA	non-RCT	145/154	62.7/58.8	44.7/45.6	102/122	0.7/13	Stryker Triathlon	N	3.65y
Carlsson2005	Sweden	RCT	27/29	74/72	-	20/22	3.7/0	PFC	N	5y
Dodd1990	UK	non-RCT	18/18	-	-	15/15	5.6/5.6	PCA	N	5y
Fernandez-Fairen2013	Switzerland	RCT	74/71	61/60	29.1/30.5	55/54	0/1.6	NexGen CR	Y	5y
Fricka2015	USA	RCT	47/46	60.2/58.6	31.4/32.7	29/33	2.1/2.2	NexGen CR	Y	2y
Fricka2019	USA	RCT	41/44	59.8/58.4	31.4/31.9	26/31	4.9/2.3	NexGen CR	Y	5y
Gao2009	Sweden	RCT	19/22	-	-	-	5.3/0	NexGen CR	Y	2y
Kamath2011	USA	non-RCT	100/312	55/63	-	-	2/1.6	NexGen CR	N	5y
McCaskie1998	UK	RCT	58/81	70.2/68.8	-	32/49	-	PFC	N	5y
Miller2017	USA	non-RCT	200/200	64.3/64.4	33.9/33.1	125/125	3.5/4	Stryker Triathlon	N	5.3y
Nam2019	USA	RCT	76/65	61.3/63	31.1/31.3	36/34	0/1.5	Stryker Triathlon	Y	2y
Pap2018	Hungary	non-RCT	134/140	59/69		53/64	1.5/1.4	SanatSwing	N	2y
Rand1991	USA	non-RCT	59/59	57/66	29.4/24.4	24/25	-	PFC	N	2.8y
Rosenberg1990	USA	non-RCT	132/139	59/70		77/82	4.5/5.8	-	N	3.6y
Sinicrope2018	USA	non-RCT	108/85	62/60	45.6/45	82/67	4.63/25.88	Stryker Triathlon	Y	5y
follow-up≦10.5y										
Baker2007	UK	RCT	224/277	71/70		103/121	8.9/8.7	PFC	N	8.7y
Boyle2017	USA	non-RCT	154/171	59.6/64.9	37.4/37.4	97/128	3.9/3.5	Stryker Triathlon	N	5.7y
Duffy1998	USA	non-RCT	55/51	54/65	29.07/27.63	23/24	16.4/5.9	PFC	N	10.2y
Karachalios2018	Greek	non-RCT	54/54	63.2/63.8	32/31.5	36/37	-	aMP system	Y	8.6y
Khaw2002	UK	RCT	177/219	71/70	-	103/121	3.95/4.11	PFC	N	7.3y
Pecina2000	Croatia	non-RCT	87/44	57/62	-	-	22.99/15.91	PCA	N	7.3y
follow-up>10.5y										
Kim2014	Korea	RCT	80/80	54.3/54.3	27.8/27.8	63/63	1.25/0	NexGen CR	Y	16.6y
Park2011	Korea	RCT	50/50	58.4/58.4	26.6/26.6	39/39	2/0	NexGen CR	Y	13.6y
Prudhon2017	France	non-RCT	100/100	72.3/73.2	-	57/59	5/10	NEW WAVETM	N	12.1y

RCT-randomized controlled trial; BMI-body mass index; PFC-Press-Fit Condylar; PCA-porous-coated anatomic; CR-cruciate-retaining;

Table 2 The quality assessment of RCTs

studies	randomization	concealment of allocation	double blinding	withdrawal and dropout	Total score
Baker2007	1	2	2	1	6
Carlsson2005	2	2	1	1	6
Fernandez-Fairen2013	2	2	2	1	7
Fricka2015	2	2	1	1	6
Fricka2019	2	2	1	1	6
Gao2009	2	2	1	1	6
Khaw2002	1	2	2	1	6
Kim2014	2	2	2	1	7
McCaskie1998	1	2	1	1	5
Nam2019	2	2	2	1	7
Park2011	2	2	2	1	7

Table 3 The quality assessment of non-RCTs

studies	A clearly stated aim	Inclusion of consecutive patients	Prospective data collection	Endpoints appropriate to the aim of the study	Unbiased assessment of the study endpoint	A follow-up period appropriate to the aims of study	Less than 5% loss to follow-up	Prospective calculation of the sample size	An adequate control group	Contemporary groups	Baseline equivalence of groups	Adeq statis anal
Abu-rajab2006	2	2	2	2	2	2	0	2	2	2	2	2
Anis2019	2	2	0	2	2	2	2	0	2	2	2	2
Bagsby2016	2	2	2	2	2	2	2	0	2	1	2	2
Boyle2017	2	2	2	2	2	2	0	0	2	2	2	2
Dodd1990	2	2	2	2	2	2	2	0	2	2	2	2
Duffy1998	2	2	2	2	2	2	0	0	2	2	2	2
Kamath2011	2	2	2	2	2	2	1	0	2	2	2	2
Karachalios2018	2	2	2	2	2	2	2	2	2	0	2	2
Miller2017	2	2	2	2	2	2	2	0	2	2	2	2
Pap2018	2	2	2	2	2	2	2	0	2	2	2	2
Pecina2000	2	2	2	2	2	2	0	0	2	2	2	2
Prudhon2017	2	2	2	2	2	2	2	0	2	0	2	2
Rand1991	2	2	2	2	2	2	2	0	2	2	2	2
Rosenberg1990	2	2	2	2	2	2	2	0	2	2	2	2
Sinicrope2018	2	2	2	2	2	2	2	2	2	2	2	2

Table 4 The specific number of revision caused by all kinds of reasons

						cementless/cement(number (%))		
studies	patients	number of revisions	aseptic loosing	PJI	instability	polyethylene wear	exchange of tibial polyethylene insert	pe
follow-up≦5.5y								
Anis2019	133/132	3□2.3□/2(1.5)		3□2.3□/2(1.5)				
Bagsby2016	145/154	1(0.7)/20(13)	0(0)/9(5.8)	1(0.7)/2(1.3)	0(0)/3(1.9)	0(0)/1(0.6)		
Carlsson2005	27/29	1(3.7)/0(0)		1(3.7)/0(0)				
Dodd1990	18/18	1(5.6)/1(5.6)	1(5.6)/1(5.6)					
Fernandez-Fairen2013	71/64	0(0)/1(1.6)		0(0)/1(1.6)				
Fricka2015	47/46	1(2.1)/1(2.2)		0(0)/1(2.2)	1(2.1)/0(0)			
Fricka2019	41/44	2□4.9□/1(2.3)	1(2.4)/0(0)	0(0)/1(2.3)				1
Gao2009	19/22	1(5.3)/0(0)						
Kamath2011	100/312	2(2)/5(1.6)	0(0)/2(0.6)	0(0)/2(0.6)	1(1)/0(0)			
Miller2017	200/200	7(3.5)/8(4)	1(0.5)/5(2.5)	1(0.5)/0(0)	2(1)/2(1)			
Nam2019	76/65	0(0)/1(1.5)		0(0)/1(1.5)				
Pap2018	134/140	2(1.5)/2(1.4)	2(1.5)/2(1.4)					
Rosenberg1990	132/139	6(4.5)/8(5.8)	2(1.5)/0(0)	1(0.8)/0(0)	0(0)/2(1.4)			
Sinicrope2018	108/85	5(4.63)/22(25.88)	1(0.93)/16(18.82)	4(3.7)/1(1.18)	0(0)/2(2.35)	0(0)/1(1.18)		
total	*1251/1450*	*32(2.6)/72(5)*	*8(0.6)/35(2.4)*	*11(0.9)/11(0.8)*	*4(0.3)/9(0.6)*	*0(0)/2(0.1)*		*1*
follow-up≦10.5y								
Baker2007	224/277	20(8.9)/24(8.7)	12(5.4)/14(5)	4(1.8)/7(2.5)	2(0.9)/0(0)	0(0)/1(0.4)	2(0.9)/2(0.7)	
Boyle2017	154/171	6(3.9)/6(3.5)	2(1.3)/1(0.6)	1(0.6)/2(1.2)				
Duffy1998	55/51	9(16.4)/3(5.9)	8(14.5)/2(3.9)	0(0)/1(2)				
Khaw2002	177/219	7(3.95)/9(4.11)	3(1.69)/1(0.46)	1(0.56)/5(2.28)		0(0)/1(0.46)	3(1.69)/2(0.91)	
Pecina2000	87/44	20□22.99□/7(15.91)	13(14.94)/4(9.09)	3(3.45)/1(2.27)			0(0)/2(4.55)	1
total	*697/762*	*62(8.9)/49(6.4)*	*38(5.5)/22(2.9)*	*9(1.3)/16(2.1)*	*2(0.3)/0(0)*	*0(0)/2(0.3)*	*5(0.7)/6(0.8)*	*1*
follow-up>10.5y								
Kim2014	80/80	1(1.25)/0(0)	1(1.25)/0(0)	-		-	-	
Park2011	50/50	1(2)/0(0)	1(2)/0(0)					
Prudhon2017	100/100	5(5)/10(10)	2(2)/6(6)	0(0)/1(1)				
total	*230/230*	*7(3)/10(4.3)*	*4(1.7)/6(2.6)*	*0(0)/1(0.4)*				*3*
TOTAL	***2178/2442***	***101(4.6)/131(5.3)***	***50(2.3)/63(2.6)***	***20(0.9)/28(1.1)***	***6(0.3)/9(0.4)***	***0(0)/4(0.2)***	***5(0.2)/6(0.3)***	***5(***
Rate of revision	***4620***	***232(5.02)***	***113(2.45)***	***48(1.04)***	***15(0.32)***	***4(0.09)***	***11(0.24)***	

PJI- periprosthetic joint infection

Figures

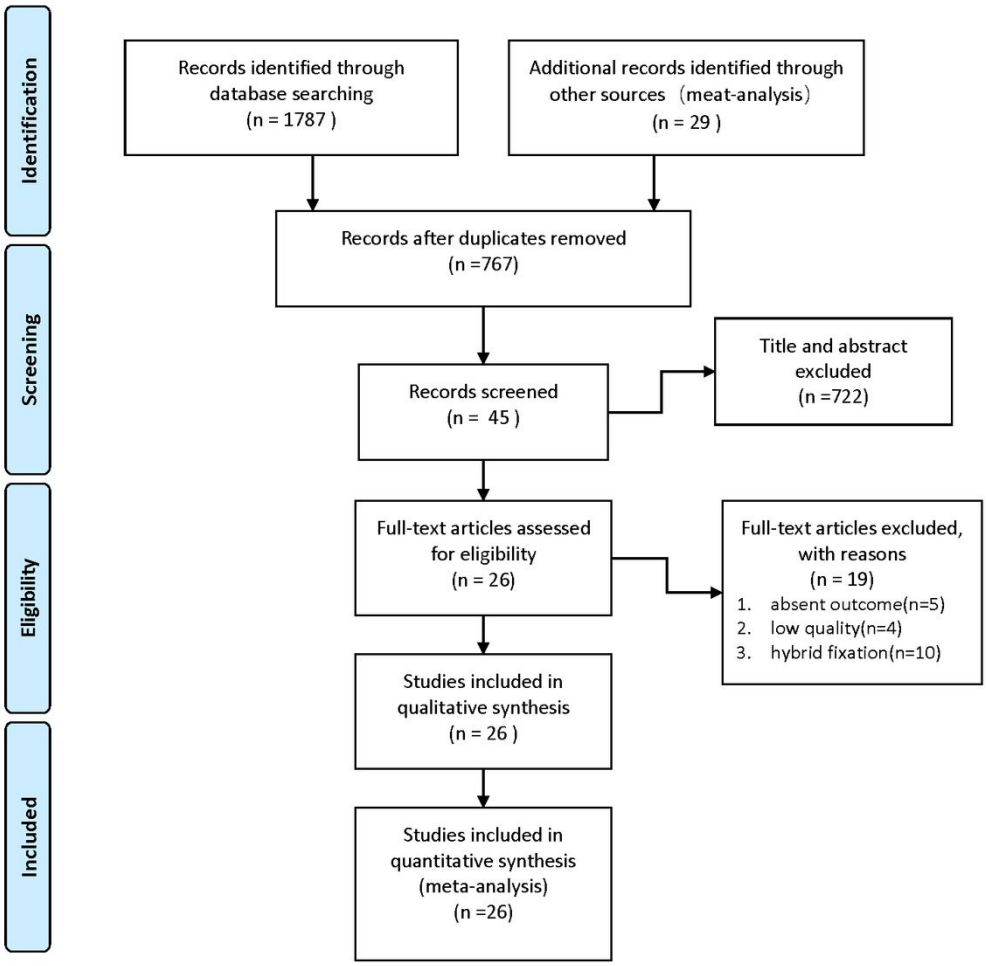


Figure 1

The flowchart of the study selection

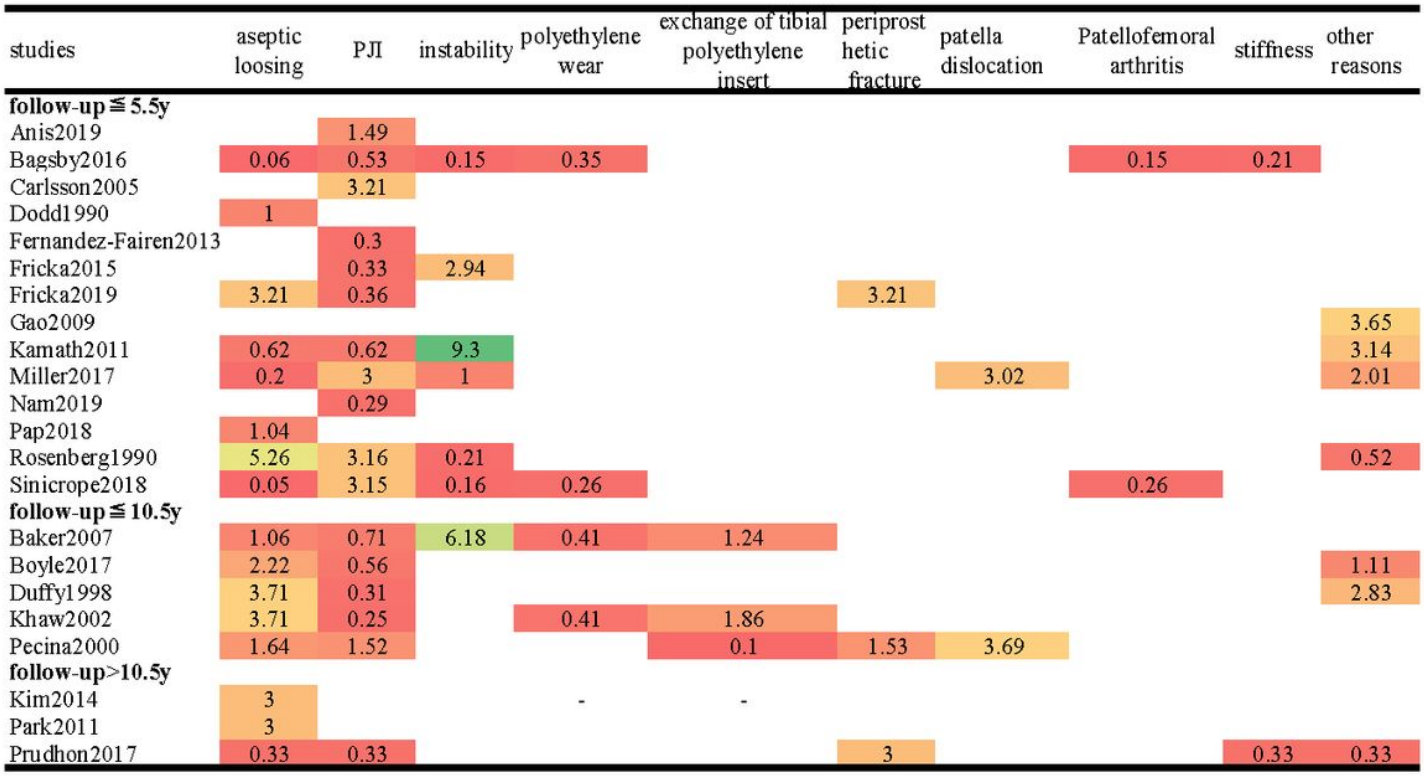


Figure 2

Heat-map regarding the risk ratio of rate of the revision and reasons in every study

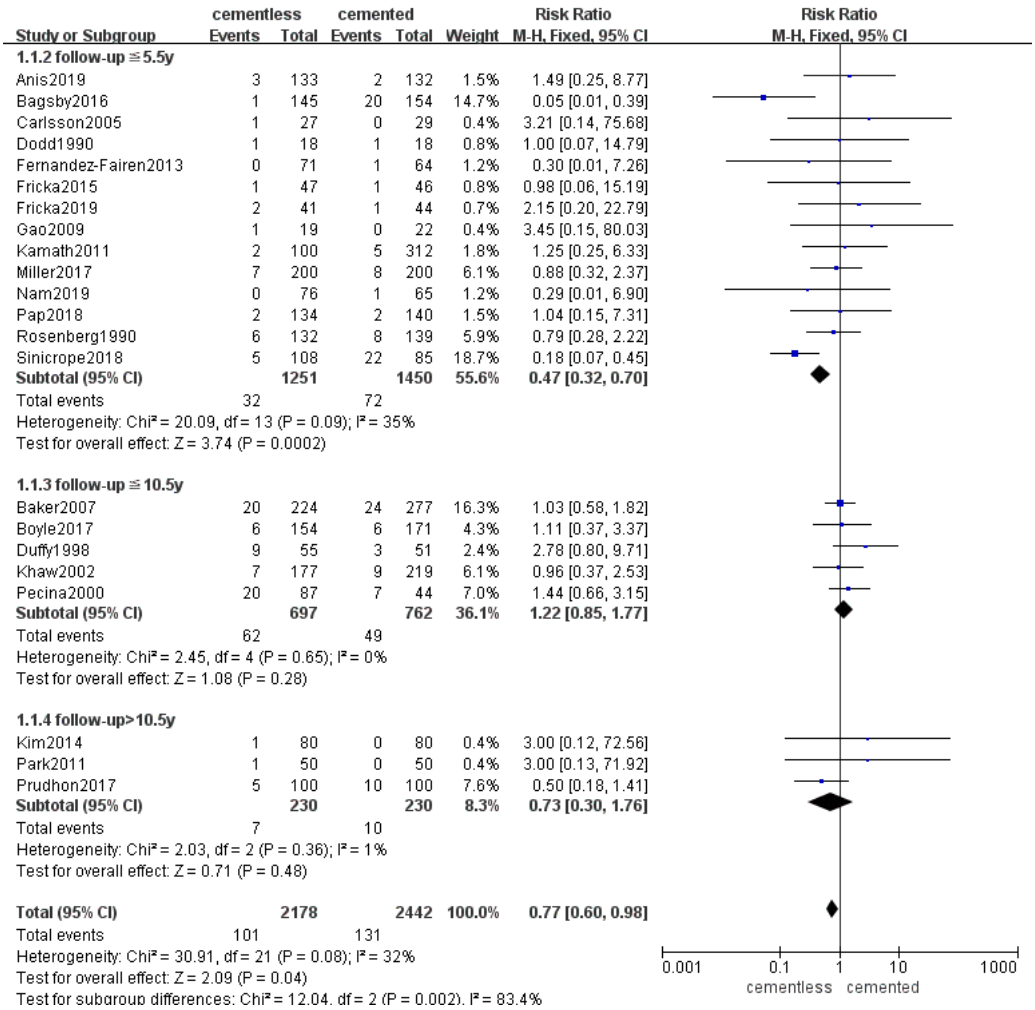


Figure 3

The frost blot about the rate of revision

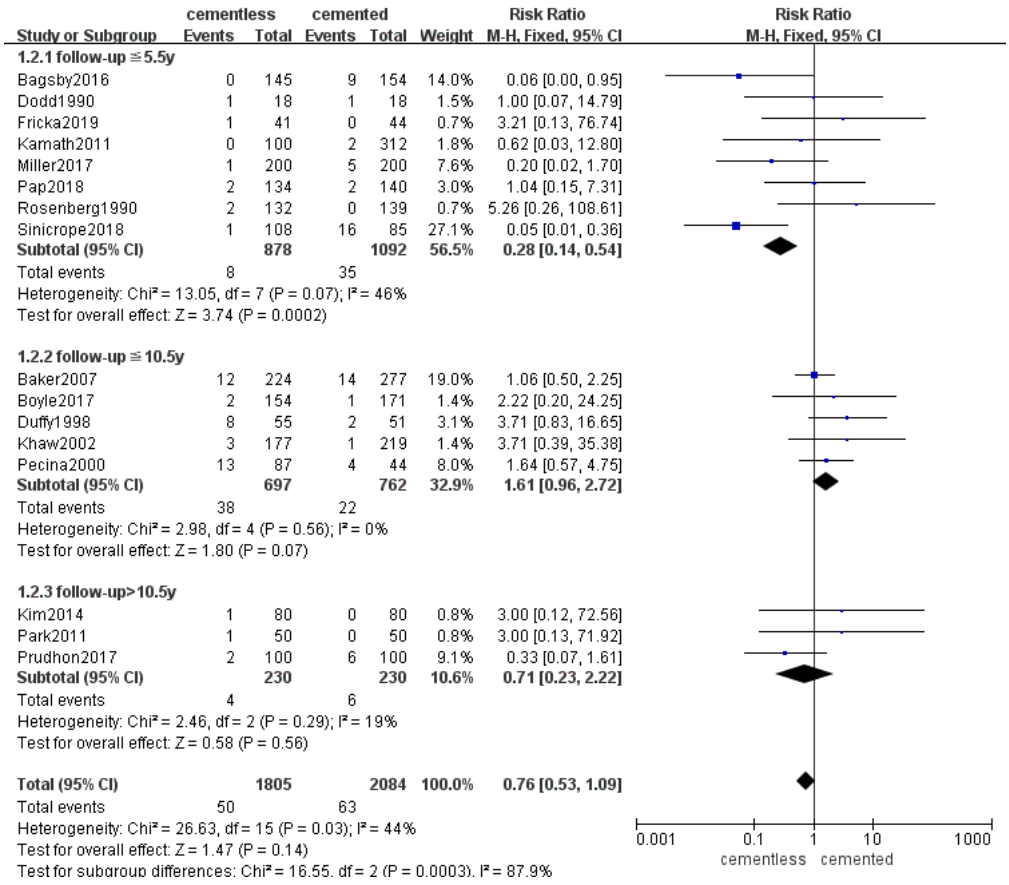


Figure 4

The frost blot about the rate of aseptic loosing

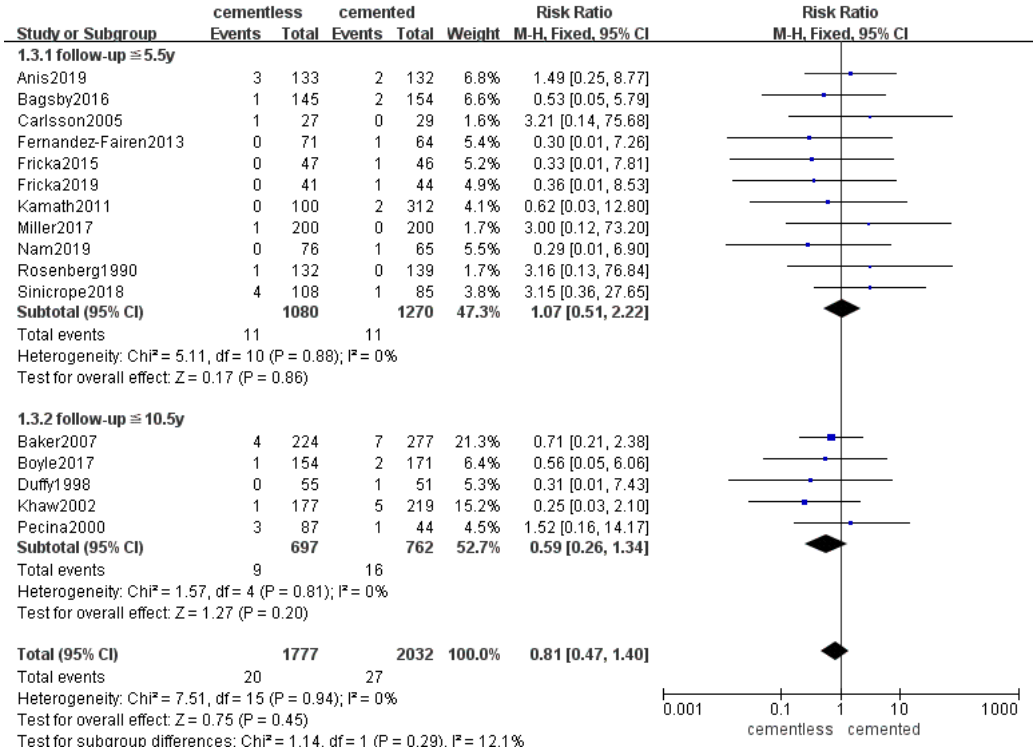
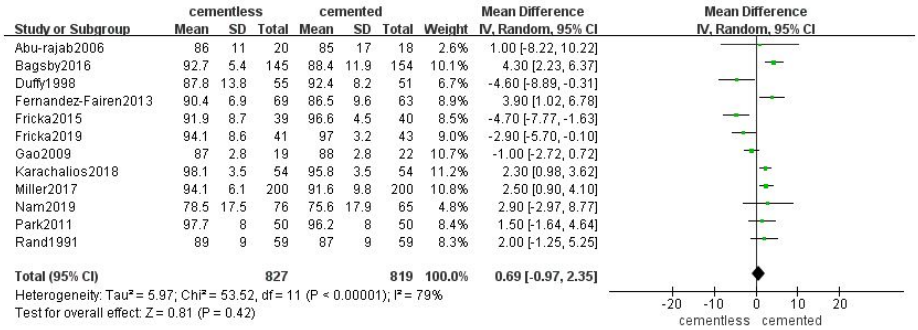


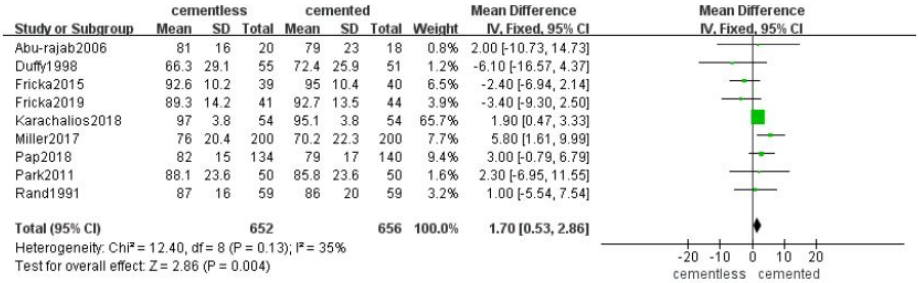
Figure 5

The frost blot about the rate of periprosthetic joint infection

A. Knee Society knee scores



B. Knee Society function scores



C. Oxford knee score

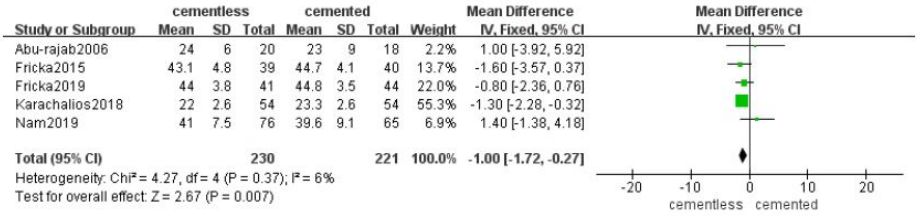


Figure 6

The frost blot about the functional recovery

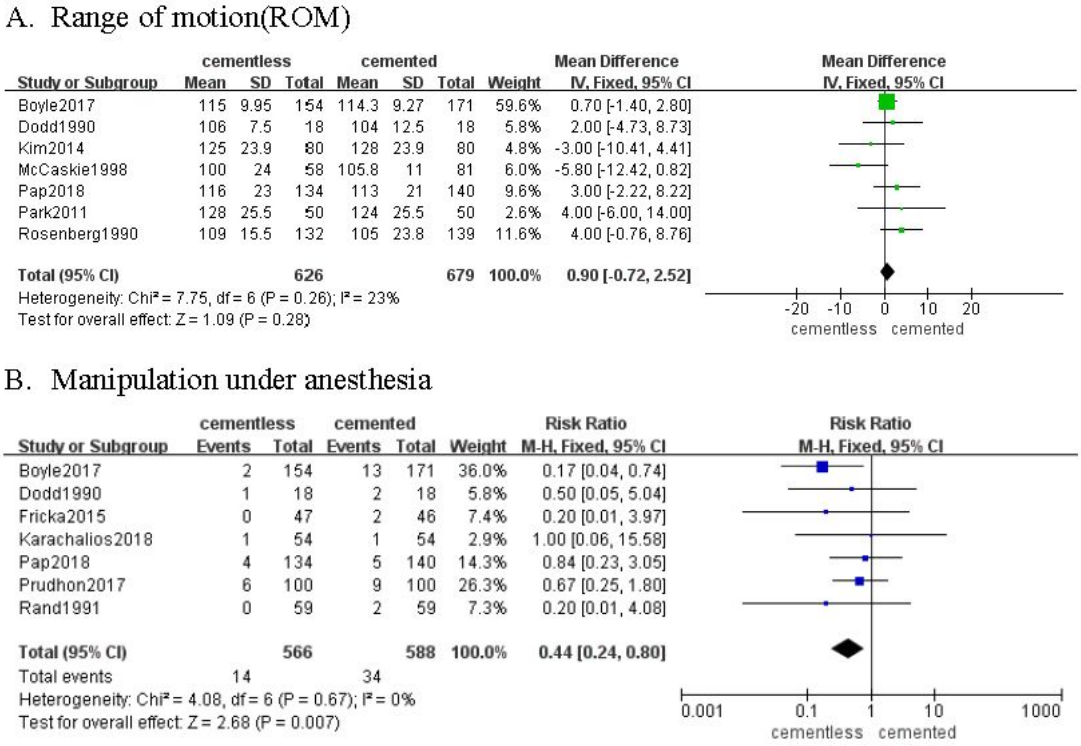


Figure 7

The frost blot about the knee motion

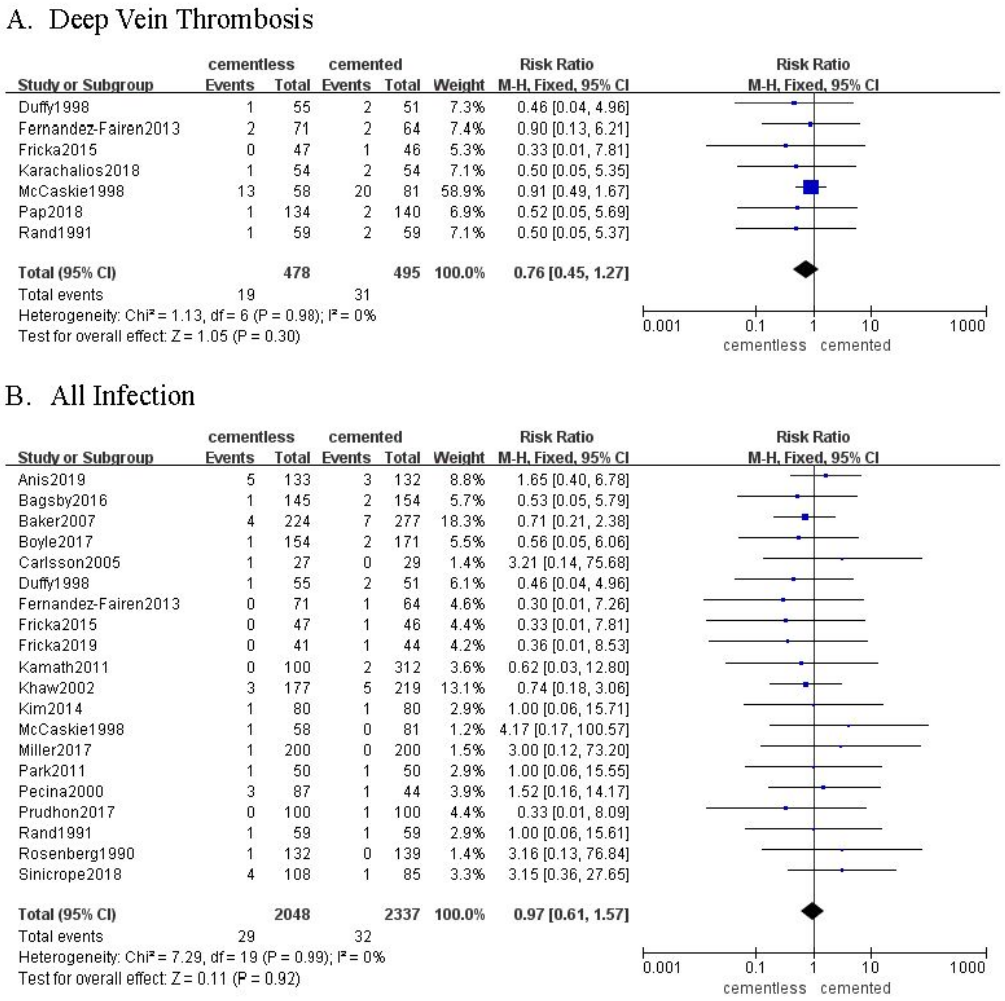


Figure 8

The frost blot about the rate of complications

Supplementary Files

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