Knee

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Cemented vs. cementless fixation in primary total knee arthroplasty: a systematic review and meta-analysis

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- Over 100,000 total knee replacements (TKRs) are carried out in the UK annually, with cemented fixation accounting for approximately 95% of all primary TKRs. In Australia, 68.1% of all primary TKRs use cemented fixation, and only 10.9% use cementless fixation. However, there has been a renewed interest in cementless fixation as a result of improvements in implant design and manufacturing technology.
- This meta-analysis aimed to compare the outcomes of cemented and cementless fixation in primary TKR. Outcome measures included the revision rate and patient-reported functional scores.
- MEDLINE and EMBASE were searched from the earliest available date to November 2018 for randomized controlled trials of primary TKAs comparing cemented versus cementless fixation outcomes.
- Six studies met our inclusion criteria and were analysed. A total of 755 knees were included; 356 knees underwent cemented fixation, 399 underwent cementless fixation. They were followed up for an average of 8.4 years (range: 2.0 to 16.6).
- This study found no significant difference in revision rates and knee function in cemented versus cementless TKR at up to 16.6-year follow-up.

Keywords: cemented; cementless; total knee replacement

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Introduction

Knee osteoarthritis (OA) affects 3.48% of the global population[1] and the demand for total knee arthroplasty (TKA) is rising. Data from the National Joint Registry[2] show that from 2015 to 2017, there were 272,133 primary total knee replacements carried out in the UK; 925,320 (94.66%) of these primary total knee replacements were cemented, with 43,011 (4.4%) uncemented and 9,157 (0.94%) hybrid.

Since 2003, the use of cemented fixation in primary TKA has increased by 6%, while the use of uncemented fixation has decreased by more than two-thirds.[2] This trend can also be seen in Australia. Data from the National Joint Replacement Registry[3] show that from 2003 to 2017, there has been an 23.3% increase in the use of cemented fixation, and a 15.4% decrease in the use of cementless fixation. The reason for this trend can be attributed to the early failures of cementless implants. Examples include the Freeman-Samuelson knee[4] and the Miller-Galante I knee,[5] which resulted in poorer patient outcomes.

Cementless implants contain roughened or porous surfaces that facilitate osseointegration through ongrowth or ingrowth respectively.[6] The surface roughness is important as it provides a mechanical interlock in the early stages, thus limiting micromotion prior to osseointegration.

The first generation cementless prostheses suffered from problems due to their poor geometry, ineffective osteoconductive surfaces and inadequate early stable fixation properties.[7] However, this has changed in recent years, resulting in a significant reduction in the stresses and micromotion occurring at the bone–metal interface.[8] There has been a recent renewed interest in uncemented knee implants[9–12] as the implant design processes and manufacturing technologies have advanced significantly, such as the use of adjunct surface coatings to improve biological fixation, and the reinforcement and design of implant components. An example can be seen in the Miller-Galante II knee, which resolved the high rate of patellofemoral complications seen in its predecessor[5,13] by making modifications in its implant design.

Another factor in the renewed interest in cementless fixation is the age of patients undergoing TKA. More TKAs are being carried out in younger patients (< 65 years),[12,14]

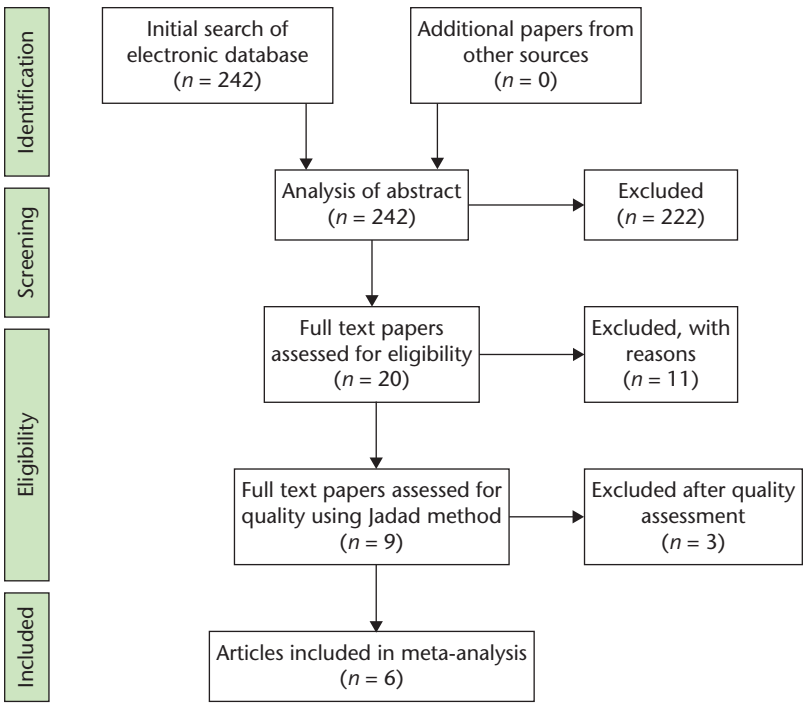

Fig. 1 PRISMA flowchart illustrating the study selection process.

who have both higher post-operative activity levels and a longer life expectancy, calling for more stable long-term fixation methods. There would be greater stresses placed on the cement mantle, which does not have the ability to remodel compared to a biologically osseointegrated component, potentially leading to higher rates of aseptic loosening. Data from the National Joint Registry show that younger patients undergoing primary cemented TKA have a higher risk of revision compared to older patients.[15] An argument could be made for prolonging the need for TKA for as long as possible in such a population. However, where this is not possible, cementless fixation may allow for increased prosthesis longevity and bone stock preservation.[8]

To investigate the aforementioned issues, we performed a systematic review and meta-analysis of randomized controlled trials comparing the outcomes of cemented and cementless fixation in primary TKA. The primary outcome assessed was the revision rate; the secondary outcome measure included post-operative functional outcome scores.

Materials and methods

Search strategy

A search was carried out using MEDLINE and EMBASE for all randomized controlled trials (RCTs) comparing primary TKA using cemented versus cementless fixation, from the earliest available date to November 2018. The search included the following terms: (Total Knee Replacement OR Total Knee Arthroplasty) AND (Cemented) AND (Uncemented OR Cementless). The reference lists of the relevant articles were explored to find additional papers.

Eligibility criteria

The inclusion criteria included: (i) patients undergoing primary total knee arthroplasty; (ii) comparison of cemented versus cementless fixation; (iii) revision rate; (iv) peri-operative functional knee scores. The included articles met the PICO criteria for systematic reviews (Population, Intervention, Comparison and Outcomes).

We excluded studies with hybrid fixation, unicompartmental knee replacement and revision surgeries.

Study selection

Two reviewers (JT and AP) screened all the abstracts retrieved, and excluded studies that did not meet the inclusion criteria (see supplementary information). The full texts of the articles were then obtained and reviewed by two reviewers (JT and AP). Fig. 1 illustrates a PRISMA flowchart of the study selection process.

The primary outcome measure was revision rate. The secondary outcome measure was post-operative functional knee scores.

Data extraction

Two reviewers (JT and AP) extracted data through a standardized data collection form. Data concerning number of patients, follow-up period, type of fixation, complications,

Table 1. Summary of results

Study	Population size (number of knees)		Time to follow-up	Prosthesis type	Additional information – mode of cementless fixation	All cause revision rate		Significant difference in revision rate?	Significant difference in pain?	Significant difference in functional score?
	Cemented	Cementless				Cemented	Cementless			
Carlsson et al[17]	49	97	5 years	PFC CR	Porous, porous hydroxyapatite	1	1	No	No	No
Fricka et al[18]	50	50	2 years	NextGen CR	Trabecular metal	1	1	No	No	No
Choy et al[19]	86	82	8 years	Low Contact Stress		0	0	No	No	No
Beaupré et al[20]	41	40	5 years	Scorpio CR	Hydroxyapatite coating	0	0	No	No	No
Park and Kim[21]	50	50	14 years	NextGen CR	Press fit	0	1	No	No	No
Kim et al[22]	80	80	16.6 years	NextGen CR	Press fit	0	1	No	No	No

Note. CR, cruciate-retaining; PFC, press fit condylar.

revision rate and post-operative functional outcome were extracted and entered into a spreadsheet. Table 1 illustrates a summary of the results extracted from the studies.

Results

Studies

A total of 20 eligible studies were identified. After reviewing the full text, a total of nine studies met the selection criteria. Eleven studies were excluded as they did not meet the PICO criteria. Only studies of a high quality, as per the Jadad scoring system (score $\geqslant 3$)[16] were included in the meta-analysis. A further three studies were excluded at this stage, leaving six studies[17–22] for meta-analysis.

Statistical methods

For the primary outcome of revision rate, data were extracted and compared quantitatively from all six studies. The Cochran's Q test and heterogeneity index I^2 was used to assess for statistical heterogeneity, and a P value < 0.1 and $I^2 > 50\%$ used to identify significant heterogeneity. The fixed-effect model was used, as no significant heterogeneity was noted. A forest plot was generated using a standardized template.

Cohort characteristics

In total, 755 TKAs (356 cemented, 399 uncemented) were included in patients with a mean age of 62.5 years (range: 43 to 80), with a male to female ratio of 1:3. They were followed up for a mean of 8.4 years (range: 2.0 to 16.6). There were 146 Press-Fit Condylar cruciate retaining (CR) TKAs (19.3%), 360 NextGen CR prosthetic TKAs (47.7%), 168 Low Contact Stress TKAs (22.3%), and 81 Scorpio CR TKAs (10.7%). The results of the six studies and cohort characteristics are summarized in Tables 1 and 2 respectively.

Outcome analysis

Revision rate

Revision rate was reported in all studies. There were two failures requiring revision surgery in the cemented fixation group (0.56%), both of which were due to infection. There were four failures requiring revision surgery in the cementless fixation group (1%), due to aseptic loosening (50%, $n = 2$) and instability (50%, $n = 2$). The specific time of failures was not recorded in the studies. There was no statistically significant difference in revision rate ($p = 0.64$). Fig. 2 illustrates the revision rate in the two groups.

Functional outcome

Functional outcome was reported in all six studies. The Knee Society Score (KSS) was used in five studies to assess knee function with an average of 91.5 (82.0 to 96.9) in the cemented group and 91 (83.0 to 97.7) in the cementless group. All studies reported no significant difference in functional score ($p > 0.05$).

Table 2. Cohort characteristics

Study	Gender		Mean age		Mean Weight/BMI	
	Cemented	Cementless	Cemented	Cementless	Cemented	Cementless
Carlsson et al[17]	38F, 11M	74F, 23M	72.5	73.0	80	78
Fricka et al[18]	33F, 17M	29F, 20M	58.6	60.2	BMI 32.7	BMI 31.4
Choy et al[19]	62F, 5M	60F, 5M	69.0	65.0	65.7	62.5
Beaupré et al[20]	25F, 16M	25F,15M	62.9	63.9		
Park and Kim[21]	39F, 11M	39F, 11M	58.4	58.4	64	64
Kim et al[22]	63F, 17M	63F,17M	54.3	54.3	68.1	68.1

Note. Weight in kg, F, female; M, male; BMI, body mass index.

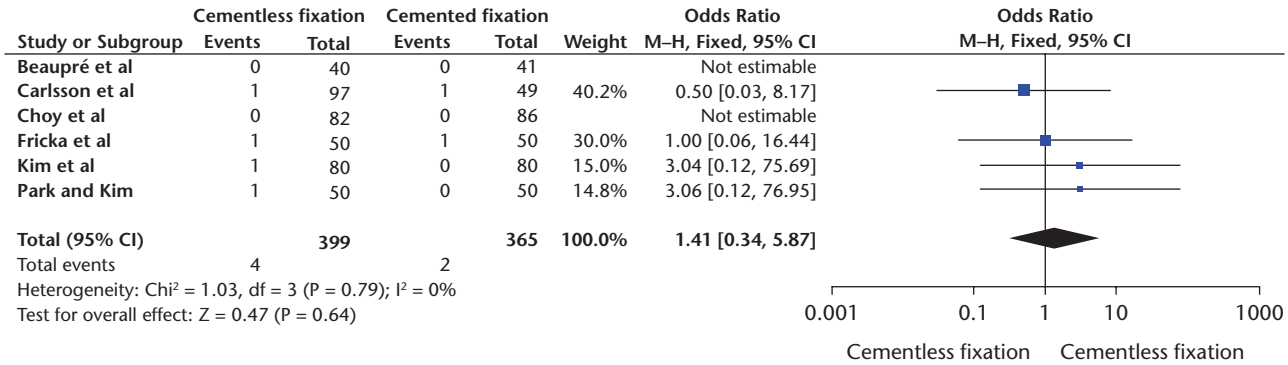

Fig. 2 Meta-analysis results for revision rate in cemented vs. cementless fixation.

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was used in four studies to assess knee function with an average of 40.3 (24.7 to 76.0) in the cemented group and 40.6 (25.4 to 74.6) in the uncemented group. All studies reported no significant difference in functional score ($p > 0.05$).

Discussion

Our review demonstrates that there is no significant difference in revision rate or post-operative functional knee scores between cemented and cementless TKA implants, up to 16.6 years follow-up (mean 8.4 years).

The theoretical advantages of cementless fixation are the avoidance of cement-induced third body wear, preservation of bone stock and the creation of a long-lasting biological fixation. The cement mantle lacks the ability to remodel, and with repetitive loading over the years, will fatigue and fail, potentially leading to higher revision rates. Theoretically, this will not occur in a biologically osseointegrated surface.

An argument could be made for a longer follow-up time, as there are some radiographic findings of aseptic loosening in the cementless group. On the basis that cementless and cemented fixation techniques show no difference in durability, one could also consider extending the use of cementless fixation to the older patient population. After all, cementless fixation could potentially have fewer cement-related complications,[23–25] a shorter surgical time (74 vs. 81 minutes, P = 0.002)[6] and pneumatic ischaemia time. In a recent study of cementless TKA in patients older than 75 years, Newman et al[26] found excellent survivorship and functional outcomes, as well as a low rate of complications.

Despite the unanimous conclusion that there was no difference in revision rates, Fricka et al[18] and Choy et al[19] noted that radiolucent lines were associated more with cementless fixation, though this did not reach significance. At eight years, Choy et al[19] found that more cementless prostheses showed a radiolucent line at the bone–implant interface than cemented prostheses (13% vs. 8%, p = 0.27), despite the all-cause revision rate for both groups being zero. This was noted on fluoroscopically assisted radiographs (more reliable than plain radiographs),[27] by an independent arthroplasty surgeon, and according to the methods of the Knee Society. Despite this not being significantly different, and with no clinical signs of aseptic loosening, it was thought that a longer-term follow-up was necessary, as radiolucent lines could suggest an impending implant loosening. The weight-bearing status of the patient in the immediate post-operative period may, in theory, influence migration. Two studies specified the weight-bearing status in the immediate post-operative period – Choy et al allowed partial weight-bearing (PWB), and Fricka et al allowed full weight-bearing (FWB) as tolerated. There was no indication to suggest the superiority of one method over the other. There is a dearth of evidence in the current literature comparing the two, though Fukumoto et al[28] and Shabana et al[29] agreed that FWB in the immediate post-operative period caused no complications with early radiological and clinical outcomes.

Periprosthetic joint infection (PJI) remains one of the most devastating complications of joint replacement surgery, and the potential of using antibiotic-infused bone cement (AIBC) in primary cemented fixation may be an argument for its clinical superiority. Our review has demonstrated no significant difference in infection rates between cemented and cementless fixation, a finding supported by other systematic reviews.[30,31] While some authors have advocated for the use of prophylactic AIBC in primary TKA,[32–34] the evidence for its clinical benefit remains controversial.[35–37] More large-scale studies are required with regard to the use of AIBC specific to primary TKA.

All six studies reported no overall difference in functional score, despite the use of different criteria to assess knee function.

Fricka et al[18] observed that patients with cementless fixation tended to have a higher pain score in the early recovery period, at four months, compared to patients with cemented fixation (P = 0.06), though this did not reach significance. This is supported by Beaupré et al,[20] whose study showed more self-reported pain at six months post-operatively in the cementless compared to the cemented group, using the RAND-36-Item Health Survey (P = 0.006). This may be attributed to the greater initial prosthetic migration with cementless fixation, as noted by Carlsson et al[17] and several other studies,[38,39] and the time needed for biological fixation to occur with cementless prostheses. This initial migration tends to stabilize within the first post-operative year in most cases,[38,39] and hence the reported pain difference did not persist at the one-year assessment.

Hence, patients undergoing cementless fixation TKA may initially experience more post-operative pain than patients undergoing cemented fixation, but this equalizes within a year. Though this effect is short term, one cannot underestimate the relevance of this difference in patient-reported pain between cemented and cementless fixation. Immediate post-operative pain tends to be one of the most important concerns for the patient,[40,41] and can negatively affect post-operative recovery.[42]

Cementless knee implants vary in design and material, and this review only covers a limited range of the various implants available on the market. It would be inappropriate to generalize all cementless TKA as equal to cemented TKA. The recall of cementless implants like the LCS Duofix femoral knee replacement in 2010[43] and the Persona knee implant in 2015[44] due to poor clinical outcomes is evidence that the newer designs can still be improved on. However, this review has proved that the cementless fixation technique can now potentially achieve outcomes comparable to those of cemented fixation.

Conclusion

The use of cementless fixation in TKA is not inferior to the use of cemented fixation. Up to 16.6 years, studies have not found an overall significant difference in post-operative outcomes, including all-cause revision rate and knee function. There is some evidence suggesting the need for an even longer follow-up, as some cementless prostheses have shown signs of potential aseptic loosening. Cementless prostheses may also result in an initial increased post-operative pain due to biological fixation, which some patients may find worthy of careful consideration.

SUPPLEMENTAL MATERIAL

Supplemental material is available for this paper at https://online.boneandjoint.org.uk/doi/suppl/10.1302/2058-5241.5.200030

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ICMJE CONFLICT OF INTEREST STATEMENT

SDB reports being a paid consultant for Adler Orthopaedics, and receives royalties, financial or material support from CRC Publishing and Orthopaedic Research UK. He is on the editorial board of Bone and Joint 360, and National Joint Registry.
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