Risk factors associated with re-revision following revision total knee arthroplasty: a systematic review

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Aims

The aim of this study was to perform a systematic review and bias evaluation of the current literature to create an overview of risk factors for re-revision following revision total knee arthroplasty (rTKA).

Methods

A systematic search of MEDLINE and Embase was completed in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. The studies were required to include a population of index rTKAs. Primary or secondary outcomes had to be re-revision. The association between preoperative factors and the effect on the risk for re-revision was also required to be reported by the studies.

Results

The search yielded 4,847 studies, of which 15 were included. A majority of the studies were retrospective cohorts or registry studies. In total, 26 significant risk factors for re-revision were identified. Of these, the following risk factors were consistent across multiple studies: age at the time of index revision, male sex, index revision being partial revision, and index revision due to infection. Modifiable risk factors were opioid use, BMI > 40 kg/m^2, and anaemia. History of one-stage revision due to infection was associated with the highest risk of re-revision.

Conclusion

Overall, 26 risk factors have been associated with an increased risk of re-revision following rTKA. However, various levels of methodological bias were found in the studies. Future studies should ensure valid comparisons by including patients with identical indications and using clear definitions for accurate assessments.

Take home message

- Key risk factors for re-revision total knee arthroplasty were age, male sex, partial index revision, and infection as index revision indication.
- Correctable risk factors were preoperative anaemia and BMI ≥ 40 kg/m^2.
- Preoperative opioid use and depression may also be correctable risk factors.

Introduction

Revision total knee arthroplasty (rTKA) is complicated and is associated with significant costs for both patients and healthcare systems compared to primary knee arthroplasty.[1] Previous studies have projected that the incidence of revisions will be tripled, or maybe even six-folded, over the next decade.[2,3] The incidence of re-revisions is also expected to rise because

implant survival is expected to decrease for each revision.[4] Revision for periprosthetic joint infection (PJI) is associated with particularly low prosthesis survival, and eradication of infection may require multiple revisions. Thus, PJI is the most significant cause of repeated revisions.[5]

Risk factors for PJI and other implant-related complications have been widely investigated in the case of primary knee arthroplasty, but limited research has focused on re-revision surgery.[6] However, re-revised patients suffer the greatest functional disabilities and constitute some of the largest costs per patient for healthcare systems.[7,8] Identifying preoperative risk factors for re-revision, and correcting them, if possible, may reduce re-revision rates. No systematic review has yet investigated risk factors associated with re-revision following rTKA. The aim of this study was to perform a systematic review and bias evaluation of the current literature to create an overview of risk factors for re-revision following rTKA.

Methods

This study is a systematic review of published scientific articles. No ethical approval was required at our institution because all data acquired are publicly available. The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were followed throughout the study.[9] The protocol for this study was submitted to PROSPERO (reg. number CRD42022380715) before the study began. Our research protocol was structured according to the Population, Intervention, Comparison, and Outcome (PICO) framework.[10] Our research question was: "Which preoperative factors increase the risk of re-revision in patients with a previous rTKA?".

Eligibility

All study designs were included except case reports. Our search was limited to English literature published from 1 January 1946 to 20 December 2022. There were three main criteria for inclusion: 1) studies had to include a population of index rTKA patients; 2) the reported primary or secondary outcomes of the study had to be re-revision; and 3) the study had to investigate any association between preoperative factors and risk of re-revision expressed as relative risk (RR), odds ratio (OR), or hazard ratio (HR). Significant results required a p-value < 0.05 or a 95% CI which did not include 1.

Search strategy

The databases MEDLINE and Embase were searched according to the PRISMA guidelines.[9] The search string was based on a combination of Medical Subject Headings (MeSH) words and free-text words: knee arthroplasty, revision, reoperation, re-revision, multiple revisions, failed revision, and repeat revision. The complete search string is available in Supplementary file i.

Statistical analysis

The screening process was managed in Covidence systematic review software (Veritas Health Innovation, Australia).[11] Two separate reviewers (JTH, UKK) screened titles and abstracts followed by full-text review. The final number of included studies was determined after full-text review. Results from multivariate analyses were prioritized over uni- or bivariate analyses. The bias evaluation was performed for articles passing the full-text review according to the principles of the Newcastle-Ottawa Scale (NOS). The NOS principles consist of selection, comparability, and outcome.[12] The maximal score was 9. A score of ≥ 6 was considered high-quality.[13] Two authors (JTH, UKK) scored each study separately before deciding on a final score. All disagreements were resolved by discussion and final decision by the author group.

Results

The search string identified 4,847 articles. Following the removal of duplications, 3,636 titles and abstracts were screened. A total of 3,551 studies were subsequently excluded; 85 studies remained for full-text review, of which 15 met the inclusion criteria and were included (Figure 1).

Study characteristics

In total, the studies reported 21,476 rTKA procedures (Table I). Two studies did not give the number of procedures but only reported on patients, which amounted to 25,759 undergoing rTKA. The included articles were either single-centre retrospective cohort studies or multicentre register studies. The mean or median age of patients in the studies ranged from 41 to 72 years. The proportion of females in the studies ranged from 41% to 68%. Only index revisions with aseptic indications were investigated in eight studies. Index revisions with septic indications were investigated in three studies, and index revisions with all indications were investigated in four studies. Length of observation periods varied from nine to 30 years. Follow-ups were not described for all studies, and some included follow-up periods as short as one year.

Risk factors

In total, the 15 studies reported 26 statistically significant risk factors for re-revision following rTKA (Table II).

Indication for index revision

The indication for index revision was associated with an increased risk of re-revision in three studies. Instability compared to arthrofibrosis increased the risk of re-revision by a HR of 8.1 (95% CI 1.6 to 14.9).[14] Aseptic loosening compared to arthrofibrosis increased the risk of re-revision by a HR of 6.9 (95% CI 1.3 to 12.7).[14] Infection compared to aseptic indications increased the risk of re-revision by an OR of 1.9 (95% CI 1.5 to 2.5),[15] and by a RR of 2.7 (95% CI 1.3 to 4.6).[16]

Patient factors

Across 11 studies, 14 patient-specific factors were associated with an increased risk of re-revision. Increasing age at the time of index revision was found to be a weak but statistically significant protective factor for re-revision in one out of four studies, with a HR of 0.97 (95% CI 0.96 to 0.99).[17] Three studies used cut-off values for age at the time of index revision.[15,18,19] They found that age patients aged below 65 years (OR 1.6 (95% CI 1.2 to 2)), aged below 60 years (RR 1.6 (95% CI 1.1 to 2.5)), aged between 50 and 59 years (HR 1.3 (95% CI 1.1 to 1.6)), and aged below 50 years (HR 1.9 (95% CI 1.5 to 2.4)) significantly increased the risk of re-revision when compared with patients aged above 60, 65, or 70 years, respectively. Male sex was associated with an increased risk of re-revision in five

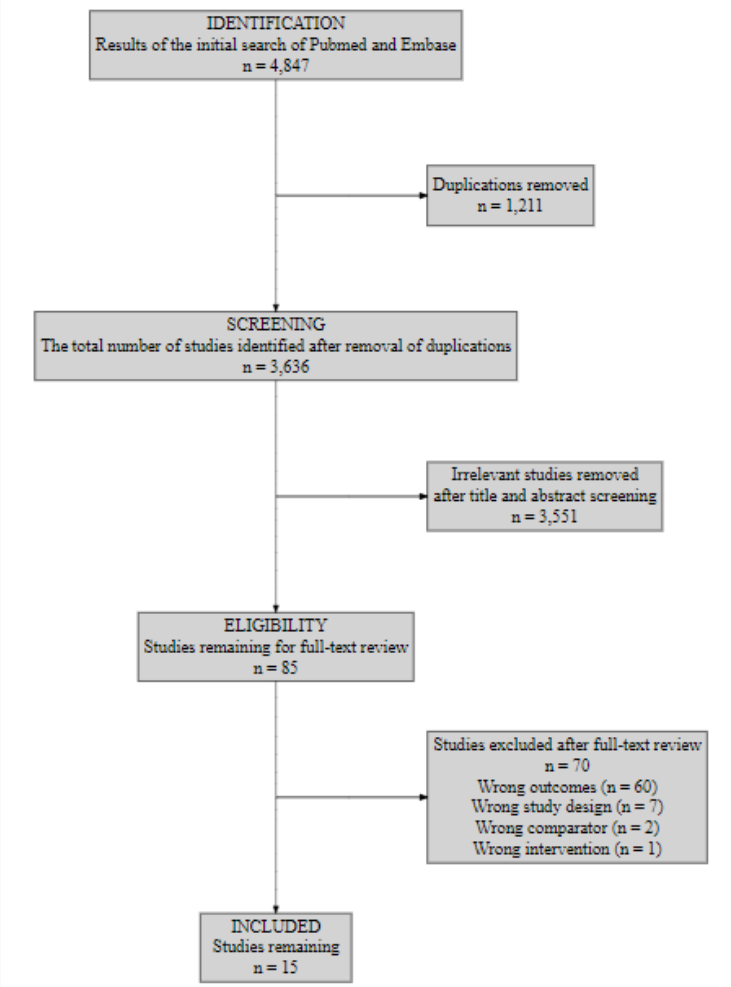

Fig. 1
Overview of the selection process.

out of seven studies.[14,15,17–21] Two studies reported HRs of 1.2 (95% CI 1.1 to 1.4) and 1.5 (95% CI 1.1 to 2.1). One study reported an OR of 1.4 (95% CI 1.1 to 1.8) and another reported a RR of 2 (95% CI 1.4 to 2.8). Female sex was a protective factor for re-revision in one study (HR for women 0.6 (95% CI 0.5 to 0.9)).[17] BMI ≥ 40 kg/m^2 increased the risk of re-revision by a RR of 2.9 (95% CI 1.3 to 6.6) compared with patients who had BMI < 30 kg/m^2.[16] However, when analyzing BMI as per unit increase, three studies found no association between BMI and an increased risk of re-revision.[14,20,22] Patients with opioid prescriptions leading up to rTKA had an increased risk of re-revision in one study.[23] The study found that patients who collected ≥ two opioid prescriptions, six months preceding rTKA, had an increased risk of re-revision by an OR of 1.4 (95% CI 1.1 to 1.9) compared to opioid-naïve patients. The same risk was found even though patients stopped their use of opioids in the year before rTKA (OR 1.4 (95% CI 1.1 to 1.9)). Patients with continuous use of opioids throughout the year preceding rTKA had an increased risk of re-revision by an OR of 1.8 (95% CI 1.5 to 2.2). However, the study did not specify whether patients were recorded more than once in the analysis. Patients diagnosed with depression, preoperative anaemia defined as haemoglobin ≤ 12 g/dL, and hepatitis C had an increased risk of re-revision by ORs of 1.2 (95% CI 1.0 to 1.4), 3.5 (95% CI 1.5 to 4.5), and 1.3 (95% CI 1.1 to 1.6), respectively.[22,24,25]

Implant-related factors

Implant-related factors associated with an increased risk of re-revision were found in eight studies. Prior revision was found to increase the risk of re-revision in one study (HR 2.6 (95% CI 1.3 to 5.3),[14] but was not a statistically significant factor in another study.[20] One study found that an isolated posterior-stabilized implant, which was inserted during the index revision, increased the risk of re-revision by a HR of 4.3 (95% CI 1.5 to 12.4) compared with higher-constraint implants.[27] The same study found that a minor index revision, defined as revision without tibial or femoral component exchange, increased the risk of re-revision by a HR of 1.3 (95% CI 1.0 to 1.6). A partial revision, defined as isolated tibial or femoral component exchange, was found to increase the risk of re-revision in four studies when compared to all-component exchange revision.[17–19,27] The studies found HRs of 1.6 (95% CI 1.1 to 2.2), 2.0 (95% CI 1.2 to 3.4), 1.5 (95% CI 1.3 to 1.8), 1.7 (95% CI 1.1 to 2.6), and 1.7 (95% CI 1.0 to 2.8), respectively. The largest risk of re-revision was found to be a history of a one-stage revision due to infection (OR 26.7 (95% CI 5.8 to 123.6)) when compared to no history of a one-stage revision

Table I. Characteristics of included studies.

Study	Size	Patients' mean or median age, yrs, at index revision	Females in the study, n (%)	Design	Includes definition of revision	Indication for index revision	Indication for primary arthroplasty	Observation period, yrs
Chalmers et al 2019[14]	135 rTKAs	43 (18 to 50)	80/135 (49)	Single centre, retrospective cohort	Yes	Aseptic indications	N/A	18
Geary et al 2020[15]	1,560 rTKAs	65 (28 to 94)	936/1,560 (60)	Single centre, retrospective cohort	Yes	All indications	N/A	30
Aggarwal et al 2014[16]	84 rTKAs	41 (16 to 48)	46/84 (55)	Single centre, retrospective cohort	Yes	All indications	All indications	11
Klasan et al 2021[17]	1,720 rTKAs	66 (SD 9.6)	839/1,720 (49)	Multiple centres, retrospective register	Yes	Aseptic indications	All indications	17
Leta et al 2015[18]	1,016 rTKAs	69 (25 to 94)	693/1,016 (68)	Multiple centres, retrospective register	Yes	Aseptic indications	All indications	18
Arndt et al 2022[19]	4,299 rTKAs	65 (22 to 96)	2,670/4299 (62)	Multiple centres, retrospective register	No	Aseptic loosening and pain without loosening	N/A	22
Wilke et al 2015[20]	78 rTKAs	69 (40 to 86)	41/78 (52)	Single centre, retrospective cohort	Yes	Septic Indications	N/A	9
Ong et al 2010[21]	1,599 rTKAs	72 (SD 5.3)	999/1,599 (63)	Multiple centres, retrospective register	Yes	All indications	Osteoarthritis	10
Cochrane et al 2022[22]	157 rTKAs	63 (SD 8.2)	21/157 (13)	Single centre, retrospective cohort	Yes	Aseptic indications	N/A	11
Wilson et al 2020[23]	11,786 patients	N/A	7,111/11,786 (60)	Multiple centres, retrospective register	No	Aseptic indications	N/A	9
Wilson et al 2020[24]	13,973 patients	N/A	8,436/13,973 (60)	Multiple centres, retrospective register	No	Aseptic indications	N/A	9
Ross et al 2022[25]	1,448 rTKAs	59 (SD 7.5)	741/1,448 (51)	Multiple centres, retrospective register	Yes	All indications	N/A	11
Citak et al 2019[26]	91 rTKAs	67 (SD 11)	37/91 (41)	Case-control study	No	Septic indications	N/A	10
Lewis et al 2022[27]	2,605 rTKAs	67 (SD 9.8)	1,565/2,605 (60)	Multiple centres, retrospective register	Yes	Only instability	Osteoarthritis	21
Leta et al 2019[28]	644 rTKAs	69 (SD 10.5)	321/644 (50)	Multiple centres, retrospective register	Yes	Septic indications	All indications	23

N/A, not available; rTKA, revision total knee arthroplasty.

due to infection.[26] Another study found a RR of 4.3 (95% CI 1.3 to 14.8).[28] However, this was only found for patients aged > 70 years, and the comparison was made against patients with a history of a two-stage revision due to infection. In addition, the sample sizes of the two studies were small. History of a two-stage revision due to infection was found to increase the risk of re-revision by an OR of 3.9 (95% CI 1.9 to 8.3) compared to patients with no history of a two-stage revision due to infection.[26] Finally, isolation of *Enterococcus* from the knee joint before index revision was found to increase the risk of re-revision by an OR of 16.9 (95% CI 2.0 to 140.9) compared to no isolation of *Enterococcus*.[26]

Risk of bias

The studies scored between four and eight points according to NOS (Table III). Ten studies scored ≥ six points. The largest differences in the bias score were found in the comparability and outcome categories. The major reasons for the differences were caused by studies comparing patients who did not have the same indication for the index revision and by studies not accounting for loss to follow-up.

Discussion

The aim of this study was to perform a systematic review and bias evaluation of the current literature to create an overview of risk factors for re-revision following rTKA. We identified 15 studies spanning a wide range of patient populations and study designs. In total, 26 significant risk factors for re-revision were found. To our knowledge, no prior study has systematically reviewed risk factors for re-revision following rTKA. Our study identified a subgroup of risk factors that remained statistically significant across several different studies: age, male sex, index revision being a partial revision, and infection as an indication for index revision. These findings emphasize the importance of the patient's revision history when assessing the risk of subsequent re-revisions. One study found several indications for the index revisions to be risk factors for re-revision.[14] However, the relevance of these findings is debatable, as the reference was index revisions with an indication of arthrofibrosis. The case-control study by Citak et al[26] highlighted the particularly high risk associated with a history of one-stage revision due to infection. The study was a retrospective case control; patients with a history of one-stage revision due to infection who underwent

Table II. Overview of studies investigating and finding significance of risk factors for re-revision.

Variable	Risk factor	Reference*	Risk, 95% CI	Studies investigating risk factor
Indication for index revision	Instability as an indication for index revision	Arthrofibrosis as an indication for index revision	HR 8.1 (1.6 to 15)	Chalmers et al 2019[14]
	Aseptic loosening as an indication of index revision	Arthrofibrosis as an indication for index revision	HR 6.9 (1.3 to 12.7)	Chalmers et al 2019[14]
	Infection as an indication for index revision		OR 1.9 (1.5 to 2.5)	Geary et al 2020[15]
		Aseptic indication for index revision	RR 2.7 (1.3 to 4.6)	Aggarwal et al 2014[16]
	History of a one-stage revision due to infection	No history of a one-stage revision due to infection	OR 26.7 (5.8 to 123.6)	Citak et al 2019[26]
		History of a two two-stage revision due to infection	RR 4.3 (1.3 to 14.8)	Leta et al 2019[28]
	History of a two-stage revision due to infection	No history of a two-stage revision due to infection	OR 3.9 (1.9 to 8.3)	Citak et al 2019[26]
	Isolation of *Enterococcus* from knee joint	No isolation of *Enterococcus*	OR 16.9 (2.0 to 140.9)	Citak et al 2019[26]
Patient factors (non-modifiable)	Age at the time of index revision	Per year increase	HR 1 (0.9 to 1.1)	Chalmers et al 2019[14]
			HR 0.97 (0.96 to 0.99)	Klasan et al 2021[17]
			HR 1 (0.9 to 1.0)	Wilke et al 2015[20]
			p = 0.197	Ong et al 2010[21]
	Age below 65 years	Age above 65 years	OR 1.6 (1.2 to 2)	Geary et al 2020[15]
	Age below 60 years	Age above 70 years	RR 1.6 (1.1 to 2.5)	Leta et al 2015[18]
	Age between 50 to 59 years	Age between 60 and 69 years	HR 1.3 (1.1 to 1.6)	Arndt et al 2022[19]
	Age below 50 years	Age between 60 and 69 years	HR 1.9 (1.5 to 2.4)	Arndt et al 2022[19]
	Male sex	Female sex	HR 1.4 (0.7 to 2.7)	Chalmers et al 2019[14]
			HR for females 0.6 (0.5 to 0.9)	Klasan et al 2021[17]
			OR 1.4 (1.1 to 1.8)	Geary et al 2020 [15]
			HR 1.2 (1.1 to 1.4)	Arndt et al 2022[19]
			HR 1 (0.4 to 2.2)	Wilke et al 2015[20]
			HR 1.5 (1.1 to 2.1)	Ong et al 2010[21]
			RR 2 (1.4 to 2.8)	Leta et al 2015[18]
	Diagnosed hepatitis C	No present diagnosis of hepatitis C	OR 1.29 (1.1 to 1.6)	Ross et al 2022[25]
Patient factors - modifiable	BMI, kg/m^2	Per unit increase	HR 1.0 (1 to 1.1)	Chalmers et al 2019[14]
		Per unit increase	HR 1.1 (1 to 1.1)	Wilke et al 2015[20]
		Per unit increase	OR 1.2 (0.9 to 1.5)	Cochrane et al 2022[22]
	BMI, kg/m^2 ≥ 40	BMI < 30	RR 2.9 (1.3 to 6.6)	Aggarwal et al 2014[16]
	Patients with > 2 opioid prescriptions before surgery	Opioid-naïve patients	OR 1.4 (1.1 to 1.9)	Wilson et al 2020[23]
	Patients stopped use of opioids before surgery	Opioid-naïve patients	OR 1.4 (1.1 to 1.9)	Wilson et al 2020[23]
	Patients with continuous use of opioids	Opioid-naïve patients	OR 1.8 (1.5 to 2.2)	Wilson et al 2020[23]
	Depression diagnosis within 1 year of revision TKA	No present diagnosis of depression	OR 1.2 (1.0 to 1.4)	Wilson et al 2020[24]
	Preoperative anaemia (haemoglobin ≤ 12 g/dl)	No anaemia (haemoglobin ≥ 12 g/dl)	OR 3.5 (1.5 to 4.5)	Cochrane et al 2022[22]
Implant-related factors	Prior revision	No prior revision	HR 2.6 (1.3 to 5.3)	Chalmers et al 2019[14]
			HR 1.1 (0.9 to 1.3)	Wilke et al 2015[20]
	Index revision: isolated posterior stabilized implant	Fully stabilized	HR 4.3 (1.5 to 12.4)	Lewis et al 2022[27]
	Index revision: minor revision†	All-component exchange	HR 1.3 (1.0 to 1.6)	Lewis et al 2022[27]
	Index revision: partial revision‡	All-component exchange	HR 1.6 (1.1 to 2.2)	Lewis et al 2022[27]
			HR 2.0 (1.2 to 3.4)	Lewis et al 2022[27]
			HR 1.5 (1.3 to 1.8)	Arndt et al 2022[19]
			HR 1.7 (1.1 to 2.6)	Leta et al 2015[18]
			HR 1.7 (1.0 to 2.8)	Klasan et al 2021[17]

*Reference is defined as the comparative factor against which the statistical analyses were conducted.
†Minor revision was defined as revision without tibial or femoral component exchange.
‡Partial revision was defined as revision with either tibial or femoral component exchange, but not both.
HR, hazard ratio; OR, odds ratio; TKA, total knee arthroplasty.

Table III. Newcastle-Ottawa Scale (NOS) bias evaluation of included studies.

NOS		Study														
		Chalmers et al 2019[14]	Geary et al 2020[15]	Aggarwal et al 2014[16]	Klasan et al 2021[17]	Leta et al 2015[18]	Arndt et al 2022[19]	Wilke et al 2015[20]	Ong et al 2010[21]	Cochrane et al 2022[22]	Wilson et al 2020[23]	Wilson et al 2020[24]	Ross et al 2022[25]	Lewis et al 2022[27]	Citak et al 2019[26]	Leta et al 2019[28]
Selection	Was the cohort truly representative?*	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
	Did patients originate from the same population?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Did the study attain exposure for re-revisions?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Was no interest of the outcome present at the start of the study?	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	Yes	No	Yes
Comparability	Did the compared populations have the same implant?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Did the compared populations have the same indication for index revision?	No	No	No	No	No	No	Yes	No	No	No	No	No	Yes	Yes	Yes
Outcome	Were assessments of outcome made from medical records or database records?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Was the follow-up period a minimum of 2 years?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes	No	Yes
	Did the study account for loss to follow-up?	Yes	No	Yes	No	Yes	No	No	Yes	No	No	No	No	No	No	No
Total number of points		6	5	7	7	8	6	5	7	4	5	5	6	8	6	8

*A truly representative cohort was defined as representative of an average population of revision knee arthroplasty patients without selection of specific socioeconomic groups or implants.

subsequent re-revision were compared to patients with a history of one-stage revision due to infection who did not undergo re-revision. Despite the methodological limitations inherent in the study, this finding underscores the importance of careful consideration and management of infections in rTKA.

It was observed that factors related to the nature of the index revision were often investigated, and often related to the risk of subsequent re-revision. This review finds a general trend of increased risk of re-revision if the index revision is performed on single components of a knee arthroplasty, suggesting that total revision of all components may result in a lower risk of re-revision. However, it is possible that all-component exchange simply lowers the surgeon's willingness to offer a re-revision, among other reasons. Correctable risk factors, after index rTKA, included preoperative anaemia and BMI ≥ 40 kg/m^2. Anaemia and increased BMI have already been identified as modifiable risk factors for revision in primary knee arthroplasties, suggesting that risk factors for first-time revision also apply to re-revisions.[29] Patient use of opioids may also be a correctable risk factor. Opioids have been shown to increase the risk of postoperative infection by indirectly causing immunosuppression.[23,30] A study by Wilson et al[23] found an increased risk of re-revision for patients with opioid prescriptions described that this association seemed dose dependent. The study found that patients with only one opioid prescription had a near-baseline risk of re-revision. The risk for re-revision was found to increase for every increase in opioid prescription. Hypothetically, reducing opioid consumption may thus reduce the risk of re-revision, but many confounders can explain this relationship. Depression was also found to be a risk factor for re-revision.[24] While this relationship is complex, as patients with chronic pain may alter their perception of pain,[31] there is evidence that psychological stress induces changes in immunological functions.[32] However, it is not possible to ascertain the causal relationship between opioid consumption, depression, and re-revision from the investigations presented in this study. Further investigations are warranted, as correcting these risk factors may reduce the risk of re-revision.

The NOS bias evaluation indicated varying degrees of methodological rigour across studies. While most studies scored well in terms of selection criteria, discrepancies in comparability and outcome assessment were identified as potential sources of bias. Ensuring that comparable study groups have the same implants and indications is important for drawing accurate conclusions. Future studies should focus on large sample sizes, study designs that include clear definitions of revision, identical indications for procedures across comparisons, and accurate descriptions of follow-up. This approach would minimize bias and allow for more precise risk assessments.

It is important to note that the most accurate comparisons and risk factor calculations should involve studies considering the same implant, indication for index revisions, indication for primary knee arthroplasty, and a well-defined concept of revision. Few studies considered the indication for primary knee arthroplasty, and some studies

lack a clear definition of revision in their work. Consequently, certain implants or certain primary indications for knee arthroplasty may be over-represented in re-revision cohorts, potentially affecting outcomes and complications across population comparisons. Variations in study designs, populations, and definitions introduce bias when summarizing findings, particularly in studies with small sub-populations. These limitations were present in most of the included studies. Conflicting results have been observed, especially regarding the impact of BMI and to some extent age and male sex, as not all studies found significant results. Future studies would benefit from adopting a unified data dictionary that can be agreed upon by the orthopaedic community. In this manner, meta-analyses would be feasible, thus strengthening the evidence for risk factors.

In conclusion, this systematic review presents an overview of risk factors for re-revision following rTKA and assesses the level of bias in the available studies. Key risk factors for re-revision were age, male sex, partial index revision, and infection as indication for the first revision. Correctable risk factors were preoperative anaemia and BMI ≥ 40 kg/m^2. Preoperative opioid use and depression may also be correctable risk factors. Future studies are needed with larger populations and clear definitions. Basic epidemiological research into patients undergoing re-revision is also needed, as limited research has been conducted.

Supplementary material

Search strategy used.

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As this study is a systematic review of publicly available papers, no ethical dilemmas are present.

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