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Isolated Femoral or Tibial Component Revision in Total Knee Arthroplasty: A Systematic Review

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Highlights of the Study

- Isolated component revision arthroplasty is recommended when the other component is well fixed and correctly positioned.
- It is not recommended when the reasons for revision are wear or instability.
- Isolated component revision arthroplasty has benefits in terms of operative time, blood loss, and costs.
- No significant difference has been found between tibial and femoral component replacement in the partial revisions.

Keywords
Femoral component revision · Tibial component revision · Total knee arthroplasty

Abstract
Objective: The purpose of this systematic review was to assess clinical and radiographic outcomes, complication rates, rates and reasons of re-revision of isolated femoral or tibial component revisions, comparing them with total knee revisions. ***Methods:*** A review of the published literature was performed using MEDLINE, Embase, and Cochrane libraries. The terms "isolate" and "revision" and "knee arthroplasty" or "knee replacement" were together used as MeSH terms. Partial knee replacement, non-English literature, case reports, and papers published before 2000 were excluded. ***Results:*** Out of 911 papers, six papers met the inclusion criteria. Mean MINORS scores achieved quite low values (13.33 and 13.67). No study encompassed revisions for septic loosening or infection. Total revisions performed for instability and wear achieved better clinical outcomes: in the other cases, partial and total revisions showed no differences in clinical outcomes. Both the cohorts showed similar radiographic features. Lesser bleeding and shorter operative times were observed in partial revisions compared to total revisions. The re-revision rates were similar in most of comparative studies: only one study noticed a significant difference in the failure rate between partial (25% at 3 years)

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and full (7% at 3.5 years) revisions. ***Conclusions:*** The poor quality of the studies precluded sound conclusions. Isolated tibial or femoral component revision is an option when the other component is well fixed and positioned and in absence of chronic periprosthetic infection; nevertheless, it should be carefully evaluated when the reasons for revision are wear or instability.

Introduction

As primary total knee arthroplasty is more and more practiced even in younger patients, the number of knee revisions is consequentially increasing [1]. In Germany, an overall increase of 20.76% in revision knees was observed between 2008 and 2018 [2]. In the USA, by 2030, the amount of revision knees is expected to almost double the number of reimplantations performed in 2014 [3, 4]. Knee revisions are demanding procedures and a higher mortality has been observed in some subcategories, in comparison to the general population [5]. Thus, when one of the two components is well fixed, partial component revision may be proposed as a feasible alternative to total knee revision, with the aim to spare bone tissue, reduce the operating time, minimize blood loss, and possibly improve clinical outcomes [6, 7]. Although partial component revision may result in less morbidity in comparison to total reimplantation, the surgical procedure could be challenging due to the limited exposure of the components, troublesome flexion and extension balancing, and possible surgeons' inexperience with the retained implants [6–9].

We designed a systematic review of relevant literature as the indications and outcomes of partial knee revisions with isolated femoral or tibial component exchange have been poorly ascertained. The aim of this review is to define when partial component revision is better than total component revision. We sought to assess (1) the clinical outcomes, (2) the radiographic outcomes, (3) the complications, the re-revision rates, and the reasons for re-revision.

Methods

Search Strategy

A systematic review was conducted on March 23, 2022, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The search was performed consulting the MEDLINE, Embase, and Cochrane Library databases. The following terms, as MeSH terms, were adopted: "isolate"; "revision"; "knee arthroplasty" or "knee replacement". The MEDLINE search string was as follows: ("isolate" [All Fields] OR "isolates" [All Fields] OR "isolated" [All Fields] OR "isolates" [All Fields] OR "isolating" [All Fields] OR "isolation and purification" [MeSH Subheading] OR ("isolation" [All Fields] AND "purification" [All Fields]) OR "isolation and purification" [All Fields] OR "isolation" [All Fields] OR "isolations" [All Fields]) AND ("arthroplasty, replacement, knee" [MeSH Terms] OR ("arthroplasty" [All Fields] AND "replacement" [All Fields] AND "knee" [All Fields]) OR "knee replacement arthroplasty" [All Fields] OR ("knee" [All Fields] AND "arthroplasty" [All Fields]) OR "knee arthroplasty" [All Fields]) AND ("revise" [All Fields] OR "revised" [All Fields] OR "revisers" [All Fields] OR "revises" [All Fields] OR "revising" [All Fields] OR "revision" [All Fields] OR "revisions" [All Fields]). All retrieved articles were scanned for other potentially relevant articles according to the inclusion and exclusion criteria.

The eligible studies included all papers describing the outcomes of isolated femoral or tibial component revisions in total knee arthroplasty, in English language, published after January 2000. We sought to assess the clinical outcomes, the re-revision rates, and the reasons for re-revisions. Inclusion criteria were adult populations, total bicompartmental or tricompartmental knee arthroplasty, single component loosening. Exclusion criteria consisted of case reports, editorials or commentaries, congress abstracts, non-English studies, populations with patients under 18 years, partial knee arthroplasty or unicompartmental knee replacement, patella or insert exchange.

Study Screening

Two blinded reviewers independently applied eligibility criteria and screened and selected studies for inclusion in the systematic review; disagreements between judgements were resolved by a third reviewer, blinded to the other reviewers' decisions.

Quality Assessment of the Included Studies

MINORS criteria for observational studies were adopted. An ideal score of 16 and 24 was required for non-comparative studies and comparative studies, respectively. Two reviewers were involved in quality assessment. The agreement between the two reviewers was assessed with an intraclass correlation coefficient (ICC).

Data Abstraction

From every selected study document, the following data were extracted into a Microsoft Excel spreadsheet: study design; age of publication; authors; number of patients; number of knee arthroplasties; participant demographics such as age, side, gender, BMI, and weight; primary implant features such as type of implant, time between implant and revision; loosened/malpositioned component. The reasons for revision, the surgical strategy, and the revised component were also recorded. The outcomes to be reviewed were clinical outcomes or score (even patient reported outcomes), survival rates, reasons for re-revisions. Two reviewers independently extracted or checked the data. Disagreements between individual judgements were resolved by the third reviewer. Study investigators were not contacted for unreported data or additional details.

Statistical Analysis

ICC was used to evaluate the quality assessment score agreement using the MINORS score. Agreement was categorized using a priori kappa value: the perfect agreement was defined by an ICC value between 0.81 and 0.99.

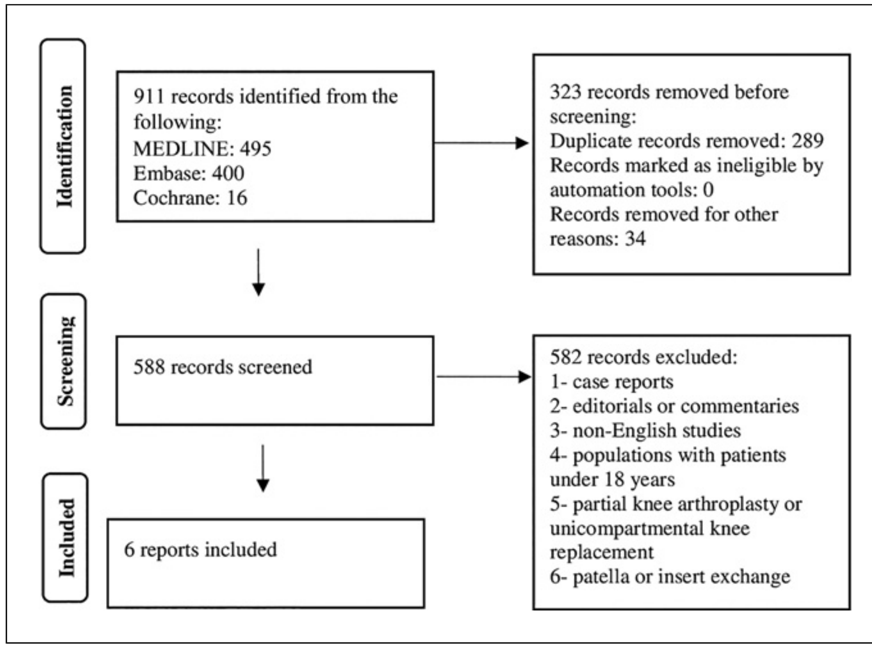

Fig. 1. Outline of systematic search strategy used in this systematic review.

Results

A total of 911 papers were initially found. After excluding duplicates and non-appropriate studies, six studies were eventually included (shown in Fig. 1). No meta-analysis could be performed due to the heterogeneity of the included studies.

Risk of Bias Assessment

MINORS mean values were 13.33 (range: 9–16) and 13.67 (range: 10–16). A perfect agreement (ICC value 0.99) between the two reviewers was obtained. Only two studies (33.33%) achieved a value of 16; all the other studies had lower MINORS scores. Among the four comparative studies, poor or moderate quality was detected.

Demographic Features

The demographic characteristics of the study populations are summarized in Table 1.

Implants Characteristics

Three studies described primary knee arthroplasty implants [7, 10, 11]. A large variety of primary knee arthroplasties was implanted, with non-homogenous distribution among comparative trials. The most implanted primary knee arthroplasties were as follows: 108 four-pegged NexGen (Zimmer, Warsaw, IN, USA), 54 AGC (Anatomic Graduated Component; Biomet, Warsaw, USA), 42 Kinemax (Howmedica, Rutherford, NJ, USA), 25 Kinematic Howmedica, 18 mini-keel NexGen Zimmer.

Partial knee revision strategy differed among studies and among the same study itself: while some cohorts revised the bone cut and adopted primary arthroplasty component with no bone graft, others implanted stemmed revision component in all cases or at surgeon discretion [7–11]. In the largest case series, 79 (58.8%) diaphyseal press-fit stems and 56 (41.5%) short cemented stems were adopted [7]. Only 19 patients (14%) required tibial cones. Liner usage was described in the table (Table 2).

Reasons for Revision

The reasons for revision of the patients involved in the selected studies were aseptic loosening, wear-related failure, ligamentous instability, flexion contracture, malalignment, and fracture (Table 2). All the studies involved patients with non-septic conditions.

Clinical Outcomes

All the studies reported clinical outcomes. The non-comparative studies reported clinical ameliorations in terms of clinical scores, pain and flexion degree, from the pre-operative scores: in the study with statistical analysis, the improvement was significant (Knee Injury and Osteoarthritis Score for Joint Replacement, pre-operative 56.1 vs. post-operative 89.7, $p < 0.0001$; Knee Society Score, pre-operative 51.6 vs. post-operative 90.1, $p < 0.0001$; knee flexion degrees, pre-operative 111.7 vs. post-operative 116.4, $p < 0.0001$) [7, 11]. Among comparative studies, no significant differences in terms of clinical outcomes were observed between partial and complete revision cohorts [6, 9, 10].

Table 1. Study design and demographics of the patients and follow-up periods

Study	Study design	*N*	No. of revisions				% female		BMI		Mean age, years		F/up, months	
			total	full	t	f	full	p	full	p	full	p	full	p
Mackay, 2003	B	67	67	42	25	–	57	64	–	–	72	73	48	48
Fehring, 2005	B	148	149	100	30	19	–	58	–	–	–	60	–	68
Berend, 2008	A	–	54	–	54	–	–	60	–	–	–	70.2	–	84
Martin, 2020	B	164	164	76	88	–	60	65	34.7	33.8	63.1	64.8	42	42
Lee, 2020	B	31	31	17	14	–	95	85	29.7	27.8	70.8	70.3	56.1	40.7
Tracey, 2021	A	135	135	–	135	–	–	62	–	36.5	–	61.3	–	61.4

A, retrospective, non-comparative; B, retrospective, comparative; *N*, number of patients; Full, full component revision; t, only tibial revision; f, only femoral revision; p, partial revision.

Table 2. Implants characteristics, reasons for revision, and re-revision

Study	Partial component revision					Full component revision				
	reasons for revision (%)	% cemented implants	% stem/ cone	% re-revisions	complications/ reasons for re-revision (%)	reasons for revision (%)	% cemented implants	% stem/ cone	% re-revisions	complications/ reasons for re-revision (%)
Mackay, 2003	A (64); D (36)	100	4	28	A (28)	A (93); B (7)	88	100	7	A (7)
Fehring, 2005	A (41); B (23); D (20); E (8); F(4); G (4)	?	?	4	A (2); B (2)	A (31); B (28); D (23); L (18)	?	?	10	A (2); B (2); C (3); E (2); K (1)
Berend, 2008	A (100)	100	48	4	B (2); E (2)	–	–	–	–	–
Martin, 2020	A (100)	81	25	6	A (2.5); C (2.5); H (1)	A (100)	76	30	9	A (1.2); C (1.2); G (1.2); I (4); J (1.2);
Lee, 2020	A (100)	?	100	14	C (14)	A (100)	?	23	0	–
Tracey, 2021	A (100)	41	100	4	B (1.5); C (2); E (0.5)	–	–	–	–	–

A, aseptic loosening; B, instability; C, infection; D, polyethylene wear; E, fracture; F, malalignment; G, joint contracture; H, extensor mechanism disruption; I, patellar avascular necrosis; J, wound dehiscence; K, PE fracture; L, various reasons.

When stratified for reasons for revision, Fehring et al. [9] found significantly higher average KSSs in the full component revision group than in the partial component one in revisions for instability (85 vs. 63, respectively, $p = 0.0001$); the KSS was greater in the revisions for wear (88 vs. 78, respectively, $p = 0.03$).

Martin et al. [8] showed a significant improvement of the range of movement in the isolated tibial revision group (0–120° vs. 0–115°). Furthermore, no patient in the tibial group had flexion instability or contracture, while 3 patients (4%) in full component group were unstable and three (4%) had flexion contracture >5°. Lee et al. [6] noticed greater blood drainage (417.2 vs. 968.1 mL, $p < 0.001$) and longer operative time (105.2 vs. 154.6 min, $p < 0.001$) in the total knee revision cohort.

Radiographic Outcomes

Four studies reported radiographic outcomes. No significant differences between partial component and full component revision groups were observed: the rate of radiolucent lines and osteolysis was similar [6, 8–10]. Lee et al. [6] also compared pre- and post-operative alignment (mechanical axis, alpha, beta, gamma, and delta angle) in partial and full component revision cohorts but found no statistical difference.

Complications and Re-Revisions

All the six studies reported the rates of re-revisions and the reasons for re-revisions (Table 2). The two non-comparative studies reported a re-revision rate of 4%, with a survival rate for aseptic loosening of 100% at a mid-term follow-up (7.4 and 3.2 years according to prosthetic type and 3.42 ± 2.53 years) [7, 11]. Both the case series reported that instability was one of the main reasons for re-revision (2% and 1.5%), with periprosthetic infection and fracture (2%) [7, 11].

One comparative study reported a re-revision rate of 5.7% for partial knee revisions and 9.2% for total knee revisions at a mean follow-up of 3.5 years, but no statistical comparison was provided [8]. Two comparative studies did not report any significant differences in terms of survival rates: periprosthetic infection was one of the main reasons for re-revisions (up to 6.5%) [6, 9]. A higher percentage of instability (10%) was found in the full component revision group compared to the partial component one (4%), but the difference was not statistically significant.

Only Mackay et al. [10] noticed that partial revisions had a higher failure rate than full revisions (respectively, 28% at a mean follow-up of 3 years and 7% at a mean follow-up of 3.5 years, $p < 0.01$). In the partial revision group, two knees (8%) failed because of loosening of both components, three (12%) because of the femoral component, two (8%) because of the tibial component. In the full revision group, one knee (2.5%) failed because of loosening of both components and two (5%) because of the tibial component [10].

Discussion

Isolated component revision in the knee emerged as a feasible procedure for non-septic reasons for revision when the other component was well fixed and correctly positioned. Wear or instability may be relative contra-indications to partial revisions [9]. The choice of revision component should be based on the intra-operative conditions, but a stemmed component can be suggested in many cases; cruciate retaining or posterior stabilized liners are valid options. Clinical and radiological outcomes were comparable, with partial revisions possibly improving range of movement, decreasing blood loss and operative time. Rates of complications and re-revisions were similar among the two cohorts in many studies, apart from one study reporting lower re-revision rates for total knee revisions [10].

Partial knee revisions achieved satisfying clinical outcomes in most of the cases. Better clinical scores were noticed in total knee revisions when instability and wear were the reasons for revision [9]. Substantial benefits of partial revisions in well-balanced and aligned knees (and no damage of the retained component) should be related to the potential lower surgical insult, preserved bone stock, lower blood loss, shorter operative time, at the cost of more challenging exposure and more complex knee balancing [6, 7]. The potential benefits of isolated component revision were observed after isolated liner exchange for wear or stiffness: 86% of the implants survived at a minimum follow-up of 10 years [12]. In the selected comparative studies, better clinical outcomes were not observed after isolated femoral or tibial component revision. However, larger articular excursions were not consistently reported after partial knee revisions [8]. It is likely that some faster clinical improvements may ensue after partial revisions, with shorter length of stay and more rapid functional recovery, but the current literature did not focus on these outcomes.

Radiographic outcomes were positive in partial knee revisions, not different from total knee revisions [6, 8, 9]. Similar rates of radiolucency and osteolysis were observed. Component alignment after isolated component revision was scarcely investigated, despite the potential relevance: the study by Lee et al. [6] observed no differences between isolated and full knee revisions.

Complications and re-revision rates were similar in partial and total knee revision arthroplasties. The non-comparative studies achieved very favourable mid-term outcomes that were not inferior to the re-revision rates of total knee revisions performed for aseptic loosening in the Danish Arthroplasty Register [13]. Comparative studies did confirm these outcomes. Only Mackay et al. [10] observed a significantly higher rate of failures of partial revisions, similarly to the outcomes reported in two coeval abstracts that are not included in this review according to exclusion criteria. The authors advised against the retention of a prosthetic component, even when well fixed, as a higher failure rate should be expected due to a threefold mechanism: microcracks in the cement mantle, polyethylene wear debris despite liner exchange, malalignment and instability [10]. Fehring et al. [9] also advised against partial knee revisions but only when reasons for revision were instability and wear. This conclusion was also supported by the modest outcomes of isolated liner exchange performed for instability, i.e., a 10-year survival rate of 69% [14, 15]. In these cases, a more comprehensive approach is needed, aiming to correct malalignment, ligament attenuation, and flexion-extension imbalance.

Total knee revision ensures a fine balancing of the new implant, better intraoperative exposure of the components and it can be performed regardless of the primary implant system [6–9]. In case of wear, all the debris generator and the osteolysis can be addressed: furthermore, knees with wear-related problems often become unstable due to wear-related chronic effusions and stretching of the soft tissue envelope, making joint balancing more challenging [9, 10]. In a recent study on the prevalence and impact of intra-operative cultures in partial hip and knee revisions, a partial knee revision strategy adopted in the first 5 years after the primary implant, regardless of the non-septic reason for revision, was found to be predictive of re-revisions for any cause; this finding should be carefully evaluated when partial revision is considered [16].

There is a lack of data on partial revision in septic component loosening. In chronic periprosthetic knee infections, the presence of bacterial biofilm precludes the prosthetic component retainment and total knee revision remains the gold standard procedure [17, 18]. While bacteria preferentially adhere to polyethylene surfaces, contamination of metallic components is almost inevitable, and isolated component approach should be discouraged [19]. Partial knee revision might be a reasonable approach only in case of single component loosening in acute periprosthetic infection, even if there is no pertinent literature supporting this indication.

The present study has limitations, due to the studies involved: among them, the retrospective design with small numbers of patients, relatively short follow-up, lack of control group in some studies [7, 11]. In comparative studies, pre-revision cohorts were not always comparable. Lack of relevant details and homogenous indications about revision components, operative time, peri-operative blood loss, and length of stay are all major flaws that do not allow us to define the appropriate surgical strategy in knee revisions. Most of the studies adopted different scores and designs, preventing a meta-analysis. Due to the above-mentioned limitations of the included studies, MINORS scores showed an average low quality.

Conclusion

Partial knee revision is a feasible strategy in revision knee arthroplasty, with plausible benefits in terms of operative time, blood loss, costs, and perhaps even morbidity. Partial revisions should be performed after a careful evaluation of the reasons for revision: in the absence of chronic periprosthetic infections, retained component malalignment, flexion-extension imbalance, and ligament instability and possibly not in the first 5 years after the primary procedure. Nevertheless, the low quality of the current available literature, with small case series and inadequate comparisons, prevents us from drawing any definitive conclusions. Propensity-matched cohort studies and use of registries may help define the appropriate candidates to partial knee revisions and the possible long-term outcomes of this procedure.

Statement of Ethics

An ethics statement is not applicable because this study is based exclusively on published literature.

Conflict of Interest Statement

Francesco Castagnini is a member of the Board of Personalized Arthroplasty Society (https://personalizedarthroplasty.org/). The other authors have nothing to declare.

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Author Contributions

All authors contributed to the study conception and design. Material preparation and data collection and analysis were performed by Marco Maestri and Francesco Castagnini. The first draft of the manuscript was written by Marco Maestri and reviewed by Francesco Castagnini. The subsequent drafts were read and reviewed by all authors. The final draft of the manuscript was read, reviewed, and approved by all authors.

Data Availability Statement

The data reported in this study are available in the original screened articles (see references).

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