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Revision total knee arthroplasty versus primary total knee arthroplasty

A MATCHED COHORT STUDY

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Introduction

The primary aim of this study was to describe a baseline comparison of early knee-specific functional outcomes following revision total knee arthroplasty (TKA) using metaphyseal sleeves with a matched cohort of patients undergoing primary TKA. The secondary aim was to compare incidence of complications and length of stay (LOS) between the two groups.

Methods

Patients undergoing revision TKA for all diagnoses between 2009 and 2016 had patient-reported outcome measures (PROMs) collected prospectively. PROMs consisted of the American Knee Society Score (AKSS) and Short-Form 12 (SF-12). The study cohort was identified retrospectively and demographics were collected. The cohort was matched to a control group of patients undergoing primary TKA.

Results

Overall, 72 patients underwent revision TKA and were matched with 72 primary TKAs with a mean follow-up of 57 months (standard deviation (SD) 20 months). The only significant difference in postoperative PROMs was a worse AKSS pain score in the revision group (36 vs 44, $p = 0.002$); however, these patients still produced an improvement in the pain score. There was no significant difference in improvement of AKSS or SF-12 between the two groups. LOS (9.3 days vs 4.6 days) and operation time (1 hour 56 minutes vs 1 hour 7 minutes) were significantly higher in the revision group ($p < 0.001$). Patients undergoing revision were significantly more likely to require intraoperative lateral release and postoperative urinary catheterisation ($p < 0.001$).

Conclusion

This matched-cohort study provides results of revision TKA using modern techniques and implants and outlines what results patients can expect to achieve using primary TKA as a control. This should be useful to clinicians counselling patients for revision TKA.

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Introduction

The incidence of revision total knee arthroplasty (TKA) is continuously increasing[1] and a six-fold increase in revision knee arthroplasty has been predicted between 2005 and 2030.[2] In the UK, the demand for primary TKA is steadily increasing.[3,4] In addition, Scottish Arthroplasty Project (SAP) National Joint Registry data has highlighted an increasing number of younger patients undergoing TKA, suggesting a potential rise in future revision workload.[5]

There is limited information regarding patient-reported outcome measures (PROMs) and satisfaction following revision TKA, and it is therefore difficult to counsel patients who may be contemplating revision surgery, and to address their postoperative expectations. Following the Montgomery ruling, the requirement for this information has become necessary for both surgeons and patients.[6] With regards to patient satisfaction, while hospital experience[7] and length of stay (LOS) can affect overall satisfaction,[8] pain has been found to be the strongest predictor of

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Table I. Indications for revision total knee arthroplasty.

Indication for revision	Patients, n (%)
Aseptic loosening	34 (47)
Instability	9 (13)
Infection	8 (11)
Pain	8 (11)
Malalignment	6 (8)
Arthrofibrosis	5 (7)
Fracture	2 (3)

dissatisfaction following TKA,[9] with poor function also contributing.[10]

There is no consensus regarding revision strategy for TKA. One option for revision TKA with significant bone loss is the use of metaphyseal sleeve implants. These implants can be used in conjunction with hinged or semi-constrained prostheses with either a fixed or rotating platform bearing. The modular porous sleeves engage in the proximal tibial or distal femoral metaphysis and accommodate type 2 and 3 bone defects with their stepped design, which compressively loads the bone according to Wolff's law.[11] Although good functional outcomes following revision TKA with metaphyseal sleeves and a hinged prosthesis have been reported,[12,13] functional outcomes following revision TKA with sleeves and a semi-constrained bearing are less common.

We wished to evaluate the concept that functional outcomes of revision TKA are inferior to primary TKA. The primary aim of this study was to describe a baseline comparison of early knee-specific functional outcomes following revision TKA using metaphyseal sleeves with a matched cohort of patients undergoing primary TKA. The secondary aim was to compare incidence of complications and LOS between the two groups.

Methods

This study was reviewed and approved by the regional ethics committee. All patients undergoing primary and revision TKA are recorded in our institution database. Both groups of patients have demographic and outcome data recorded preoperatively and postoperatively at one year, two years, three years, and five years by a dedicated team of specialist arthroplasty nurses, who remined constant throughout this study. During a six-year period (2009 to 2016; the revision database commenced in 2008), we reviewed all patients undergoing single-stage revision TKA during the period the database was running. The inclusion criteria for the study was all cases using a single-stage revision TKA (TC3 system; DePuy Orthopaedics, Warsaw, Indiana, USA) with uncemented metaphyseal sleeves and a rotating platform bearing for any indications and a grade II or greater bone defect on either the femoral or tibial surface graded using the AORI classification. Indications for revision TKA are summarized in Table I based on the SPECIFIC criteria.

The study cohort was identified and matched to a control group undergoing primary TKA utilizing the sigma PFC TKA (DePuy Orthopaedics) for osteoarthritis (OA). Patients were matched using four preoperative factors: age, sex, body mass index (BMI), and preoperative haemoglobin at a ratio of 1:1 from the local knee arthroplasty database, which has continuously collected prospective functional outcome data since 1997. Only patients who underwent primary TKA for varus OA with complete follow-up were selected for the matched cohort.

Preoperative American Knee Society Score (AKSS)[14] and Short-Form 12 (SF-12)[15] scores were calculated at the preoperative assessment clinic and postoperatively at 24 months by postal questionnaire. Data regarding the procedure including length of hospital stay, operation time, requirement for blood transfusion, intraoperative lateral release, and mortality were recorded from interrogation of medical records. General health was extrapolated from the preoperative American Society of Anestheologists (ASA) score.[16]

During the study period, one of the two senior authors performed all procedures in a laminar-flow equipped theatre. All patients had a high-thigh tourniquet applied for the duration of the operation and no drains were used. A mid-line midvastus approach was made in all patients undergoing primary TKA. Sizing of the femoral component and rotation was performed manually. Conventional jig alignment technique used intramedullary referencing for the femur and extramedullary for the tibia. The specified bone cuts were 7° of valgus for the distal femoral cut based on the position with reference to Whiteside's line,[17] and posterior condylar referencing for rotational alignment. The tibial bone cut was made to produce neutral varus/valgus alignment in the coronal plane with 3° of posterior slope. All patients received a single dose of prophylactic antibiotics (ceftriaxone), except in cases of revision for infection, where intraoperative samples were sent prior to commencing broad-spectrum antibiotics. All patients received four weeks of pharmacological deep venous thrombosis (DVT) prophylaxis with a factor X inhibitor (rivaroxaban), unless there was a specific contraindication. Between 2009 and 2011, this was used in our institution with the agreement of the pharmacy prior to full licencing of its use in 2011.

All revision TKAs were undertaken through a medial parapatellar approach after reopening the existing scar. The primary prosthesis was removed with particular attention being paid to minimizing bone loss. Anderson Orthopaedic Research Institute (AORI)[18] grading was carried out intraoperatively by the lead surgeon following removal of the primary prosthesis. Depending on the size of the defect, metaphyseal sleeves were used for

Table II. Descriptive variables in the revision and primary total knee arthroplasty groups.

Variable	Revision TKA	Primary TKA	p-value
Mean age, yrs	69.1	68.5	0.708*
Number of female patients (%)	29 (40)	29 (40)	1.00†
Mean BMI	31.2	31.7	0.589*
Mean preoperative Hb	137.4 g/l	137.9 g/l	0.846*
Mean preoperative AKSS (SD)	37.5 (17.2)	33.4 (15.7)	0.174*

*Chi-squared test.
†Paired *t*-test.
BMI, body mass index; Hb, haemoglobin; AKSS, American Knee Society Score.

Table III. Anderson Orthopaedic Research Institute (AORI) grade from intraoperative findings.

AORI grading	n (%)
Tibia	
1	44 (61)
2	18 (25)
3	8 (11)
Femur	
1	46 (64)
2	18 (25)
3	6 (8)

the femoral or tibial components. Patellar resurfacings were performed in all cases in the revision group unless there was insufficient patellar bone stock. This is the unit practice owing to a deep intracondylar box design on the TC3 femoral component, which engages the patella early during flexion. If the patella is not resurfaced then this can lead to patellofemoral maltracking, crepitus, and increased anterior knee pain. Patellar resurfacings were not undertaken in the primary group.

There was no change in blood transfusion practice during the study period. Routine perioperative tranexamic acid was introduced in May 2009 and used consistently for both primary and revision knee arthroplasty. The current blood transfusion policy was introduced in October 1998.[19]

All patients were treated postoperatively according to a standardized physiotherapy protocol with full weight-bearing permitted from the first postoperative day.

Patients were followed up both radiologically at an average of 57 months (standard deviation (SD) 20 months). All radiographs were reviewed by the senior authors independently to assess for signs of loosening.

Statistical analysis. Results were analyzed using SPSS software v. 23 (SPSS, Chicago, Illinois, USA). Data were analyzed for normality using histograms and the Shapiro-Wilk statistic. The independent-samples *t*-test was used to compare means between the study and control groups. Normal data are reported as mean with SD. Non-normal data are reported as median with interquartile range. The Mann-Whitney U test was used to compare independent groups. Paird *t*-tests are reported throughout. A p-value of < 0.05 was considered statistically significant.

Results

Patient cohort. Overall, 72 patients were included who underwent single-stage revision TKA during the study period. There were five patients excluded from the same period who underwent two stage revision for deep infection. There were no significant differences between the study and control group for age, sex, BMI, and preoperative haemoglobin. None of the revision TKA patients were lost to follow-up: all were reviewed or confirmed deceased. Patient demographic data for both groups is summarized in Table II.

Intraoperative details. All cases of primary TKA were performed for OA of the knee refractory to nonoperative treatment. The most common diagnosis in the revision group was aseptic loosening (47%). Eight patients underwent single-stage revision for infection (11%). Intraoperative AORI grading is summarized in Table III. The mean operation time was 116 minutes in the revision group and 67 minutes in the primary group (p < 0.001), which was an anticipated finding. In all, 18 patients (25%) in the revision group required intraoperative lateral release (compared with two patients (3%) in the primary group (p < 0.001)). Overall, 53 patients (74%) required a femoral and tibial sleeve, 18 (25%) required a tibial sleeve only, and one (1%) required a femoral sleeve only. Additional stems were required for 20 (28%) femoral prostheses and 17 (24%) tibial prostheses.

Postoperative results. LOS was significantly longer in the revision group (9.3 vs 4.6 days, p < 0.001). There were 11 (15%) blood transfusions in the revision group and five (7%) in the primary group (p = 0.184).

Patient-reported functional outcomes. Mean postoperative AKSS was 85.3 (SD 10.1) and 87.9 (SD 11.4) in the revision and primary groups, respectively (p = 0.183). Average improvement in AKSS pain score was 36 in the revision and 44 in the primary group (p = 0.002). There were no statistically significant differences between the two groups for postoperative functional outcomes measured by the AKSS (Table IV). For physical and mental components of the SF-12 (Table V), the physical component score (PCS) change in the revision patients was -6.5 to -2.1, giving a mean difference of 4.4 (p = 0.178). The mental component score (MCS) change from the preoperative to the postoperative scores was 3.2 to -0.6 (p = 0.148) in the revision and primary control groups, respectively. Removing all patients undergoing single-stage revision for infection (n = 8) made no statistically significant difference to the results. All outcome scores were collected by arthroplasty nurse specialists who were unaware of the study and remained constant during the study period.

Table IV. American Knee Society Score.

	Revision group	Primary group	p-value*
Mean preoperative pain score	7.4	9.8	> 0.05
Mean postoperative pain score	36	44	0.002
Mean change in pain score	28.6	34.5	0.075
Mean preoperative AKSS score	33.41	34.25	> 0.05
Mean postoperative AKSS score	85.3	87.9	> 0.05

*Paired *t*-test.
AKSS, American Knee Society Score.

Table V. Short-Form 12 Physical and Mental component scores.

	Revision TKA with infected cases	Revision TKA without infected cases	Primary TKA	p-value*
SF-12 PCS change	-6.5	-6.2	-2.1	> 0.05
SF-12 MCS change	-3.2	-4.6	-0.6	> 0.05

SF-12 PCS, Short-Form 12 physical component score; SF-12 MCS, Short-Form 12 mental component score.
*Mann-Whitney U test.

Complications. In the revision group, one patient who underwent revision for infection subsequently required amputation for chronic infection, two patients had died due to causes unrelated to their surgery. This complication profile compares well with other studies of revision TKA.[5,15,19] Five patients had undergone secondary patellar resurfacing, with no other revision or component change, of whom one developed a deep infection as a consequence required a subsequent two-stage revision. There was one periprosthetic fracture and one radiological case of tibial sleeve subsidence, both of which were managed conservatively. Both of these cases went on to make a full recovery and did not require further intervention. In the primary TKA group, there was one superficial infection, which was treated with antibiotics alone, and one patient died from a cause unrelated to their surgery.

Discussion

Although previous studies[20-22] have demonstrated that functional outcomes following revision TKA are inferior to those of primary TKA, the results from this study provide comparative description of the results using primary TKA as a control. The results from this study are less inferior than might be expected. These results are important for providing informed consent to patients undergoing revision TKA following the Montgomery ruling in the UK. Both groups recorded a postoperative improvement in AKSS from their respective baselines, though the difference in total score observed between the groups was not significantly different,[23] and the observed variation was less than the minimal clinically important difference for AKSS, which is 5.3 to 5.6 for KS-KS and 6.1 to 6.4 for KS-KF. Patients requiring revision TKA for infection were included, which may have confounded the results. However, subsequent analysis of the results with these cases removed did not affect the findings.

The published literature on revision TKA in general relates to hard endpoints, such as reinfection, mortality, re-revision, and complications.[24] There are fewer studies which focus on function or PROMs. The widely accepted view is that outcomes are worse following revision than primary TKA. Our study provides a description of any likely deficit, with the mean AKSS overall scores for both groups (85.3 (SD 10.1) vs 87.9 (SD 11.4)) would be classified as excellent.[25] This may provide reassurance for patients undergoing either procedure that there is a significant likelihood of improving their symptoms and knee function without necessarily achieving the same as a primary.

There are limitations to using PROMs for assessing outcome post-TKA.[26,27] However, the aim of this study was to benchmark the results of revision TKA using modern implants in comparison to those obtained following a primary procedure. They also to add to the information needed for consenting patients. Interestingly, there were no significant differences observed in preoperative AKSS or SF-12 between the two groups, suggesting that patients considering revision TKA feel their condition has deteriorated to a level comparable to their original functional prior to their primary procedure.

These findings of this study suggest revision TKA behaves differently to a primary TKA in that for a contralateral primary TKA, patients have greater expectations of their operated knee which is therefore linked to a reduced satisfaction.[28,29] However, our findings are consistent with previous studies which demonstrated patients can experience improvement in functional outcome of patients following revision TKA.[30-32] There are several published reports on the use and durability of metaphyseal sleeves used with a coronal constrained revision TKA with up to five-years follow-up. Metaphyseal sleeves have been in use for far longer with reports of their long-term use in hinged devices. The previous results for both kinds of device demonstrate promising clinical and functional outcomes, so it is worthwhile assessing how this combination performs in comparison to a primary procedure.[1,33]

The LOS and operation time was significantly higher in the revision group, which was an anticipated finding and demonstrates that revision TKA is a more complex procedure than primary TKA. The LOS is likely skewed by eight patients, who were revised for infection necessitating a longer LOS for intravenous antibiotic treatment. Given the small number of revisions for infection included in the study, it is difficult to infer any effect on function in cases of revision for infection. We have analyzed all revisions for infection as a separate study focusing on this. The increase in lateral releases with observed in the revision surgery is also unsurprising as this is often required for access prior to explanation, as part of the debridement, or to improve patellar tracking. A previously published cohort study of 1,859 TKAs showed that patients requiring lateral release had longer hospital stays and higher transfusion rates.[34] This, along with increased total operation and tourniquet time, may explain the higher LOS observed in the revision group. The aim of this study was to evaluate the functional outcome against primary TKA, rather than to look specifically at LOS or operative time.

The main strength of this study is that it uses prospectively collected data, reducing the risk of recall bias. It is further strengthened by a well-matched control group. Moreover, as a single unit series containing two experienced revision TKA surgeons, utilizing the same approach to this pathology, there was minimal surgical variability.

The main limitation of this study is the inclusion of patients undergoing revision for infection in the analysis, though when these patients were removed there was no change in statistical outcomes.

In summary, this matched-cohort study suggests that following revision TKA using modern techniques and implants, it is possible to achieve improvement in function and PROMs which are acceptable to patients and set realistic expectations of how the results would compare to a primary TKA. Our findings update the existing view[21,35] that patients undergoing revision TKA, particularly those with significant bone loss, will experience poorer clinical results. This information is important when discussing treatment options with patients and addressing their expectations regarding the outcome following revision TKA.

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- P. Stirling: Analyzed the data, Wrote and revised the manuscript.
- S. D. Middleton: Analyzed the data, Wrote and revised the manuscript.
- I. J. Brenkel: Designed the study, Acquired the data.
- P. J. Walmsley: Designed the study, Acquired the data, Wrote and revised the manuscript.

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- P.Walmsley reports payment for lectures, including service on speaker bureaus, on cadaveric courses, and lectures and skills training, as well as payment for development of educational presentations, all of which are unrelated to this paper. I. Brenkel reports payment from Depuy for lectures, including service on speakers bureaus, and for travel/accommodation expenses, all of which are unrelated to this paper. S. Middleton reports payment for stock options from Stryker and GlaxoSmithKline, both of which are unrelated to this article.

Ethical review statement
- The study protocol was approved by our local research and ethics committee.