Original Article

Revision Total Knee Arthroplasty: Causes and Outcomes

Kae Sian Tay, [1]*MBBS*, Ngai Nung Lo, [1]*MMed (Surg), FRCS (Edin), FAMS*, Seng Jin Yeo, [1]*MBBS, FRCS (Edin), FAMS*, Shi-Lu Chia, [1]*MBBS, FRCS (Surg), PhD*, Darren KJ Tay, [1]*MBBS (S'pore), M Med (Ortho), FRCS (Edin)(Ortho)*, Pak Lin Chin, [1]*MBBS, MMed (Ortho), FRCSEd (Ortho)*

Abstract

Introduction: Local data on revision total knee arthroplasty (TKA) are limited. This study aims to assess the causes and outcomes of revision TKA in a single institution, with a 2-year follow-up. Materials and Methods: A retrospective review of case records of patients who underwent revision TKA in 2008 and 2009 in the authors' institution was performed. Outcome was assessed using SF-36, Oxford knee score and Knee Society Clinical Rating System preoperatively, at 6 months and at 2 years' follow-up. Results: Forty-one patients (41 knees) were included in the study. Indications for revision were aseptic loosening in 13 (31.7%), mechanical wear/component failure in 10 (24.4%), infection in 9 (22.0%), malalignment in 4 (9.8%), instability in 3 (7.3%), periprosthetic fracture in 1 (2.4%) and persistent stiffness in 1 (2.4%). Significant improvements were seen postoperatively in all 3 instruments used to evaluate clinical outcome. These improvements were seen at 6 months after surgery, and were maintained through the 2-year follow-up period. There were no significant changes in all scores between 6 months and 2 years follow-up. There was 100% survivorship of the implants with no postoperative complications requiring surgical intervention. Conclusion: Indications for revision TKA locally are similar to those in other large centres. Revision total knee arthroplasty results in significantly improved function and quality of life for patients, which is maintained over a 2-year follow-up period. In our series, we obtained 100% implant survivorship.

Ann Acad Med Singapore 2013;42:178-83

Key words: Failure, Infection, Instability, Loosening, Malalignment

Introduction

The first prosthetic knee was introduced in 1954 as a hinged prosthesis by Shiers.[1] In his follow-up of 19 primary operations, 8 required at least 1 revision—a revision rate of more than 40% over a mean follow-up time of 4 years.[2] Since then, total knee arthroplasty (TKA) has come a long way. With improvements in prosthesis design, surgical technique and measures to prevent infection, revision rates have dropped; based on the latest joint registers worldwide, the revision rate for the total knee arthroplasty is on average 12% over a period of 10 years.[3]

Despite this vast improvement, the lifespan of the prosthesis is ultimately finite. A significant number of patients eventually face the prospect of revision knee arthroplasty for reasons such as mechanical wear, aseptic loosening, infection, instability, malalignment and periprosthetic fractures.[4] The revision procedure is an unenviable task, as the surgeon often faces difficulties in handling bone loss and soft tissue insufficiency. The overall outcome thus is, unsurprisingly, not as good as primary arthroplasty.[5-10]

Local data on revision knee arthroplasty are limited. This paper is the first to present local registry data on the causes of revision TKAs in a single institution—Singapore General Hospital, as well as the clinical outcome of these patients over 2 to 3 years.

Materials and Methods

Forty-six patients (46 knees) had revision total knee arthroplasty between January 2008 and December 2009, based on our knee registry. Five patients were lost to follow-up. The remaining 41 were included in the study. Information

[1]Department of Orthopaedic Surgery, Singapore General Hospital
Address for Correspondence: Dr Tay Kae Sian, 38 Greenleaf Drive, Singapore 279545.
Email: k_s_tay@hotmail.com

was retrieved from case notes and computer records.

The patients were assessed for knee function and quality of life using the Knee Society Clinical Rating System, Oxford Knee Score, and SF-36 surveys. Patient satisfaction and meeting of expectations were also assessed. These assessments were carried out preoperatively, at 6 months follow-up, and at 2 years follow-up.

Statistical analysis was carried out using SPSS (Version 19) for Windows. Normally distributed data were described using standard parametric statistics. Statistical evaluation of scores was calculated using 95% confidence intervals and parametric paired t-tests. A *P*-value of 0.05 or less was considered statistically significant.

Results

There were 41 patients in the study. The patient demographics are reflected in Table 1. Figure 1 is a Kaplan-Meir survival graph demonstrating the survival of the primary implants. The indications for revision are summarised in Table 2.

Amongst the 13 patients diagnosed with aseptic loosening, the average time between primary and revision arthroplasty was 95.0 months (range, 10.2 to 187.6). There were 2 patients with early aseptic loosening requiring revision surgery at 10.2 and 14.1 months after primary TKA.

In 10 patients, mechanical wear including component failures resulted in a need for revision arthroplasty. Malalignment had been excluded in this group. This occurred on average 90.1 months after primary arthroplasty (range, 17.8 to 190.0). In 6 patients this was due to polyethylene wear, on average 74.9 months after primary TKA. In 3 patients there was a fracture of the polyethylene tibial post necessitating revision (average 97.9 months post primary TKA), and in 1 patient there was significant wear of the femoral component with resulting metallosis (157.4 months after primary TKA).

Table 1. Patient Demographics

Category		**n**
Gender	Male	7
	Female	34
Type of implant used in revision surgery	Constrained condylar knee	26
	Posterior stabilised knee	11
	Total condylar knee	4
Diagnosis at time of primary arthroplasty	Osteoarthritis	40
	Rheumatoid arthritis	1
Category	**Mean (95% CI)**	
Age at primary arthroplasty (years)	60.9 (58.4 to 63.5)	
Age at revision arthroplasty (years)	66.5 (64.3 to 68.8)	
Duration of follow-up (months)	30.1 (28.1 to 32.0)	
Time between primary and revision arthroplasty (months)	67.1 (50.5 to 83.7)	

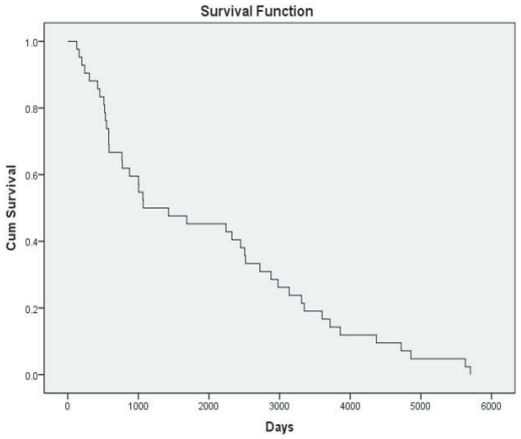

Fig 1. Survival of primary knee implant.

Table 2. Reasons for Revision of Primary Total Knee Arthroplasty

Indication for revision	**n (%)**
Aseptic loosening	13 (31.7%)
Mechanical wear / Component failure	10 (24.4%)
Infection	9 (22.0%)
Malalignment	4 (9.8%)
Instability	3 (7.3%)
Periprosthetic fracture	1 (2.4%)
Persistent stiffness	1 (2.4%)

Four patients were diagnosed with malaligned knees. The criteria for malalignment was any lower limb mechanical axis outside of the range of 3 to 7 degrees valgus.[11] These patients underwent revision arthroplasty on average 20.7 months after the initial surgery. Three patients had instability leading to revision knee arthroplasty. The average survival of their primary implants was 41.1 months.

Infection was the indication for revision in 9 patients. These patients were classified based on timing of the infection, as Tsukayama described.[12] One patient had an acute haematogenous infection, while 8 patients had late chronic infections. The average lifespan of the primary implant was 36.8 months (range, 5.4 to 90.7). All patients who had periprosthetic infection were treated with a 2 stage revision protocol. The average time between removal of implants and re-insertion was 6.0 months (range, 2.9 to

Table 3. Preoperative And Follow-up Scores

Category		Preoperative	6 months	2 years	*P* value*
SF-36	Physical functioning	23.5	55.9	63.3	<0.001
	Role functioning—physical	14.4	53.5	68.9	<0.001
	Bodily pain	29.6	59.0	63.2	<0.001
	General health	62.5	62.6	68.7	0.239
	Vitality	57.7	65.9	71.7	0.005
	Social functioning	31.4	74.0	77.7	<0.001
	Role functioning—emotional	76.8	92.3	100	0.003
	Mental health state	68.5	78.7	81.0	0.016
Oxford Knee Score		38.7	23.6	22.2	<0.001
Knee Society Clinical Rating System	Knee Score	28.1	77.2	77.6	<0.001
	Functional Score	40.9	59.5	65.6	<0.001

* comparing preoperative and 2-year follow-up scores

9.0). There was 1 patient with a periprosthetic fracture. The reason for revision arthroplasty was malunion of the fracture leading to malalignment. The revision was performed 15.0 months after primary TKA. The patients' functional scores after revision knee arthroplasty were assessed as an entire group. The preoperative Knee Society knee score for the patients was on average 28.1, and this improved to 77.2 and 77.6 at 6-month and 2-year follow-up respectively. This was a statistically significant improvement (P <0.001). The Knee Society functional score also increased significantly from a preoperative mean of 40.9 to 59.5 at 6 months and 65.6 at 2 years follow-up (P <0.001). Neither the knee score nor the functional score showed a significant difference between the 6 months and 2 years follow-up (P = 0.466 and P = 0.055 respectively) (Table 3).

The Oxford Knee Scores demonstrated significant improvement as well. Preoperatively, the mean score was 38.7, and this decreased to 23.6 and 22.2 at 6 months and 2 years follow-up respectively (P <0.001). No significant difference was seen between the score at 6 months postoperatively and at 2 years postoperatively (P = 0.075) (Table 3).

The SF-36 surveys showed significant increases in scores in 7 out of 8 categories. Physical functioning scores increased from a preoperative average of 23.5 to 63.3 at 2-year follow-up (P <0.001), role functioning scores increased from 14.4 to 68.9 (P <0.001), bodily pain scores increased from 29.6 to 63.2 (P <0.001), vitality scores increased from 57.7 to 71.7 (P = 0.005), social functioning scores improved from 31.4 to 77.7 (P <0.001), emotional functioning scores improved from 76.8 to 100 (P = 0.003), and mental health state scores improved from 68.5 to 81.0 (P = 0.016). There was no significant change in general health scores, mean preoperative scores being 62.5, and mean scores at 2-year follow-up being 68.7 (P = 0.239) (Table 3, Fig. 2).

The patients' satisfaction with the surgery had an average score of 2.79 (95% CI, 2.40 to 3.18) at 6 months' follow-up, and 2.72 (95% CI, 2.29 to 3.15) at 2 years follow-up, corresponding to a level between 'good' and 'very good'. There was no significant difference between the scores at these 2 follow-up times (P = 0.312). Thirty-two out of 41 patients (78.0%) reported that the results of the surgery were at least 'good', at the 2-year follow-up. Regarding meeting of expectations, the mean score at 6 months follow up was 2.97 (95% CI, 2.49 to 3.44), and 2.91 (95% CI, 2.38 to 3.43) at 2 years follow up. This corresponds to 'yes, quite a bit', on the scale. There was no significant difference between the scores at 6 months and at 2 years follow up (P = 0.195). Thirty-one out of 41 patients (75.6%) reported that the surgery had met their expectations at least 'quite a bit' at the 2-year follow-up.

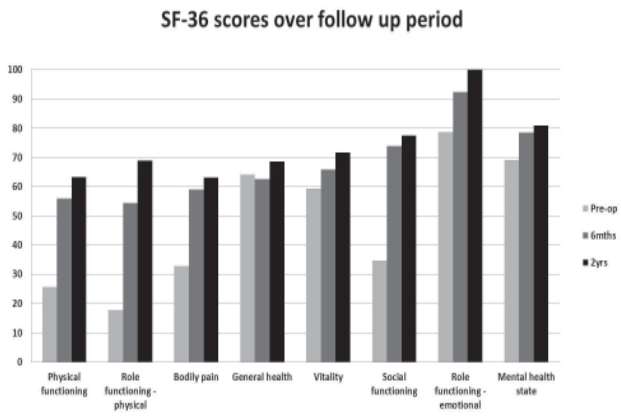

Fig. 2. SF-36 scores over follow-up period.

Notably, there was 100% survivorship of the implants in all 41 patients at the latest follow-up visit. None of the patients required further surgical intervention of any sort, including arthrotomy, joint washout or replacement of any component.

Discussion

There are several well-defined causes of failure of total knee arthroplasty, such as mechanical wear, aseptic loosening, infection, instability, malalignment and periprosthetic fractures.[4] In this study, the modes of failure leading to revision are distributed similarly to other recent larger series, with approximately half of the failures attributed to aseptic loosening and mechanical wear, and a significant minority attributed to infection.[4,13-15]

Thirteen patients diagnosed with aseptic loosening did not have noticeable malalignment on radiographs, and infection had been excluded by means of intraoperative cultures and serum inflammatory markers. All the primary implants had been cemented, with the exception of 1 patient with a press-fit femoral implant. There were 2 patients with early aseptic loosening.

The first patient was a 60-year-old lady who suffered from left knee osteoarthritis with chronic synovitis. She had undergone arthroscopic debridement with no relief of symptoms. She thus underwent a cemented TKA. However, her synovitis persisted and resulted in eventual loosening of her implant with persistent knee pain. She had no systemic symptoms of inflammatory arthritis, and autoimmune markers were negative. She thus had revision TKA performed 10.2 months later. Repeated cultures (both from aspiration and intraoperative) were negative and histology from arthroscopy, primary TKA, and revision TKA all showed chronic synovitis consistent with osteoarthritis. She has been followed up for 3 years since the revision TKA with good functional status.

The second patient was a 75-year-old lady who had left knee osteoarthritis with valgus deformity. Her initial cemented TKA was well-aligned and performed well. However, she started developing varus deformity on follow-up, and radiographs showed severe osteolysis of the medial tibial plateau. She underwent revision TKA 14.1 months after primary arthroplasty. She has been followed up for 30 months since with good functional status.

For the remaining 11 patients with aseptic loosening, the average lifespan of the primary implant was a reasonable 110.1 months. In particular the patient with the uncemented femoral implant had a primary implant survival of 110.4 months.

Among the patients who presented with periprosthetic infection, one suffered from an acute haematogenous infection 5.4 months after the primary arthroplasty. This patient was known to have rheumatoid arthritis. Although no source was identified, the patient presented with an acutely septic knee with purulent aspirate. Despite attempts to salvage the prosthesis with arthrotomy, washout and debridements, the infection persisted and a 2-stage revision was eventually performed. Re-implantation was performed 7.0 months after removal of implants. She has been followed up for 30 months since re-implantation, with good functional status. The remaining 8 patients suffered from late chronic infection which was diagnosed with a combination of clinical presentation, radiographs, serum inflammatory markers and knee joint aspiration. These patients were all treated with a 2-stage revision protocol, which is the current gold standard in treatment of infected TKAs.[16,17]

The single patient who required revision due to periprosthetic fracture suffered a fall 6 months after her primary TKA, resulting in a femoral supracondylar fracture. There was no evidence of predisposition to fracture (e.g. femoral notching) on her follow up radiographs prior to the fall. The fracture was initially plated, but malunion resulted in a malaligned knee. She subsequently underwent revision knee arthroplasty 15 months after the initial arthroplasty.

With regard to clinical outcome, results of revision knee arthroplasty have been variable. Rand et al[7] reported a 67% satisfactory result in 142 knees, Insall et al[8] reported 89% good to excellent results in 72 knees, while Goldberg et al[9] reported only 46% good to excellent results in 65 knees. In a local study, Su et al[10] reported 67% good to excellent results in terms of knee scores, but only 33% good to excellent results in terms of functional scores, in 18 knees.

The inconsistency of results in these studies can be attributed to several reasons. Varying benchmarks for a successful outcome are used. Moreover, differences in implant types, demographics, indications for revision, and follow-up periods combine to create a heterogenous group of patients, which makes comparison difficult. Attempts to stratify groups have not resulted in consistency of results—Barrack et al[18] and Wang et al[19] reported poorer clinical outcome in septic compared to aseptic revision knee arthroplasty, but Patil et al[20] reported the opposite result in his series.

In our study, significant improvements were seen postoperatively in all 3 instruments used to evaluate clinical outcome—Knee Society scoring, Oxford knee scoring, as well as SF-36 surveys. These improvements were seen at 6 months after surgery, and were maintained through the 2-year follow-up period. There were no significant changes in all scores between 6 months and 2 years follow-up. This suggests that the gain in function plateaus after 6 months. The NAKAR study group found that general health scores plateaued after 12 months up to 24 months post-surgery, but

that knee-specific indicators showed a slight but significant deterioration in the second year after surgery.[14] This study supports the conclusion of plateauing of scores in the second postoperative year, but there was no significant deterioration in any aspect up to 2 years follow-up. Both the NAKAR study and this study were performed in institutions with a high volume of arthroplasties, hence it is unlikely the difference can be attributed to surgical expertise. It may be reflective of differences in indications for revision, demographics, or implant types. The clinical significance is in terms of follow-up of patients after revision TKA. With a well-established pattern of function gain after surgery, a patient may only require close follow-up for the first 6 months to ensure maximum function gain, and thereafter be followed up less closely.

In terms of implant survival, recent series have placed both 5- and 10-year survival at between 85% and 90%. Ong et al[5] reported a 5-year survivorship of 87.4% in 1599 revised knees, and Hossain et al[6] reported a 10-year survivorship of 90.6% in 349 revision knee arthroplasties.[5] Hardeman et al[13] reported 5-year survival of 90% and 10-year survival of 85% in 146 revision TKAs.

There was 100% survivorship of the implants with no postoperative complications requiring surgical intervention in this study. While the duration of follow up is short, this is still a notable result, because there were no early failures, as defined by failure within 2 years of implantation, despite a significant proportion (22%) of the revision surgeries being performed for infected TKAs. Suarez et al[15] investigated the mechanisms of failure of revision TKA, and showed 29% failure rate for septic revision TKAs, with many of these occurring early, within 2 years of surgery. Kubista et al[21] showed a 15.8% re-infection rate in 368 revisions performed for infection, at a median time of 3.6 years follow-up. The fact that all infected TKAs treated in the authors' institution underwent a 2-stage revision would have contributed to this success. Single stage exchange has been described for infected TKA but this was not performed in this cohort.[22] We did not identify other factors which may have contributed to this, but postulate this may also be due to the high volume of knee arthroplasties (~1500 per year) performed at the authors' institution and subsequent surgical expertise of the surgeons.

In this study, more than three quarters of the patients expressed satisfaction with the result of their surgery, and felt that the surgery had met their expectations. This is comparable with other series.[6,10,19] The strength and relevance of this study lies in several areas. This study is one of few that use multiple instruments to measure clinical outcome. The use of multiple instruments would enable a more global assessment of functional status and overall health. While there is considerable overlap in the areas assessed, there are specific indicators which may provide information on early changes in localised function (e.g. knee scores) before global health and function (e.g. SF-36) is affected. The trending of functional and knee scores also provides valuable information which can guide clinical follow-up. Many other studies only provide measurements of clinical outcome at a single end-point. This study also spans a shorter time period than other studies, as the patients included were all operated on in a 2-year span (2008 to 2009). The significance is that surgical technique and expertise of surgeons will be relatively constant throughout. This study is also particularly relevant from a local standpoint where only one other study on revision arthroplasty, involving 18 knees, has been published.[10] The causes of revision knee arthroplasty in a local setting have not been previously described either. Hence this study contributes valuable data in this aspect.

This study can be improved by obtaining a larger sample size, which would allow for stratification and accurate subgroup analysis as well. In addition, increasing the duration of follow-up would enable us to ascertain the survivorship of our implants in the longer term. Another advantage of longer follow-up would be to follow the trend of functional scores over the follow-up period, which provides a different perspective for the long-term clinical outcome of the patients undergoing revision TKA.

Conclusion

The indications for revision TKA locally are similar to those in other large centres. Revision total knee arthroplasty results in significantly improved function and quality of life for patients. The improvement is greatest over the first 6 months and then plateaus over the next 2 years of follow-up. In our series, we obtained 100% implant survivorship at 2-year follow-up, but further investigation is required to confirm this at a later interval and to elucidate possible reasons for the better outcome.

Acknowledgements

The authors would like to thank Ms Chong Hwei Chi and the Orthopaedic Diagnostic Centre at Singapore General Hospital for their help in data collection.

REFERENCES

1. Shiers LG. Arthroplasty of the knee; preliminary report of new method. J Bone Joint Surg 1954;36-B:553-60.
2. Shiers, LGP. Arthroplasty of the knee; interim report of a new method. J Bone Joint Surg 1960;42-B:31-9.
3. Labek G, Thaler M, Janda W, Agreiter M, Stöckl B. Revision rates after total joint replacement: cumulative results from worldwide joint register datasets. J Bone Joint Surg Br 2011;93:293-7.
4. Sharkey PF, Hozack WJ, Rothman RH, Shastri S, Jacoby SM. Why are total knee arthroplasties failing today? Clin Orthop Relat Res 2002;404:7-13.
5. Ong KL, Lau E, Suggs J, Kurtz SM, Manley MT. Risk of subsequent revision after primary and revision total joint arthroplasty. Clin Orthop Relat Res 2010;468:3070-6.
6. Hossain F, Patel S, Haddad FS. Midterm assessment of causes and results of revision total knee arthroplasty. Clin Orthop Relat Res 2010;468:1221-8.
7. Rand JA, Bryan RS. Revision after total knee arthroplasty. Orthop Clin North Am 1982;13:201-12.
8. Insall JN, Dethmers DA. Revision of total knee arthroplasty. Clin Orthop Relat Res 1982;170:123-30.
9. Goldberg VM, Figgie MP, Figgie HE 3rd, Sobel M. The results of revision total knee arthroplasty. Clin Orthop Relat Res 1988;226:86-92.
10. Su DH, Chan CW, Seow KH, Lo NN, Yeo SJ, Tay BK, et al. Results of revision total knee arthroplasty. Singapore Med J 2000;41:6-8.
11. Fang D, Ritter MA. Malalignment: forewarned is forearmed. Orthopedics 2009;32:681.
12. Tsukayama DT, Goldberg VM, Kyle R. Diagnosis and management of infection after total knee arthroplasty. J Bone Joint Surg Am 2003;85-A Suppl 1:S75-80.
13. Hardeman F, Londers J, Favril A, Witvrouw E, Bellemans J, Victor J. Predisposing factors which are relevant for the clinical outcome after revision total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2011 Jul 29. [Epub ahead of print]
14. Ghomrawi HM, Kane RL, Eberly LE, Bershadsky B, Saleh KJ; North American Knee Arthroplasty Revision (NAKAR) Study Group. Patterns of functional improvement after revision knee arthroplasty. J Bone Joint Surg Am 2009;91:2838-45.
15. Suarez J, Griffin W, Springer B, Fehring T, Mason JB, Odum S. Why do revision knee arthroplasties fail? J Arthroplasty 2008;23(6 Suppl 1):99-103.
16. Insall JN, Thompson FM, Brause BD. Two-stage reimplantation for the salvage of infected total knee arthroplasty. J Bone Joint Surg Am 1983;65:1087-98.
17. Kalore NV, Gioe TJ, Singh JA. Diagnosis and management of infected total knee arthroplasty. Open Orthop J 2011;5:86-91.
18. Barrack RL, Engh G, Rorabeck C, Sawhney J, Woolfrey M. Patient satisfaction and outcome after septic versus aseptic revision total knee arthroplasty. J Arthroplasty 2000;15:990-3.
19. Wang CJ, Hsieh MC, Huang TW, Wang JW, Chen HS, Liu CY. Clinical outcome and patient satisfaction in aseptic and septic revision total knee arthroplasty. Knee 2004;11:45-9.
20. Patil N, Lee K, Huddleston JI, Harris AH, Goodman SB. Aseptic versus septic revision total knee arthroplasty: patient satisfaction, outcome and quality of life improvement. Knee 2010;17:200-3.
21. Kubista B, Hartzler RU, Wood CM, Osmon DR, Hanssen AD, Lewallen DG. Reinfection after two-stage revision for periprosthetic infection of total knee arthroplasty. Int Orthop 2012;36:65-71.
22. Silva M, Tharani R, Schmalzried TP. Results of direct exchange or debridement of the infected total knee arthroplasty. Clin Orthop Relat Res 2002;404:125-31.