Why do knees after total knee arthroplasty fail in China: a single center's experience

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Research Article

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Abstract

Background

The number of revision Total Knee Arthroplasty (TKA) is rising in many countries. This study aimed to assess causes for revision TKA in China and compared reasons with previously published data.

Methods

In this study patients who had revision TKA between 2007 and 2020 were retrospectively included. Revision causes were categorized using all available information from patients' records including preoperative diagnostics, intraoperative findings as well as the periprosthetic tissue analysis' results. Patients were divided into early (up to 2 years) and late revision (more than 2 years). The reason for revision before 2012 and after 2012 was also compared.

Results

We assessed 337 patients who underwent 373 revision TKAs. In 345 knees this was the first revision surgery after primary TKA. Among the first revisions, half of the revisions were late revisions (50.4%). Overall, the most frequent reason for the revision was infection (38.6%), followed by aseptic loosening (28.1%) and instability (10.1%). Infection (56.1%) and aseptic loosening (49.4%) were the most frequent reason for early and late revisions.

Conclusions

In our specialized arthroplasty center infection was the most common reason for revision. Infection and aseptic loosening needed to be considered for early or late-stage revision.

Background

Total knee arthroplasty (TKA) is one of the most frequent surgical procedures and a very effective treatment option for advanced knee osteoarthritis[1]. The number of primary TKAs performed annually increased rapidly worldwide combined with the increase of revision TKAs[2]. Although revision TKA is reported to be a reliable and cost-effective procedure for failed TKA[3, 4], it is recognized as more technically difficult and more expensive than primary TKA. Additionally, the result of revision TKAs is diverse to the patients. Therefore, a thorough understanding of the causes of failure after TKA is necessary to improve surgical and implant performance, minimize the risk of failure, and avoid the revision TKAs.

Previous studies investigated the failure causes after total knee arthroplasties and differentiated between early (within the first 2 years after primary TKA) and late revision (thereafter). Polyethylene wear and aseptic loosening were the most common causes for late revisions[2]. Infection and instability were the most common revision causes in the early failure groups[5]. However, over the last decade, failure mechanisms have changed[6, 7].

Some studies have reported information on TKA survival and revision causes in large populations obtained from Arthroplasty registries or health care provider data. However, these data are not very specific and come from many different persons who might have different judgments for categorizing the revision causes[8-10]. Single-or multi-center studies with a reliable review of the patients' records can give a more detailed picture of the revision causes.

China is the most populous country with the world's largest aging population, and the incidence of knee OA in China was high[11]. The number of TKA performed in China has grown rapidly during the last decade. In the meantime, the demand for revision TKA has increased rapidly. However, there is a lack of studies reporting the causes of revision TKA in China even in single or multi-center studies. This study aimed to assess causes for revision TKA and the changes during the last fifteen years in China.

Methods

The retrospective review was approved by the ethics committee of the Peking University People's Hospital. All revision surgeries of TKA from January 2007 to December 2021 in our department were included. The revision TKA was defined as the replacement of at least one component (femur, tibia, patella, or polyethylene insert), I or II stage revision for infectious patients, and debridement for early infections. A two or multiple-stage revision with the temporary placement of an antibiotic-loaded bone cement spacer was always performed and considered as one surgery. The cause of revision was based on analysis of x-rays, blood tests, joint aspiration, intraoperative findings, culture, and histology results. The revision cause was determined by authors using all available data and definitions described below. Three authors (Zhang LY, Gao X, Kang WL) independently verified the data and determined the revision cause. The disagreement was resolved by the fourth author (Li ZC) to reach a consensus. Causes were assessed in detail and categorized into infection, aseptic loosening, polyethylene wear, instability, pain, restricted range of motion/fibrosis, and patellar complications. The other reasons, such as periprosthetic fracture, extensor mechanism insufficiency, implant failure, or allergy against implant materials, were all classified into others. In the case of more than one cause for revision, the leading cause was reported.

The diagnosis of infection was based on the Musculoskeletal Infection Society criteria[12]: as two positive periprosthetic cultures with phenotypically identical organisms, or a sinus tract communicating with the joint or having three of the following minor criteria: elevated serum c-reactive protein (CRP), elevated synovial fluid white blood cell count, elevated synovial fluid polymorphonuclear neutrophil percentage, positive histological analysis of

periprosthetic tissue or a single positive culture. Periprosthetic fractures, mechanical implant failure, instability, and aseptic loosening were assessed radiographically. Polyethylene wear was assessed by macroscopic findings on the insert. Pain and restricted range of motion were clinical diagnoses by positive history and suitable physical examination. The pain was used as a revision cause only if no other reason could be determined. Fibrosis was defined as a limited range of motion (ROM) in flexion and/or extension due to the absence of pre-operative soft-tissue fibrosis[13].

The interval from primary TKA to the first revision surgery was recorded and the patients were categorized into early and late failure groups according to a 2-year cut-off[2]. Patient demographics, age, and gender were documented.

Data description is based on means, standard deviations (SD), and percentages. Differences between groups were analyzed using a chi-square test for categorical values. A p-value of 0.05 was considered as statistically significant. All data analyses were carried out using R 4.2.0 for Windows.

Results

373 TKA revisions in 337 patients between January 2007 and December 2021 were included in this study. The mean age of our patients was 69±9, and 83.5% were female. 329 patients had just one surgery, 8 patients were revised bilaterally and 13 knees were revised more than one time during the investigation period. In 345 first revision surgeries, the mean time after primary TKA was 59 months (range 0.3 – 324 months). Among the first revisions, half of the patients were late revisions after 2 years (n = 174; 50.4%). (Table 1)

Table 1 Demographics of the Patients Who Had Revision TKAs.

	Numbers(%)	Gender (Male/Female)	Age	Average months (min month-max moth)
Infection	133	33/100	69±8	31(1-276)
Aseptic loosening	97	11/86	70±9	104(10-276)
Polyethylene wear	10	1/9	70±10	155(60-228)
Instability	35	4/35	70±8	49(3-204)
Fibrosis	11	1/10	65±20	16(4-48)
Pain	7	1/6	75±7	32(2-108)
Patellar complications	20	2/18	69±7	22(1-48)
Others	32	4/28	66±7	67(0.3-324)

The number of revisions in our center increased annually from 1 in 2007 to 49 in 2019. (Fig 1)

Overall, the most frequent reason for the revision was infection (38.6%) followed by aseptic loosening (28.1%) and instability (10.1%). In early revisions, the most frequent reason for the revision was infection (56.1%), followed by instability (9.4%) and Patellar complications (8.2%). As for late revisions, the most frequent reason for the revision was aseptic loosening (49.4%) followed by infection (21.3%) and instability (10.9%). The reasons for early and late revisions were significantly different. ($p<0.01$) (Fig 2)

Before 2012, the most frequent reason for the revision was infection (64.4%), followed by aseptic loosening (15.3%). After 2012, the most frequent reason for the revision was infection (33.2%), followed by aseptic loosening (30.8%) and instability (12.2%). The reasons for revisions before and after 2012 were significantly different. ($p=0.02$) (Fig 3)

Table 2 Clinical studies by failure modes (%).

Author	Year	Region	Number	Infection	Aseptic loosening	Instability	Fibrosis	Wears	Patellar complications	Pain	Others
Fehring TK[5]	2001	US	279	38	3	27	-	7	8	-	17
Sharkey PF[2]	2002	US	212	25/7.8	17/34	21/22	17/12	12/44	10/2	-	14.8/14.8
Mulhall KJ[22]	2006	US	318	10.4	41	28.9	-	24.9	1	-	17
Bozic KJ[15]	2010	US	60436	25	16	-	-	5/3	-	-	34
Hossain F[23]	2010	UK	349	11.5/21.2	2.9/12.0	4.3/3.4	2.3/0.2	0.9/11.5	2.9/1.4	-	6.3/11
Harper C[24]	2012	GER	150	10/6	5/25	9/16	6/11	0/3	-	1/1	2/3
Schroer WC[25]	2013	US	844	8.1/8.2	6.6/24.5	8.9/9.8	4.5/2,5	0.4/9.6	1.8/2.6	-	5.1/7.5
Kasahara Y[26]	2013	Japan	147	24	40	9	-	9	-	-	18
van Kempen RW[27]	2013	NL	150	23	27	15	10	-	-	-	25
Dalury DF[28]	2013	US	820	30/8	14.8/24.1	24/15	14.5/6.6	0.2/1.3	-	14.5/6.6	7.9/3.6
Sharkey PF[6]	2014	US	781	37.6/22	22.8/51.4	6.1/10.3	-	2/4	3.5	-	3/2
Le DH[29]	2014	US	253	24/25	14/13	26/18	18/14	2/9	4	2	39/34
Koh IJ[30]	2014	Korea	634	38	33	7	3	13	1	1	11
Thiele K[7]	2015	GER	358	14.5	21.8	21.8	4.5	7	7	-	24
Huang Z[31]	2015	China	181	53	16	6.6	10	4.4	5	-	5
Motiffard M[32]	2015	Iran	36	44.4	25	2.8	-	-	25	-	2.8
Delanois RE[33]	2017	US	337597	20.4	20.3	7.5	-	2.6	-	-	12
Abdel MP[34]	2017	US	112	54	13	16	1	7	-	-	8
Khan PS[35]	2017	India	53	87/35	2.5/43	-	-	-	2	-	12
Pitta M[36]	2018	US	405	25.7	21.2	24.4	14.1	2.5	3	1.3	8
Postler A[37]	2018	GER	402	36.3	21.6	6.7	4.5	5.2	3.7	6	21.7
Kulshrestha V[38]	2019	India	201	33/28.4	2.0/15.4	4.0/3.5	2.5/0.5	-	3.0	-	4/4
Mathis, DT[39]	2020	Switzerland	200	2/2.5	6/8	29/29	9.5/4.5	0/2	24/26	1.5/1.5	19.5/19.5
Geary, MB[16]	2020	US	1632	38.5	20.9	14.2	4.5	2.9	-	-	18.7

Sharkey et al., Hossain et al., Le et al., Haasper et al., Khan et al., Mathis et al and Kulshrestha et al: First number is early (<2years) failures, second number is late failures; Schroer et al. : First number is early (<2years) failures, second is overall failures. Dalury et al. : First number is early (<5years) failures, second is late (≥5 years) failures.

Discussion

In this study, we found that the most frequent reason for the revision was infection (38.6%), followed by aseptic loosening (28.1%) and instability (10.1%). Infection (56.1%) and aseptic loosening (49.4%) were the most frequent reasons for early and late revisions. The reasons for revision TKA have changed over the last decade, and the numbers of infections have decreased combined with the increase of aseptic loosening.

With a growing number of TKA, the number of revisions increases. The revision risk at 10 years in the major Arthroplasty registries is reported to be about 5%: the Australian Joint Replacement Report stated a 5.5% revision rate after 10 years[9]; for the UK[14], the reported revision rates are below 5% and slightly more than 5.5% for Sweden[10]. The revision causes, however, are different from those listed in the published data, see Table. 2.

In 2002, Sharkey did a retrospective review for reasons of revision TKA. They found that the most common reason for failure among the patients was polyethylene wear, followed by aseptic loosening, instability, and infection[2]. In 2010, using the Nationwide Inpatient Sample database, Bozic found that the most common causes of revision TKA were infection (25.2%), followed by implant loosening (16.1%)[15]. However, over the last decade, failure mechanisms have changed and polyethylene wear as a revision cause decreased combined with the increase of infection. In 2014, 12 years after their first article, Sharkey et al. found a dramatic decrease in the rate of polyethylene wear as the cause of revision. Infection and aseptic loosening were still the most common reasons of revision TKA[6]. In the latest article, Geary reported a 30-year experience of revision TKA and found that the leading cause for failure was infection (38.5%), followed by aseptic loosening (20.9%) and instability (14.2%)[16]. Our result showed that the reasons for revision TKA in China were comparable to those in this study.

In this study we found that reasons for early and late revisions were different. In early revisions, the most frequent reason for the revision was infection followed by instability and Patellar complications. As for late revisions, the most frequent reason for the revision was aseptic loosening, followed by infection and instability. Several studies had reported the difference between early and late revision. Infection and aseptic loosening were the leading reasons for early and late revisions. Infection was the most common reason for revision TKA. The American registry even tops this number by 63% infections accounting for early failures (<3 months from the primary procedure)[17]. Aseptic loosening is the second most common reason for revisions, and unlike infection, it occurred frequently throughout follow-up. Many risk factors contributed to aseptic loosening, and most of them need a long time to come into play[18]. Moreover, some patients had a higher tolerance for this symptom, which prolonged the diagnostic time.

Over the last decade, with the development of surgical technique and advancement in prosthesis design, failure mechanisms have changed. In this study, we found that the numbers of infections have decreased combined with the increase of aseptic loosening. Several studies reported the increasing of aseptic loosening and decreasing of instability[6]. We compiled literature from a 20-year period and found that the revision rate of aseptic loosening before 2010 was low combined with a high proportion of instability. (See table 2) After 2010, the proportion changed. Such improvements in stability following TKA may be attributable to advancements in the operative technique, the development and increased utilization of posterior stabilized prostheses may also be responsible. Loosening of the prosthesis is related to TKA component fixation methodology. There is still a debate concerning optimal fixation, which includes the cement technique and the use of cementless components. Although perioperative prophylactic antibiotics and other anti-infection modalities have been widely utilized in primary TKA, infection is still one of the most common major complications, the most difficult to treat, and the most expensive complication related to joint replacement surgery.

In our center, 7 patients received revision TKA because of the diagnosis of pain. The rate of pain in published articles was low and some articles did not include this diagnosis. However, in the registries of New Zealand, Norway, England, Wales, Northern Ireland, and the Isle of Man, high rates of revision due to unexplained pain have been reported, with an incidence as high as 29.4% observed in New Zealand knee revisions[19]. However, the registries system may not have detailed information about revisions. Patients who suffered from instability, patellar complications or even low-grade infection might be misdiagnosed with pain. Some authors agree with the common sense that revision operations should only be performed if the cause(s) of the complaints described have been identified and fit the clinical picture, as revision surgery for unexplained pain has consistently been shown to result in poor outcomes[20, 21].

We acknowledge the strengths and limitations of this study. Firstly, it is one of the first studies to determine the cause of revisions in China, as there is no registry system in China. Our single-center study filled the gap for the lack of research in this area in China. Secondly, we garnered detailed information about all previous revisions, which made our diagnosis more accurate. We believe that our data are representative of tertiary care centers.

However, most patients were referred to our department and we did not have complete baseline information on the primary TKA. Furthermore, we collected the operation time which was not always the precise time to failure. Time to failure is usually less than the operation time, which may lead to bias to the group study. We were not able to get detailed information about all previous revisions in all cases. Thus, we could not account for the potential effect of other patient characteristics that might be strongly associated with TKA failures, such as patient comorbidities, preoperative deformities, functional status, activity level, socioeconomic status, and education level. In some cases, more than one reasons lead to revision and we categorized the patients into the leading revision cause. Our study was a single-center study, which may lead to selection bias in patients, a case that is unlikely to occur for multi-center or joint replacement registry studies. However, there are no joint registry systems in China, and studies focused on this field in China were limited. Further multi-center or registry system studies with detailed information focused on the revision TKA are still needed in China.

Conclusion

In our specialized arthroplasty center, infection was the most common reason for revision. Infection and aseptic loosening needed to be considered for early or late-stage revision.

Abbreviations

TKA: Total knee arthroplasty. OA: Osteoarthristis.

Declarations

Ethics approval and consent to participate

The retrospective review was approved by the ethics committee of the Peking University People's Hospital. Written informed consent was obtained from all participants according to the Declaration of Helsinki

Consent for publication

Not Applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to the policy of our hospital but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

JL and ZL designed the study. LZ and ZL analyzed the data and wrote the manuscript. WK and XG participated in the data collection, analysis, and interpretation. All authors read and approved the final manuscript.

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Figures

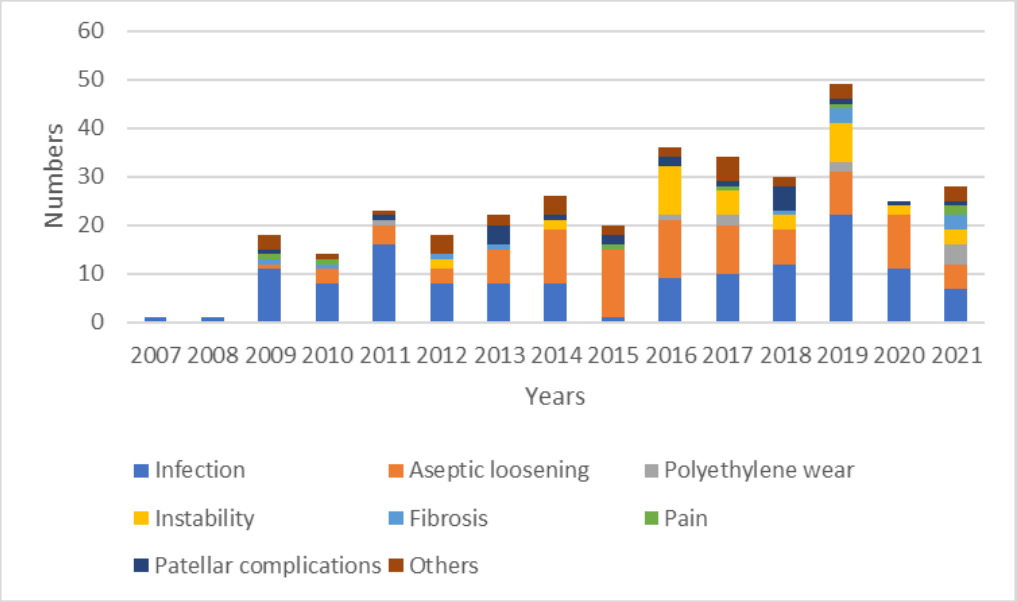

Figure 1

Time trend for revision TKAs.

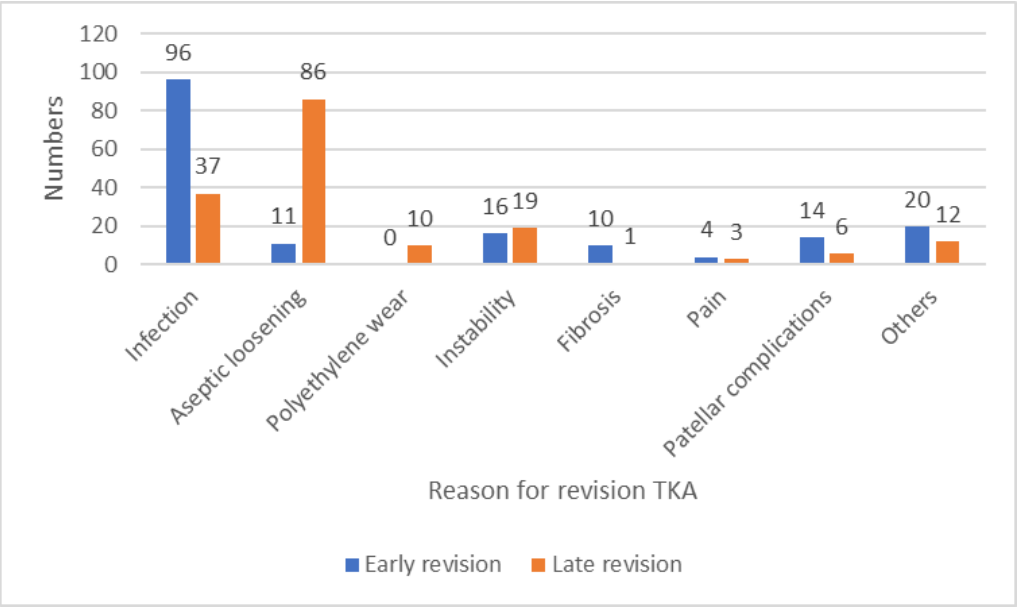

Figure 2

Revision causes according to early or late revision.

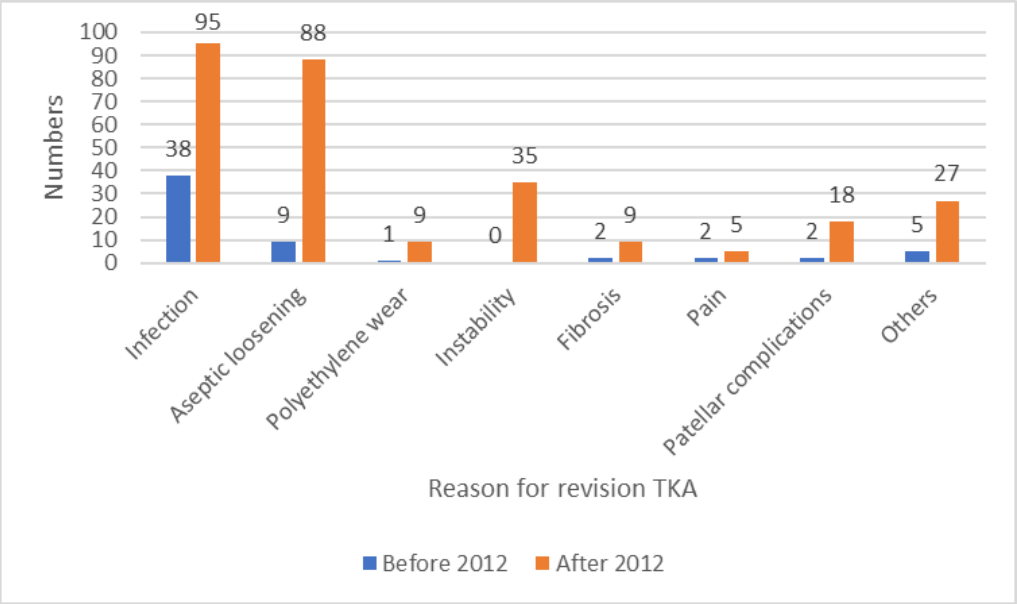

Figure 3

Revision causes before or after 2012.