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Original article

Have the frequency of and reasons for revision total knee arthroplasty changed since 2000? Comparison of two cohorts from the same hospital: 255 cases (2013–2016) and 68 cases (1991–1998)

Julien Pietrzak[a,b,*], Harold Common[c], Henri Migaud[a,b], Gilles Pasquier[a,b], Julien Girard[a,b], Sophie Putman[a,b]

[a] Université Lille Nord de France, 59000 Lille, France
[b] Service d'orthopédie, Hôpital Salengro, CHRU de Lille, place de Verdun, 59037 Lille cedex, France
[c] Service d'orthopédie, CHU Ponchaillou, Université de Rennes 1, 2, rue Henri-Guilloux, 35000 Rennes, France

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ABSTRACT

Introduction: The number of total knee arthroplasty (TKA) revisions is expected to increase 601% in the United States between 2005 and 2030. This type of information is not available in France, and the last national study on this topic was done in 2000. This led us to perform a comparative study to determine if 1) the frequency of TKA revisions has increased and 2) the reasons for reoperation have changed relative to data gathered in 2000 at a single hospital in France.

Hypothesis: The frequency of TKA revision has increased between the two studies, performed 15 years apart.

Material and methods: In this retrospective observational single-center study (January 2013 to December 2016), all patients with a TKA who were reoperated with or without any component change were included. This cohort was compared to our historical cohort defined in 2000 of 68 TKA reoperations between January 1991 and January 1998. The reasons for revision were determined by consulting computerized patient records to find the disease history, clinical examinations, imaging findings, laboratory tests and the surgery report. Cases due to periprosthetic fractures, infection and skin-related complications were excluded in order to be consistent with the indications of the historical cohort.

Results: Between 2013 and 2016, 349 TKA revisions were performed, and 255 met the inclusion criteria. Note that the historical cohort had 68 cases. The mean time elapsed between the primary TKA and revision procedure was 5.3 years [34 days to 31 years]. Eight reasons for reoperation were identified. Aseptic loosening (85 cases (33.3%)), stiffness (70 cases (27.5%)), tibiofemoral laxity (39 cases (15.3%)) and patellar complications (34 cases (13.3%)) were the four most common reasons for reoperation.

The frequency has changed over time: relative to 2000, the annual frequency increased by a factor of 6.5. The reasons have also changed over time: there was an increase in revisions for aseptic loosening (33.3% vs. 23.5%), stiffness (27.5% vs. 20.6%) and knee joint laxity (15.3% vs. 10.3%). Conversely, there was a reduction in revisions for patellar complications (13.3% vs. 26.5%), unexplained pain (0.4% vs. 8.8%) and patellar clunk syndrome (1.2% vs. 4.4%).

Discussion: The number of TKA revisions has increased by a factor of 6.5, with aseptic loosening still being the most common reason. The number of revisions performed for stiffness and knee joint laxity have increased. Fewer revisions are being done for unexplained pain because surgeons are now better able to determine the cause of TKA-related pain. There were fewer patella-related complications because of technical progress. The data generated from our single-center study are consistent with current published data.

Level of evidence: II, comparative study.

* Corresponding author at: Service d'orthopédie, Hôpital Salengro, CHRU de Lille, place de Verdun, 59037 Lille, France.
E-mail address: pietrzak.julien@icloud.com (J. Pietrzak).

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1. Introduction

If the trend observed from 1990 to 2003 were to continue, Kurtz et al. [1] estimate that in the United States, the number of total knee arthroplasty (TKA) revisions will increase by 601% between 2005 and 2030. This increasing trend has been reported in several countries based on data from national joint registers [2,3], but the lack of register in France means this trend has not been confirmed in France.

The latest research on this topic was conducted by the French Hip and Knee Society (SFHG) in 2014 and captured 703 revision cases over 11 years in a retrospective study and 158 cases in a 1-year prospective study [4]. That study was based on discontinuous data since 15 hospitals participated (6 cases annually for the retrospective study and 10 cases annually for the prospective study [4]), and does not confirm an increase in the number of TKA revisions relative to another study reported at the French Society of Orthopedic and Traumatological Surgery (SOFCOT) meeting in 2000 [5]. The SFHG study, which can only be found on the internet, provides important data such as the predominance of loosening following by revisions for tibiofemoral laxity [4], but does not allow for a detailed epidemiological analysis nor a reliable comparison with data from the 2000 SOFCOT symposium to which our team contributed 68 cases (2 cases of periprosthetic fracture excluded) [5].

Thus, we performed a single-center retrospective study to determine if:

- the frequency of TKA revisions has increased;
- the reasons for reoperation have changed relative to data gathered in 2000 at a single hospital in France.

We hypothesized the frequency of TKA revision has increased between the two studies, 15 years apart.

2. Materials and methods

2.1. Patients and methods

We carried out a single-center retrospective epidemiological study to analyze the reasons for TKA revision and their frequency between January 2013 and December 2016. These data were compared to our historical cohort from 2000 that included 68 reoperations of TKA patients between January 1991 and January 1998.

Our current series used the same inclusion criteria as the ones used in 2000 and excluded cases with periprosthetic fracture, skin-related complications (hematoma and skin necrosis) and infections (Fig. 1). It included patients who had either a primary or revision TKA and underwent reoperation at our hospital, independent of the implant's constraint level. TKA reoperations included implant revision and reoperations without implant change. The reasons for revision were determined by consulting computerized patient records to find the disease history, clinical examinations, imaging findings, laboratory tests and the surgical report. An additional analysis was done based on the time to revision (less than 2 years or 2 + years later).

2.2. Statistics

The reasons for TKA revision were described in terms of counts and percentages. Gaussian numerical parameters were described by their mean and standard deviation values, while non-Gaussian variables were described by their median and interquartile range. The normality of the distribution of numerical variables was verified graphically and using the Shapiro–Wilk test. To compare patient profiles, the index implant and reasons for reoperation, a Chi-square test was done with qualitative variables and Student's *t*-test was done with continuous, normally distributed variables.

3. Results

3.1. Descriptive analysis

Between January 2013 and December 2016, 349 reoperations were performed on patients with a TKA at our hospital. Of these, 255 cases met the inclusion criteria and were analyzed for this study (Fig. 1, Table 1). The mean time elapsed between the primary TKA procedure and the revision was 5.3 years [34 days to 31 years]. The implants were changed in 183 cases (Table 2). The reoperations occurred in patients with a primary TKA in 163 cases, TKA that had previously undergone reoperation but no implant change in

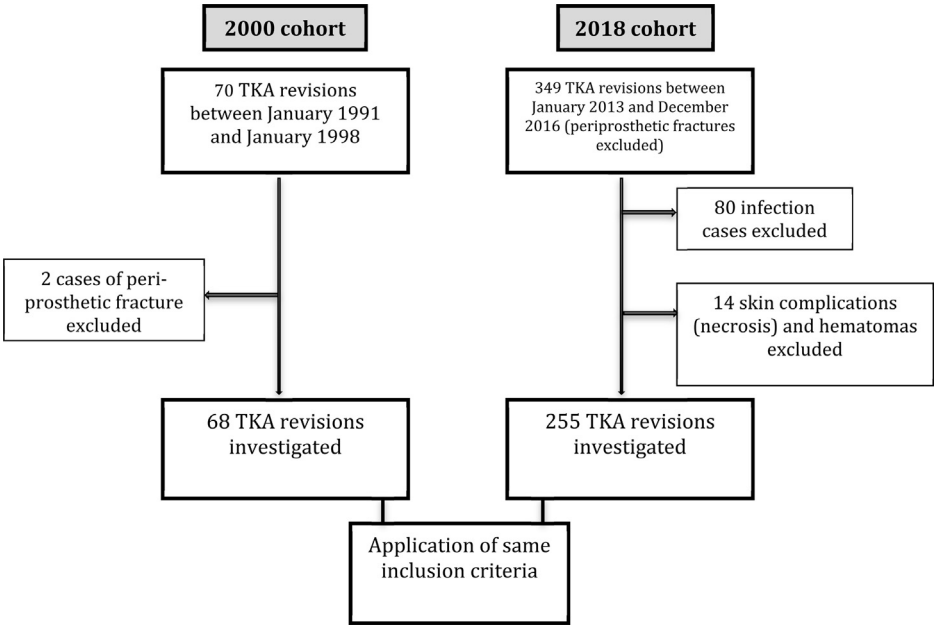


Fig. 1. Flowchart. TKA reoperations in 2000 and in 2018.

Table 1
Characteristics of the patients and TKA implants revised in the 2000 and 2018 studies.

Variables (*n* (%))	2018 study (*n* = 255)	2000 study (*n* = 68)	Study comparison
Sex			
Men/Women	81 (32%)/174 (68%)	13 (19%)/55 (81%)	$p > 0.05$
Mean age at revision(min–max)	62.7 years (29–97)	65.5 years (38–79)	$p > 0.05$
Diabetic	47 (18.4%)	ND	NA
Mean BMI (min; max)	32.2 (24–48)	ND	
Implant constraint level:			
PCL-sparing TKA	3 (1%)	41 (60.2%)	$p < 0.0001$
Posterior-stabilized TKA	194 (76%)	20 (29.5%)	
Semi-constrained TKA	18 (7%)	5 (7.3%)	
Hinged TKA	40 (16%)	2 (3%)	
PE insert:			
Mobile	94 (37%)	ND	NA
Fixed	157 (63%)		
Patella:			
Resurfaced	234 (92%)	ND	NA
Not resurfaced	21 (8%)		
Initial TKA indication:			
Primary OA	215 (84%)	54 (79.4%)	$p > 0.05$
Post-traumatic OA	12 (5%)	5 (7.4%)	
Secondary OA/other	28 (11%)	9 (13.2%)	
Mean time to revision (min; max)	5.3 years (34 days; 31 years)	4.6 years(0; 10 years)	$p > 0.05$
TKA revision	183 (71.8%)	35 (51.5%)	$p < 0.001$
Original hospital:			
CHRU Lille	141 (55%)	ND	NA
Other facility	114 (45%)		

BMI: Body Mass Index, ND: no data, NA: Not applicable.

Table 2
Details on the TKA reoperations and mean time to revision in 2018.

Procedure name	Number of cases	Mean time to revision (mean (min–max))
TKA implant change	183	6.4 years (62 days; 31.2 years)
Mobilization	28	52 days (34 days; 77 days)
Surgery extensor mechanism	20	3.1 years (49 days; 14,6 years)
Arthroscopic arthrolysis	14	11.5 months (76 days; 2.7 years)
Change of PE tibial insert	8	8.4 years (1.2 years; 26.9 years)
Open arthrolysis	2	2 years (1.9 year; 2.1 years)
Arthroscopy for synovectomy	1	6.1 years

52 cases and reoperation of revision TKA implants in 40 cases.

We identified eight reasons for TKA reoperation. The four most common were aseptic loosening (85 cases, 33.3%), stiffness (70 cases, 27.5%), tibiofemoral laxity (39 cases, 15.3%) and patellar complications (34 cases, 13.3%) (Table 3, Appendix A). Patellar complications included tendon rupture (10 cases) and mechanical failure included polyethylene wear (8 cases).

When the analysis was repeated based on time to revision (Fig. 2), the primary reason for early revision was stiffness (46 cases, 30.3%) and then patellar complications including tendon rupture (21 cases, 21.9%). The primary reasons for late revisions were loosening (70 cases, 35.5%) and tibiofemoral laxity (28 cases, 17.6%). Early revisions before 2 years made up nearly 38% of cases.

3.2. Comparison between current and historical series

Since there were 68 revision cases reported in 2000 (7-year inclusion period) and we found 255 cases in 2018 (4-year inclusion period), the annual frequency of reoperations has increased 6.5 times in 15 years at our hospital. The two cohorts were comparable in terms of sex, age at revision, mean time to revision and initial indication ($p > 0.05$). There was a significant difference in the type of TKA revision with a larger number of PCL-sparing TKA ($p < 0.001$) in the 2000 series and implant change being more frequent in the 2018 series ($p < 0.001$).

There was also an increase in the number of revisions for aseptic loosening (from 23.5% to 33.3%% ($p > 0.05$)) which became the number one reason for TKA revision (Fig. 3). Patellar complications, which were the leading reason for revision in 2000, was the fourth leading reason in 2018 (26.5% to 13.3%% ($p < 0.05$)). There was an increase in the number of revisions for stiffness (20.6% to 27.5%% ($p > 0.05$)) and for tibiofemoral laxity (10.3% to 15.3%% ($p > 0.05$)). Revision for unexplained pain decreased greatly (8.8% to 0.4%% ($p < 0.001$)) as did revisions for patellar clunk syndrome (4.4% to 1.20%% ($p > 0.05$)).

4. Discussion

This study found a large increase in the number of TKA reoperations, with the annual frequency having increased 6.5 times in 15 years at our teaching hospital. Our hypothesis is confirmed.

4.1. Trends in reasons for revision

In our study, aseptic loosening has become the primary reason for revision, surpassing patellar complications, which was the primary reason in 2000. Abdel et al. [6] showed that a BMI > 35 kg/m^2 increases the risk of tibial loosening by two-fold. In a meta-analysis, Nakama et al. [7] found that the risk of loosening within the first 2 years post-TKA was larger with cementless implants than cemented implants, but that this trend had reversed after 2 years. Gandhi et al. [8] reported better survival of cemented implants compared to cementless implants with a follow-up of 2 to 11 years.

The reoperation rate for stiffness also increased (20.6% to 27.5%). In our study, there were more men and younger patients relative to the general population. According to Brophy et al. [9], young male patients are most likely to have a history of knee surgery before the TKA, which is a known risk factor for postoperative stiffness [10–12]. Pasquier et al. [13] showed that improved knee flexion

Table 3
Reasons for reoperations of TKA patients in 2018 and 2000 (*n* (%)).

Reasons	2018 Lille study (*n* = 255)	2000 Lille study(*n* = 68)	Study comparison
Aseptic loosening	85 (33.3%)	16 (23.5%)	$p > 0.05$
Tibial	45 (54%)		
Femoral	18 (22%)		
Tibial and femoral	20 (24%)		
Stiffness	70 (27.5%)	14 (20.6%)	$p > 0.05$
Flexion	39 (55.7%)		
Extension	1 (1.5%)		
Mixed	30 (42.8%)		
Tibiofemoral laxity	39 (15.3%)	7 (10.3%)	$p > 0.05$
Patellar complications	34 (13.3%)	18 (26.5%)	$p < 0.05$
Patella fracture	3 (8.8%)		
Anterior knee pain	10 (29.4%)		
Patellofemoral instability	11 (32.4%)		
Tendon rupture	10 (29.4%)		
Mechanical failure	22 (8.6%)	4 (5.9%)	$p > 0.05$
PE insert wear	8 (36.4%)		
Patellar clunk syndrome	3 (1.2%)	3 (4.4%)	$p > 0.05$
Unexplained pain	1 (0.4%)	6 (8.8%)	$p < 0.01$
Allergy	1 (0.4%)	0	NA

NA: Not Applicable.

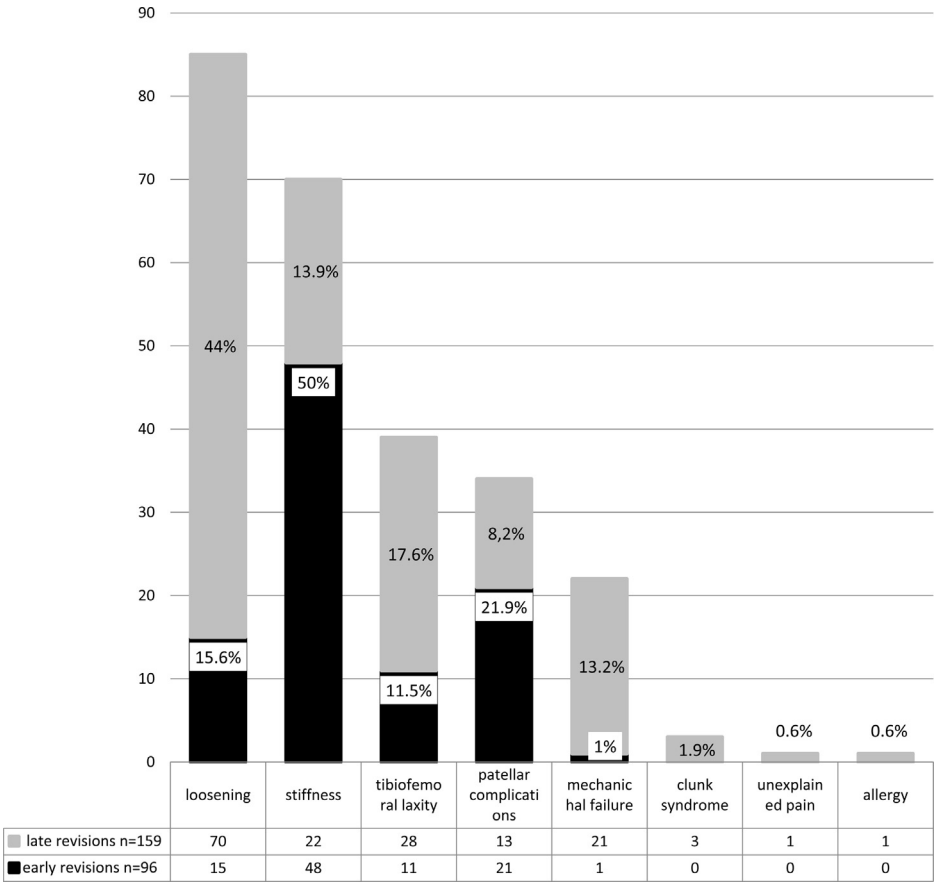
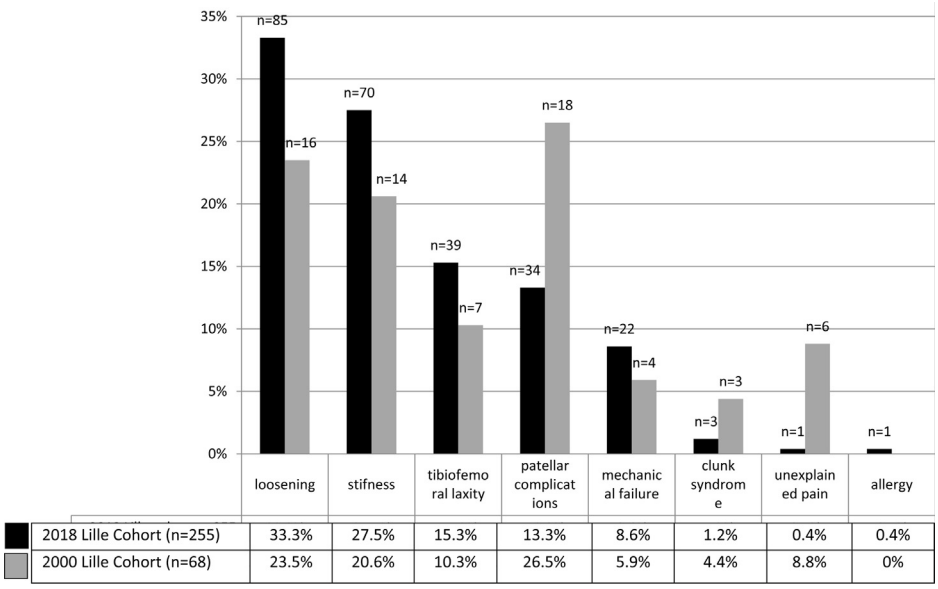


Fig. 2. Reasons for TKA revisions (2018 study) divided in early revisions (less than 2 years post-TKA) and late revisions (more than 2 years post-TKA).

after primary TKA occurred in 66% of cases, but that 15% had no improvement and 19% had a reduction in postoperative flexion range. TKA revision for stiffness results in worse outcomes than for other causes of revision according to Baker et al. [14].

Revisions for tibiofemoral laxity increased from 10.3% to 15.3%. According to several studies, tibiofemoral laxity is due to a combination of errors, such as inappropriate implant sizing and errant surgical technique [15–17]. The number of patellar complications decreased from 26.5% to 13.3%, likely because of changes in implant design with a more anatomical trochlear groove, special attention placed on femoral and tibial rotation, and changes made to the patellar implants [18,19]. In a retrospective study of 499 TKA revision cases, Mortazavi et al. [20] found patellar complications to be the third leading cause of failure (12.8%) behind infection (44.1%) and stiffness (22.6%).



	loosening	stifness	tibiofemoral laxity	patellar complications	mechanical failure	clunk syndrome	unexplained pain	allergy
2018 Lille Cohort (n=255)	33.3%	27.5%	15.3%	13.3%	8.6%	1.2%	0.4%	0.4%
2000 Lille Cohort (n=68)	23.5%	20.6%	10.3%	26.5%	5.9%	4.4%	8.8%	0%

Fig. 3. Reasons for TKA revision (counts and percentages) relative to our team's 2000 study. Excluded were infection, acute postoperative complications and periprosthetic fractures.

We found a clear decrease in the number of reoperations for unexplained pain, from 8.8% to 0.4% in our study. This may be due to improved detection with systematic use of CT scan and better understanding of the causes of TKA failure. We found a reduction in the number of revisions for patellar clunk syndrome from 4.4% to 1.2%. Allergy is a known TKA complication, but its diagnosis is challenging [21] as evidenced by the single case in our series.

4.2. Comparison to published data

There is little difference in the type of patient included in our series (revision of primary TKA and re-revisions) and in the methodology (comparable reasons for revision) used to generate the 2000 symposium data [5]. Aseptic loosening was the leading cause of TKA revision, like in our current series. However, our current series had fewer revisions for patellar complications and more for cases of stiffness [5]. In 2015, the SFHG symposium on TKA revision also reported a large number of reoperations with 703 cases between 1999 and 2010 [4]. Aseptic loosening was by far the most common reason for revision (46%) followed by tibiofemoral laxity (13%), stiffness (11%) and extensor mechanism complications (10%). However, that was a multicenter retrospective study that does not allow us to determine how the reasons for TKA change over time or to carry out a reliable comparison with the 2000 SOFCOT symposium data.

Sharkey et al. [22,23] did two retrospective studies 10 years apart. They reported a clear decrease in polyethylene wear and significant increase in aseptic loosening and infection between 2002 and 2012. Early revisions (within 2 years) made up less than 50% of the cases in 2012 and nearly 56% in 2002. In our study, these made up nearly 38% of cases; however infection was excluded despite the fact it is one of the most common reasons for early revision [23].

Currently, the 10–15 year TKA survival rate is above 90% [24,25]. Despite the differences in methodology and study populations in recent published studies, loosening and infection are known to be the main reasons for TKA revision as reported by Lum et al. [26] in their review of studies over the past 20 years (Table 4) [22,23,27–29]. Infection, which was excluded in our study, made up a large part of our TKA revision cases between 2013 and 2016 (80/349 cases excluded). (Fig. 1).

4.3. Study limitations

Our study has several limitations:

- potential bias due to computerized data collection and missing information in patient records, especially for patients who had undergone the primary TKA procedures at other hospitals. The fact that a single surgeon extracted the data should theoretically have reduced any data collection bias;
- retrospective epidemiology study, although the large number of cases made the analysis more robust and allowed us to work with normally distributed variables;
- number of cases in 2000 study was limited; however our study provides a reliable comparison as it comes from the same surgical team whose revision criteria have changed little over time.

We encourage the other hospitals that participated in the 2000 symposium to repeat our study and to pool our records to increase the study's power.

Table 4
Summary of previous published studies.

	Number of reoperations	Loosening	Infection	Stiffness	Tibiofemoral laxity	Periprosthetic fracture	Patellar complications	Mechanical failure	Acute postoperative complication	Tendon rupture	PE wear	Incorrect implant positioning	Patellar clunk syndrome	Unexplained pain	Allergy
Sharkey et al. [22]	203 cases	24.1%	17.5%	14.6%	21.2%	2.8%	11.7%	ND	ND	Included in patellar complications	**25%**	11.8%	ND	ND	ND
Bozic et al. [24]	60355 cases	16.1%	**25.2%**	ND	ND	1.5%	ND	9.7%	ND	ND	4.9%	6.6%	ND	ND	ND
Sharkey et al. [23]	781 cases	**39.9%**	27.4%	4.5%	7.5%	4.7%	7.3%	ND	ND	Included in patellar complications	3.5%	ND	ND	ND	ND
Pitta et al. [25]	405 cases	21.2%	**25.4%**	14.1%	24%	3.5%	2.8%	ND	ND	Included in patellar complications	2.5%	2.5%	0.5%	1.3%	0.7%
Abdel et al. [27]	295 cases	5.1%	20.7%	**36.3%**	6.1	3.1%	ND	ND	13.2%	ND	ND	ND	6.8%	ND	ND
Lille cases in 2000 SOFCOT symposium	68 cases	23.5%	ND	20.6%	10.3%	Excluded	**26.5%**	5.9%	ND	Included in patellar complications	Included in mechanical failure	ND	4.4%	8.8%	ND
Current study 2018	255 cases	**33.3%**	Excluded	27.5%	15.3%	Excluded	13.3%	8.6%	Excluded	Included in patellar complications	Included in mechanical failure	ND	1.2%	0.4%	0.4%

ND: no data. In bold: leading cause of TKA revision for each study.

5. Conclusion

Our study reinforces the published data on reasons for TKA revision and their trends. Aseptic loosening, stiffness and tibiofemoral laxity are the main reasons for reoperation. The annual frequency of TKA revision increased by a factor of 6.5 at our hospital in a 15-year period, with nearly 38% of reoperations done within 2 years of the primary surgery. Our single-center study appears comparable to current published data. Given the increasing number of TKA cases being performed worldwide, it is important to understand why they fail to reduce the incidence of revisions.

Disclosure of interest

None of the authors has conflicts to declare directly related to this study. Outside the scope of this study, Sophie Putman is a consultant for Corin-Tornier, Gilles Pasquier is a consultant for Zimmer-Biomet, Henri Migaud is consultant for Zimmer-Biomet, Corin-Tornier, MSD and SERF, while Julien Girard is a consultant for Microport and Smith & Nephew. The other authors have no conflict of interest outside this study.

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Author contributions

Julien Pietrzak and Harold Common collected data and wrote the article. Henri Migaud initiated the study, operated on patients and collected data for the study in 2000. Gilles Pasquier and Julien Girard operated on patients and contributed to writing the article. Sophie Putman supervised the study and writing, operated on patients and managed the statistical analysis.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.01.025.

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