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Why Reintervention After Total Knee Arthroplasty Fails? A Consecutive Cohort of 1170 Surgeries

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ABSTRACT

Background: The aim of this study was to analyze why contemporary reintervention after total knee arthroplasty (RiTKA) fails.
Methods: Between January 2006 and December 2010, from a multicenter cohort of 1170 RiTKAs, we assessed all failures of RiTKA requiring additional surgery. All indications for the index reintervention were included. The minimum follow-up period was 3 years.
Results: A total of 192 (16.4%) patients required additional surgery after RiTKA (re-reintervention). The mean follow-up period was 7.7 years. Mean age was 69.2 years. The mean time to re-reintervention was 9.6 months with 90.1% of rTKA failure occurring within the first two years. Infection was the main cause of new surgery after RiTKA (47.9%; n = 92/192). Other causes included extensor mechanism pathology (14.6%), stiffness (13.5%), pain (6.8%), aseptic loosening (5.2%), laxity (5.2%), periprosthetic fracture (3.6%), and wound pathology (3.1%). In four groups, the main indication for re-reintervention was recurrence of the pathology leading to the first reintervention: RiTKA for infection (59/355, 16.6%, $P < .05$), stiffness (18/174, 10.3%, $P < .05$), extensor mechanism failure (9/167, 5.4%, $P < .05$), and RiTKA for pain (4/137, 2.9%, $P = .003$). Global survival curve analysis found 87.9% survivorship without re-reintervention at one year and 83% at eight years.
Conclusion: Contemporary RiTKA failures mainly occur in the first two postoperative years. Infection is the main cause of failure in RiTKA. Recurrence of the initial pathology occurs in four groups of RiTKA and is the main indication for re-reintervention in these groups; infection (16.6%), stiffness (10.3%), extensor mechanism failure (5.4%), and pain (2.9%).

The number of primary total knee arthroplasties (TKAs) performed is constantly increasing [1,2] with a growth estimate of 637% by 2030 in the United States of America alone [3]. This rise will inevitably lead to a greater number of primary TKA failures and a subsequent increase in reintervention after TKA (RiTKA) [4]. These surgeries represent a challenge for surgeons, patients, and hospital systems. The clinical outcomes after revision are inferior to those of primary arthroplasty [5–7] with a higher rate of complications (6% to 8.7%) [8,9]. Surgical procedures are more difficult, sometimes requiring specific prostheses or allografts to

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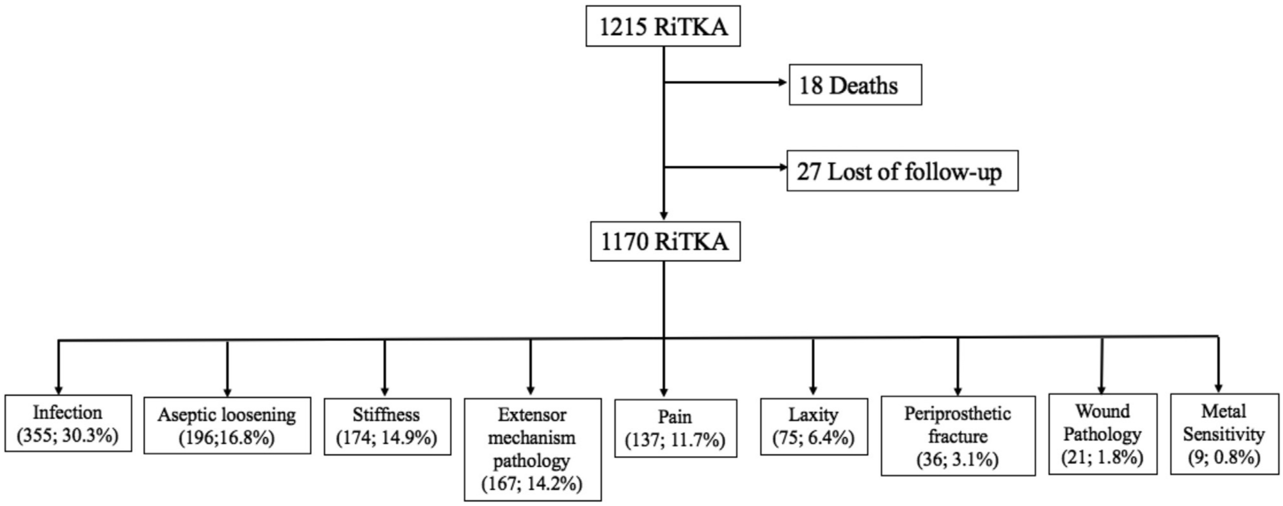

Fig. 1. Flow chart of the study. RiTKA, reintervention after total knee arthroplasty.

compensate for bone loss and ligamentous insufficiency [10–12]. Furthermore, the global cost to society and to hospital systems is much greater [13,14] with longer rehabilitation and a higher rate of rehospitalization [13].

To reduce the rate of reintervention, learned societies have analyzed the causes of failure in primary TKA, to develop new surgical techniques and improve implant design and manufacturing. Initially, polyethylene wear was the main cause of failure, leading to instability and aseptic loosening, secondary to osteolysis [15,16]. The development of modern, highly crosslinked polyethylene [17] has significantly reduced this issue. More recent studies reveal that infection is now the primary cause of failure in both the short and long term (44.1%), followed by aseptic loosening (41.3%), instability (28.9%), and stiffness (22.6%) [18,19]. Infection risk is higher in revision surgery because of poor tissue vascularization, longer surgery time, greater patient age, and other comorbidities [20]. Few studies assess survivorship and mechanisms of failure mode for RiTKA [18,19,21].

The aim of this study was to analyze why contemporary RiTKA fails, through a global analysis of the mechanisms of failure and by specific survival analysis according to each pathology. A better understanding and knowledge of complications in RiTKA may allow us to reduce their incidence. Our hypothesis was that the initial cause for reintervention will influence survivorship and the mechanism of failure in RiTKA.

Method

From a retrospective, multicenter (7 centers) cohort of 1215 RiTKAs (1192 patients) performed between January 2006 and December 2010, we assessed all failures requiring additional surgery. Inclusion criteria were all indications for reintervention (periprosthetic joint infection, aseptic loosening [femoral, tibial or bipolar], stiffness, extensor mechanism pathology, pain, laxity, periprosthetic fracture [femoral or tibial], wound pathology [hemarthrosis, cutaneous necrosis], and metal sensitivity) and all reintervention procedures (component exchange, irrigation and debridement, extensor mechanism surgery, stiffness and balancing surgeries, osteosynthesis, arthroscopy, synovectomy, and above knee amputation). Exclusion criteria were follow-up less than 3 years, revision of unicompartmental knee arthroplasty, and tumor disease.

Eighteen patients died during the study period, and twenty-seven were lost of follow-up, without reintervention at their last follow-up. A total of 1170 RiTKAs (1147 patients) were included in the final analysis (Fig. 1, Table 1).

Any surgical reintervention, called re-reintervention (Re-RiTKA), whatever the indication and the procedure performed, required after the RiTKA was considered as new failure and as an endpoint for the study.

Diagnosis of infection was established according to the Musculoskeletal Infection Society diagnostic criteria [22,23]. We distinguished acute prosthetic joint infection and chronic infection. When the complication appeared precociously after the initial surgery during the first postoperative month, we defined it as an acute infection. The treatment was debridement, irrigation, polyethylene insert exchange, implant retention, and prolonged postoperative antibiotics (DAIR) [24]. For chronic infection, the treatment was component exchange with debridement, irrigation, and antibiotics. Mostly, a two-stage revision surgery was performed, which is considered the gold standard. One-stage surgery was used when the microorganism was identified preoperatively on an articular aspirate, the organism had a low-resistance profile to antibiotics, when there was no previous history of infection, no sinus tract, and when component exchange did not required a massive prosthesis or graft (bone or extensor mechanism) [25–27].

The indication of pain included all cases in which isolated knee pain was the main symptom leading to reintervention. This was further divided into cases of unexplained pain, where the preoperative assessment could not determine the origin of the pain, and explained pain, where assessment revealed a plausible explanation for the symptom.

Isolated extensor mechanism procedures included all surgeries on the quadriceps tendon, patella, patellar ligament, and anterior tibial tuberosity (Table 2) [28,29]. In most cases, several different procedures on the extensor mechanism were performed at the same time.

A diagnosis of metal sensitivity is difficult to establish and was based on several factors. First, patients reported cutaneous reaction to metals in their medical history, with positive dermatological cutaneous tests (patch tests) to metals. Specific laboratory tests, such as lymphocyte transformation testing [30], were used in some cases. Patients present generally with unexplained pain or loosening of the components without suspicion of infection [31]. Periprosthetic tissue samples excluded infection and confirmed an inflammatory reaction with a nonspecific lymphocytic infiltration and fibrosis. Revision with a hypoallergenic prosthesis was performed.

Table 1
Demographic Characteristic of the Initial Population.

Total (n)	1170
Initial indication for reintervention after total knee arthroplasty	
Infection	355 (30.3%)
Aseptic loosening	196 (16.8%)
Femoral	53 (27.1%)
Tibial	88 (45%)
Bipolar	55 (27.9%)
Stiffness	174 (14.9%)
Extensor mechanism pathology	167 (14.2%)
Pain	137 (11.7%)
Laxity	75 (6.4%)
Periprosthetic fracture	36 (3.1%)
Wound pathology	21 (1.8%)
Metal sensitivity	9 (0.8%)
Surgical procedures performed	
Component exchange	638 (54.5%)
Irrigation, debridement and polyethylene insert exchange	179 (15.3%)
Isolated extensor mechanism procedure	133 (11.4%)
Stiffness surgery	130 (11.1%)
Balancing surgery	29 (2.5%)
Osteosynthesis	22 (1.9%)
Arthroscopy	17 (1.5%)
Above knee amputation	7 (0.6%)
Other (synovectomy, material removal)	15 (1.3%)
Age (y)	69.9 ± 10.2 (29-101)
Sex (male/female)	446 (38.1%)/724 (61.9%)

The mean age at inclusion was 69.9 ± 10.2 (29-101) years, and the mean follow-up was 7.7 ± 4.7 (3.2-9.1) years. Early failure was defined as any Re-RiTKA occurring during the two first post-operative years, and later failure occurring thereafter [32].

In cases of reintervention with implant exchange at inclusion, the new prosthesis was cemented in all cases. It was a posterior-stabilized primary TKA prosthesis in 29.8% (190/638), a revision TKA prosthesis with stems and augments (Fig. 2) or a varus-valgus constrained prosthesis in 37.9% (242/638), a rotating-hinge prosthesis in 28.8% (184/638), and an arthrodesis-prosthesis in 3.4% (22/638). Descriptive outcomes of the cohort are presented in Tables 1 and 2.

Ethics Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

Statistical Analysis

Statistical analysis was performed using the online software EasyMedStat (http://www.easymedstat.com/; Neuilly-Sur-Seine, France). Distribution of continuous variables was reported as mean with range and standard deviation. Statistical analysis was performed using Student's *t*-test or Wilcoxon nonparametric test. Categorical variables were compared using a Fisher exact test. A survival analysis was conducted with reintervention as the endpoint. Global survival curves were estimated with a Kaplan-Meier model, and the comparison of survivorship between the different initial etiologies was estimated with log-rank. The level of significance was set at $P < .05$ for all tests.

Table 2
Complementary Details of Procedure Performed During RiTKA of the Initial Population.

Component exchange (n = 638/1170; 54,5%)	• 1 stage: 453/638 (71%) • 2 stage: 185/638 (29%)
Balancing surgery (n = 29/1170; 2.5%)	• Ligament pie-crusting • Polyethylene liner exchange
Isolated mechanism extensor surgery (n = 133/1170; 11.4%)	• Extensor mechanism reconstruction: allograft or synthetic (Hanssen): 19 • Patellar resurfacing • Patellar implant change • Lateral patellar facetectomy • Lateral retinacular release • MPFL ligamentoplasty • Tibial tuberosity osteotomy • Insall plasty • Tibial tuberosity pseudarthrosis • Tendinous suture • Osteosynthesis (tibial tubercle, patella)
Stiffness surgery (n = 130/117; 11.1%)	• Manipulation under anesthesia (86/130; 66.2%) • Arthroscopic arthrolysis (31/130; 23.8%) • Open arthrolysis (13/130; 10%).

RiTKA, reintervention after total knee arthroplasty; MPFL, medial patellofemoral ligament.

Results

Global

One hundred ninety-two (16.4%) patients had a further surgical reintervention (Re-RiTKA). The mean age at re-reintervention was 69.2 ± 10.3 (32-92) years, with a female sex predominance (118/192; 61.5%). The mean time to re-reintervention was 9.6 months ± 12.5 (0.07-63.8). In 90.1% of cases (173/192), the re-reintervention occurred early, during the first two postoperative years.

The indication for re-reintervention (Re-RiTKA) performed is summarized in Table 3.

The indication for re-reintervention evolved between the index RiTKA and the subsequent Re-RiTKA (Fig. 3). In most cases (76.5%), the Re-RiTKA was due to the recurrence of three main etiologies—infection (92/192; 47.9%), extensor mechanism pathology (28/192; 14.6%), and stiffness (26/192; 13.5%)—while the indications for the index reintervention were mainly infection (355/1170; 30.3%), aseptic loosening (196/1170; 16.8%), stiffness (174/1170; 14.9%), and extensor mechanism pathology (167/1170; 14.2%).

Concerning the sub-group of RiTKA for infection, the treatments were irrigation with debridement and polyethylene insert exchange (179/355; 50.4%), component exchange in one stage (21/355; 5.9%), component exchange in two stages (148/355; 41.7%), and above-the-knee amputation (7/355; 1.9%). The detailed results regarding DAIR and component exchange are summarized in the Figure 4.

Concerning the sub-group of RiTKA for pain, the majority were cases of *unexplained* pain (82/137, 59.9%) rather than *explained* pain (55/137, 40.1%). The rate of Re-RiTKA was higher when no cause for the pain could be identified (13.4% vs 7.3%, $P = .25$; odds ratio = 0.5; 95% confidence interval [CI]: 0.15-1.68) with no statistical correlation (Table 4).

Initial Etiology and Indication for Re-reintervention

In four situations, the most common indication for re-reintervention was the recurrence of the initial pathology. This occurred after RiTKA for infection, stiffness, extensor mechanism pathology, and pain (Table 5 and Fig. 5). Infection was the main failure mode after RiTKA for aseptic loosening, laxity, periprosthetic fracture, and wound pathology (Table 5 and Fig. 5).

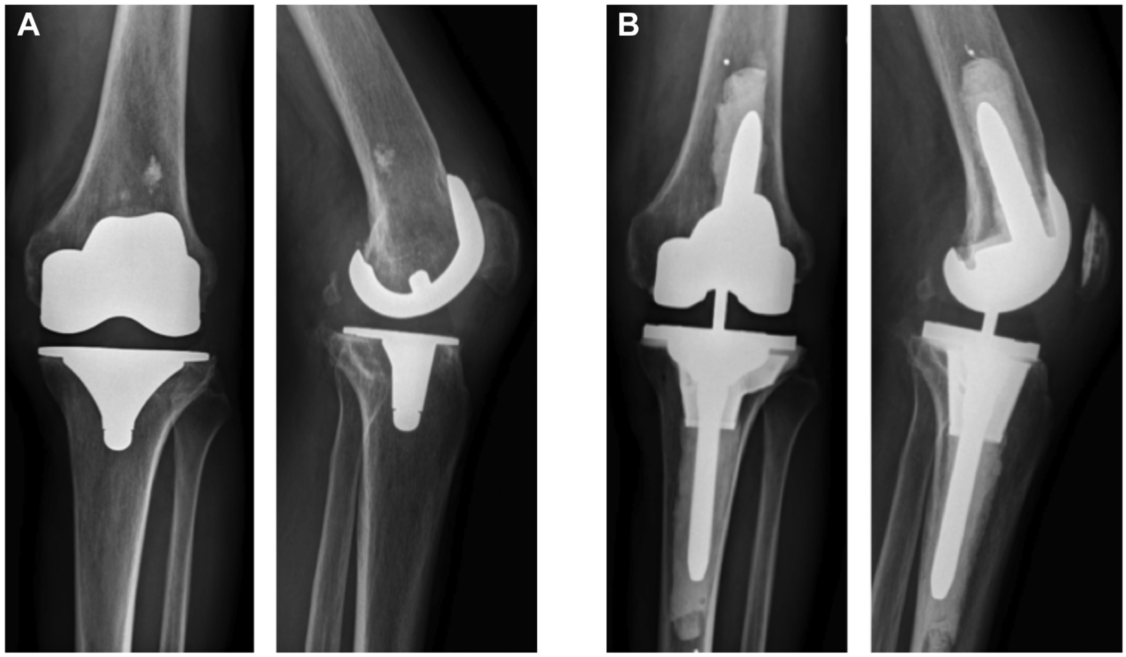

Fig. 2. (A) Revision TKA for chronic infection with tibial loosening and bone defect of the posterolateral tibial plateau requiring a two-stage component exchange. (B) A revision TKA varus-valgus constrained prosthesis with cemented stems and tibial augments was implanted to reconstruct the bone defect. TKA, total knee arthroplasty.

The rate of re-reintervention and the time to re-reintervention were dependent on the initial etiology of RiTKA. RiTKA for infection and wound pathology had the highest rate of Re-RiTKA, 21.1% and 28.6%, respectively. RiTKA for pain and periprosthetic fracture had the lowest rate of re-reintervention, 10.9% and 11.1%, respectively (Table 5). New surgery after RiTKA for wound pathology, infection, and laxity occurred earliest, before the seventh postoperative month, while in cases of RiTKA for extensor mechanism pathology or periprosthetic fracture, the Re-RiTKA occurred latest, after the fifteenth postoperative month (Table 5).

Survival Curves

A global analysis for all etiologies found a survivorship without re-reintervention at 1 year of 87.9% (±0.084, 95% CI: 0.859-0.897), at 2 years of 85.2% (±0.076, 95% CI: 0.83-0.871), and at 7.7 years of 83% (±0.07, 95% CI: 0.81-0.85) (Fig. 6).

Specific analysis depending on the indication for index RiTKA found differences between the groups (Table 5, Fig. 7). RiTKA for infection had the lowest survival rate (77.5% at 7.7 years). RiTKA for metal sensitivity had no failures in this study. RiTKA for pain and aseptic loosening had the best survival rates, at 88.9% and 87% at 7.7 years, respectively.

Table 3
Indications and Re-reintervention Performed After RiTKA.

Indication for re-reintervention (Re-RiTKA)	• Infection (47.9%; 92/192) • Extensor mechanism pathology (28/192; 14.6%) • Stiffness (26/192; 13.5%) • Pain (13/192; 6.8%) • Aseptic loosening (10/192; 5.2%) • Laxity (10/192; 5.2%) • Periprosthetic fracture (7/192; 3.6%) • Wound pathology (6/192; 3.1%) • Metal sensitivity (0)
Surgical procedures performed	• Component exchange (61/192; 31.8%) • Irrigation, debridement, and polyethylene insert exchange (57/192; 29.7%) • Isolated extensor mechanism surgery (23/192; 11.9%) • Stiffness surgery (20/192; 10.4%) • Osteosynthesis (12/192; 6.3%) • Balancing surgery (10/192; 5.2%) • Above knee amputation (3/192; 1.6%) • Arthroscopy (3/192; 1.6%) • Material removal (3/192; 1.6%).

RiTKA, reintervention after total knee arthroplasty.

Discussion

Rate of Re-reintervention

In our study, we found a rate of re-reintervention (Re-RiTKA) of 16.4% at 7.7 years mean follow-up. Our results are similar to the literature, with reported failure rates between 12% at 3.3 years [33] and 18.3% at 5.4 years [19].

Etiologies of Failures

Three indications were responsible of 75% of Re-RiTKA. As for primary TKA [18,34], the leading cause of new failure in our study was infection (47.9%; 92/192), confirming the results of other authors [19,33]. The two others main indications, which differ from primary TKA, were extensor mechanism pathology (14.6%) and stiffness (13.5%). Mortazavi et al [19] also found the main causes of failure after RiTKA to be infection (44.1%), stiffness (22.6%), and extensor mechanism pathology (12.8%). Similar to our study, Suarez et al [33] reported failure rate due to infection at 46%, but the next two most common etiologies were aseptic loosening (19%) and laxity (13%). These were also the main mechanisms of failure in the study of Hossain et al [21].

Evolution of Indications

Analysis of the indication for the index RiTKA and the subsequent cause of failure reveal that the initial pathology could again

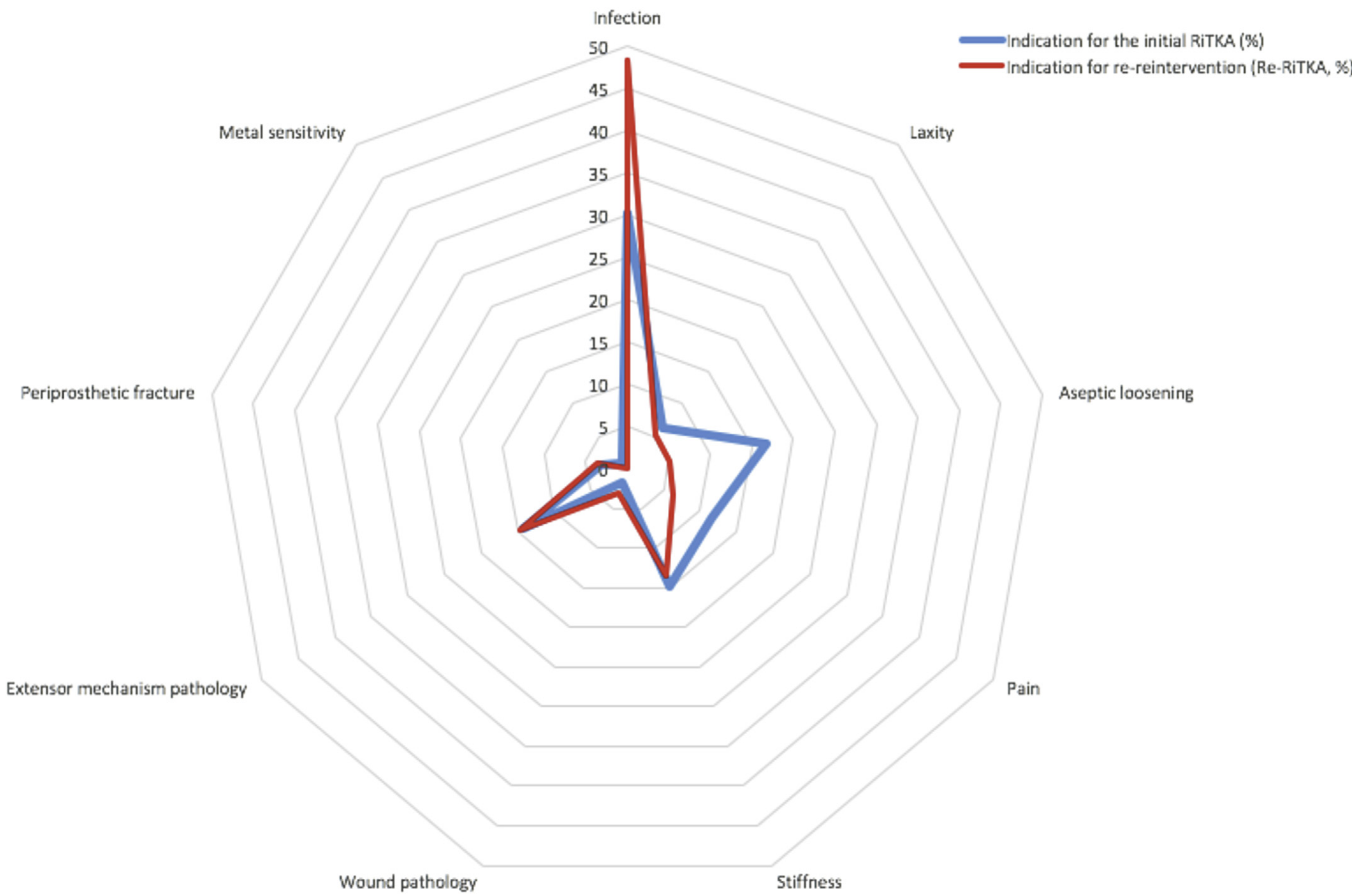

Fig. 3. Evolution between indication for index RiTKA (blue) and indication for re-reintervention (red).

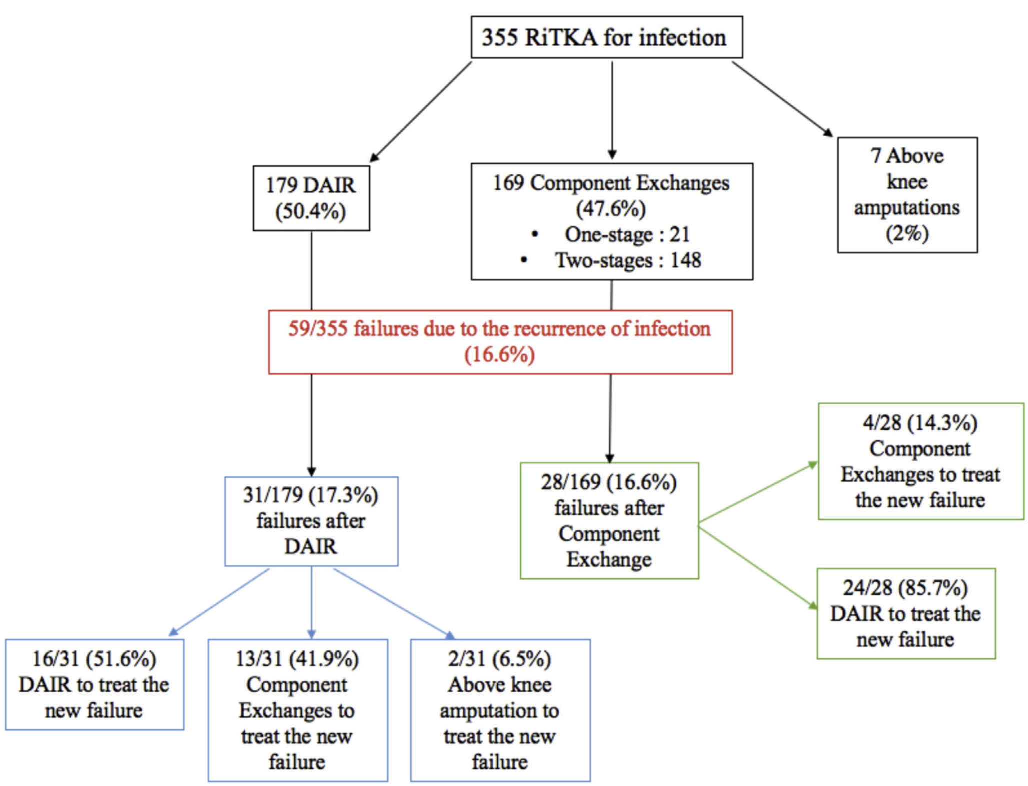

Fig. 4. Detailed results of RiTKA for infection according the surgery performed: DAIR and component exchange.

Table 4
Characteristics of the Pain Subgroup.

	Unexplained Pain	Explained Pain
Total	82/137 (59.9%)	55/137 (40.1%)
Cause	Unidentified	• Oversized components = 17 (30.9%) • Impingement = 15 (27.3%) • Malposition = 10 (18.2%) • Other (synovitis, osteonecrosis, calcifications, foreign bodies) = 7 (12.7%) • Clunk syndrome = 6 (10.9%)
Re-reintervention (n, %)	11/82 (13.4%)	4/55 (7.3%)
Indication for re-reintervention	• Infection = 2 • Aseptic loosening = 1 • Stiffness = 3 • Pain recurrence = 2 • Extensor mechanism pathology = 3	• Infection = 1 • Stiffness = 1 • Pain recurrence = 2

Re-reintervention rate (unexplained painful TKA vs explained painful TKA: 13.4% vs 7.3%, P = .25; OR = 0.5; 95% CI: 0.15-1.68.
CI, confidence interval; OR, odds ratio; TKA, total knee arthroplasty.

be the main cause of failure after RiTKA (Fig. 3). Among the four principal indications for index RiTKA (infection, aseptic loosening, stiffness, and extensor mechanism pathology), three are the principal causes of failure in RiTKA, due to either recurrence of the pathology or *de novo* appearance. We observed very few failures due to aseptic loosening, which may be explained by an insufficient duration of follow-up. No new reintervention was observed in case of RiTKA for metal sensitivity; however, the number of cases was limited.

In four situations (Figs. 3 and 5), the cause of failure was mainly recurrence of the initial pathology. This occurred after RiTKA for infection (16.6%), stiffness (10.3%), extensor mechanism pathology (5.4%), and pain (2.9%).

Concerning RiTKA for stiffness, the literature is unanimous about the difficulty in treating these cases and the uncertain clinical outcomes [35]. Recurrence of stiffness is the main complication with reported rates between 7.1% and 49% [36–39].

Conversely, for pain, the literature seems contradictory. While some authors have found no significant correlation between pain after TKA and implant malposition [40], others report a high incidence of implant malpositioning in painful TKA or in cases of bad clinical outcomes [41,42] and a clear improvement after correction of this malpositioning [43]. In our study, the re-reintervention rate was lower in cases of explained pain due to implant malpositioning [44], oversizing, or impingement [45–47], but no significant difference was found (Table 4; Fig. 8).

Extensor mechanism pathologies are generally multifactorial and occur secondary to malalignment [48,49], inappropriate trochlear prosthetic design [50], or rupture of the extensor mechanism [10]. It is one of the main causes of failure after RiTKA reported in literature, with a prevalence reaching up 41% [51–53]. This high prevalence of patellofemoral disorders in the failure of TKA and RiTKA reflects the difficulty in clearly identifying and treating extensor mechanism pathologies.

Concerning infection, it was the primary cause of failure after RiTKA with a high risk of recurrence at 16.6% in our study (Figs. 4 and 9). Mortazavi et al [19] found a risk of recurrent infection of 27% after RiTKA where infection was the indication for the index revision. In our study, 59 of 92 (64.1%) RiTKAs that failed due to infection had a previous history of septic revision, clearly demonstrating the risk of recurrence of this pathology.

Global and Specific Survivorship

In our study, most of the reinterventions after TKA failures occurred during the first two postoperative years (90.1%). Mortazavi et al [19] reported a similar result, with 83% of new surgery occurring in the same period after revision TKA.

Even if the global survival rate is inferior to the results of primary TKA, which are superior to 90% at 10 years [54,55], we found a very satisfactory result with 83% survivorship at 7.7 years. In their study, Hossain et al [21] reported a better survival rate of 90.6% at 10 years. However, this difference may be explained firstly by the patient selection, with the inclusion of revisions of unicompartmental knee arthroplasty, and secondly by the limitation of the reinterventions evaluated, which included only component

Table 5
Results According to Indication for Index RiTKA.

Initial Etiology of RiTKA	Age (y)	% (n) Complication	Time Period of Failure (mo)	Main Etiology of RiTKA Failure	Early Complication (n; %)	7.7-y Survivorship
Pain	69.9 ± 10.1 (32-101)	10.9 (15/137)	9.8 ± 13.4 (0.9-45.5)	Pain = 4 (2.9%), OR = 43.4, 95% CI: 1.01-11.27, P = .03	13; 86.7%	88.9% ± 0.3, 95% CI: 0.82-0.93
Fracture	74.6 ± 11.3 (59-101)	11.1 (4/36)	18.8 ± 29 (1.5-62,4)	Infection = 2 (5.6%), P = .95	3; 75%	83% ± 0.07, 95% CI: 0.8-0.85
Aseptic loosening	7.7 ± 9.4 (49-94)	12.8 (25/196)	10.4 ± 11.8 (0.9-52.8)	Infection = 8 (4.1%), P = .08	23; 92%	87% ± 0.2, 95% CI: 0.81-0.91
Extensor mechanism	71.7 ± 9.3 (48-92)	14.4 (24/167)	15.1 ± 14.7 (0.07-50.6)	Extensor mechanism = 9 (5.4%), OR = 4.7, 95% CI: 1.58-12.2, P = .001	17; 70.8%	85.4% ± 0.2, 95% CI: 0.79-0.90
Stiffness	64.7 ± 9.6 (32-86)	16.7 (29/174)	11 ± 11.5 (0.6-38.9)	Stiffness = 18 (10.3%), OR = 31.7, 95% CI: 11.3-89.1, P = .00001	26; 89.7%	83.3% ± 0.2, 95% CI: 0.77-0.88
Laxity	70.7 ± 9.4 (43-88)	18.7 (14/75)	6 ± 4.9 (0.4-13)	Infection = 6 (0.08%), P = .7	14; 100%	81.3% ± 0.3, 95% CI: 0.71-0.89
Infection	70.3 ± 10.4 (34-91)	21.1 (75/355)	7.9 ± 12.4 (0.1-64)	Infection = 59 (16,6%), OR = 4.6, 95% CI: 2.94-7.13, P < .00001	70; 93.3%	77.6% ± 0.1, 95% CI: 0.73-0.82
Wound pathology	67 ± 8.9 (51-84)	28.6 (6/21)	4.6 ± 5.3 (0.1-13)	Infection = 3 (50%), P = .6	6; 100%	80% ± 0.4, 95% CI: 0.61-0.91

CI, confidence interval; OR, odds ratio; RiTKA, reintervention after total knee arthroplasty; TKA, total knee arthroplasty.

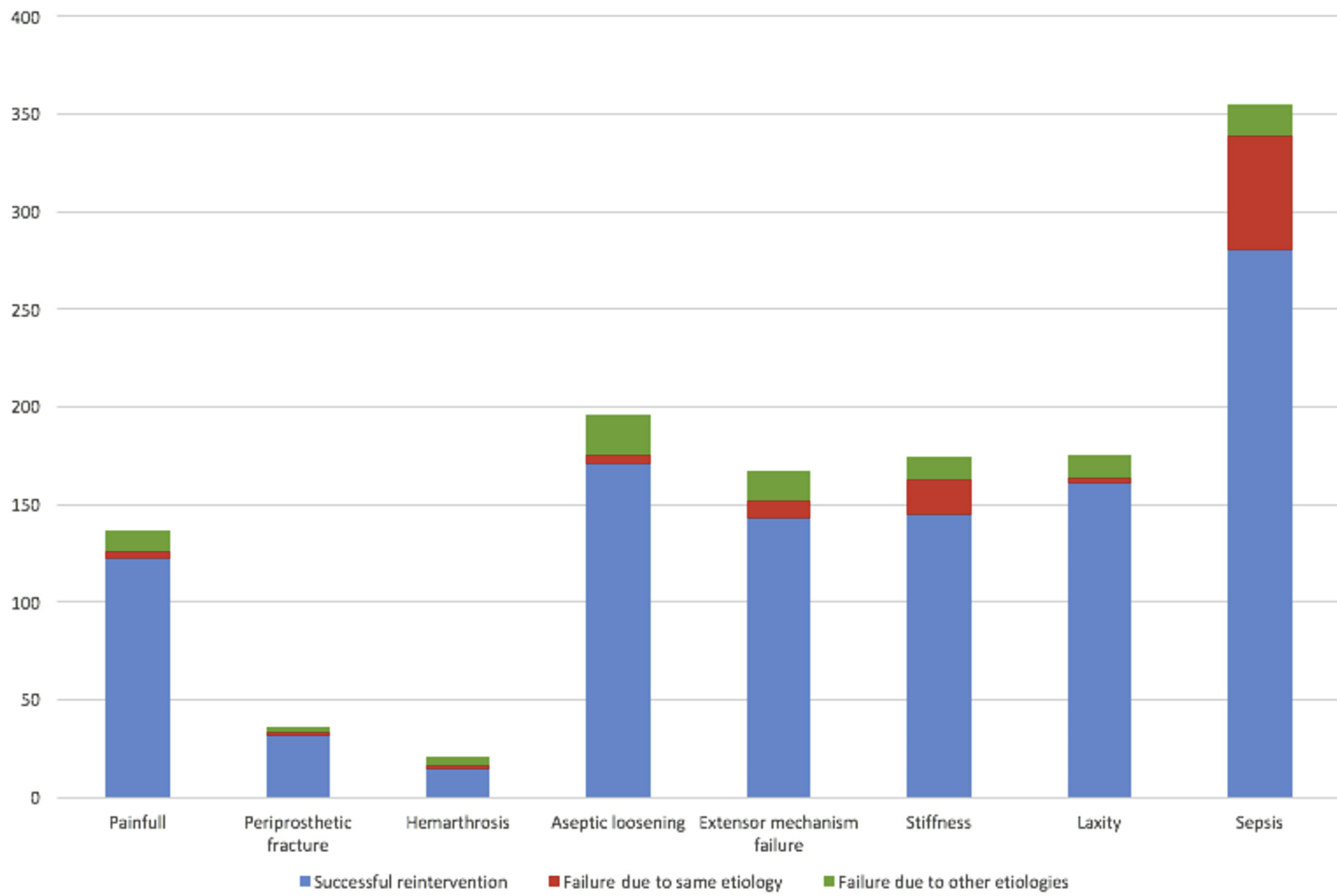

Fig. 5. Outcomes according to indication for index RiTKA. Blue: successful reintervention. Red: failure due to the same indication (recurrence of the initial pathology). Green: failure due to other etiologies.

exchange and excluded all other additional procedures such as patellar resurfacing or irrigation and debridement. Those additional procedures represent in our study a substantial proportion of the reintervention performed (45.5%). Here, exclusion would have an important impact on the survivorship. We made the decision to include them as we felt all the reintervention procedures performed on a TKA, whatever may be the complexity and the severity of the surgery, should be considered as an adverse occurrence in

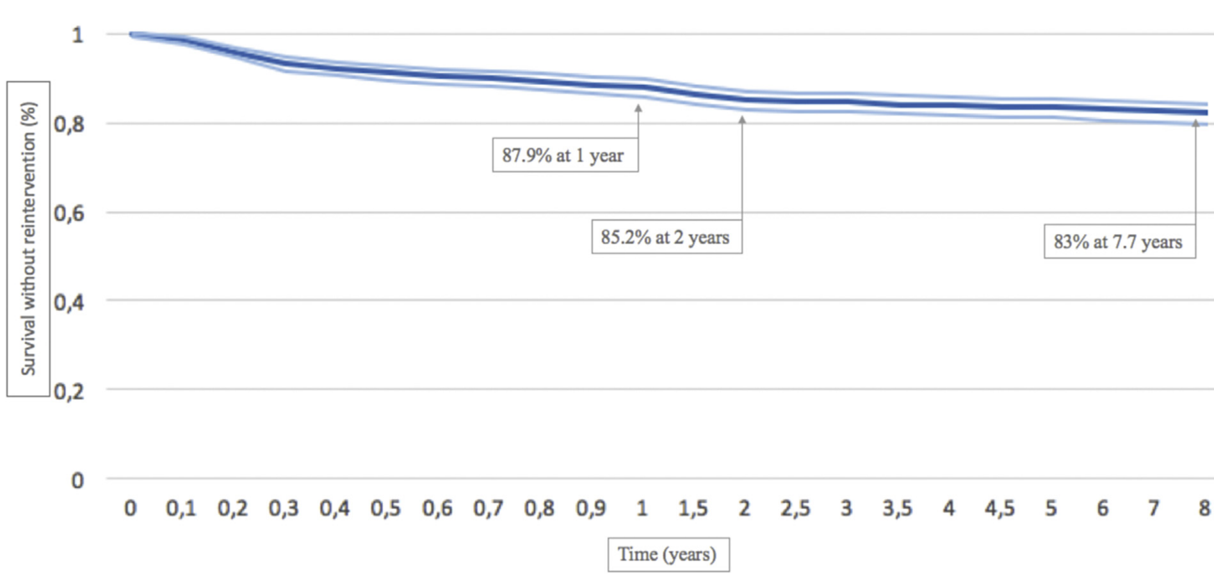

Fig. 6. Global survival curve without reintervention including all index indications.

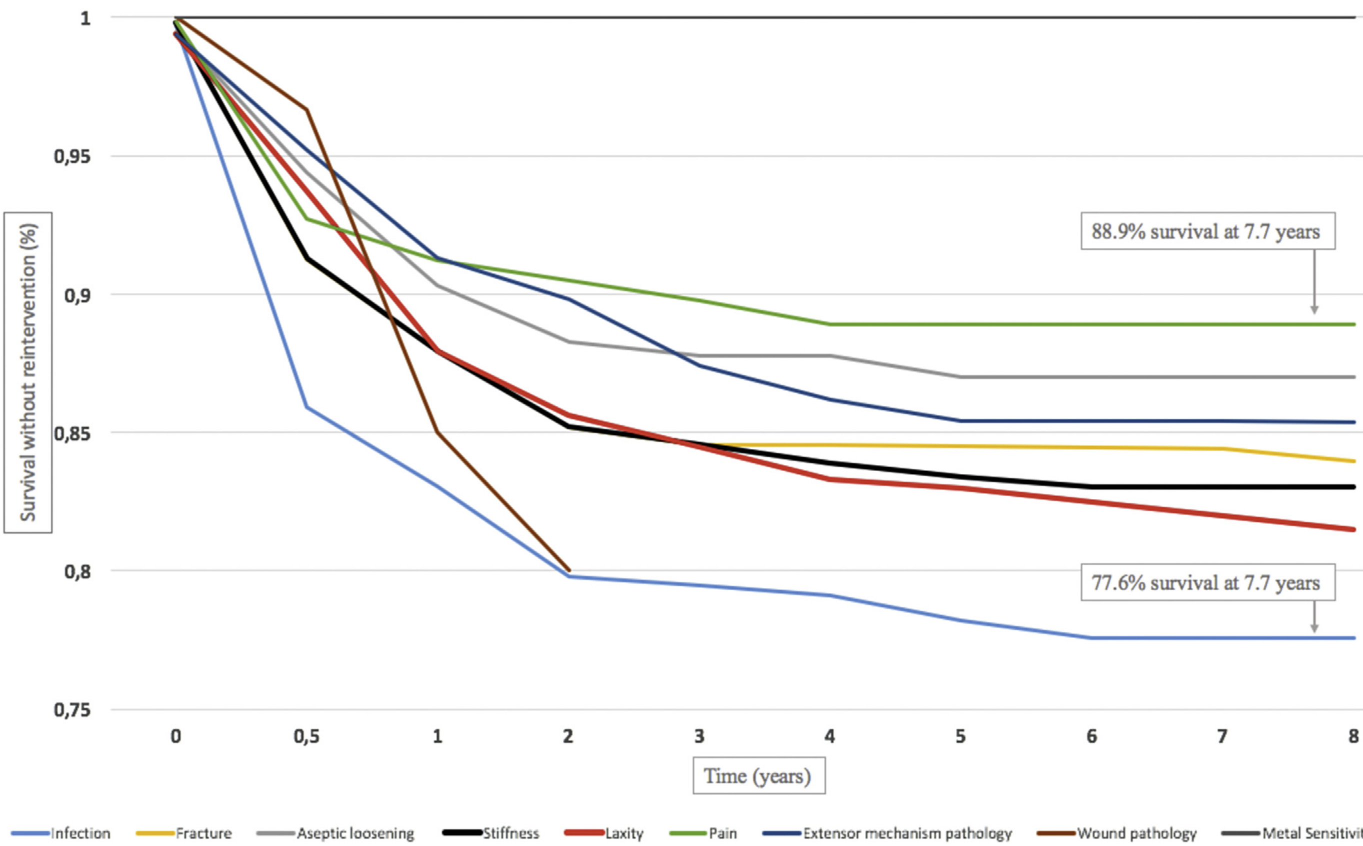

Fig. 7. Survival curves without reintervention according to indication for index RiTKA.

the story of the prosthetic knee, especially from the patient's point of view. Suarez et al [33] found a survival rate without reintervention similar to our results of 85% at 9 years. Other studies report inferior survivorship of 72.9% at 7.5 years [19] and 79% at 10 years [56].

Different survivorship was observed depending the indication for the index RiTKA. Best survival rates were observed after RiTKA for pain (88.9% at 7.7 years) and aseptic loosening (87% at 7.7 years). The worst survival rates were observed in cases of RiTKA for infection (77.6% at 7.7 years) and for wound pathology (80% at 2

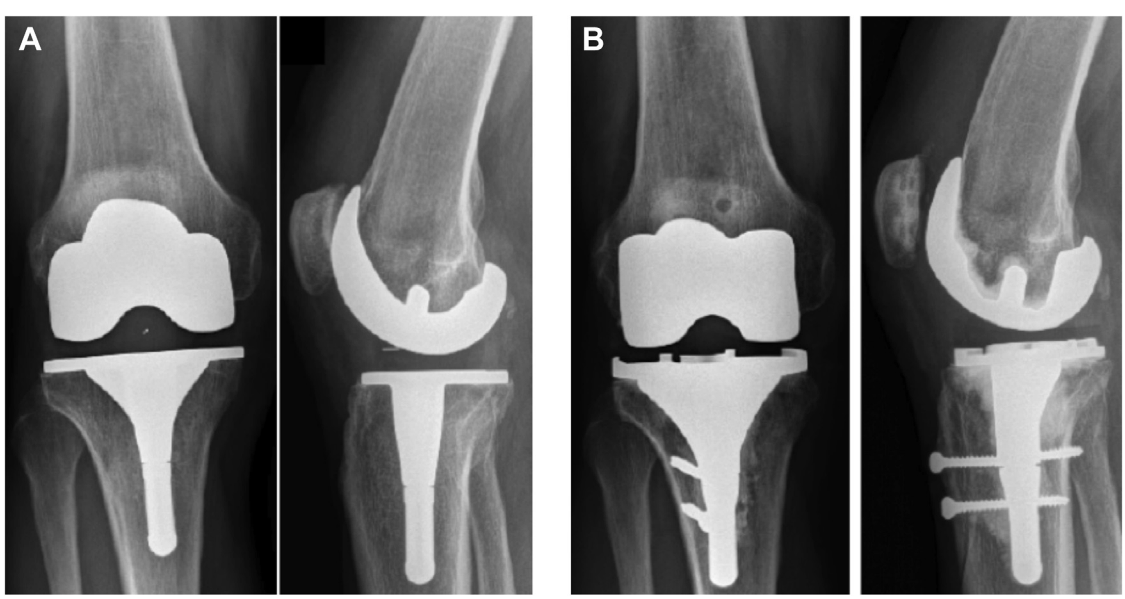

Fig. 8. (A) Seventy-five-year-old man with a painful TKA due to mediolateral oversizing. (B) A one-stage revision was performed using a posterior stabilized TKA with an extended stem, with good outcome and no re-revision at 4 years.

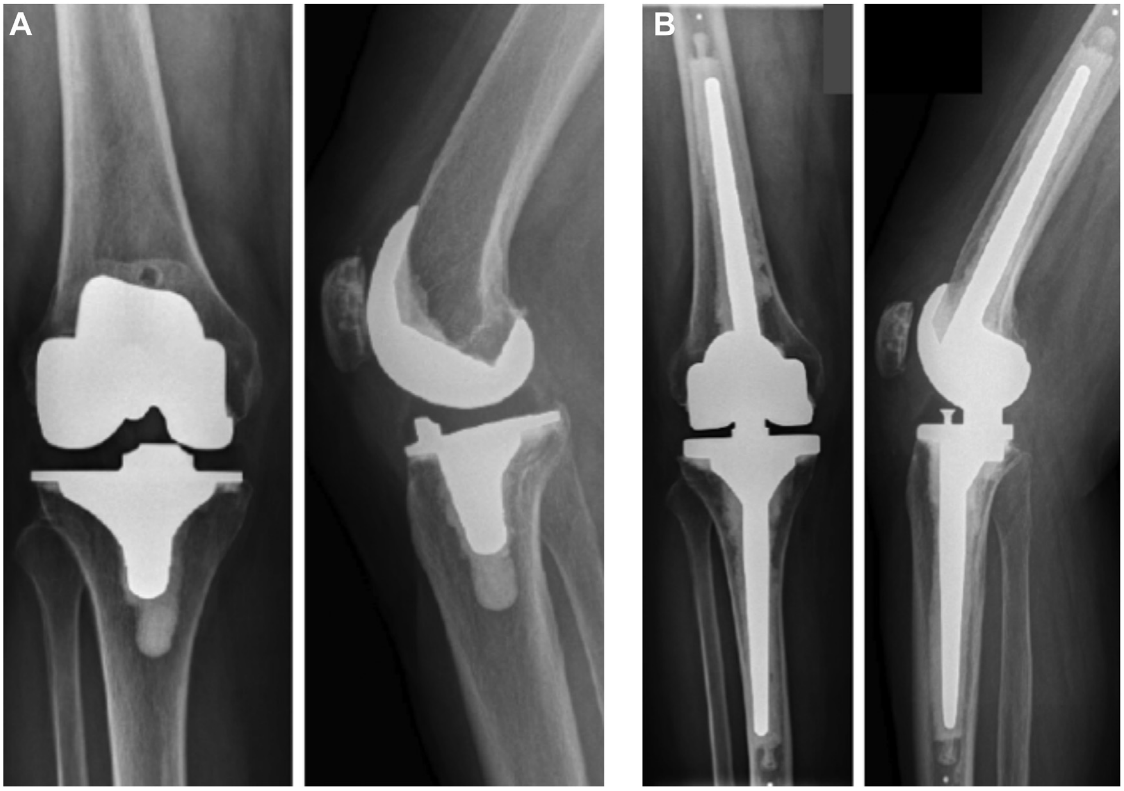

Fig. 9. (A) Eighty-six-year-old women presenting a hematogenous infection. (B) A one-stage revision was performed with a rotating-hinge prosthesis.

years). There are several possible explanations for these findings. First, as infection is the major cause of failure after RiTKA, with high risk of recurrence and complications [57], this would explain the lower survivorship due to the higher number of Re-RiTKA for this sub-group [58,59]. Second, considering only reintervention as an end point may limit the number of failures, especially in the complex cases of metal sensitivity and unexplained pain. In this subgroup of painful TKA, because of a lack of an identified cause for the persisting pain after revision, patients could be in a *therapeutic deadlock* with no other possible surgery. Theses *desperate* cases could have a theoretical indication for reintervention because of their poor clinical outcome; however, no new surgery is proposed because of failure of the previous intervention and the potential morbidity and uncertain outcome of further interventions. These patients are not counted as a failure, and the survival curve is not impacted [60,61]. Third, regarding aseptic loosening, as an initial etiology or as a complication, we found good results which could be explained by the insufficient follow-up to observe a recurrence of the pathology or a *de novo* apparition.

Limitations and Advantages

Our study has several limitations. First, while this multicenter case series study allows us to report data from a high volume of patients, it is retrospective in nature. Second, the lack of long-term follow-up could impact the occurrence of some complications. Even if most of the failures after RiTKA appear early, it could be a bias concerning pathology with a slow evolution such as aseptic loosening or chronic infection. Third, one of the center of this study is a reference center for the treatment of bone and joint infection, which could introduce a bias with an overestimation of infection cases, especially the chronic and complex cases which are difficult to treat with a high risk of recurrence. Furthermore, the use of reintervention as the study end point may underestimate the rate of clinical failure in complex cases, as further surgery may not be performed because of the potential risks and the uncertain benefits.

The strength of this study is the size of the cohort and the full representation of the pathologies occurring after RiTKA, through the inclusion of all mechanisms of failure and all additional procedures performed on a prosthetic knee. This gives orthopedic surgeons a wide overview on this surgery and reflects all the possible outcomes after reintervention on TKA.

Conclusion

Contemporary RiTKA failures mainly occurs in the first two postoperative years and is associated with a higher risk of reintervention than primary TKA, with a rate of 16.6% at 7.7 years. Infection is the primary cause of failure after RiTKA (92/192; 47.9%), particularly after a history of infection in the index TKA. The two other major causes of failure are extensor mechanism pathology (28/192; 14.6%) and stiffness (29/192; 13.5%). Recurrence of the initial pathology occurs in four groups of RiTKA and is the main reason of failure: infection (16.6%), stiffness (10.3%), extensor mechanism failure (5.4%), and pain (2.9%). For the other groups of RiTKA, the main cause of failure was infection. The survivorship without reintervention is good at short- and medium-term follow-up (87.9% at 1 year and 83% at 7.7 years).

A complete preoperative analysis of the indication leading to the index RiTKA is crucial to understand the problem and to attempt to resolve it in one-stage surgery. Concerning infection, which remains the main factor compromising the results of RiTKA, all preventive measures must be employed, and in case of proven infection, multidisciplinary management in a reference center is recommended.

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Level of evidence: IV: retrospective or historical series.

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