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(Citation)
Indian Journal of Orthopaedics,58(3):308-315

(Issue Date)
2024-03

(Resource Type)
journal article

(Version)
Accepted Manuscript

Mid- to Long-Term Results of Total Knee Arthroplasty for Charcot Arthropathy of the Knee

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'Declarations of interest: None'.

Acknowledgements:

We would like to thank Editage (www.editage.com) for English language editing.

Abstract

Background: Total knee arthroplasty (TKA) for Charcot arthropathy of the knee is considered controversial because of its higher complication rate compared with that of TKA for osteoarthritis. In this study, we investigated the clinical outcomes, survival rates, and complications of primary TKA for Charcot arthropathy.

Methods: We conducted a retrospective analysis of nine patients (12 knees) with Charcot arthropathy who underwent TKA. The mean age of the patients was 63.9±9.4 years (range, 52–83 years). The most frequent causative disease was diabetes mellitus (three patients). Patients' clinical outcomes, including the 2011 Knee Society Score and the range of motion, were compared between preoperative and the most recent postoperative data. The 5- and 10-year survival rates for aseptic revision, revision due to infection, and complications were examined. The mean follow-up period was 7.3±3.9 years (range, 3–14 years).

Results: The 2011 Knee Society Score and the knee flexion angle significantly improved after TKA surgery ($P<0.05$). The 5-year survival rates for aseptic revision, revision due to infection, and complications were 100%, 91.7%, and 83.3%, respectively; the 10-year survival rates for these parameters were the same. One patient underwent revision for insert replacement due to periprosthetic infection, and the other patient had varus/valgus instability due to soft tissue loosening.

Conclusions: The mid- to long-term results of TKA for Charcot arthropathy were generally favorable. Our findings indicate that TKA may be a viable treatment option for Charcot arthropathy.

Keywords: Charcot arthropathy; neuropathic arthropathy; total knee arthroplasty; survival rates; constrained condylar prosthesis; rotating hinge prosthesis

Introduction

Charcot arthropathy is a degenerative neuropathic arthropathy that leads to severe joint destruction and instability, caused by repetitive asymptomatic microtrauma due to decreased or absent joint nociception[1]. The global increase in the incidence of diabetes mellitus (DM), the main causative disease of Charcot arthropathy, is expected to lead to a higher prevalence of Charcot arthropathy[2,3]. Because of the nature of Charcot arthropathy, patients rarely complain of pain during the early deformity stages and typically seek treatment only after severe deformity, instability, and gait disturbance have occurred[4]. This makes Charcot arthropathy one of the most difficult conditions for orthopaedic surgeons to treat.

Although total knee arthroplasty (TKA) for Charcot arthropathy was previously not recommended because of its high rate of complications, such as periprosthetic infection, fracture, and dislocation[5,6], several recent studies have shown good short-term clinical outcomes with TKA[2,7]. However, there is limited literature on the mid- to long-term results of TKA for Charcot arthropathy[8,9], and important questions regarding survival rates, potential complications, and clinical outcomes of TKA remain unresolved. This lack of information may prevent proper management of Charcot arthropathy. Therefore, we aimed to report the mid- to long-term results of primary TKA for patients with Charcot arthropathy.

Materials and methods

Patients

The study was approved by the Institutional Review Board of our institution (Permission No; 1510), and written informed consent was obtained from the patients. We conducted a retrospective analysis of 11 consecutive patients with Charcot arthropathy of the knee who underwent primary TKA at our institution between August 2008 and March 2020. Two patients were excluded from the study because they died within one year for reasons unrelated to TKA. The remaining nine patients (12 knees), consisting of four men and five women with a mean age of 63.9±9.4 years (range, 52–83 years) at the time of TKA, were enrolled in the study. None of the patients had undergone arthroscopic debridement or other knee surgeries prior to the TKAs. Prior to TKA, three patients had ipsilateral ankle joint fractures and underwent open reduction and internal fixation.

The Charcot arthropathy-causative neuropathy was diagnosed by neurologists using nerve conduction studies, electromyography, and clinical evaluations. Orthopaedic surgeons verified the diagnoses by physical examination and radiographic studies, revealing features characteristic of Charcot arthropathy, including severe deformity, instability, and restricted range of motion. The nine patients included in the study had a variety of causative diseases. Of these, DM was the most common (three patients), with a mean HbA1c of 5.9±0.2% (range, 5.6–6.1%). Two patients had neurosyphilis, one had Charcot-Marie-Tooth disease, one had Guillain-Barre syndrome, one had cervical ossification of the posterior longitudinal ligament, and one had meningeal aneurysm (Table 1). None of the patients were lost to follow-up, and the mean follow-up period was 7.3±3.9 years (range, 3–14 years).

Operative procedures

All surgeries were performed by senior surgeons with >15 years of experience in TKA procedures. All patients received general anesthesia and femoral/sciatic nerve block with 0.75% ropivacaine (40 mL). After inflating the air tourniquet to 250 mmHg, the knees were exposed by medial parapatellar arthrotomy; osteotomy was performed using the measured resection technique. A Legacy constrained condylar knee prosthesis (LCCK; Zimmer Biomet, Warsaw, IN, USA) was inserted in ten knees and a rotating hinge knee prosthesis (RHK; Zimmer Biomet) was inserted in two knees presenting hyperextension. Stems were used in both the femur and tibia for seven knees; in four knees, the stems were used in the tibia only; in one knee, no stems were used, following a protocol to use stems in fragile bones. Augmentation was applied to replace tibial bone defects of >5 mm in eight knees. All the femoral and tibial prostheses were fixed with cement after pulsed lavage, drying, and pressurization of the cement. Patellar resurfacing was conducted in seven knees with patellar deformity. After all the prostheses were implanted, lateral retinacular release was needed in four cases of knees based on the assessment of patellar tracking. During surgery, no cases had soft tissue injuries such as medial or lateral collateral ligaments or patellar tendons (Table 1).

Postoperative therapy

The operated knee did not wear any brace from the day of surgery. From the day after surgery, all patients were allowed full weight-bearing and began active knee motion exercises, along with quadriceps-strengthening exercises and standing at the bedside or walking with crutches or a walker under the supervision of a physical therapist. On the

14th postoperative day, the wound stitches were removed. No patient had any infection or wound dehiscence at this point. Two to four weeks after surgery, patients were discharged from the hospital, and physical therapy at the outpatient clinic was conducted once a week for three months after surgery. In addition to the inpatient rehabilitation program, outpatient rehabilitation focused on activities of daily living exercises such as bathing, hill walking, and stair climbing, tailored to each patient's condition. For postoperative analgesia, NSAIDs were administered up to 1 month postoperatively and acetaminophen from 1 to 3 months postoperatively. After diagnosis of osteoporosis by dual energy X-ray absorptiometry, patients received oral administration of 35 mg alendronate once a week and 0.75 μg eldecalcitol daily.

Clinical and radiographic evaluations

Clinical and radiographic evaluations were performed for each patient preoperatively, and at 3-, 6-, and 12-months postoperatively, and annually thereafter.

The 2011 Knee Society Score (KSS)[10] was recorded and assessed. The range of motion (ROM) was measured three times each using a goniometer in the supine position by several senior physiotherapists with >5 years of clinical experience.

During radiographic evaluation, the femorotibial angle (FTA) was measured in full-length views of the lower extremities, in the standing position. The stage of Charcot arthropathy was classified according to the Koshino classification[11]. Prosthesis loosening was assessed by component subsidence >2 mm or by a complete radiolucent line around the component[12]. All radiographic evaluations were independently analyzed by two investigators, who had >10 years of clinical experience and were not involved in the operations.

Statistical analysis

All values were normally distributed and were expressed as mean ± standard deviation (SD). All statistical analyses were performed using the statistical software EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan)[13]. Paired t-tests were used to compare the 2011 KSS and ROM between preoperative and the most recent data. For patients who died or experienced revision surgery, the values at the pre-event visit were considered the most recent data. The Kaplan–Meier method was used to create survival curves for revision and complications[14]. Statistical significance was set at $P<0.05$.

Results

Clinical outcomes

The average pre- and postoperative 2011 KSS and their subscales, ROMs, and mobility are presented in Table 2. The 2011 KKS, all its subscales, and knee flexion angles were significantly improved following surgery ($P<0.05$) (Table 2). Preoperatively, none of the patients could walk independently and only three patients could walk with a single cane; however, postoperatively, three patients were able to walk independently and five patients could walk with a single cane (Table 2).

Radiographic results

According to the Koshino classification, two knees had stage II, and 10 knees had stage III Charcot arthropathy (Table 1). Preoperatively, the FTA of eight varus knees was 199.8±11.1° (range, 186–223°) and the FTA of four valgus knees was 155.1±5.4° (range, 148–163°); postoperatively, the FTA improved to 176.6±3.7° (range, 170–183°). No cases showed component subsidence >2 mm or progressive radiolucent lines around the femoral, tibial, or patellar components (Fig. 1, 2).

Implant survival, revisions, and complications

The survival rates for aseptic revision, revision due to infection, and complications are presented in Figure 3. The 5-year survival rates were 100% (12/12) for aseptic revision, 91.7% (11/12) for revision due to infection, and 83.3% (10/12) for complications. The 10-year survival rates were the same. Only 2 out of 12 patients had complications during follow-up period.

One patient experienced a periprosthetic infection 4 years postoperatively. Under general anesthesia, the polyethylene insert was removed, and the knee joint was thoroughly debridement and washed with 9 L of saline solution. The femoral and tibial components showed no septic loosening and were not replaced. A new polyethylene was inserted and the wound was closed. The drain placed in the knee joint was removed the day after surgery. The pathogenic bacteria was E. coli, and the patient was treated with ceftriaxone intravenously for 6 weeks postoperatively, followed by cefditoren pivoxil orally for 6 weeks. No additional revision surgery was required in this case.

The other patient had coronal plane instability due to soft tissue loosening 1 year postoperatively. Lateral loosening was significant, and a lateral thrust was observed. No lateral collateral ligament injury was observed during surgery, however, the soft tissue fragility was apparent, probably due to increased postoperative activity and stress. The patient needed to wear a hinged knee brace when walking.

None of the patients developed patellar dislocation, periprosthetic fracture, deep vein thrombosis, or patellar crank syndrome.

Discussion

The most important finding of this study is that TKA was generally a safe treatment option for Charcot arthropathy of the knee. Clinical outcomes including 2011 KSS and ROM were significantly improved at the last follow-up, similar to previous reports[7,8], and the mid- to long-term survival rate for aseptic revision in this study was 100%. However, several postoperative complications were observed.

Survival rates for aseptic revision of TKA for Charcot arthropathy have been reported to be excellent, with 100% at five years and 88% at ten years[8], and our data support that result. However, the previous report showed a high incidence (16%) of periprosthetic infections, which occurred at an average of 3 years postoperatively (range, 1–6 years)[8]. In our study, the incidence of periprosthetic infection was slightly lower, affecting 1 in 12 knees (8%). Charcot arthropathy patients are often frail due to their underlying disease, and the frailty increases the incidence of infection after TKA[15]. DM, the most common disease causative of Charcot arthropathy, is also related to a high incidence of periprosthetic infection[16]. In this study, one case experienced postoperative varus/valgus instability, which was similarly reported in previous reports and required revision surgery in some cases[6,9]. However, the patient did not need revision surgery because of no symptoms related to the instability with a brace. Joint instability is one of the most important complications in Charcot arthropathy because ligamentous laxity often occurs due to advanced joint deformity. Remaining hyperextension of the knee after TKA increases the risk of neurovascular injury and residual knee pain. In such cases, it is important to choose RHK to restrict the extensor mechanism and avoid revision surgery[17,18], and this hinged prosthesis was applied for 2 cases in the series of the study.

In TKA for Charcot arthropathy, various prostheses have been used, including cruciate-retaining (CR), posterior-stabilized (PS), LCCK, and RHK. The choice of implants is still a matter of debate[19,20]. Unrestrained components (e.g., CR, PS) are often inappropriate for Charcot arthropathy, because they can lead to postoperative joint instability due to severe deformity and soft-tissue imbalance[4,19]. RHK should be selected carefully, because excessive restraint can increase the risk of aseptic loosening and periprosthetic fractures[18,20]. Therefore, some surgeons consider that LCCK, which provides good stability with minimal restriction, is the optimal prosthesis for Charcot arthropathy[7,8]. In our study, LCCK was the preferred prothesis, with RHK used only in patients presenting with knee hyperextension. Moreover, when using constrained components, the use of long stems is important to distribute the increased stress on the bone[21,22]. In a previous report, 16% of Charcot arthropathy patients treated without stems developed aseptic loosening within 5 years[4]. Conversely, another study reported no cases of aseptic loosening after five years and only 6% after 10 years in patients treated with stems[8]. Of the patients included in our study, stems were used in 92% of cases, with none of the patients showing aseptic loosening during the follow-up period.

Management of large bone defects in Charcot arthropathy is a major concern. Treatment strategies for bone defects include autografts, allografts, metal augmentation, and tantalum implants[6,23]. However, the bone structure of Charcot arthropathy is very weak, and even if autologous or allogeneic bone is grafted into the defect, a bone union is difficult to achieve[9,24]. Therefore, in our cases, metal augmentation was used to fill the bone defect. Immediately after surgery, full weight bearing was allowed; however, no cases resulted in loosening or periprosthetic fractures.

This study had some limitations. First, it was a retrospective case series with a limited

number of patients. This limited the ability to perform subgroup analysis based on causative disease, Charcot stage, or implant type. To perform subgroup analysis, a larger number of patients is needed. Second, a longer follow-up period is desirable to accurately evaluate the efficacy of the TKA procedure in Charcot arthropathy.

In conclusion, our mid- to long-term results of TKA for Charcot arthropathy were generally favorable. Patients in this study achieved definite improvement in knee pain, function, and mobility, and the 5- and 10-year survival rates for aseptic revision were excellent. Therefore, TKA may be a viable treatment option for Charcot arthropathy while the complications such as periprosthetic infection and instability should be kept in mind.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent All participants provided informed consent prior to their participation.

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312 **Figure legends**

313 **Fig. 1** Radiographs of a 61-year-old male with Koshino classification stage III Charcot
314 arthropathy (No. 2 in Table 1) preoperatively (A, B), immediately postoperatively (C, D),
315 and most recently, 14 years postoperatively (E, F).

316

317 **Fig. 2** Radiographs of a 74-year-old female with Koshino classification stage III Charcot
318 arthropathy (No. 4.1 in Table 1) preoperatively (A, B), immediately postoperatively (C,
319 D), and most recently, 5 years postoperatively (E, F).

320

321 **Fig. 3** Kaplan–Meier curves of survival rates for aseptic revision, revision due to infection,
322 and complications.

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Table 1. Patients' characteristics

No	Age	Sex	Diagnosis	Koshino stage	Constraint	Stem	Augmentation	Complication	Revision	Follow-up (years)
1.1	70	F	GBS	III	LCCK	F, T	T			9 (death)
1.2				III	LCCK	F, T	T	Infection	Insert replacement	9 (death)
2	61	M	T2DM	III	LCCK	T	T			14
3.1	83	F	C-OPLL	III	LCCK	T	T			13
3.2				II	LCCK					13
4.1	74	F	CMT	III	RHK	F, T				5
4.2				III	RHK	F, T				5
5	52	M	Meningocele	III	LCCK	F, T				5
6	57	M	Neurosyphilis	III	LCCK	T	T			5
7	63	M	Neurosyphilis	III	LCCK	F, T	T	Instability		4
8	59	F	T1DM	II	LCCK	F, T	T			3
9	56	F	T1DM	III	LCCK	T	T			3

F, female; M, male; GBS, Guillain-Barre syndrome; T2DM, type 2 diabetes mellitus; C-OPLL, cervical ossification of the posterior longitudinal ligament; CMT, Charcot-Marie-Tooth disease; T1DM, type 1 diabetes mellitus; LCCK, Legacy constrained condylar knee; RHK, rotating hinge knee; F, femur; T, tibia

331 Table 2. Clinical outcomes pre- and post-operatively

	Pre-operatively	Post-operatively	*P value*
2011 KSS			
Total (180 points)	58.7±25.7 (26–102)	122.0±35.2 (52–162)	*<0.001**
Symptoms (25 points)	7.9±6.0 (0–19)	16.8±5.6 (8–23)	*<0.001**
Satisfactions (40 points)	18.2±5.8 (10–30)	29.6±7.1 (18–38)	*0.003**
Expectations (15 points)	12.3±1.4 (10–15)	13.8±1.2 (11–15)	*0.002**
Activities (100 points)	20.2±19.0 (-6–52)	62.1±23.3 (17–90)	*0.002**
ROM			
Extension (°)	-6.7±11.8 (-20–15)	-0.8±2.8 (-10–0)	*0.121*
Flexion (°)	111.7±18.6 (70–140)	124.2±8.9 (110–140)	*0.002**
Mobility			
Independent	0	3	
Single cane	3	5	
Double cane	4	0	
Wheelchair	2	1	

332 * $P<0.05$

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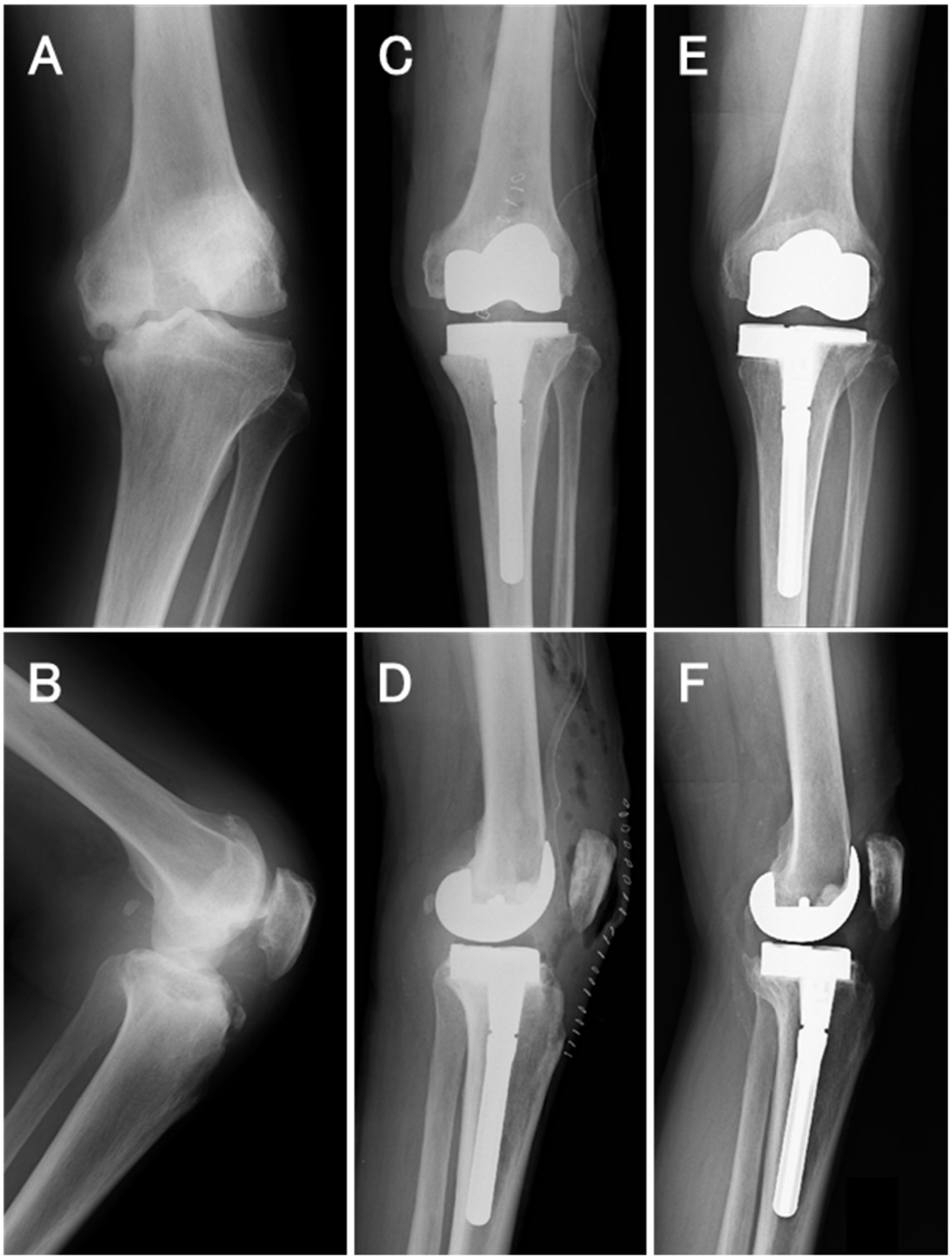
335 Figure 1.



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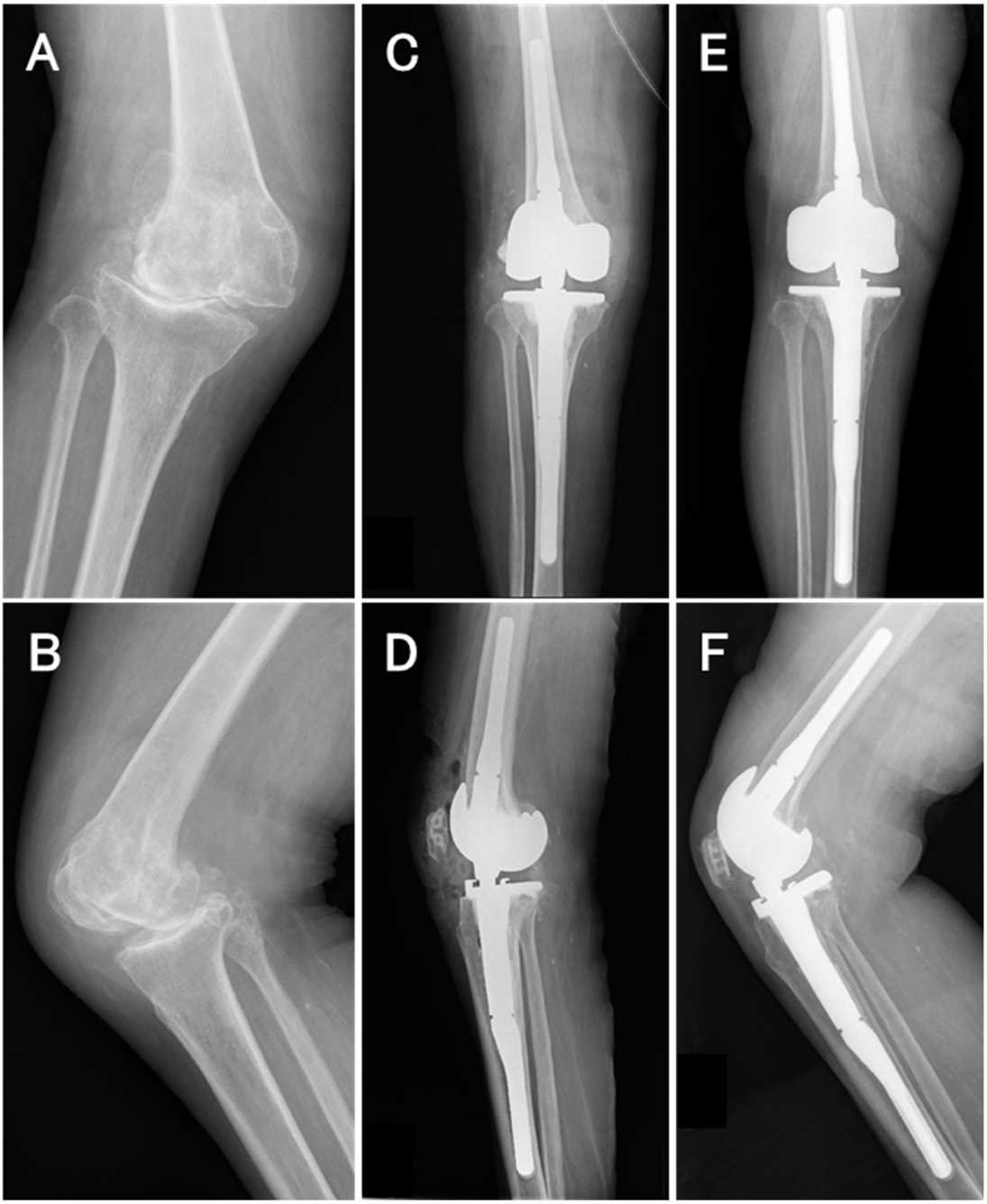
339 Figure 2.



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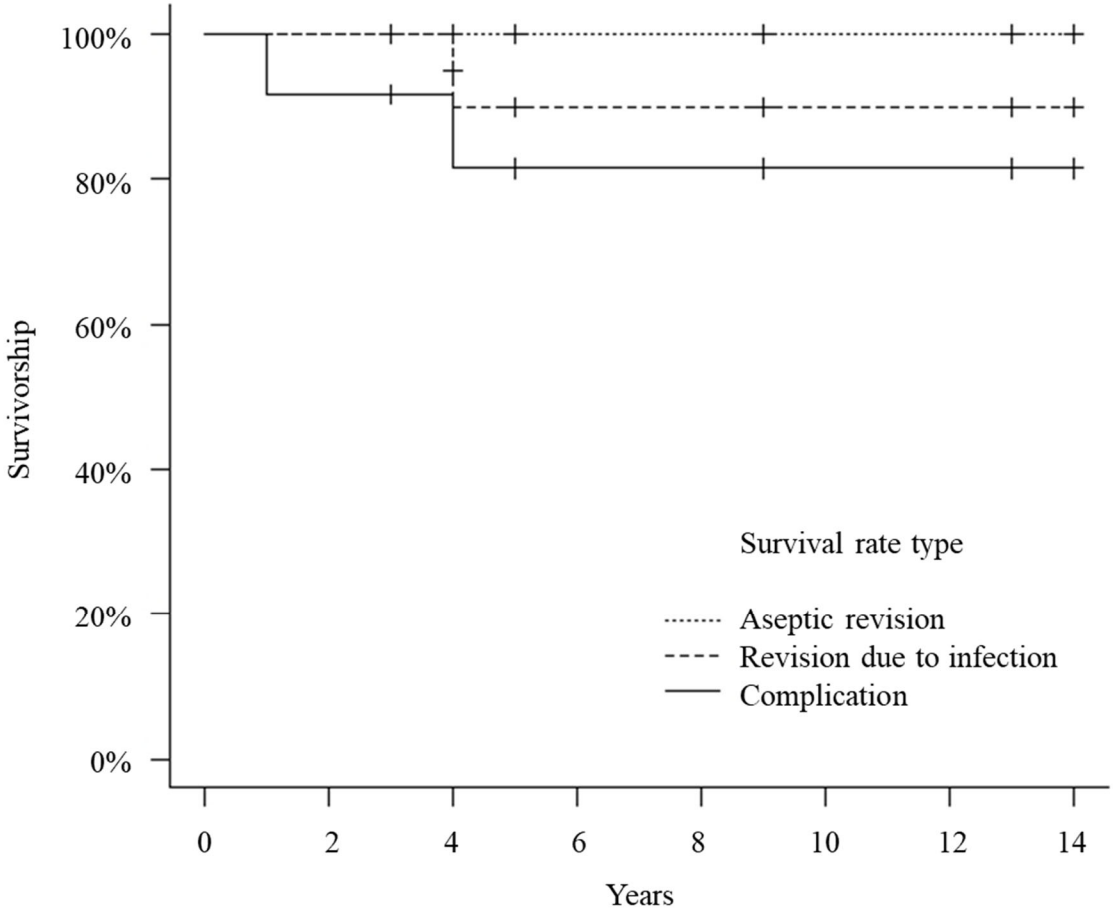
343 Figure 3.



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